

The Journal of The Royal Astronomical Society of Canada

# Journal

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PROMOTING  
ASTRONOMY  
IN CANADA

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Inside this issue:

Une structure du Crabe,  
Messier 1

*A winding scorpion*



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*Dave Dev imaged the Dark Scorpion Nebula (LDN1152) from River Place Park in Ayton, Ontario, on 2022 July 31. He used an Askar 400 mm APO together with an ASI 2600 colour camera for a total of 7 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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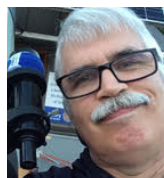
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Canada



## President's Corner

### When Telescopic Asterisms... Aren't



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

I first viewed Brocchi's cluster, popularly known in Western culture as "the Coathanger" at the telescope eyepiece of fellow astronomer Danny Sklazeski, and it has been a go-to for me at outreach ever since. The Coathanger appears on every list of telescopic asterisms I've ever seen. I first viewed the open cluster Messier 44 (the Beehive Cluster) and the double-star system Mizar and Alcor at the eyepiece of my own telescope. It wasn't until I got involved in RASC's World Asterisms Project that I discovered that these three asterisms are not telescopic asterisms at all.

Brocchi's Cluster is listed in many texts as having been discovered by Italian astronomer Giovanni Battista Hodierna in 1654, and it is named for American amateur astronomer Dalmero Francis Brocchi, who created a map of it in the 1920s. However, the first recorded unaided eye sighting was by famous Persian astronomer 'Abd al-Rahman al-Sufi in 964. The Beehive was observed by Galileo in 1609, and was added to French astronomer Charles Messier's catalogue in 1769. However, this open cluster appears as "the Crab" in ancient Babylonian cuneiform texts. Hipparchus called it "Little Cloud," Aratus called it "Little Mist," and Eratosthenes and Ptolemy called it "the Manger." Chinese astronomers of the Ming Dynasty called it "Cumulative Corpse Gas" and ancient Korean astronomers called it "Pile of Dead." Ancient Babylonian texts refer to Alcor as "the Fox." Ancient Mongolians called Alcor the "Recover and Protector Star" and believed Alcor had been placed there by their God of Heaven, Tengeriin, to protect Mizar. They believed that you could not be an archer unless you could see both stars. In the Ming Dynasty, astronomers called Alcor "the Assistant." Clearly people all over the world could see these asterisms with the unaided eye before the invention of the telescope. Why are they now typically listed as "telescopic asterisms"?

The misuse of artificial light at night is what happened. Billions of dollars are wasted every year on excessive and improper lighting, disrupting the migratory patterns of birds, disrupting peoples' circadian rhythms, and decreasing safety by blinding people at night with the glare. That is why I'm pleased to see that the RASC's Light-Pollution Abatement Committee is now beginning work with two Canadian communities, one from each end of the country, to help them become Dark-Sky Communities. This involves working with them to amend By-Laws to require full-cutoff lighting of the

correct colour temperature. New construction will require this lighting, and in the coming years, as old systems need replacement, they will be converted to the new standard. This is definitely possible: One of those communities is Sechelt, B.C., which is where I live. Twelve years ago, our astronomers in the Sunshine Coast Centre took sky quality measurements all over the coast. I repeated these measurements in 2019 to determine

how much the sky quality had degraded due to ongoing construction and expansion. Sechelt had been putting up new full-cutoff street lighting since the original tests. I was pleased to see that the readings a decade later had not increased. As a result, these communities will save money, improve safety, improve health, and restore these asterisms to the list of unaided eye asterisms where they belong. ✨

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## News Notes / En manchette

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Compiled by Jay Anderson

### JWST begins to deliver the goodies

Galaxy clusters are the most massive structures in our Universe and make powerful gravitational telescopes that collect and magnify the light from distant objects that lie behind them. These “telescopic” objects are presented to the observer as multiple magnified and distorted images, which, nevertheless, show fine structural detail.

One of the first science images released by the *James Webb Space Telescope* (JWST) was centred on the cluster SMACS J0723.3–7327 and showed a forest of misty white cluster galaxies surrounded by dozens of orangey-red arcs, bending toward the centre of the lensing cluster. The arcs showed brightness variations along their length that spoke of massive nebulas, star-forming regions, and active nuclei—nifty stuff.

Using this first JWST image, an international team of scientists has taken an older model of the mass distribution within SMACS J0723.3–7327 and built an improved version

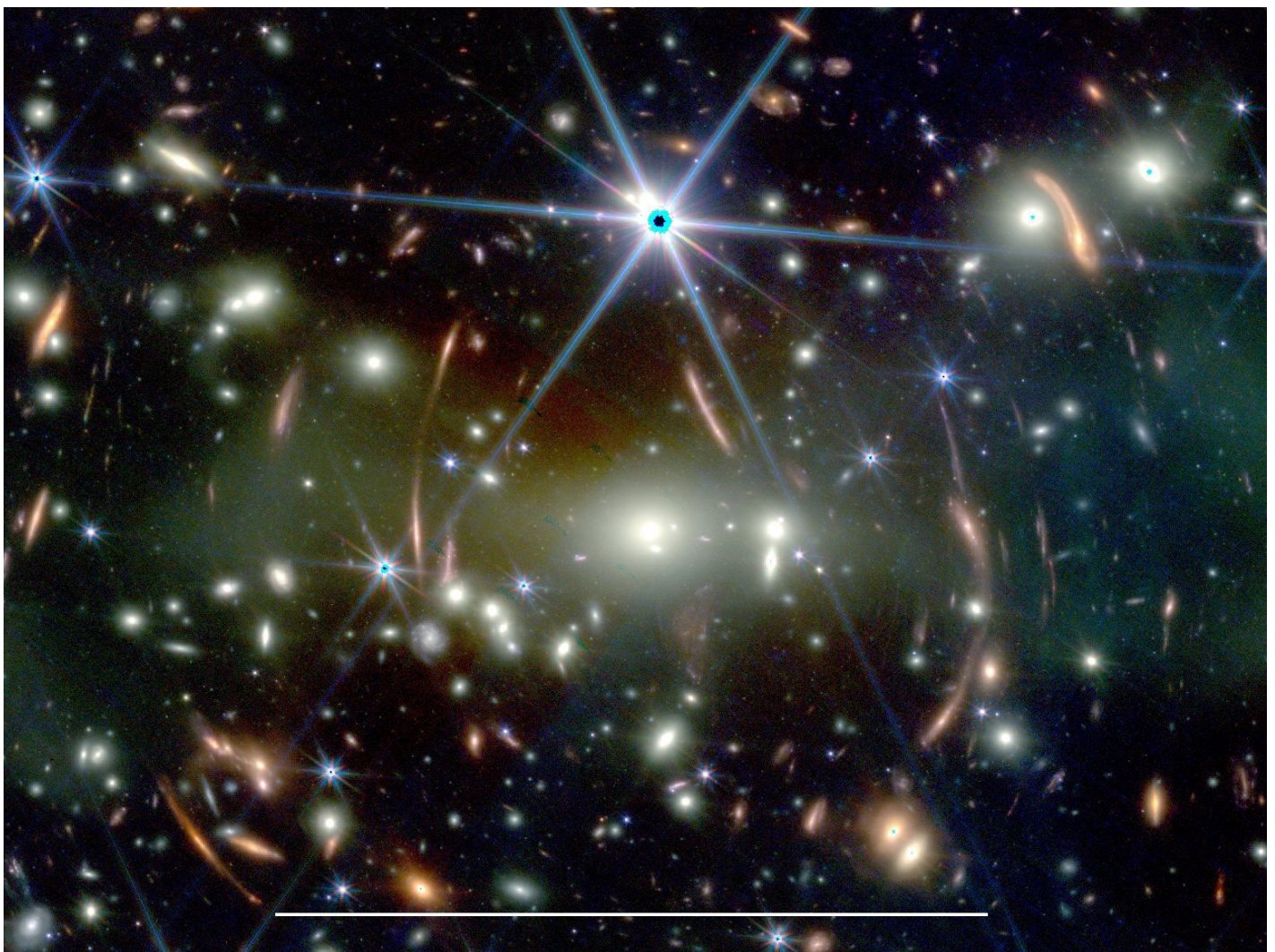


Figure 1 – This JWST image shows the galaxy cluster SMACS J0723.3–7327 with a large number of lensed background galaxies. The white bar at the bottom corresponds to 50 arcsec, which is approximately the maximum size of Jupiter observed from Earth. Credit: NASA, ESA, CSA and STScI.

that gives a more detailed map of the cluster's structure. This was possible because of the much-improved resolution and greater light-collecting ability of the JWST images. In effect, the shapes and positions of the lensed background objects allowed a refinement of the characteristics of the lensing cluster.

Careful examination—even casual examination—of the JWST image will show that individual galactic arcs can be matched up with other similar-appearing arcs. These matches are multiple images of the same background galaxy, though typically inverted and reflected as they surround SMACS J0723.3–7327. Before JWST, 19 multiple images of six background sources had been detected in images of the cluster's surroundings. The JWST data now reveal 27 additional multiple images from another ten lensed sources—a total of 16 lensed galaxies producing 46 doppelgängers.

Interpretation of the lensed background galaxies depends critically on the mass of the foreground lensing galaxy and the distribution of mass within the lensing cluster. This “first JWST study” was dedicated to refining the model of the shape and structure of SMACS J0723.3–7327 in order to better understand the nature of the more distant galaxies. The refined modelling techniques can also be used for future studies of other galactic clusters. The science team estimated the mass of SMACS J0723.3–7327 to be  $8.6 \times 10^{13} M_{\odot}$ , about 10 percent higher than previous estimates.

“In this first step towards the road opened by JWST, we used recent data from this brand-new telescope, to model the lensing effect of SMACS0723 with great accuracy,” points out Gabriel Bartosch Caminha, postdoc fellow at the Technical University of Munich (TUM), the Max Planck Institute for Astrophysics (MPA) and the German Centre for Cosmological Lensing (GCCL). The collaboration first used data from the *Hubble Space Telescope* (HST) and its Multi-Unit Spectroscopic Explorer (MUSE) to build a “pre-JWST” lens model, and then refined it with the newly available JWST near-infrared images. “The JWST imaging is absolutely astounding and beautiful, showing many more multiply lensed background sources, which allowed us to substantially refine our lens mass model,” Caminha added.

Many of these new, lensed sources do not yet have distance estimates, and the scientists used their new mass model to estimate how far away these lensed galaxies are most likely to be. One of them was found to be probably at the amazing distance of 13 Gyrs (redshift  $> 7.5$ )—a galaxy from the Universe's earliest stages. This galaxy was multiply lensed into three images and its luminosity was magnified by a factor of  $\approx 20$  in total.

To study these primordial objects, it is fundamental to describe accurately the lensing effect of the foreground galaxy cluster. “Our accurate mass model forms the foundation for the exploration of the JWST data,” emphasizes Sherry Suyu, Professor of Observational Cosmology at TUM, Max Planck Research Group Leader at MPA, and a Visiting Scholar at the Academia Sinica Institute of Astronomy and Astrophysics. “The spectacular JWST images show a great variety of strongly lensed galaxies, which can be studied in detail thanks to our accurate model.”

The new model for the mass distribution of the foreground cluster is capable of reproducing the positions of all multiple images with a high accuracy, making the model one of the most accurate available. For follow-up studies of these sources, the lens models, including magnification maps and redshifts (distances) estimated from the model have been made publicly available. “We are very excited about this,” Suyu adds. “We are eagerly awaiting future JWST observations of other strong lensing galaxy clusters. These will not only allow us to better constrain the mass distributions of galaxy clusters, but also to study high-redshift galaxies.”

*Compiled in part with material provided by the Technical University of Munich.*

## LRO finds a home away from home

NASA-funded scientists have discovered shaded locations within pits on the Moon that always hover around a comfortable  $17^{\circ}\text{C}$  using data from NASA's *Lunar Reconnaissance Orbiter* (LRO) spacecraft and computer modeling.

The pits, and caves to which they may lead, would make thermally stable sites for lunar exploration compared to locations on the Moon's surface, which heat up to about  $127^{\circ}\text{C}$  during the day and cool to minus  $173^{\circ}\text{C}$  at night. Lunar exploration is part of NASA's goal to explore and understand the unknown in space, to inspire and benefit humanity. A day on the Moon lasts about 15 Earth days, during which the surface is constantly bombarded by sunlight and is frequently hot enough to boil water. Brutally cold nights also last about 15 Earth days.

Pits were first discovered on the Moon in 2009, and since then, scientists have wondered if they led to caves that could be explored or used as shelters. The pits or caves would also offer some protection from cosmic rays, solar radiation, and micrometeorites.

“About 16 of the more than 200 pits are probably collapsed lava tubes,” said Tyler Horvath, a doctoral student in planetary science at the University of California, Los Angeles, who led the new research.

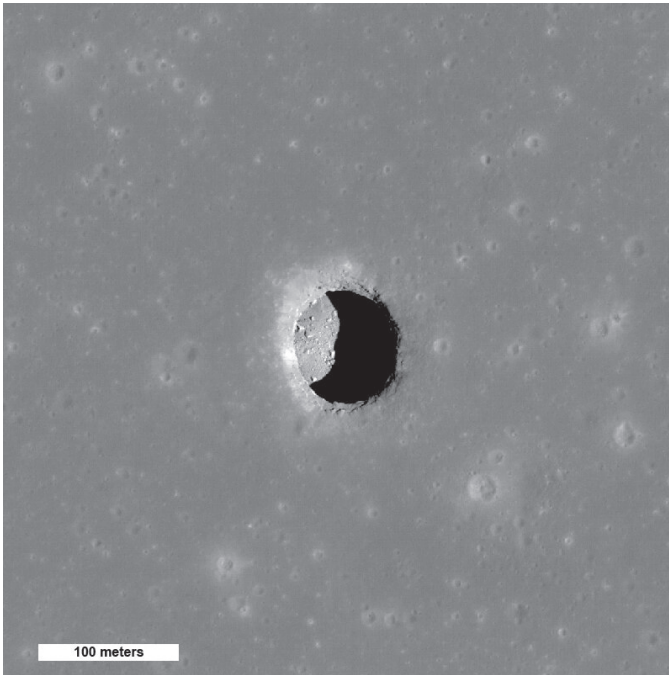


Figure 2 – A spectacular high-Sun view of the Mare Tranquilitatis pit crater revealing boulders on an otherwise smooth floor. This image from LRO’s Narrow Angle Camera is 400 metres (1,312 feet) wide; north is up. Credit: NASA/Goddard/Arizona State University

“Lunar pits are a fascinating feature on the lunar surface,” said LRO Project Scientist Noah Petro of NASA’s Goddard Space Flight Center in Greenbelt, Maryland. “Knowing that they create a stable thermal environment helps us paint a picture of these unique lunar features and the prospect of one day exploring them.”

Lava tubes, also found on Earth, form when molten lava flows beneath a field of cooled lava or when a crust forms over a river of lava, leaving a long, hollow tunnel. If the ceiling of a solidified lava tube collapses, it opens a pit that can lead into the rest of the cave-like tube.

Two of the most prominent pits have visible overhangs that clearly lead to caves or voids, and there is strong evidence that another’s overhang may also lead to a large cave.

“Humans evolved living in caves, and to caves we might return when we live on the Moon,” said David Paige, a co-author of the paper who leads the Diviner Lunar Radiometer Experiment aboard LRO that made the temperature measurements used in the study. Horvath processed data from Diviner—a thermal camera—to find out if the temperature within the pits diverged from those on the surface.

Focusing on a roughly cylindrical 100-metre-deep depression about the length and width of a football field in an area of the Moon known as the Mare Tranquilitatis, Horvath and

his colleagues used computer modelling to analyze the thermal properties of the rock and lunar dust and to chart the pit’s temperatures over time.

The results revealed that temperatures within the permanently shadowed reaches of the pit fluctuate only slightly throughout the lunar day, remaining at around 17 °C. If a cave extends from the bottom of the pit, as images taken by LRO’s Lunar Reconnaissance Orbiter Camera suggest, it too would have this relatively comfortable temperature.

The team, which included UCLA professor of planetary science David Paige and Paul Hayne of the University of Colorado Boulder, believes the shadowing overhang is responsible for the steady temperature, limiting how hot things get during the day and preventing heat from radiating away at night.

### Roadrunner star has Milky Way’s fastest orbit

Searching for the farthest/biggest/brightest thing in astronomy is almost a cottage industry. Every week seems to bring a new “farthest galaxy,” “most distant star,” “closest exoplanet,” or some such announcement. They aren’t frivolous, as each one establishes a new scientific benchmark, even though they may be supplanted in the following week or month.

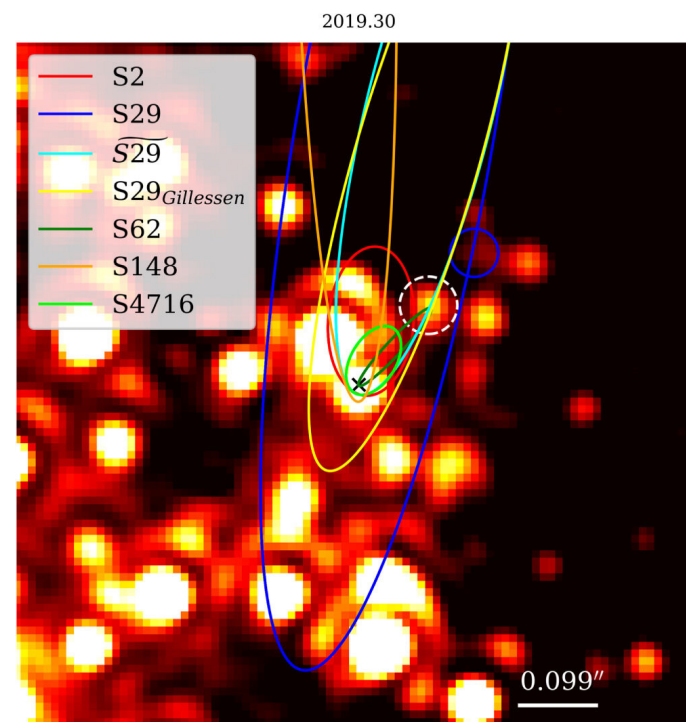


Figure 3 – An infrared view of the galactic centre observed with NIRC2 (Keck) in 2019.30 showing stars and their orbits in the S Cluster close to Sgr A\*, which is indicated by a black cross. The brightest star in the image is S2, lying above and left of the galactic core. Here north is up and east is to the left. Credit: The Astrophysical Journal (2022). DOI: 10.3847/1538-4357/ac752f.

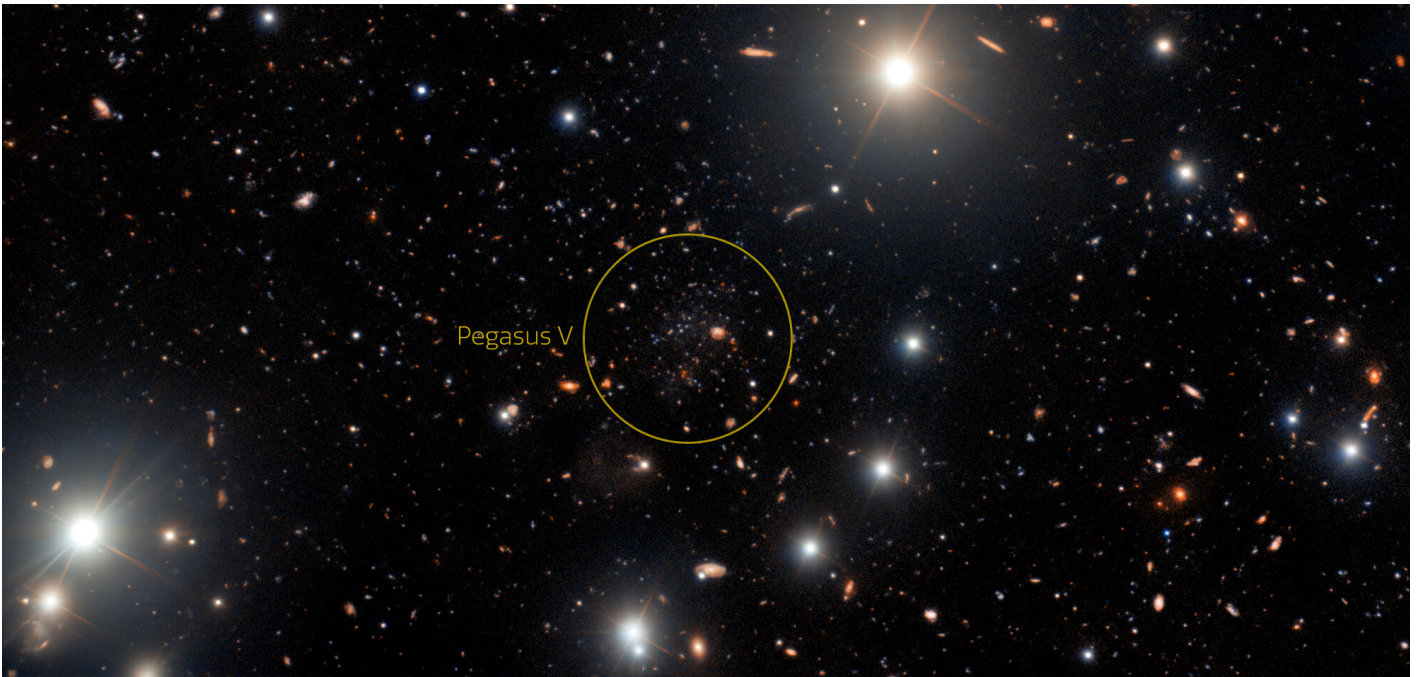


Figure 4 – The ultra-faint dwarf galaxy Pegasus V (circled). Credit: International Gemini Observatory/NOIRLab/NSF/AURA. Acknowledgment: Image processing: T.A. Rector (University of Alaska Anchorage/NSF’s NOIRLab), M. Zamani (NSF’s NOIRLab) & D. de Martin (NSF’s NOIRLab)

In June of this year, a new benchmark was established: a star with the shortest orbital period—four years—speeding around the Milky Way’s central super massive black hole (SMBH, known as Sagittarius A\*) at a distance of only 100 au (astronomical units). (One au corresponds to the mean distance of the Earth from the Sun.) The star, designated S4716, reaches an orbital speed of around 8,000 kilometres per second in a modestly eccentric orbit around the galaxy’s nucleus that takes it approximately from the distance of Saturn to the orbit of Neptune

S4716 is a member of a cluster of over 100 stars, known as the S Cluster, all in orbit around Sagittarius A\*. It is not the fastest moving star around Sagittarius A\*—that honour belongs to another member of the S Cluster, S4711, which has a much more eccentric, longer-period orbit around the Milky Way’s core but moves more quickly when at perigee. Nevertheless, S4716 is moving at 2.6 percent of the speed of light in its orbit. It’s a big star, about 4 times the mass of the Sun and 130 times more luminous. Using the mass estimate for S4716 and its orbital period, the mass of our galaxy’s black hole can be determined: 4.02 million times that of the Sun. Its distance from the Sun comes out at around 26,000 light-years; all of these measurements are consistent with previous determinations.

While finding a fast-moving star and determining its orbit seems like a relatively straight-forward process, the extreme density of stars in the region around Sagittarius A\* and the complications of intervening gas and dust demand careful calibration and attention to details. A particular problem is the

brightest star in the S Cluster, known as S2, which dominates the region around Sagittarius A\* and scatters light into the field, complicating the detection of faint stars such as S4716.

“One prominent member, S2, behaves like a large person sitting in front of you in a movie theatre: it blocks your view of what’s important,” said Dr Florian Peissker, lead author of the new study. “The view into the centre of our galaxy is therefore often obscured by S2. However, in brief moments we can observe the surroundings of the central black hole.”

By means of continuously refined methods of analysis, together with observations covering almost twenty years, the researchers have now conclusively identified a star, S4716, that travels around the central SMBH in just four years. A total of five telescopes observed the speedy star, with four of these five being combined into one large telescope to allow even more accurate and detailed observations. “For a star to be in a stable orbit so close and fast in the vicinity of a supermassive black hole was completely unexpected and marks the limit that can be observed with traditional telescopes.” said Peissker.

The discovery sheds new light on the origin and evolution of the orbit of fast-moving stars in the heart of the Milky Way. “The short-period, compact orbit of S4716 is quite puzzling,” Michael Zajačec, an astrophysicist at Masaryk University in Brno who was involved in the study, said. ‘Stars cannot form so easily near the black hole. S4716 had to move inwards, for example by approaching other stars and objects in the S cluster, which caused its orbit to shrink significantly,’ he added



Observations of the region surrounding Sagittarius A\* have been gradually refined over the past two decades so that we now have a good understanding of the dynamical environment in which the S Cluster resides. Now the question can turn to how the cluster was able to form in the first place in such a high-energy chaotic place.

*Compiled in part with material provided by the University of Cologne.*

## Amateur astronomer finds Andromeda companion

An unusual ultra-faint dwarf galaxy has been discovered on the edge of the Andromeda Galaxy using several facilities of the National Science Foundation's NOIRLab. The galaxy, called Pegasus V, was first detected as part of a systematic search for Andromeda dwarfs coordinated by David Martinez-Delgado from the Instituto de Astrofísica de Andalucía, Spain. Amateur astronomer Giuseppe Donatiello found an interesting 'smudge' in data in a DESI Legacy Imaging Surveys image. The image was taken with the Dark Energy Camera on the Víctor M. Blanco 4-metre Telescope at Cerro Tololo Inter-American Observatory (CTIO).

Follow-up deeper observations by astronomers using the larger, 8.1-meter Gemini North telescope with the GMOS instrument, revealed faint stars in Pegasus V, confirming that it is an ultra-faint dwarf galaxy on the outskirts of the Andromeda Galaxy. Gemini North in Hawai'i is one half of the International Gemini Observatory.

"We have found an extremely faint galaxy whose stars formed very early in the history of the Universe," commented Michelle Collins, an astronomer at the University of Surrey, UK and lead author of the paper announcing this discovery. "This discovery marks the first time a galaxy this faint has been found around the Andromeda Galaxy using an astronomical survey that wasn't specifically designed for the task."

The observations with Gemini revealed that the galaxy appears to be extremely deficient in heavier elements compared to similar dwarf galaxies. The faintest galaxies are considered to be fossils of the very first galaxies that formed, and these galactic relics contain clues about the formation of the earliest stars. While astronomers expect the Universe to be teeming with faint galaxies like Pegasus V, they have not yet discovered nearly as many as their theories predict. If there are truly fewer faint galaxies than predicted, it would imply a serious problem with astronomers' understanding of cosmology and dark matter.

Discovering examples of these faint galaxies is therefore an important endeavour, but also a difficult one.

"The trouble with these extremely faint galaxies is that they have very few of the bright stars, which we typically use to identify them and measure their distances," explained Emily Charles, a PhD student at the University of Surrey who was also involved in the study. "Gemini's 8.1-metre mirror allowed us to find faint, old stars, which enabled us both to measure the distance to Pegasus V and to determine that its stellar population is extremely old."

"We hope that further study of Pegasus V's chemical properties will provide clues into the earliest periods of star formation in the Universe," concluded Collins. "This little fossil galaxy from the early Universe may help us understand how galaxies form, and whether our understanding of dark matter is correct."

"The public-access Gemini North telescope provides an array of capabilities for community astronomers," said Martin Still, Gemini Program Officer at the National Science Foundation. "In this case, Gemini supported this international team to confirm the presence of the dwarf galaxy, associate it physically with the Andromeda Galaxy, and determine the metal-deficient nature of its evolved stellar population."

*Compiled with material provided by Gemini Observatory.\**

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## Une structure peu connue des amateurs dans la partie nord de la nébuleuse du Crabe, Messier 1

Gilbert St-Onge<sup>1b</sup>, (RASC / CDADFS / SAM / FAAQ/)

Denis Bergeron<sup>2b</sup>, (RAAOQ-FAAQ),

Denis St-Gelais<sup>3b</sup>, Mexique,

### Résumé

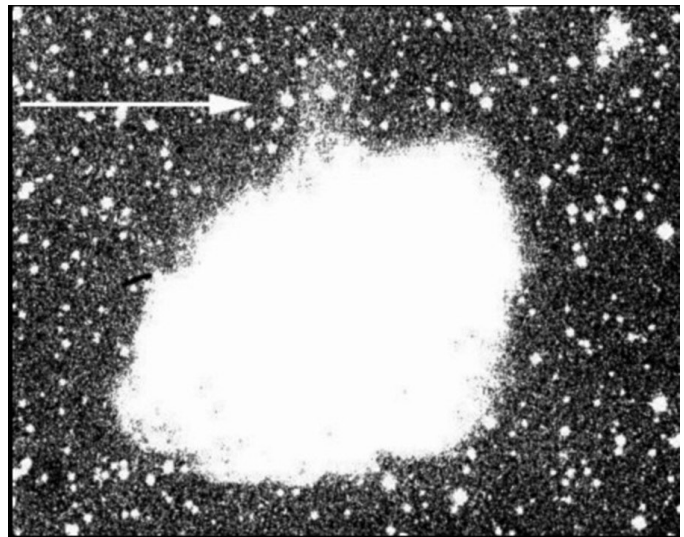
Des images à haute résolution ont mis en évidence une structure cylindrique de type jet qui s'éloigne sur le ciel de la section nord-ouest de la nébuleuse planétaire Messier 1. Peu d'amateurs connaissent cette structure qui est à la limite de détection de la plupart des instruments d'amateurs. Elle est une source d'émission plus intense en [OIII] à ~500 nm et plus difficile à détecter en visible à large bande. Les objectifs ont été de détecter cette source sur des images d'amateurs dans des conditions d'image (RGB) standard et avec des filtres [OIII] et H $\alpha$ . Des réductions d'imagerie différentielles ont été appliquées à certaines images pour souligner certains aspects de cette superbe nébuleuse et son environnement. Les principaux objectifs ont été atteints, soit : 1) Détecter cette structure en jet avec des images d'amateurs; 2) Isoler du continuum les émissions de l'hydrogène alpha à ~656 nm et de l'oxygène [OIII] à ~500 nm; 3) Utiliser la méthode de l'imagerie différentielle.

### Abstract

*High resolution images have detected a jet-type cylindrical structure moving away over the sky from the northwest part of Messier 1 nebula. Few amateur astronomers know this structure, at the detection limits of most of their instruments. While it is a more intense source of [OIII] emission at ~500 nm, it is nevertheless difficult to detect in broadband visible. Our goals were thus to detect it in amateur images under standard (RGB) conditions, and with [OIII] and H $\alpha$  filters. Differential imaging reductions have been applied to some images to underline some aspects of this magnificent nebula and its environment. The main goals achieved have been to: 1) detect this jet structure with amateur equipment; 2) extract from the continuum the emissions of H $\alpha$  at ~656 nm and oxygen [OIII] at ~500 nm; 3) use the differential imaging method.*

### Introduction et historique:

À l'origine de ce projet, le travail de l'astronome canadien Sidney van den Bergh qui, en 1970, à l'aide de la caméra



Palomar 1970 Figure 1a

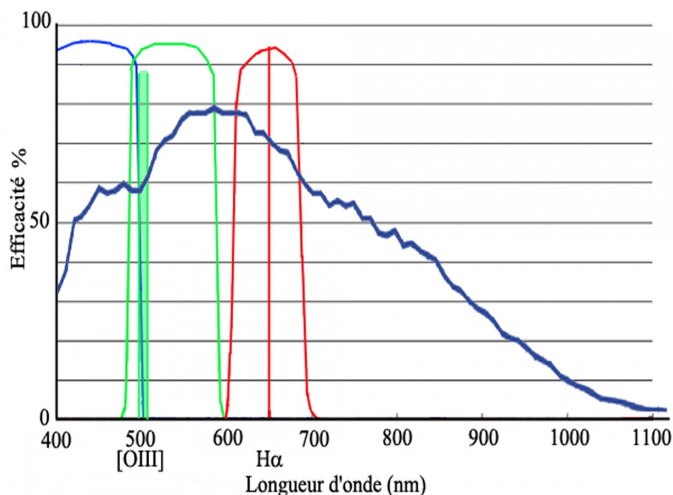


D. Bergeron 2020 Figure 1b

La Figure 1a (en haut) — présente l'image prise au télescope Schmidt de 48 pouces de Palomar en 1970, par Sidney van den Bergh. Il s'agit d'une reproduction de l'image de la découverte (la flèche indique le jet), disponible à: Sidney van den Bergh (1970). A Jetlike Structure Associated with the Crab Nebula <http://articles.adsabs.harvard.edu//full/1970Apl...160L..27V/L000027.000.html>

La Figure 1b (en bas) — présente l'image LRGB+H $\alpha$ , prise par Denis Bergeron en 2020. Cette image permet de constater la difficulté de détecter cette structure en jet au nord, elle est très pâle en lumière visible, même pour de grands télescopes et de longues poses.

48 pouces Schmidt du Mt Palomar, mit en évidence une faible structure en jet qui s'échappe au nord-ouest de la nébuleuse Messier 1. On sait maintenant que le jet présente des structures en filaments du même type que le reste de la nébuleuse principale Messier 1 et que celui-ci s'éloigne de la nébuleuse principale avec une grande vitesse s'apparentant à celle des filaments qu'on trouve dans la nébuleuse principale. Le grand axe de propagation du jet ne semble pas aligné avec le centre d'expansion des filaments de la nébuleuse principale



Graphique 1c — Il nous présente les domaines de sensibilité de chaque filtre.

Les filtres RGB, [OIII] et Hα. B = bleu, G = vert, R = rouge

La grande courbe foncée représente l'efficacité du détecteur CCD.

ni avec la position du pulsar dans la nébuleuse. En plus, on ne trouve pas de contre partie (contre jet bipolaire) de l'autre côté de la nébuleuse.

Des images en émission [OIII] à haute résolution ont permis d'estimer la vitesse tangentielle de plusieurs nœuds du grand jet. Ces mesures indiquent les premiers moments d'éjection (Top of jet) autour de l'année  $1055 \pm 24$  (G. C. Rudie et al. 2008), ce qui correspond assez bien avec la supernova observée en 1054.

Quelques hypothèses proposées pour expliquer cette structure au nord-ouest qui est presque cylindrique :

\*Le « Plasma instabilities model », à très haute vitesse, qui se serait échappé de la grande nébuleuse au nord.

\* « An asymmetrical explosion » qui aurait peut-être favorisé des pertes de masse de l'étoile géante en fin de vie sur ce plan (~ nord) possiblement même un peu avant que l'étoile n'explose en une supernova.

### Réductions des images de D. Bergeron

Les réductions appliquées aux images, Hα LRGB de Denis Bergeron : on sait que la structure en jet est plus intense en domaine d'émission [OIII], ses deux raies, dites interdites, se situent sur le spectre lumineux tout près de 500 nm, soit à (~495.9 nm et ~500.7 nm). On sait que le filtre G couvre ce domaine du spectre lumineux, on a donc tenté d'en tirer parti. De plus, comme nous n'avions pas d'images en filtre [OIII] pour cette première série d'images, pour créer notre image en continuum, nous avons dû utiliser les images Hα pour l'enlever de l'image en filtre R, ce-dernier couvrant la région du Hα, on peut donc le réduire pour fabriquer un continuum artificiel acceptable.

Le graphique 1, nous présente les domaines de sensibilité de chaque filtre.

On y constate que le filtre B est complètement à gauche de (<400 aller à ~500 nm), que le filtre G est juste après sur sa droite de (~480 à ~580 nm), que le R suit de (~610 à ~690 nm). Le filtre [OIII] est à ~500nm (~vert) et Hα est à ~656 nm (très rouge). Comme on peut le constater sur ce graphique (la grande courbe foncée), le détecteur CCD peut permettre de détecter des traces significatives du proche infra-rouge, après 700 nm juste qu'à ~1000 nm.

On a donc sélectionné les images en filtres R, G et Hα. Ces images n'ont subi aucun autre traitement. Sur celles-ci, on

a réussi à détecter des traces de cette structure au nord, par des additions et des piles médianes de ces images. On a dû aussi ajuster agressivement la luminosité et le contraste des images au point de les surexposer pour arriver à voir une toute petite trace sur le ciel de cette structure en jet.

### Méthodologie : Application de l'imagerie différentielle sur les images R, G et Hα.

Normalement, on utilise des filtres dédiés à cette réduction, soit des filtres comme le [OIII] pour détecter le signal en émission et un [OIII]C pour détecter le continuum correspondant, alors on peut effectuer des fonctions de type  $([OIII] - [OIII]C)$  et  $(H\alpha - H\alpha C)$  ou  $(C = continuum)$ . Mais nous n'avions pas accès à ces filtres.

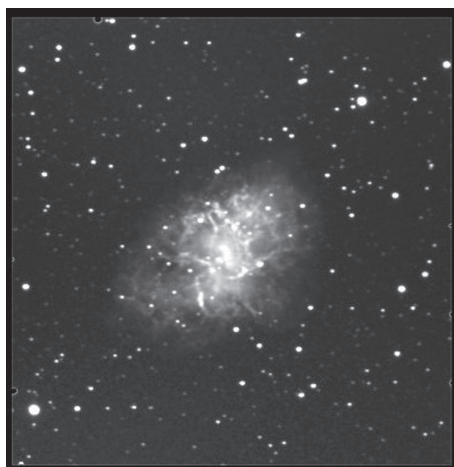


Figure 1.5 Messier 1 en filtre "R"

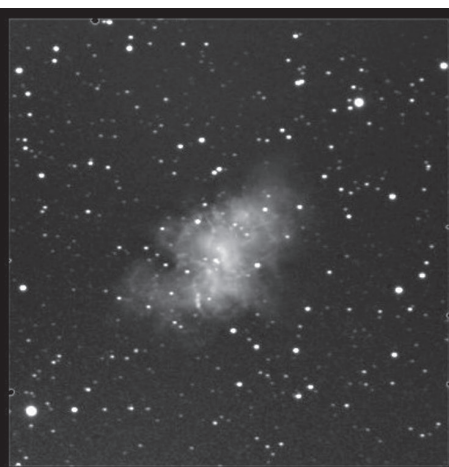
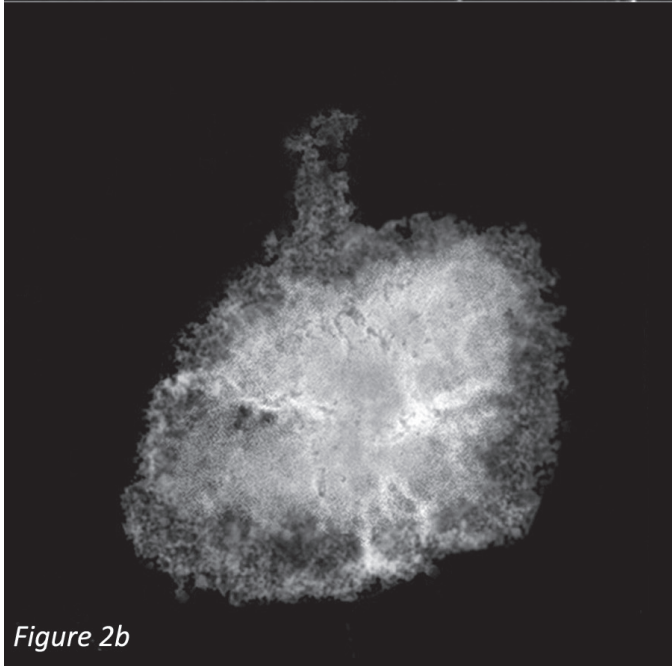


Figure 1.6 Messier 1 en filtre "~continuum"

La figure 1.5 (de gauche) — est l'image obtenue à l'aide du filtre R. Elle est l'image de référence pour construire notre continuum. La principale émission de celle-ci est l'Hydrogène alpha à ~656 nm. On retire donc l'Hydrogène alpha de l'image de tel manière qu'on conserve principalement la composante (continuum) de celle-ci.

La Figure 1.6 (de droite) — On peut constater le résultat (continuum) sur la figure 1.6.



obtenu la Figure 2b (les images de gauche, celle du bas) qui détecte très bien le jet sur le ciel.

On peut constater que dans l'image 2a, il n'y a pas de trace significative de la structure en jet au nord de la nébuleuse principale, celle-ci est dans l'image, mais elle est perdue dans l'ensemble des détails de l'image R, G et H $\alpha$ .

Dans l'image 2b, le jet est facilement détecté après réduction en utilisant la séquence G-(R-H $\alpha$ ) + des ajustements. Le fond du ciel a été lissé pour augmenter le contraste.

**\*Un autre collaborateur, Denis St-Gelais, a obtenu des images en [OIII], H $\alpha$  et R. Réductions des images de D. St-Gelais**

Un des objectifs était d'arriver à isoler les deux régions en émission visées par ce projet, soit les [OIII] à ~500 nm et le H $\alpha$  à ~656 nm. Il a donc fallu créer une image continuum puisqu'on n'avait pas accès à des filtres (continuum) correspondant à ces filtres, tels les [OIII]C et H $\alpha$ C (C= continuum), ni même à un filtre i. Le continuum est fait comme suit : le filtre (R-H $\alpha$ )  $\approx$  continuum, référez-vous à la (Figure 1.6), la plage restante ne présente que peu de traces d'émission. On a donc fait disparaître de l'image originale en filtre R la signature de la raie H $\alpha$  en émission qui y est normalement détectée pour en faire une image du signal continu qui a été ensuite enlevé des images en émission ciblées sur le [OIII] et le H $\alpha$ . Les figures 3a et 3b présentent les résultats.

Figures 3a / 3b : En haut, on peut voir les images de Messier 1 en H $\alpha$  à gauche (en 3a) et en [OIII] à droite (en 3b), telles qu'elles apparaissent avec des filtres de (H $\alpha$  de ~3 nm) et un ([OIII] de ~8 nm) de transmission, elles contiennent donc aussi du continuum de part et d'autre des raies d'émission visé. Au centre on peut voir les mêmes images en H $\alpha$  et [OIII], à celles-ci on a retiré le continuum, il s'agit de H $\alpha$  et de [OIII] exclusif, on peut bien voir la différence entre ces images et celles d'origine en haut. Puis, en bas, un zoom sur ces images exclusives qui visent la région de la structure en jet au nord de Messier 1, on peut constater que cette structure est plus intense en [OIII] qu'en H $\alpha$ , les lignes horizontales du côté gauche indiquent la taille relative du jet et son intensité avec chacun de ces filtres, ce jet est très faible, presque à la limite détectable avec nos instruments. Cependant sur celles-ci, on peut bien voir certaines structures en filaments plus intenses sortant de la grande nébuleuse à la base du jet.

**Ces images ont été ensuite montées en code trois couleurs de type (RGB).**

**Les réductions des images ont été effectuées comme suit :**

On a dû créer une image bleue qu'on a nommée (B<sub>2</sub>) pour l'insérer au code tricolore.

L'image B<sub>2</sub>, est le résultat de; (H $\alpha$  exclusif - [OIII] exclusif) = B<sub>1</sub>, donc ([OIII] exclusif - B<sub>1</sub>) = B<sub>2</sub>. Comme on a eu accès à seulement 2 images en émission, il a fallu en créer une

La figure 2a (en haut), est l'image de départ en R, G et H $\alpha$ .

La figure 2b (en bas) — est l'image réduite de ces filtres par la réduction G-(R-H $\alpha$ )

Considérant que la principale émission du jet est en [OIII] et que cette région du spectre est détectée principalement par le filtre G, on a procédé comme suit. Nous voulions isoler le mieux possible le jet [OIII].

Il fallait donc enlever le plus de continuum possible à l'image G, pour conserver au premier plan le signal en émission désiré. On a donc utilisé le filtre R auquel on a enlevé le maximum du signal H $\alpha$  par soustraction contrôlée pour en arriver à (R-H $\alpha$ )  $\approx$  continuum. En appliquant par soustraction contrôlée ce résultat à l'image en filtre "G", soit G-(R-H $\alpha$ ), nous avons

troisième pour montrer des résultats en couleurs de type 3 images (RGB<sub>2</sub>). En utilisant le H $\alpha$  comme rouge, le [OIII] comme vert, on a donc créé un bleu artificiel en utilisant les deux autres images pour obtenir une image bleue dont l'apparence soit proche des propriétés observables de l'image en [OIII]. Voir le résultat des montages à la Figure 4.

### Discussion / Observations :

#### Images en émission exclusives montées en 3 couleurs (RGB<sub>2</sub>)

Le code de couleurs est appliqué comme suit : H $\alpha$  = Rouge, [OIII] = Vert, B<sub>2</sub> = Bleu

Ces images couleurs permettent de voir comment se distribuent le H $\alpha$  et le [OIII] dans la nébuleuse et de constater certains aspects physiques de celle-ci. On peut aussi observer la signature des étoiles environnantes qui peuvent parfois nous dévoiler certaines de leurs propriétés. On peut y voir la principale distribution du H $\alpha$  en rouge, du [OIII] en vert, et de la composante créée de ces deux images en bleu. Cette image ne présente à peu près pas de continuum, seulement de l'émission de ces deux domaines distincts.

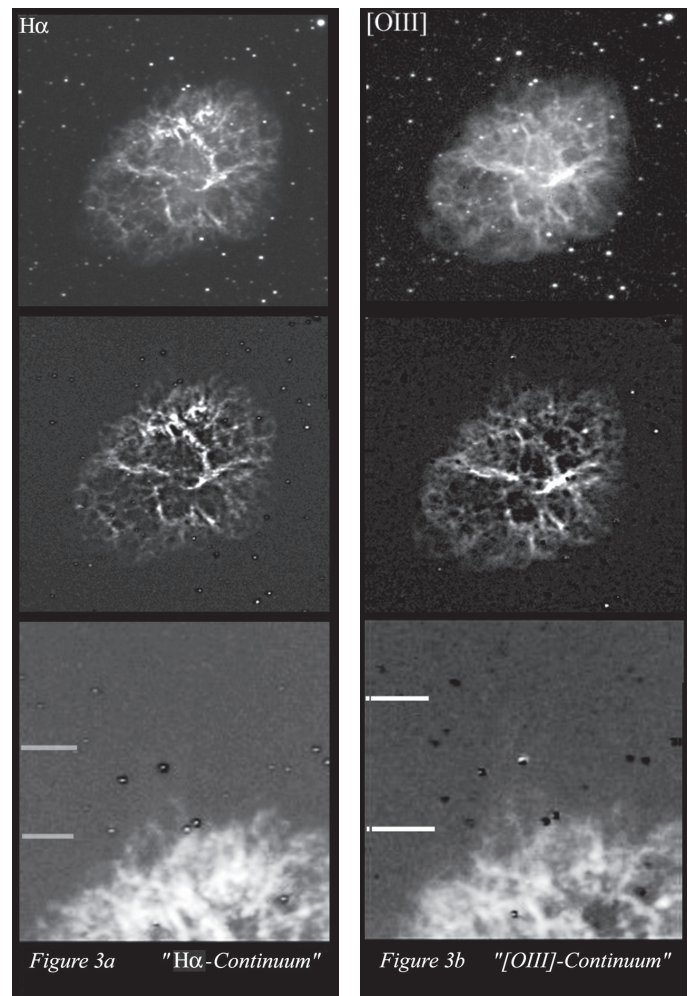
Description des Figures 4a :

Dans le montage de la Figure 4a (du haut), le codage de l'image 4a indique la distribution des éléments correspondants dans la nébuleuse, on peut ainsi voir qu'il y a à la base du jet dans la nébuleuse beaucoup de H $\alpha$ , celui-ci est probablement orienté plutôt de notre côté de la nébuleuse, alors que le jet, lui, plus intense en [OIII], est peut-être incliné de l'autre côté de la nébuleuse et se trouve probablement un peu en arrière du H $\alpha$  pour l'observateur.

Description des Figures 4b :

Dans Figure 4b (du bas), on a accentué la luminosité sur le ciel, on arrive ainsi à mieux saisir l'étendue de la structure en jet au nord de la nébuleuse Messier 1. La contribution du [OIII] (en vert) y est dominante. En plus, une composante d'intérêt s'observe du côté sud de la nébuleuse. Presque alignée sur le grand axe du grand jet au nord, on peut voir principalement en [OIII] une grande plume au sud qui semble en avant plan sur la nébuleuse, peut-être une manifestation de la contrepartie du jet?

La morphologie détectable sur la Figure 4b, de la structure en jet qu'on observe au nord, présente plusieurs filaments lumineux qui pâlisent en s'éloignant de la nébuleuse et en courbant vers le nord-ouest. Cette structure en jet au nord est inclinée sur le ciel de telle manière qu'elle donne l'impression de s'éloigner de l'observateur, sa base est en partie constituée de structures en filaments d'importances qui semblent s'échapper sur le ciel tout près de la grande nébuleuse. Puisqu'on les détecte aussi sur les images en visible (RGB), il n'est pas clair si ces filaments à la base du jet font partie intégrale du jet lui-même ou s'il s'agit aussi d'une contribution de certains



Les figures 3a et 3b — On a pu obtenir des images qui reflètent la présence du H $\alpha$  et du [OIII] exclusif dans cette nébuleuse planétaire Messier 1. "Voir la description"

matériaux de la surface de la grande nébuleuse qui ont été arrachés à celle-ci par le passage de ce jet d'importance à cet endroit.

#### Qu'en disent les professionnels.

Selon les astronomes professionnels Fesen, R., Staker, B., 1993, Structure and Motion of the Crab Nebula Jet, MNRAS, 263, p. 69–74, les filaments s'éloignent de la nébuleuse (outward from the nebula) à une vitesse de (0.26") par année, ce qui approche 2460 km/seconde. Ils ont utilisé comme référence une distance de ~2 000 pc. La taille mesurée du jet est estimée à ~0.5 par ~0.9 pc, et sa vitesse radiale estimée à (VR $\approx$  300 km/s).

De l'autre côté de la nébuleuse, au sud, on ne semble pas voir de traces d'une deuxième composante du jet. Ces jets sont souvent bipolaires donc en deux sections qui sont généralement assez bien alignées sur leur grand axe de part et d'autre de la source sur le ciel environnant. On a par contre une structure en forme de plume qui est détectable en domaine [OIII] principalement, ou en filtre G. En rouge ou en hydrogène alpha, elle est beaucoup plus discrète. Celle-ci est assez bien alignée avec le grand axe du jet au nord. Elle

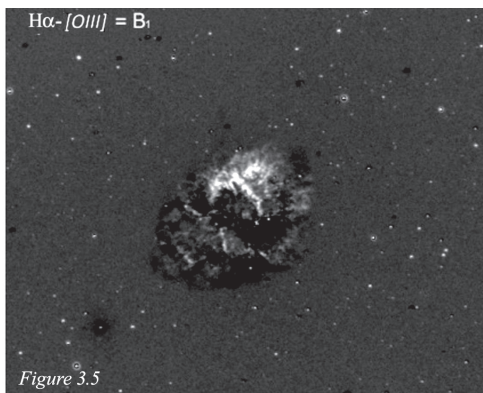


Figure 3.5 — Il s'agit de l'image résultante de la fonction,  $(H\alpha \text{ exclusif} - [OIII] \text{ exclusif}) = B_1$

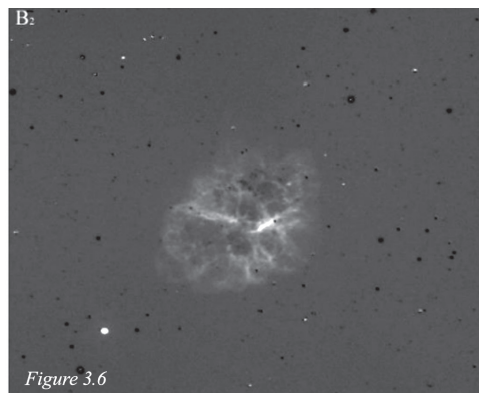


Figure 3.6 — Il s'agit de l'image résultante de la fonction,  $([OIII] \text{ exclusif} - B_1) = B_2$

présente une morphologie assez particulière sur le pourtour de la nébuleuse principale (Figure 5a).

Il pourrait peut-être s'agir d'une manifestation de la contrepartie (Blueshift) du jet qu'on observe au nord? Sur des images couleurs standard RGB, on peut la voir de couleur vert/bleu sur le sud-est de la nébuleuse principale. La figure 1b de Denis Bergeron la montre très bien. Elle est bleutée au sud-est dans la nébuleuse. Une superbe image par Rémi Lacasse, en filtres L, H $\alpha$  (R), G, B, de mai 2017 la met en évidence (Figure 6).

\*On peut bien voir la composante en plume au sud (bleu/vert) et du côté opposé on détecte que quelques départs de filaments du grand jet au nord qui sont assez bien alignés avec la plume du côté sud.

**\* Quelques paramètres physiques qu'on peut mesurer de cette structure en jet sur nos images ;**

Messier 1 est à une distance de  $\sim 6\,500$  années-lumière (ou  $\sim 2000$  pc). La caméra de Denis Bergeron, est une *Stl11000M* qui est un montage de pixels d'une taille de 9 microns, l'échantillonnage de son montage permet des images à,  $0.725''$  par pixels (en bin  $1 \times 1$ ).

Sur ses images G+R+H $\alpha$  de départ, on peut estimer la taille de la structure en jet (longueur totale et largeur à mi-hauteur).

Images utilisées pour effectuer les estimations / G+R+H $\alpha$ . (voir la Table 1).

Dans la Figure 7, une ligne blanche a été insérée de chaque côté du jet, là où il diminue d'intensité pour se perdre sur le fond du ciel. La demi-ligne blanche du bas représente le point d'origine des mesures du côté de la nébuleuse principale, juste au-dessus des filaments de la grande nébuleuse. On a opté pour cette position puisque dans le visible c'est à cette position que la grande nébuleuse disparaît sur le ciel.

Les lignes vertes représentent la surface mesurée pour cette structure. Celle avec les flèches est la longueur mesurée et la ligne verte centrale perpendiculaire (horizontale) est la largeur à mi-hauteur. La ligne rouge plus haute, tout au bout sur le ciel, représente la structure en jet telle que détectée par le télescope Subaru de 8 mètres.

Les structures sortant de la nébuleuse principale sur le ciel, à la base du jet, sont des filaments qui s'échappent de la surface de celle-ci et qui font peut-être partie intégrale de la structure en jet. On peut voir de

telles structures filamenteuses à cet endroit sur les images à haute résolution du télescope Subaru. Donc, le jet est peut-être encore plus long à sa base que ce qu'on mesure sur les images de départ. On peut voir ces filaments qui s'échappent vers le nord au niveau du jet, ils s'étalent au-dessus de la ligne de contour rouge qui courbe au niveau de la nébuleuse. Ceci valide les résultats de la Figure 2b où la structure en jet présente une taille plus importante que sur les images de départ.

Pour valider les résultats, des mesures ont été faites de la nébuleuse sur son grand axe. Une des principales difficultés est de déterminer où prendre les mesures, car il s'agit d'une nébuleuse dont les extrémités sont plutôt irrégulières. Nous avons donc opté pour des mesures sur les bords les plus denses de celle-ci en ne tenant pas compte des extensions filamenteuses plus pâles à l'extérieur sur le ciel. La sensibilité des nouvelles caméras et leur plage de transmission sont si larges par rapport aux vieilles images argentiques dans le domaine visible qu'on ne peut pas directement comparer les images d'une époque à l'autre sans induire des différences de mesures significatives.

On arrive ainsi à  $\sim 6.2'$  sur le grand axe. Dans la littérature on indique généralement  $\sim 6'$  sur le grand axe, on indique aussi que cet axe a une dimension qui excède les 10 années-lumière comparativement à  $\sim 11,8$  al dans le présent article.

Considérant que Messier 1 est à 2000 pc, la taille mesurée de la nébuleuse Messier 1 est ainsi de :

(")	(')	(UA)	(al)
373.955	6.232	747 910	11.8263

\*Une année-lumière équivaut environ à  $\sim 63241.1$  UA, ou  $\sim 0.306601$  pc.

Jet de Messier 1	Dimensions (")	Conversion (UA)	Conversion (al)	Conversion (parsecs)
Hauteur	78.3	$\approx 156\,600$ UA	$\approx 2.4762$	$\approx 0.7595$ pc
Largeur à $\frac{1}{2}$ hauteur	38.9	$\approx 77\,800$ UA	$\approx 1.2302$	$\approx 0.3773$ pc

Table 1 — comme étant les résultats des mesures de surface détectable du jet au nord.

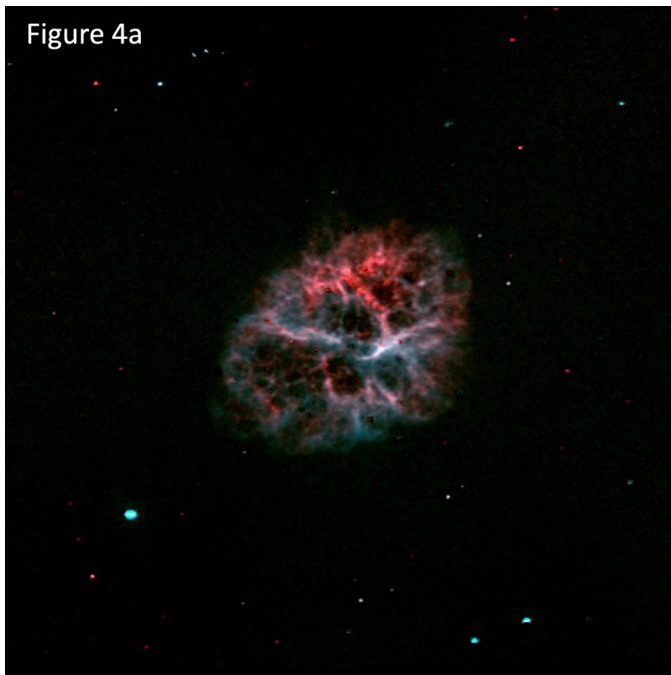


Figure 4a

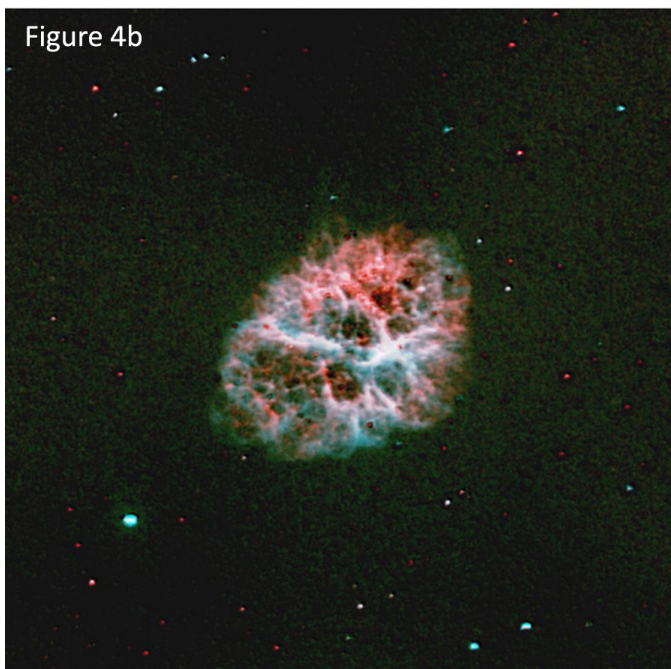


Figure 4b

Figures 4/4b — Code de couleurs correspondantes aux domaines d'émission. (Voir la description)

Certains ont inclus les filaments externes à leurs mesures, on peut voir des estimations qui vont jusqu'à ~13 al sur le grand axe. En utilisant nos bases de calcul et en utilisant leurs estimations, qui sont d'un peu plus de ~7' sur le grand axe, on arrive à 13.28 al, ce qui est raisonnable considérant l'erreur potentielle sur leur longueur estimée à environ 7'.

### \*Conclusion :

Les observations confirment que cette structure en jet est très difficile à détecter avec des instruments d'amateurs, principalement si les conditions du ciel ne sont pas suffisantes et

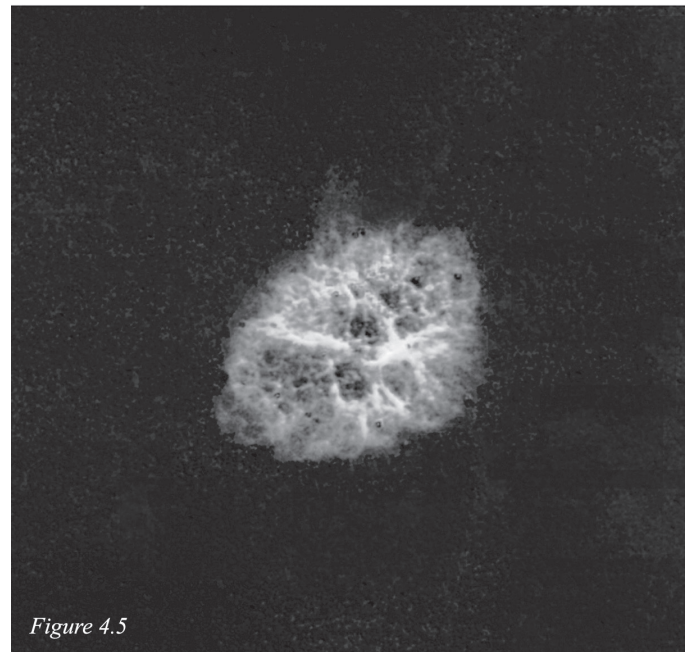


Figure 4.5

La Figure 4.5 — On a enlevé les étoiles de notre image de la Figure 4b. Ce qui permet de bien voir la structure en jet au nord et la plume au sud de la nébuleuse planétaire Messier 1.

qu'on n'utilise pas la bonne approche, soit les bons filtres et les bonnes techniques de réduction d'images. Les astrophotographes qui ont participé à cette étude ont dû faire des dizaines d'heures d'intégration pour arriver à dévoiler cette structure en jet associée à Messier 1. C'est ce qui a permis d'atteindre les objectifs fixés au départ.

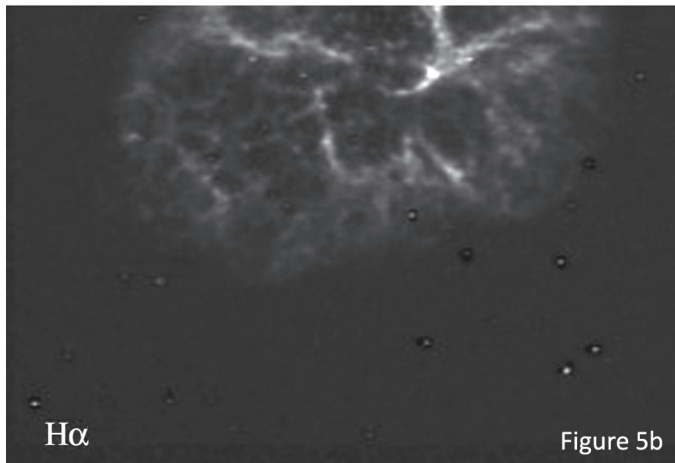
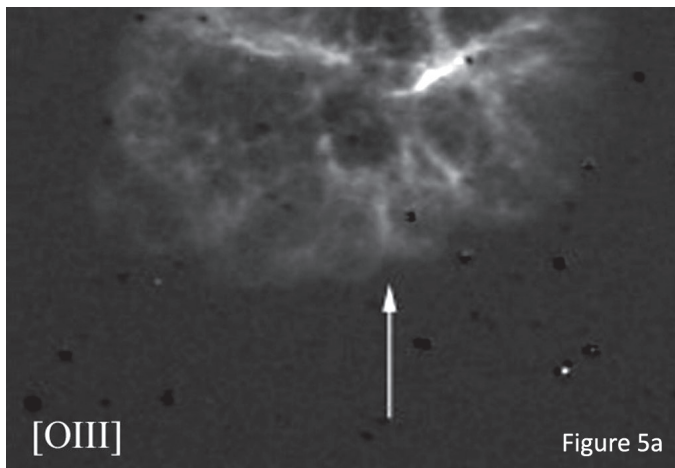
Nous avons pu mettre en évidence que cette structure a une taille plus importante en filtre [OIII] qu'en domaine H $\alpha$ . De plus, les instruments d'amateurs ont dévoilé certaines des principales structures filamenteuses à la base de celle-ci. Nous avons pu voir qu'en H $\alpha$  les filaments à la base du jet sont plus intenses et d'apparence mieux définie qu'en [OIII], mais le jet est beaucoup plus pâle et de plus petite taille en s'éloignant de la nébuleuse vers le nord comparativement à l'image en [OIII]. Voir les Figures 3a et 3b.

L'imagerie différentielle utilisée a permis de mettre en évidence l'aspect différent des filaments en émission de la nébuleuse dans deux domaines de longueur d'ondes spécifiques aux [OIII] et H $\alpha$ . Cet exercice appliqué à des images non prévues à cet effet, les images RGB, a permis de développer une nouvelle approche pour optimiser et développer certains paramètres de cette technique d'imagerie. Nous avons pu aussi constater que même les étoiles d'arrière-plan sur le ciel peuvent

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La Figure 5a — (du haut) est le [OIII], elle permet de bien voir la structure en plume.

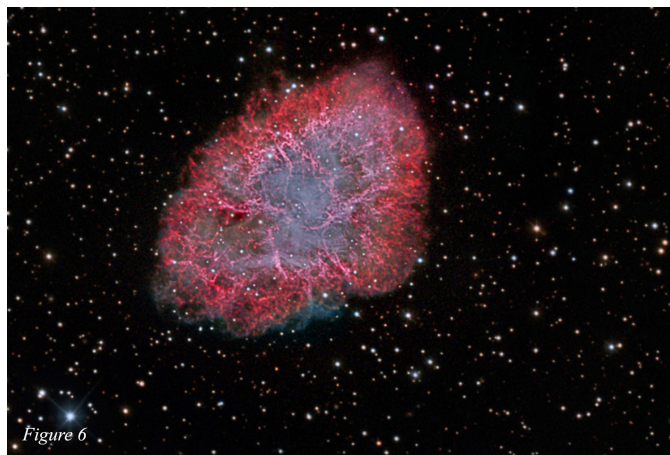
La Figure 5b (du bas) — est le H $\alpha$ , on a de la difficulté à y voir la structure en plume.

dévoiler certaines de leurs propriétés de surface, elles sont généralement sombres, mais certaines d'entre elles peuvent être lumineuses (émettre) dans un des domaines d'émission visé.

Les estimations de la surface de cette structure, soit sa longueur totale et sa largeur à mi-hauteur, étaient bien appropriées aux instruments et moyens utilisés, donc satisfaisantes comparés aux estimations effectuées par des professionnels.

De plus on a noté que la morphologie des grands filaments intenses à la base du jet cylindrique se présente comme s'allongeant sur le plan du **grand axe** du jet soit ( $\sim$ S-N). Ils sont même détectés en RGB. La morphologie détectable du jet plus loin sur le ciel est un peu différente. Les images prises avec le télescope Subaru en [OIII] par (G.C. Rudie et al), montrent un complexe filamenteux plutôt transversal, comme si certaines structures filamenteuses du jet étaient plutôt circulaires sur les parois du grand jet et parfois croisées sur le plan du petit axe du jet (sur sa largeur).

On peut penser que les régions des filaments intenses à la base du jet, de morphologie un peu différente, ont peut-être un certain lien avec la surface de la grande nébuleuse plutôt qu'être des matériaux du jet exclusivement.



La Figure 6 — Messier 1, par Rémi Lacasse, en filtres L, H $\alpha$ , R, G, B, de mai 2017, de son observatoire à St-Faustin-du-Lac-Carré en utilisant le Télescope RCOS 12.5".

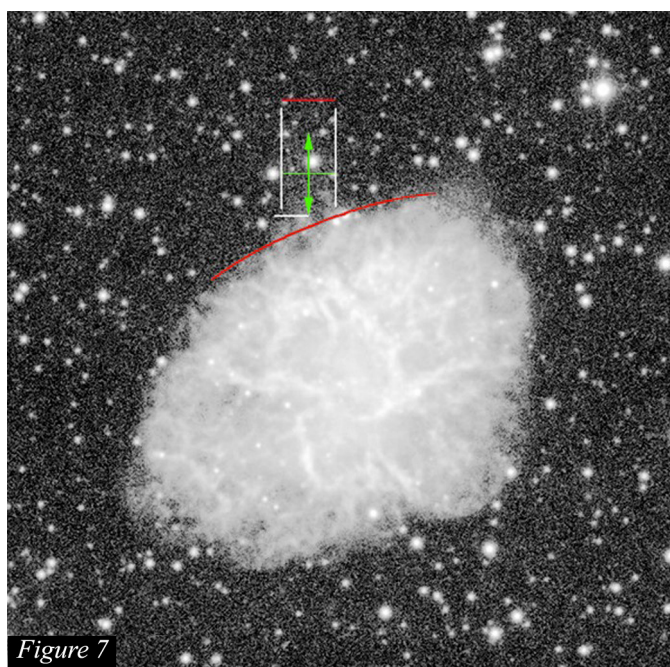


Figure 7 — Image de l'emplacement des mesures qu'on a effectués de cette structure en jet au nord de Messier 1

Dans l'avenir, nous projetons d'essayer de détecter cette structure en jet sur des images en filtres "[OIII], H $\alpha$  et GR et i", dans un ciel de la banlieue de Montréal. Certaines expériences précédentes ont permis avec l'imagerie différentielle de détecter au nord de la nébuleuse (variable) de Hubble NGC 2261 des nœuds du jet HH39 dans un ciel médiocre de la banlieue de Montréal. Nous voulons donc vérifier s'il est possible de détecter des traces de cette structure en jet dans de mauvaises conditions. Voir la flèche, Figures 8b ainsi que la référence Figure 8a.

#### \*L'environnement immédiat de Messier 1 ;

Des dizaines de galaxies et d'objets non stellaires ont également pu être dévoilées sur les images LRGB de Denis



Bergeron tout autour de la nébuleuse Messier 1. Pour cela nous avons utilisé comme référence l'image "This color image of Messier 1, the Crab Nebula, was taken at the Large Binocular Telescope during November 2006 by Vincenzo Testa" qui est citée à la référence #6.

Notre image pointant ces objets est disponible sur : [astrosurf.com/cdadfs/CDADFS2/recherches/XProjet\\_Messier1\\_V322c.pdf](http://astrosurf.com/cdadfs/CDADFS2/recherches/XProjet_Messier1_V322c.pdf)

Voir la Figure 15 à la page 13. ★

## \*Remerciements

Merci: Damien Lemay (Rimouski-RASC-FAAQ-AAVSO), réviseur du document, pour ses commentaires et arguments de grand intérêt qui ont été très appréciés et constructifs.  
Damien Lemay | Astronomes – Le Canada sous les étoiles ([astro-canada.ca](http://astro-canada.ca))

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Manon Décary (CDADFS), correctrice.

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Des poses en : «HII, 28×200s et OIII 25×250s»
- 6) Messier 1 - This color image of Messier 1, the Crab Nebula, was taken at the Large Binocular Telescope during November 2006 by Vincenzo Testa and collaborators from Rome Observatory. The image is a true-color composite composed of separate images in red, green and blue light obtained by the 36 megapixels Large Binocular Camera at the prime focus of the left 8.4m primary mirror.  
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Authors: Andriolat, H.  
Journal : L'Astronomie, Vol. 73, p.215  
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The Astronomical Journal, 139:2083–2096, 2010 May doi:10.1088/0004-6256/139/5/2083 C\_2010.

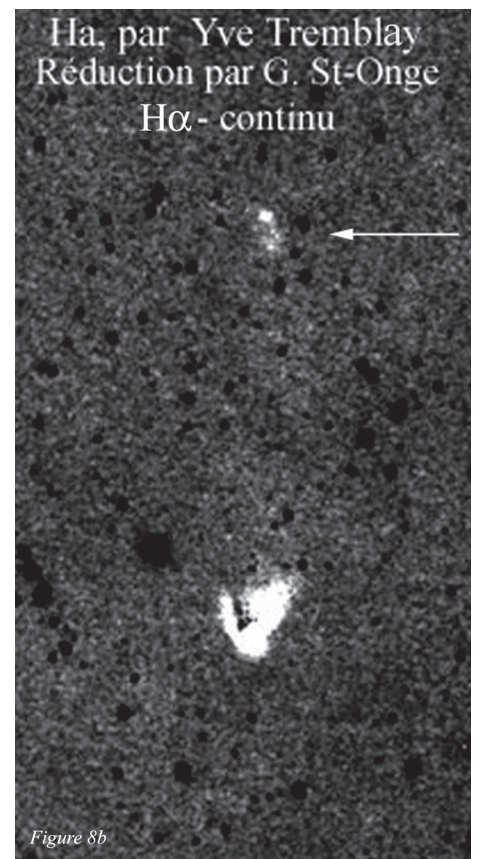
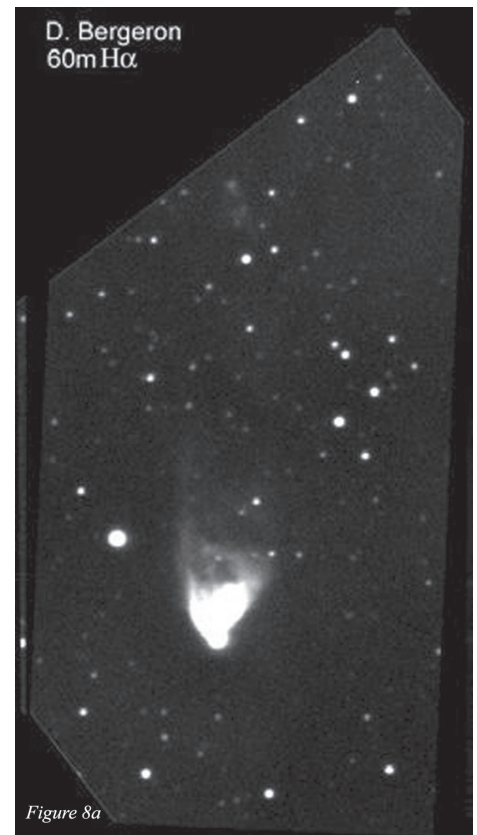


Figure 8a — Pose de 60 minutes dans un ciel très sombre de Val-des-Bois en Outaouais.  
Figure 8b — Image prise dans un ciel pollué de la banlieue de Montréal, en H $\alpha$  et visible. (Vaudreuil-Dorion)

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<https://iopscience.iop.org/article/10.1088/0004-6256/139/5/2083/pdf>

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*Réduction des datas images, méthodologie, documentation, développement et interprétation*

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Denis Bergeron (RAAOQ-FAAQ)

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De Val-des-Bois en Outaouais.

Télescope PlaneWave CDK 12" à f/8, LF 2555 mm.

La caméra ccd est une Std11000M, de 9 microns / pixel.

Le filtre H $\alpha$  utilisé est un Astrodon de 3 nm de transmission + LRGB.

3b)

Denis St-Gelais

[denis\\_st-gelais@hotmail.fr](mailto:denis_st-gelais@hotmail.fr)

De Las Ranas, Fracc. El Mirador (El Marques), Ciudad: Querétaro, Estado: Querétaro, Mexico

Télescope: PlaneWave CDK14" à f7.2, LF 2538.4, monture: Astro-physics 1100GTO,

Caméra: SBIG STL1001c, 24x24 microns / pixel.

Filtre BAADER OIII NB : 8.5 nm

*\*Les images sont de Denis Bergeron, Denis St-Gelais, une de Rémi Lacasse, Yves Tremblay / G. St-Onge*



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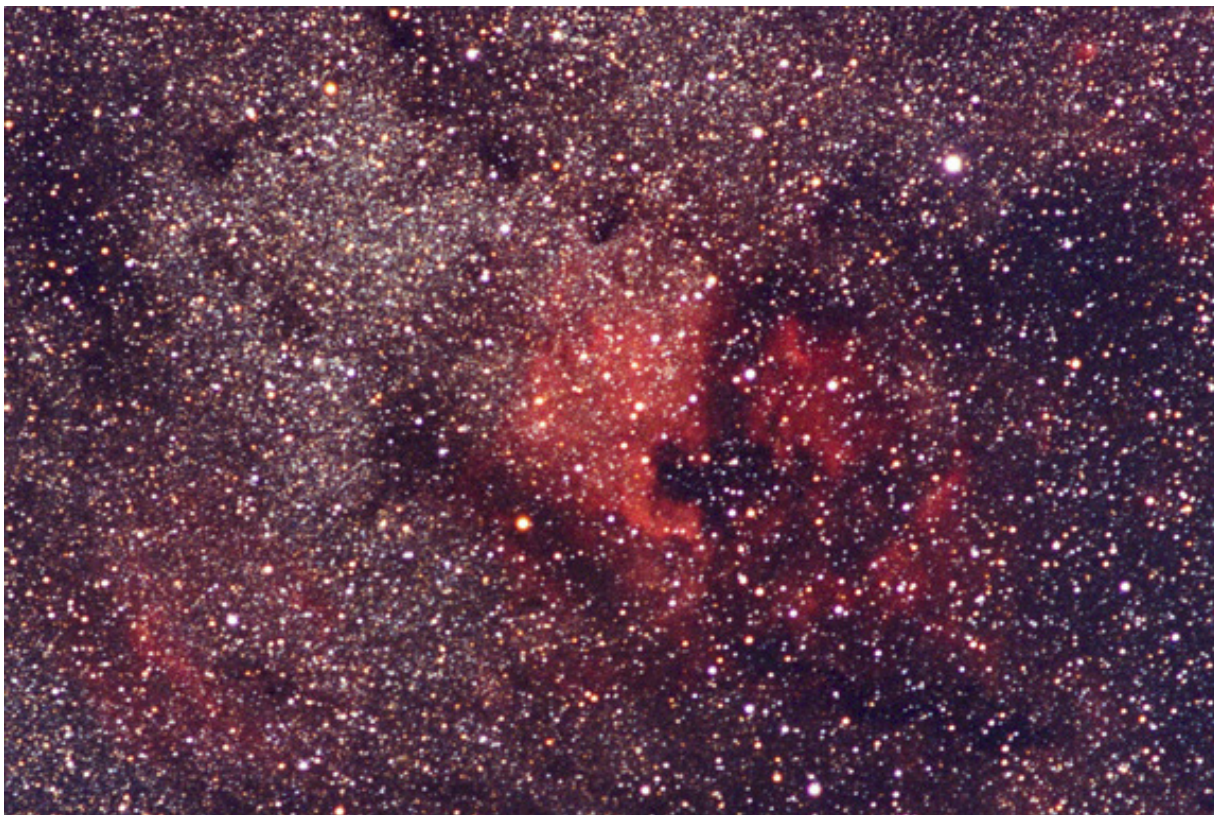
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The North America Nebula, photograph taken with a Nikon FA with 135 mm f/2.8 Ektachrome 400 20-min exposure on Byers 812. Taken August 1998 (Mt Kobau Star Party).

This image was submitted as an entry for an RASC Astroimaging Certificate. See [rasc.ca/astro-imaging-certificate](http://rasc.ca/astro-imaging-certificate)

## Burnham & Browning on the Virtue of Small Telescopes, 1890–1891



by R.A. Rosenfeld, FRASC  
(r.rosenfeld@rasc.ca)

### Abstract

In the year (1890) of the Society's revival it actively cultivated connections to the learned world beyond its local horizon, by offering honorary membership to prominent astronomical figures, or initiating correspondence with them regarding matters of interest. One such question concerned the capability of small telescopes, and the experts consulted were Sherburne Wesley Burnham, the prolific and observationally meticulous discoverer of multiple star systems at Lick Observatory, and John Browning, a leading maker of scientific instruments in London. There are some surprises in how this topic was addressed from within the Toronto Astronomical & Physical Society (i.e., RASC) 131 years ago. The topic can still be encountered on astronomical *fora* today.

### The same, but different...

When institutions, practices, or offices are revived, they are usually different in some degree from what inspired them, even if the revival incorporates the avowed aims of its model, and shares personnel, and some resources. The reasons are simple; the Earth has not stood still in the interim, that is, society and circumstances change, and if the revival aspires to be a living institution, it cannot be static. The institutional structure of science in France before and after the revolution is a case in point. The *Institut national des sciences et des arts* (1795–1816) was, and was not, a revival of the *Académie royale des sciences* (1699–1793) (Crosland 1992, 58–62). And so it was with the “RASC,” when the original Toronto Astronomical Club/Toronto Astronomical Society (TAS) of 1868–1869 was revived as The Astronomical and Physical Society of Toronto (TA&PS, which became the RASC in 1903).

Among the ways the Society of the 1890s differed from that of the 1860s were its somewhat different membership profile, more elaborate governance structure, possession of a formal publications program, and aspiration to be more actively connected to the world of astronomy beyond the Dominion's borders. One of the principal means to the latter end was the establishment of the office of Corresponding Secretary. And in doing this, the TA&PS was following a precedent—not a “TAS” precedent, but one established by the senior English scientific and astronomical societies, which were the natural

models for the TA&PS; the Royal Society of London, and the Royal Astronomical Society (RAS).

Cultural relations across international borders were crucial to the functioning of the “republic of letters” since before it acquired that name in the 17th century. The international dimension to the conduct of science is not a development of the modern age. From nearly its beginnings in 1820 the RAS had a Foreign Secretary, the linguistically gifted John Herschel (Turner 1923, 7; the post no longer exists). And the RAS office was built on the experience of the Royal Society, whose Foreign Secretaryship took a century to come into formal existence after its funding was secured in 1723. In fact, the office existed in all but name within two years of the Society's founding (1660), in the person of Henry Oldenburg (1619–1677), their incomparably capable early administrator, who deployed his vast network of learned correspondence to help shape the Royal Society (Lyons 1940, 125–126; Hall 2002, 125–238). Formal and informal interchanges between learned societies across borders could aid, or hinder the progress of science; for example, Antoni van Leeuwenhoek's work was greatly aided by the Royal Society, while the development of calculus was hindered by the priority dispute between Newton and Leibniz, in which the Royal Society did not play a wholly positive role (Hall 2002, 237–239; Robertson 2016; Sonar 2018, 494). A lot of power resided at the tip of the quill of whomever controlled the foreign correspondence—the reputation of an institution could ride on it.

The TA&PS's equivalent of the office of Foreign Secretary was the Corresponding Secretary, a role created and filled at the meeting of 1890 February 25. George E. Lumsden, FRAS (1847–1903, Figure 1), a senior provincial civil servant and committed avocational astronomer, was nominated, and acclaimed as the first holder of the office at the same meeting (TA&PS 1890–1893, 16; Broughton 1994, 3). The duties of the Corresponding Secretary were set out in the TA&PS *Constitution and Bylaws*:

“Article III. Officers...4. The Corresponding Secretary shall conduct the official correspondence of the Society and shall keep copies of all letters written by him and shall preserve and index all communications received and shall read such communications to the Society at the first regular meeting after such receipt.” (TA&PS 1890–1893, pp. 2–10, at 7).

The same document makes it clear where the office stands, below that of President, Vice President, and Treasurer, but above that of Recording Secretary (in charge of the records of “internal” Society business), and Librarian<sup>1</sup>. This can be read as an indication of the importance of international relations to the Society. It all seems straightforward enough.

To judge by the many surviving letters of the 1890s in our Archives from prominent astronomical figures in Great

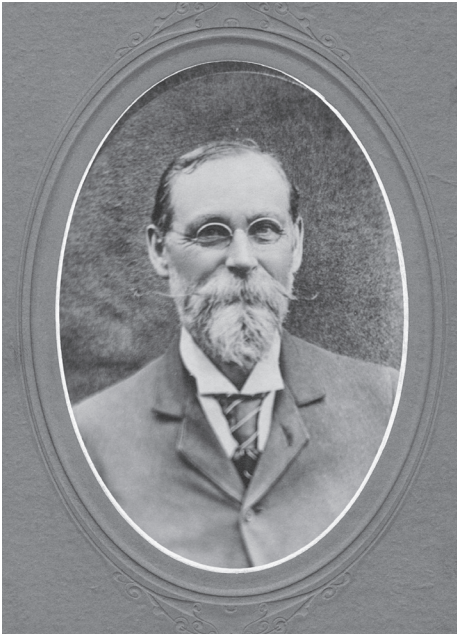


Figure 1 —  
George E. Lumsden,  
FRAS (1847–1903),  
the Society’s first  
Corresponding  
Secretary  
(1890–1899).

Photograph taken  
in the summer of  
1901. Reproduced  
courtesy of the  
RASC Archives.

Britain, Europe, and the United States (many of them leading professionals), Lumsden was kept very busy in fulfilling his office, particularly when it is recalled that most of the correspondence was initiated by the TA&PS. The impression from reading the letters is that Lumsden was respected by his correspondents, which was certainly to the Society’s advantage. Many of them agreed to the proffers of honorary membership. The advantage to Lumsden is that he was the one member of the Society whom the likes of William Christie (Astronomer Royal), George Darwin (dynamicist and Plumian Professor of Astronomy at Cambridge—and Charles Darwin’s son), Sir William Huggins, James Keeler (Director of the Lick Observatory), S.P. Langley (Secretary of the Smithsonian Institute), E.C. Pickering (Director Harvard College Observatory), Otto Struve (Director of the Pulkova Observatory), Camille Flammarion (Director of the Juvisy Observatory, and founder of the Société astronomique de France), and others of that stature would have some chance of knowing by name. None of this seems to have gone to his head

George Lumsden was no Henry Oldenburg (such figures are rare), and the TA&PS was no Royal Society, for our honorary membership would not much enhance the career of any to whom it was offered, and we played no outstanding role in either furthering progress on the frontiers of astronomy, or hindering it. In the 1890s we were simply not in that league, but the TA&PS did establish a place for itself in the astronomical world, and that was recognized and appreciated at the time by those who were on the front lines of research, and popularization.

Having offered the great and the good of astronomy honorary membership, the Society occasionally called upon them for contributions to its publications (some, like Agnes Mary Clerke 1842–1907, the leading historian of and commentator on contemporary astronomy, were happy to oblige), and for

their opinions on specific questions of interest to the Society (or if not the Society, at least to the Corresponding Secretary in the Society’s name!). One such question was the place of small telescopes in astronomy.

## Questioning the place of small instruments

The question “is there a role for small apertures in astronomy” may now seem a little quaint, rather like the seemingly endless telescope “wars” debating the relative merits of optical systems such as refractors vs. reflectors, until one reflects that these things are *still* actively debated on online amateur forums, such as Cloudy Nights ([www.cloudynights.com](http://www.cloudynights.com)), or Stargazers Lounge ([stargazerslounge.com](http://stargazerslounge.com)).

Lumsden’s original letter posing the question doesn’t survive in our Archives, so we don’t know precisely how he framed it, but we do have the replies of those who received the question. He sought advice from Sherburne Wesley Burnham (1838–1921), a prolific and observationally meticulous discoverer and measurer of multiple star systems then working at Lick Observatory, whose reputation in his avocation (which at times was a vocation) couldn’t have stood higher, and John Browning (1830/31–1925), a leading maker of scientific instruments based in London, whose reflectors with optics by George With were considered outstanding, and who supplied spectroscopic equipment for people like the rival spectroscopists Sir William Huggins and Norman Lockyer (Jackson 1922; Aitken 1921; Frost 1921; Batten 2014; Anon. 1930; Meliconi 2004).

The reply from Burnham (Figure 2a–b) is transcribed as follows:

Dec 19, 1890

My dear sir,

I have your note of the 6<sup>th</sup> inst. [i.e. “of this month.”] I should be very glad to give you any assistance in reference to your proposed paper before the Society, but my time is so taken up with observing<sup>2</sup>, I have very little opportunity to do much writing, even in connection with my own work. You will certainly have no difficulty in making out a strong case in favor of the use of small telescopes in many departments of important astronomical work.

Most of the Early Telescopic work [<sup>p.2</sup>] was done with instruments which would now be considered as inferior to modern instruments, in quality as well as size. You are doubtless familiar with much of the amateur work, in this country and elsewhere, done with comparatively small apertures. The most important condition is to have the refractor, whatever its size may be, of the highest optical perfection,<sup>3</sup> and then the rest will depend on the zeal and industry of the observer.

I am glad to know that your Society is prospering, and trust that the interest of the members will result in some good work.

Sincerely yours,  
S.W. Burnham



Figure 2a-b — Letter from Sherburne Wesley Burnham, frans (1838–1921), to G.E. Lumsden, 1890 December 19. Reproduced courtesy of the RASC Archives.

And the reply from Browning (Figure 3a–c) reads as follows:

8<sup>th</sup> January 1891

My dear Sir,

In reply to your kind letter of the 6<sup>th</sup> of December. I regret exceedingly that the number of my engagements prevents me from writing you a short paper as I should wish to do on the use of small apertures by Amateurs in Astronomy.

I am clearly of opinion that the work that can be done with small apertures is far from exhausted; the advantages of large apertures are not as great as is generally supposed, such instruments have serious drawbacks; for instance, it is seldom that the atmosphere is not good enough to make successful observations with a telescope of 3" aperture but here in England at all events the nights that 6" of aperture

can be used with the best results are comparatively few.

The use of small apertures is a most valuable training for observers, they are encouraged to improve the keenness of their vision by [<sup>p.2</sup>] Observation instead of trusting to more light and higher magnifying power.

I know many observers who can see the snow caps on the poles of Mars with a 3" aperture, though 6" of aperture is generally considered to be necessary for the purpose.

I know one Lady<sup>3</sup> who gets excellent views of the Spectra of the larger Stars with a 2<sup>1/2</sup>" object glass and a McClean<sup>4</sup>]s Star Spectroscope<sup>4</sup>, the two instruments complete cost only £12..10..0.

Again I have known many Observers who have done admirable work with telescopes of 4" Aperture and have been induced to obtain telescopes of 8" aperture but they have never done better work with them than with the smaller apertures.

I should like to go on adding illustrations to this but time prevents me.

Trusting these few remarks will show my opinion on the subject and begging you to excuse my brevity. With best wishes for the success of your Society

I am

Yours faithfully,  
John Browning

G.E. Lumsden Esq  
719 Ontario Street

Toronto Canada P.T.O.

[<sup>p.3</sup>] N.B,

For the sake of Simplicity I have confined all my remarks to the use of Achromatic Telescopes, but all I have said would refer to Reflecting Telescopes, indeed I may say that those who use Reflecting Telescopes have continually begun with apertures of large size while they would have done better work had they begun with smaller apertures and in many cases if they had stopped their apertures down to a moderate diameter.

The first thing to note is how accommodating these prominent figures are, even when they feel they can't accede to the full request (author an article for the TA&PS's *Transactions*), they nonetheless provide an opinion. Expectations at the time doubtless dictated that they do at least that much. One wonders how many of our comparably placed contemporaries?

*Continued on page 182*



Figure 1 – This great catch of Comet C/2017 K2 PanSTARRS and globular cluster M10 was captured by Shelley Jackson from Athens, Ontario. She used an 81mm WO GT APO triplet with a field flattener/.8 reducer, a 50mm guide scope, ZWO 120 mono guide camera, A Sky-Watcher EQ6-R pro mount and a ZWO ASI183MM COMOS cam cooled to 0 °C. Stacked and processed with PixInsight for a total of 50 × 30 sec lights.



Figure 2 – Katelyn Beecroft captured M16, also known as the “Pillars of Creation,” thanks to the iconic image taken by the Hubble Space Telescope in 1995. Katelyn says, “I played with the processing a lot for this one and ended up deciding on a palette that is more true to the reds of the nebula.” She used a Sky-Watcher Evostar 72ED with 1.0 field flattener on an HEQ5 mount with a ZWO ASI533MC. Total integration was 32 × 300 s.



Figure 3 – Messier 13 is a favourite of many amateur astronomers in the Northern Hemisphere, and Steve Leonard did a spectacular job of capture the colours of this magnificent globular cluster. He used an AstroTech AT115EDT 4.5" triplet refractor at  $f/5.6$ , with an HEQ5 mount, NINA, ASI 1600MM Pro camera, and Astrodon LRGB filters. The final image was processed in PixInsight and Topaz AI with 2 hr Luminance, and 45 minutes each on RGB.

Figure 4 – This interesting nebula is NGC 7129, found in Cepheus. Shawn Nielson took this image from his backyard in Kitchener, Ontario. "Overlooked perhaps by more prominent nebulae nearby, NGC 7129 is a reflection nebula and star-forming region located 3,300 light-years away. Astronomers believe that our own Sun may have formed billions of years ago in a cluster similar to NGC 7129," Shawn writes. He used Starfield Optics 8in astrograph, a Starizona Nexus reducer/corrector for  $f/3$ , along with a QHY268M CMOS camera and filter wheel with Optolong LRGB filters on a Syk-Wwatcher EQ6 mount on a SkyShed Pier. Acquisition was done with NINA 2.0 and the final image was processed in PixInsight for a total of 7.5 hours' total exposure time.



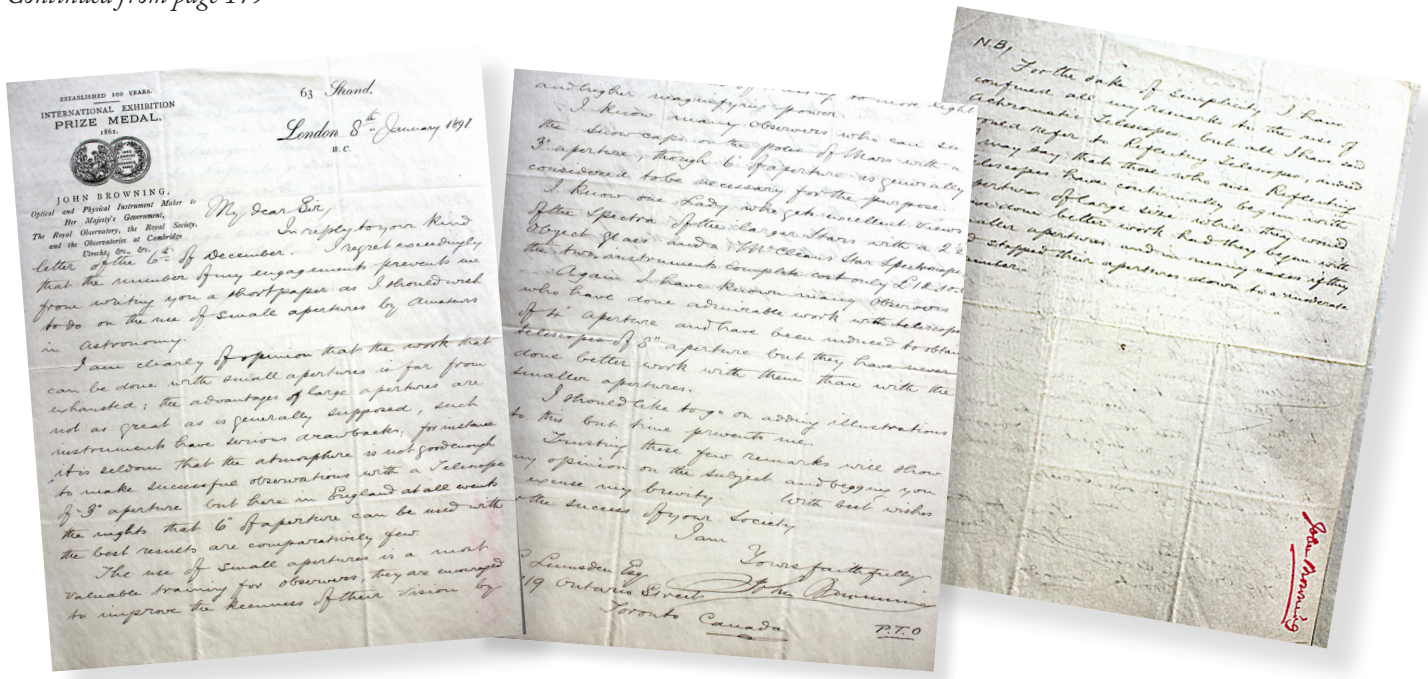


Figure 3a-c — Letter from John Browning, FRAS (1830/31–1925), to G.E. Lumsden, 1891 January 8. Reproduced courtesy of the RASC Archives.

There is nothing particularly novel in the answers. Burnham appeals to historical examples (the discoveries of earlier astronomers were done with instruments that would be considered as lesser now), and Browning prefers to cite examples from present practice. Burnham’s advice, “The most important condition is to have the refractor, whatever its size may be, of the highest optical perfection, and then the rest will depend on the zeal and industry of the observer,” would be considered as sound today as when he wrote it. Burnham’s perspective seems to be orientated toward contributing to science (i.e. gathering useful data), whereas Browning’s emphasis seems more on training oneself to see better under instrumental and atmospheric constraints. The advice from the two experts is never in conflict. The one surprise is that Browning doesn’t seem to endorse the mantra one frequently encounters on amateur forums today, that “aperture is king,” for his reputation as a maker was derived at least in part from his producing large reflectors for the amateur market!

### A few contextual curiosities...

It’s unfortunate that the letter Lumsden sent to Burnham and Browning doesn’t survive, for neither of their responses give any hint as to why Lumsden is asking their opinions on this question.

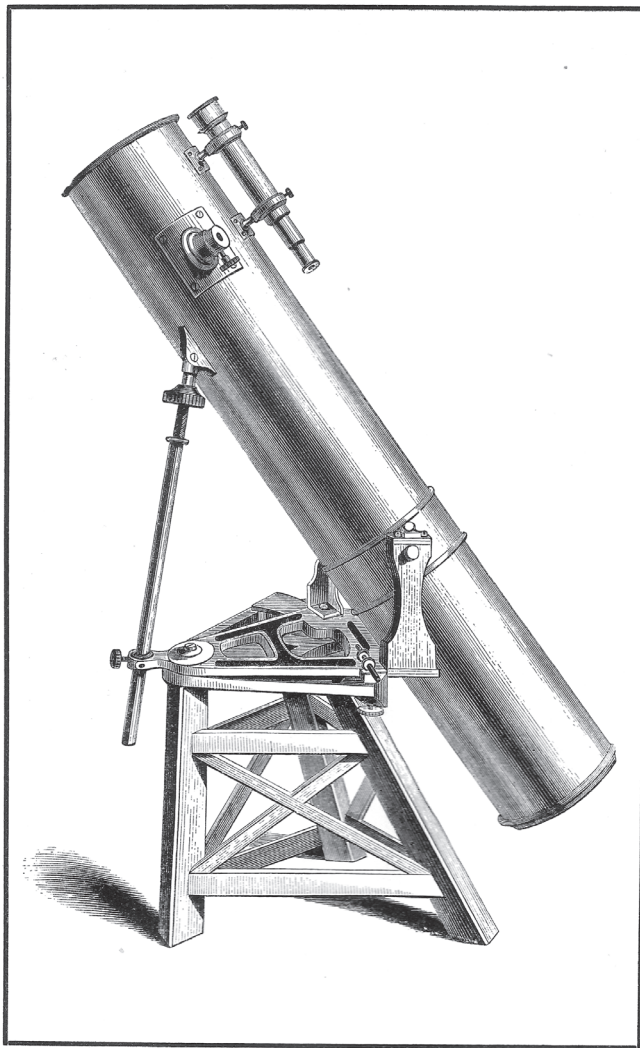
When his two experts declined to write for the TA&PS on the case for small apertures, Lumsden himself undertook the task. And, for reasons that remain opaque, he didn’t publish his paper in the *Transactions* of the Society; instead it appeared as “A Plea for the Common Telescope” in *Scientific American*,

where it would have enjoyed wider circulation than if it had appeared in the TA&PA *Transactions* (Lumsden 1891). Perhaps the answer lies there.

The bulk of Lumsden’s paper consists of a brief history of the telescope, and a rather error-ridden one at that. Its practical advice, observations, and suggestions are pedestrian at best. Why did he write and publish it? Presumably because there was a local demand for the treatment amongst his colleagues in Toronto, but that doesn’t explain why *Scientific American* elected to publish it. Even more puzzling is that the case for what could be accomplished by amateurs with small apertures was much more competently, attractively, and usefully stated by Mary Ward (1859), the Rev’d T.W. Webb (1859; 1881), and Denning (1891, 20–37), to name a few, and these works were well known in the amateur community.

The one possible glimmer of originality in Lumsden’s article is his definition of a small apertures: “When making use of the term “common telescope,” I would like to be understood as referring to good refractors with object glasses not exceeding three or three and one-half inches in diameter” (Lumsden 1891, 13297). That lies between the instrument for which Mrs. Ward writes, a refractor with a 2-inch objective or less (Ward 1859, 2), and Webb’s common telescope with an objective of 3 to 5 inches (Webb 1881, 1)<sup>5</sup>. Another contextual curiosity is that the topic of aperture had recently (1885–1886) been thoroughly debated by prominent amateurs and professionals, such as W.F. Denning (elected a Corresponding Member of the TA&PS in 1891), G.W. Hough, C.A. Young, and Burnham himself in some of the leading astronomical periodicals—*The*

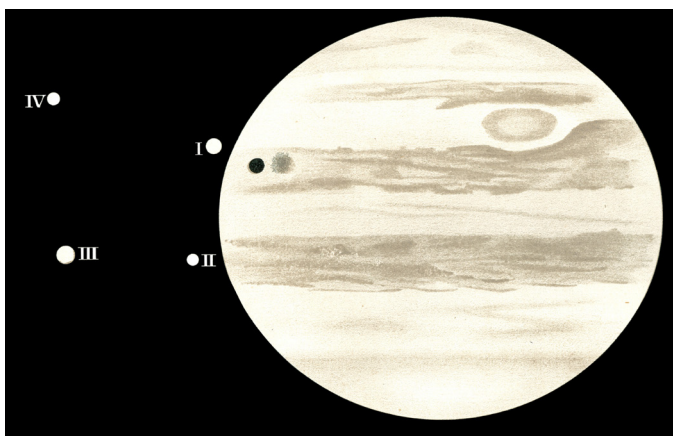




SILVERED-GLASS REFLECTOR. (By Browning.)

Aperture, 10½ in.

R 1



Alexander & Cable CP Ltd. Toronto. Jupiter, 1891. September 20. 12:05 E.S.T. = 17:05 G.M.T. G.E. Lumsden, Del.

Figure 5a — Reproduction of sketch of Jupiter and the Medicean moons, 1891 September 20, by G.E. Lumsden with his 10-inch Browning-With reflector. Frontispiece to the Transactions of the Astronomical and Physical Society of Toronto, for the Year 1891... Toronto: Toronto Astronomical and Physical Society, published in 1892. Reproduced courtesy of the RASC Archives.

Figure 4 — Woodcut of a 10.25-inch aperture reflector by John Browning — Lumsden owned a similar instrument. Detail of figure 185, plate XXXV from Chambers, G.F. (1868). Descriptive Astronomy. Oxford: Clarendon Press. Reproduced courtesy of the Specula astronomica minima.

Observatory, Nature, and the Sidereal Messenger (Lankford 1981).<sup>6</sup> In that debate “small apertures” were 8-inches or less, and large ones were 15-inches or greater (in contrast to Lumsden’s more modest definition). Lumsden’s paper came late, made no reference to the relevant literature of the preceding five years, and in turn was not cited when the debate resumed in better placed and informed astronomical circles (1895–1896). In light of the heat generated by the principal players, Lumsden’s discussion seems oddly serene, and even more so given the flame wars which were soon to erupt over who saw the true surface of Mars, pitting the advocates of small (or stopped-down) apertures against the advocates of full apertures on big telescopes (Sheehan & Bell 2021, 159–194).

Why did Lumsden quote Burnham as an authority, based on the letter he received, but didn’t mention Browning or his letter? Lumsden’s arguments could have derived additional support from Browning’s opinion, and name. By 1891 Burnham was an honorary member of the TA&PS, but Browning was never elected, for reasons unknown.

The strangest circumstance in all this is that Lumsden possessed one of the largest aperture instruments owned by a



Figure 5b — Sketch of Mars by Andrew Elvins using Lumsden’s 10-inch Browning-With reflector, 1892 August 2. Reproduced courtesy of the RASC Archives.

member of the TA&PS. His was a Browning-With reflector with a 10-inch primary mirror (Figure 4)! His fellow TA&PS members who owned small telescopes were certainly not adverse to borrowing it (Figure 5a–b). Why would the owner of a premium relatively large-aperture amateur instrument of the period write an article singing the virtues of small apertures? *Noblesse oblige*, perhaps?

As mentioned earlier, the topic of small apertures hasn't been relegated to the irrelevancies of amateur astronomical history, to judge from the interchanges on amateur forums, and the fact that premium examples are currently available, such as the Takahashi FOA-60Q, and the Tele Vue 60. They wouldn't be marketed if there wasn't sufficient demand. There is a professional aspect to this as well. Small aperture systems have continued to be used for some professional work (Percy 1987). And a particularly innovative approach to intelligently combining small telescopes to deliver a big scientific yield is the Dragonfly Telescope Array ([www.dragonflytelescope.org](http://www.dragonflytelescope.org)). Small apertures, it seems, can still be used for astronomy that matters. ★

## Acknowledgements

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

## Endnotes

- 1 The separate office of Corresponding Secretary barely survived Lumsden's tenure of it (1890–1899), for in 1902 it was combined with that of the Recording Secretary into the office of Secretary.
- 2 A not uncommon complaint in Burnham's correspondence (he almost seems an Isaac Casaubon of the eyepiece), but the reward for this attitude was his remarkable productivity.
- 3 In ordering his own 6-inch refractor from Alvan Clark and Sons, he stipulated "...that its definition should be as perfect as they could make it, and that it should do on double stars all that it was possible for any instrument of that aperture to do;" Jackson 1922, 259.
- 4 This instrument, a small but flexible spectroscope with a three-prism train, was designed by the engineer and "Grand Amateur" (to use Allan Chapman's formulation) (Frank McClean 1837–1904; Browning 1882, 26–29; Newall 1912, xiii). They proved quite popular with amateurs.
- 5 The 3 to 5-inch Webb specifies for refractors can be taken as generally accepted for "small telescopes," but variation persisted among respected authors; when referring to "small telescopes," Denning appears to include everything in the range from 3 to 12 inches (1891, 31, 34)!
- 6 Lankford's corpus of texts from 1885–1911 proved not to be the final word on the subject, and Treanor's (professional) results reported in 1946 (257) are fascinating in light of the earlier debate, for they concede some of the amateurs' points.

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## The Sky Reborn and Baade's Window



by David Levy, Kingston  
& Montréal Centre

Ever since I read Bart J. Bok's foreword to Rose Wilder and Gerald Ames's *The Golden Book of Astronomy*, I have marvelled at what the night sky had to offer and how much of that has changed. "Such wonders," Bok wrote, "fill this book." I have never forgotten those beauties, in particular Bart's favourite: the Eta Carinae Nebula, deep in the southern sky.

On Tuesday, 2022 July 12, NASA released the first-light images from the *James Webb Space Telescope*. One of them is the Eta Carinae Nebula. If Bart Bok could come back to us for one minute, he would be thrilled and elated beyond expression. The image is unadulterated joy. It shows so much more than anyone has ever seen before. It tells how this faint star suddenly became the second brightest star in the sky in 1843, the year of a great comet, and it had a second eruption near the end of the 19th century. If Eta Carinae should one day become a supernova it may become as bright as, or even much brighter than Venus.



Figure 1 — Eta Carinae Nebula

The other picture that really got to me was Stephan's Quintet. It was the first compact group of interacting galaxies ever discovered. First observed from France by Édouard Stephan, it consists of four galaxies interacting with one another; plus a fifth, NGC 7320, which is much closer to us. I have seen this cluster many times. Seeing these images from the new telescope pierced my eyes and warmed my heart. But my mind kept returning to the image of Eta Carinae and to Bart and Priscilla Bok and their lives together.

Bart loved to tell the story of how he and Priscilla attended the opening of the Flandrau Planetarium in November 1975. They



Figure 2 — Stephan's Quintet

arrived early that morning, and they walked toward an exhibit in the back, in the galaxy room. Suddenly Priscilla stopped.

"Bart," she said softly as she gazed upon a picture of Eta Carinae, "When I am gone, I will be in this nebula. Whenever you look at the nebula, you will see me there."

Priscilla passed away just four days later from a heart attack. In her memory, Bart funded a beautiful concrete bench in the aviary at the Desert Museum. Bart often visited the museum and always enjoyed her bench.

"Another audience with the roadrunner soon took place," I wrote later. "As he watched this roadrunner, Bart's thoughts wandered off to a far-off place and time. A memory of Priscilla, happy and alert as she fed a group of magpies, filled his mind. Slowly the image faded, and he imagined once again the exquisite swirls of the nebula in Carina."

The *James Webb Space Telescope* belongs to the world. In January 1610, Galileo pointed his telescope at Jupiter. Over the course of a few nights, he discovered four moons orbiting the Solar System's biggest planet, and the night sky has not been the same ever since.

In July 1994, the *Hubble Space Telescope* also pointed at Jupiter. It recorded the crash of a comet on the Solar System's biggest planet, and the night sky changed again.

On Tuesday, July 12, the world saw the *James Webb Space Telescope's* first view of the Eta Carinae Nebula. The night sky will never be the same.

## On first looking through Baade's window

*Much have I travell'd in the realms of gold,  
And many goodly stars and clusters seen;  
Round celestial islands have I been  
With telescope after telescope to the night sky hold.  
Oft of one wide expanse had I been told  
That Galileo ruled as his demesne;  
Yet did I never breathe its pure serene  
Till I heard Baade speak out loud and bold:  
Then felt I like some watcher of the skies  
When a new star cluster swims into his ken;  
Through his majestic window looks upon the Milky Way  
He star'd at the centre of our galaxy.  
Like a diamond shining in the sky, with a wild surmise—  
Silent, through the mists of space and time.*

– Keats, “On First Looking into Chapman’s Homer,”  
adapted for this article

Lying in the western portion of Sagittarius, the archer, is a small region of sky that has unusual importance for astronomers around the world and which to me is one of the most beautiful things in the whole sky. It was most thoroughly studied by the German astronomer Walter Baade while using the great 100-inch Hooker reflector at Mount Wilson Observatory in California while searching for the centre of the Milky Way. Before this time, the location of the Milky Way Galaxy’s centre was not well understood.

Walter Baade had an interesting and unusual life. In the mid-1930s, he lost his application papers for United States citizenship. Consequently, in 1941 he was classified as an

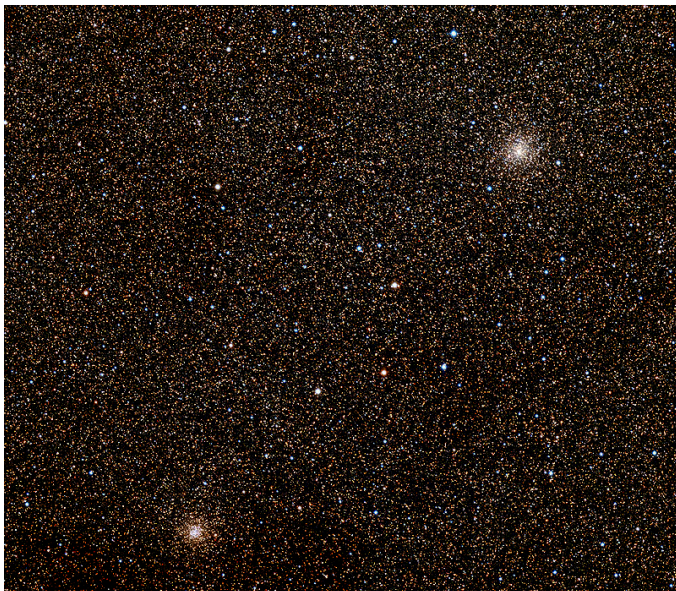


Figure 3 — Baade’s “window,” NGC 6522 and NGC 6528

enemy alien and was held virtually under house arrest. Somehow a compromise was reached, and he was allowed to state his address as Mount Wilson Observatory. With a monopoly of observing time on the great 100-inch telescope, he concentrated his efforts on the Milky Way Galaxy.

One of Baade’s most important projects was a search for a region of the sky that could be close to the centre of the galaxy. He took good advantage of the wartime blackout over the city of Los Angeles. Intended to help obscure the city from attacking warplanes from Japan, it also darkened the sky significantly so that Baade could try to find areas near the galactic centre. Although he did not find it, he did uncover a small area in Sagittarius relatively free of dust. This “window” was slightly south of the main centre of the galaxy. The globular cluster NGC 6522 is at the middle of this area, and NGC 6528 is near its edge.

Astronomers still use this window to study stars in the Milky Way’s central bulge. Important information on the internal structure of the Milky Way is still being better understood by measurements made through this “window.” The window’s shape is irregular in outline and delimits about one degree of the sky, an area of about two moon diameters. It is centred on NGC 6522, which might be, at 12 billion years, the oldest star cluster in the sky. Baade’s window is the largest of the six areas through which stars in the Milky Way’s central bulge can be seen. Stars observed through Baade’s Window can be called BW (for Baade’s Window) stars, similarly giant stars can be called BW giants. OGLE and other observation programs have successfully detected extrasolar planets orbiting around central stars in this area.

On a rare clear evening during the summer of 2022, I gazed at the clusters and stars through this window. I shall never forget the exquisite majesty of this distant region which, thanks to Walter Baade, allows me to peer toward the middle of the enormous Milky Way Galaxy, which is our home. ★

*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 Nail 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

## Pierre Chastenay: Astronomy Educator Extraordinaire



by John R. Percy, FRASC  
([john.percy@utoronto.ca](mailto:john.percy@utoronto.ca))

What is astronomy, and what is its purpose and value? Who are astronomers, and what do they do? Media coverage would sug-

gest that astronomy is frontline discoveries made by research astronomers, but there is much more to astronomy than that. Among other things, astronomy permeates and advances the other sciences, the humanities, and the arts. In this column, I argue that astronomy education, outreach, and communication deserve more recognition because they are essential for public understanding, appreciation, and support for astronomy, and are therefore essential for the health of astronomy itself. No one does those things better than Pierre Chastenay<sup>1</sup>. The purpose of this column is to highlight his work and its importance and raise some questions about how school and public astronomy education could be improved, such as by making his work, and the work of others like him, better known and applied across Canada. One challenge is that the majority of his work has been done in the French language. But we are, after all, in Canada! We should be able to *benefit* from bilingualism and biculturalism.

Chastenay completed a B.Sc. and M.Sc. in physics/astrophysics at Université Laval and immediately launched his career in astronomy education. From 1988 to 2013, he filled increasingly senior roles at the Planétarium de Montréal. Meanwhile, he created, wrote, and hosted more than 600 episodes or segments of TV science documentaries, notably *Les électrons libre* and *Le code Chastenay*, among others. He also wrote award-winning children's books, astronomy columns in newspapers, book chapters and articles in popular magazines and professional journals.

Meanwhile, he completed a Ph.D. in Science Education in 2013 and, for the past decade, has been a Professor of Education at the Université du Québec à Montréal (UQAM), carrying out education research, training school teachers, and continuing his many informal education, outreach, and communication activities. His awards occupy two pages in his *curriculum vitae* and span the full range of his activities. They include the Sandford Fleming Medal of the Royal Canadian Institute for Science, and the Qilak Award of the Canadian Astronomical Society<sup>2</sup> for outstanding communication of science, and of astronomy respectively. He is also a Chevalier de l'Ordre de la Pléiade for excellence in science popularization across the whole of the francophone world.

When not at UQAM, he retreats to his country house, about an hour outside Montréal, a very good place to be during a pandemic. It even includes a sugar bush, where he produces



Figure 1 — Professor Pierre Chastenay is an award-winning astronomer who has made diverse, sustained, and significant contributions to astronomy education, outreach, and communication. Source: UQAM.

maple syrup for his family and friends, and for sale. Sports-wise: he runs 5K and 10K, and cycles, and is passionate about rugby, especially the All Blacks, the New Zealand national team. In quieter moments, he reads books about true crime, and historical fiction and non-fiction.

Why is Chastenay's work so important to astronomy, and to science and education in general? Why should he and his work be better known, especially in anglophone Canada?

- His planetarium work has helped to inform and inspire millions of visitors, including hundreds of thousands of schoolchildren. They will have left the planetarium with a very positive and accurate image of astronomy and science in general. For many, the planetarium experience will be remembered for a lifetime.
- His more than 600 award-winning TV episodes and radio programs and podcasts have had a huge impact, and are the most important way in which the public at large develop their knowledge of and attitude to science beyond school.
- Children still read, and books on astronomy (and dinosaurs)—like Chastenay's award-winning books—may inspire them to become more interested in science, and perhaps even to embark on STEM careers.
- Chastenay's numerous and varied articles—technical and otherwise—have reached a large and diverse readership, from newspaper readers to professional scientists and educators.
- A large fraction of our population learns (or should learn) astronomy and other sciences in school. One of the most powerful ways to increase public understanding and appreciation of science is therefore to ensure that it is taught and taught well. Astronomy is especially problematic, since few teachers have any background in astronomy, or astronomy teaching. They need high-quality, appropriate pre-service or in-service professional development<sup>3</sup>. Chastenay has confronted this problem through his faculty of education courses—which have gained rave reviews—and by reviewing or creating appropriate educational materials.
- Science education and outreach is only effective if done using “best practices,” as determined by formal education

research, assessment, or reflection. Chastenay is one of the few professionally trained astronomer/educators who is carrying out such work today. For instance, he has done extensive research on students' conceptions of moon phases, developed practical activities on this topic, and published the results in top journals, e.g. Chastenay (2016), Chastenay and Riopel (2019). Moon phases is one of the very few astronomical phenomena that students can observe easily and safely. His philosophy is to have students think and work as scientists do.

Most, but not all, of Chastenay's work is in French, and carried out in Québec. This raises the important question: how can it be used to improve astronomy education across Canada, and beyond? More generally: how can important information and ideas be communicated more effectively between anglophone and francophone Canada? Must we really live in parallel universes? And within the anglophone universe, communication could be improved.

Astronomy is a compulsory topic in the school curriculum, usually at the grades 6 and 9 level. The science curriculum is reasonably consistent across the country, thanks in part to the Pan-Canadian Science Protocol, many years ago. As far as I know, Chastenay's university is the only one in Canada with an astronomer in its faculty of education, so non-astronomer teacher educators need to know the essence of Chastenay's materials and methods.

Schoolteachers are generally also required to take in-service professional development. This could include training in astronomy teaching if (i) there were appropriate instructors, instruction, and resource material available in both English and French; and (ii) these were known about and approved by the organizations and individuals who administer the professional development. These include organizations such as the Science Teachers Association of Ontario<sup>4</sup>, science coordinators and consultants at the school-board level (a dying breed, unfortunately), and instructional leaders or science department heads at the school level. Some years ago, partly as an International Year of Astronomy 2009 project, STAO developed teaching modules for grade 6 and 9 astronomy. They are still available online<sup>5,6</sup>.

The situation is further complicated by the fact that education is a provincial responsibility in Canada. We also lack a national science organization like the American Association for the Advancement of Science in the US. I'm pleased to note, though, that there is such an organization in francophone Canada, ACFAS—Association Canadienne Française pour L'avancement des Sciences—which is celebrating its centenary this year!

Canada has an excellent national bilingual astronomy education program, *Discover the Universe*<sup>7</sup>, directed by award-winning astronomer/educator Julie Bolduc-Duval. It is especially known for its webinars for teachers, which attract audiences from across Canada and beyond. Its funding and therefore its resources are limited, however. If it could be used

and supported by schools across Canada, it could expand and fill a truly national role.

There are also other organizations and individuals, across Canada, which are creating and offering programs and material which would be useful to teachers. These include the RASC<sup>8</sup>. Unfortunately, these resources may only be known locally, if at all. It would help to have a national astronomy education website. And this website would have to be well-publicized to all potential audiences. The Canadian Astronomical Society developed an excellent site many years ago, but sadly it was not well publicized or used. I am partly to blame for that. Likewise: many decades ago, I instituted an Education Notes column in JRASC, to help spread information about astronomy education. I'm not sure how much of the information got to where it was needed. Planetaria and science centres can help, as Chastenay showed so well in Montréal. But planetaria come and go, as we so sadly know in Toronto. On a more positive note: Discover the Universe has an excellent presence on Facebook. Perhaps social media is the key. Younger teachers than me can let us know!

Pierre Chastenay's contributions to education, outreach, and communication, at all levels and in many different settings have been diverse, significant, and sustained. Let's celebrate this astronomy educator extraordinaire and use his work to help inspire and improve astronomy teaching in schools across the country! ★

*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.*

## Endnotes

- 1 Pierre Chastenay: [professeurs.uqam.ca/professeur/chastenay.pierre/](http://professeurs.uqam.ca/professeur/chastenay.pierre/)
- 2 Chastenay's Qilak Award: [casca.ca/?p=8890](http://casca.ca/?p=8890)
- 3 Why astronomy is useful and should be taught in school: [www.astro.utoronto.ca/~percy/useful.pdf](http://www.astro.utoronto.ca/~percy/useful.pdf)
- 4 Science Teachers Association of Ontario: [stao.ca](http://stao.ca)
- 5 STAO Grade Six Astronomy Resource: [stao.ca/resource/stao-grade-six-space-unit-user-guide/](http://stao.ca/resource/stao-grade-six-space-unit-user-guide/)
- 6 STAO Grade Nine Astronomy Resource: [www.astro.utoronto.ca/~percy/GradeNineAstronomyResource.pdf](http://www.astro.utoronto.ca/~percy/GradeNineAstronomyResource.pdf)
- 7 Discover the Universe: [discovertheuniverse.ca](http://discovertheuniverse.ca)
- 8 RASC Public Education and Outreach: [rasc.ca/education-public-outreach](http://rasc.ca/education-public-outreach)

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# Binary Universe

## The Sky Tonight



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

### What's Up?

I heard about this app on Cloudy Nights last fall. The original poster said:

“The makers of *Star Walk* have released a new app called *Sky Tonight* which seems aimed at the more serious user. I really like the ‘What’s up tonight’ views along with the transit graphs, etc.”

That caught my attention. Sounded like it might be a reasonable planning tool for the mobile phone or tablet.

It is available for iOS and Android.

<https://vitotechnology.com/>

I downloaded the free version (1.4.2) to my Microsoft Surface running the Blue Stacks Android emulator. Be prepared for frequent advertisements as you use the free edition.

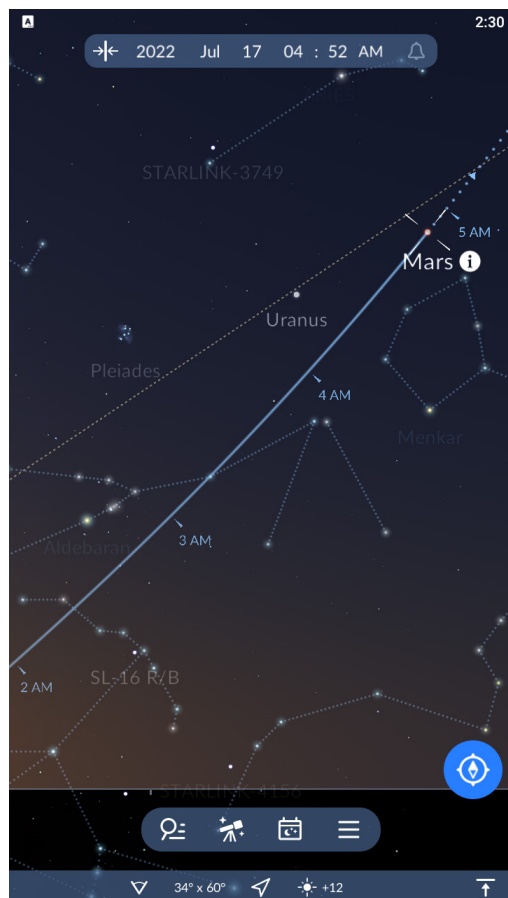


Figure 1 — First screen in Sky Tonight, a naturalistic-coloured sky chart. Mars selected.

## Sky Chart

On opening the app, the user is presented with a fairly standard-looking digital sky chart (see Figure 1).

Initially, I noted the app showed artwork for a single constellation, the one centred on the screen. Loud spacey music played at the start! I quickly shut that off..

The common pinching gesture can zoom the field. Swipe to pan.

At the top of the screen, there’s an interactive date/time toolbar. Near the bottom of the screen, there’s a small toolbar for the different modes or screens in the app. And below that, a handy panel to rapidly change view settings in the app or one’s location.

Tapping an object will show a spinning cursor and its name along with an information icon/button.

## Object Info

A circled information button positioned near a selected object, when tapped, will display rich, detailed object information screens.

The Info panel shows an image and the usual facts including alternate names, the coordinates, distance, etc. Below is verbose text and occasionally diagrams.



Figure 2 — Object information screen with Figures panel showing target elevation.

The Figures panel (Figure 2) reveals an excellent altitude graph helping you determine when the object will culminate, for its best appearance visually or photographically.

The Events panel shows rise, transit, and set times for the object over the next few nights. Below that is a table of noteworthy events, such as conjunctions.

## What’s Visible Tonight?

Arguably, the most important feature of *Sky Tonight* is the Visible Tonight screen (Figure 3). This is accessed by tapping the telescope icon button on the bottom toolbar.

For a given date, the screen lists objects that can be viewed in the evening. Initially, this list is sorted by Type but may be reorganized alphabetically,

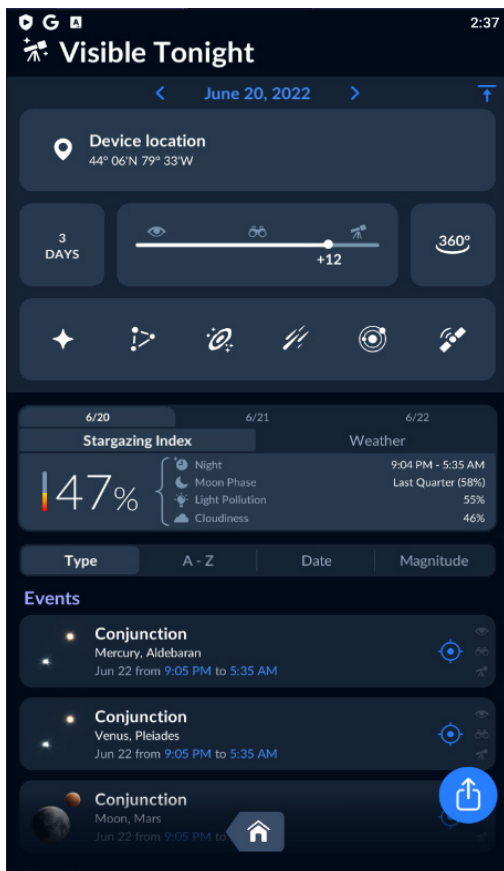


Figure 3 — Visible Tonight screen with events listed by type. Filter panel expanded.

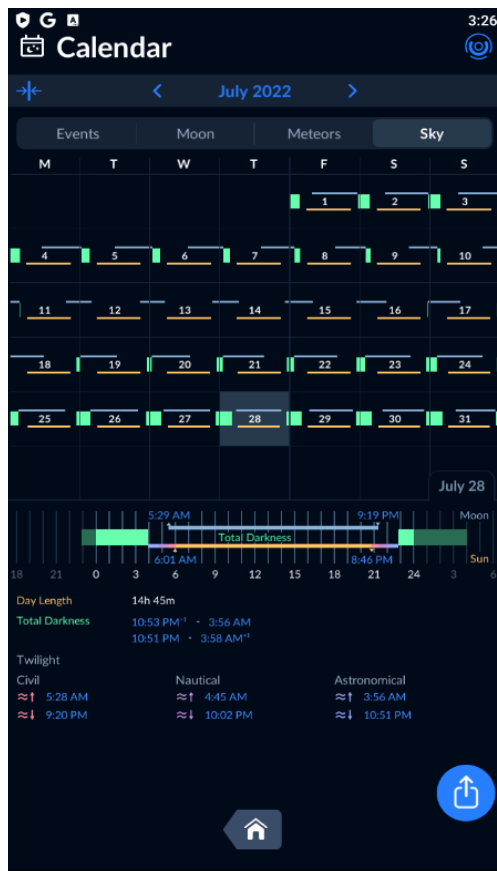


Figure 4 — Calendar screen in Sky mode. Green segments in horizontal bar show total darkness.

The Moon mode shows our celestial neighbour's phase night by night with rise and set times.

The Meteors display is quite nice showing active showers with peaks highlighted.

Finally, the Sky mode for the calendar, in either a horizontal bar style or something akin to a pie graph, shows the particulars for an evening. The user is looking for long green bars or arcs indicating periods of total darkness. I do wish the horizontal bar style was centred on midnight.

Events from an evening can be shared, with an illustration and a QR code.

## Searching

The first button in the bottom toolbar on the main screen is for finding items. Keyword searches are allowed, but one might also choose from the list of suggestions.

by time, and by magnitude. Any of the objects listed may be tapped which, of course, shows the object information screen.

Atop the Visible Tonight screen is a toolbar. This lets you alter the time frame from one day to three days or one week, set a magnitude limit, and filter out objects (in case you're not interested in satellite flyovers for example).

Below the toolbar is the Stargazing Index and Weather panel. This clearly shows that *Sky Tonight* takes your local weather and light pollution into effect. The higher the percentage value, the more promising the evening.

## What's Visible Next Week?

If conducting some long-range planning, for instance what's visible during the next new Moon phase, you will want to use Calendar screens (figure 4). Tapping the month-at-a-glance button in the bottom toolbar switches to this mode.

The calendar can be shown in four ways: Events, Moon, Meteors, and Sky. The Events style uses little icons to show notable events like conjunctions, meteor showers, lunar occultations, and the like.

Tapping a search result displays the object information screen.

Tapping the target icon button then shifts to the date and time and then shows the object marked in the sky chart.

## Lots of Options

Via many screens, various settings are offered to manage the appearance and control of the app. There are also a few handy tools provided, such as Telrad display. Of course, the app can be run in red mode.

*Sky Tonight* supports reminders which can help you avoid missing interesting events. You may also mark an object as a favourite using the heart icon. There's also an augmented reality display which turns on the back camera and the app can operate in pointing mode using the device's sensors.

There is a built-in tips and tricks section to help one get up to speed in the app.

## Location

The app uses the phone or tablet's location by default. This can be adjusted, and it is easy to look up a location by city or town



name or to enter a location by latitude and longitude, however, it is not possible to save a location.

## How's the Sky?

*Sky Tonight* by Vito Technology is a rather good tool for anticipating and planning astronomical sessions. By using your local weather, you can determine if it's worth heading out for the evening. It's a good tool for long-range planning and it is impressively thorough. I was pleasantly surprised how they displayed meteor shower "runs."

I emailed the support address about a question, and they were quick to respond.

The free app has a lot of pop-up ads (many of which had sound), but it's a good way to try out the app; in fact, you can

try the full app for one week, in a trial. They offer a monthly subscription for less than \$2. There appears to be a life-time premium one-time-only access fee as well.

## Bits and Bytes

*Stellarium Mobile* 1.9.3 was updated for better handling of ocular and camera fields of view. *Stellarium* for computers 0.22.2 was updated with a plethora of new features. ★

*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.*

# AAVSO

## Your Monthly Guide to Variable Stars – Series Two



by Jim Fox, AAVSO

### CH Cygni (CH Cyg) (September)

CH Cygni is a member of the symbiotic class of variable stars. Symbiotic stars are peculiar in that their spectra show both absorption lines of a cool star and emission lines of a hot star! How can this be? As the class name suggests, they are actually two (or multiple) stars: a cool red star and a compact hot star. Furthermore, they are usually embedded in a nebular shell. The class name was promoted by Paul W. Merrill of Mt. Wilson Observatory in 1932.

A symbiotic variable can have a very complex light curve that is hard to interpret. Each component of the system can contribute to observed light variations. The cool star may exhibit Mira-type pulsations; the two stars may eclipse one another; the hot component may accrete material and exhibit occasional nova-like explosions; the surrounding gas shell may have regions of differing transmission or emissions; rotational effects may bring star spots into play on either or both stars. All these effects may be superimposed on the light we see from Earth.

CH Cygni has become distinctive, even within this unusual class of variables. From its identification in the early 20th

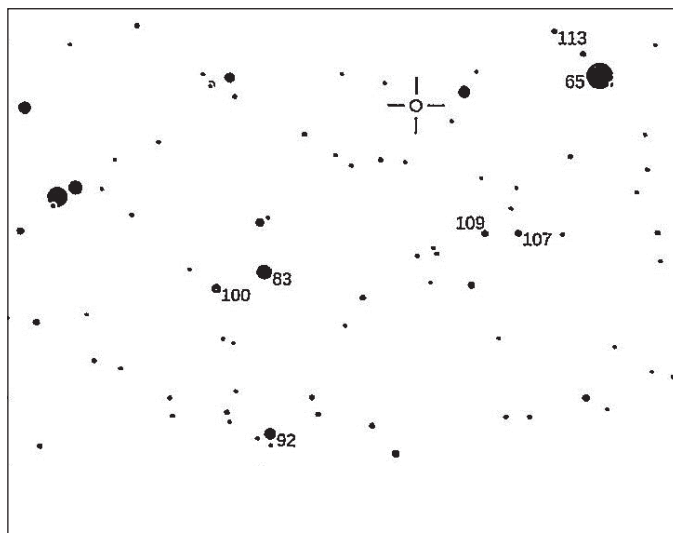


Figure 1 — CH Cygni (CH Cyg)

century until 1976, the star behaved like a semiregular variable, varying by about a magnitude around visual magnitude 7.5 with a period around 1 to 3 years. In 1976, CH Cyg erupted, eventually reaching magnitude 5.6. During the outburst, a powerful radio jet was detected by the Very Large Array. Three different models have been proposed to explain the complex behaviour of CH Cyg, but additional observations are needed to distinguish between them.

To observe CH Cyg, you will need a small telescope. It currently (2021) resides around visual magnitude 7.5 and can be found at 19h 24m 33s, +50°14'29" in western Cygnus, 1.6° south-southwest of Iota2 Cygni (SAO 31702) and 12' east of SAO 31623, the star labelled 65 on this chart. Figure 1 is not inverted with north up and east left. CH Cyg is the highlighted open circle. Chart courtesy AAVSO.

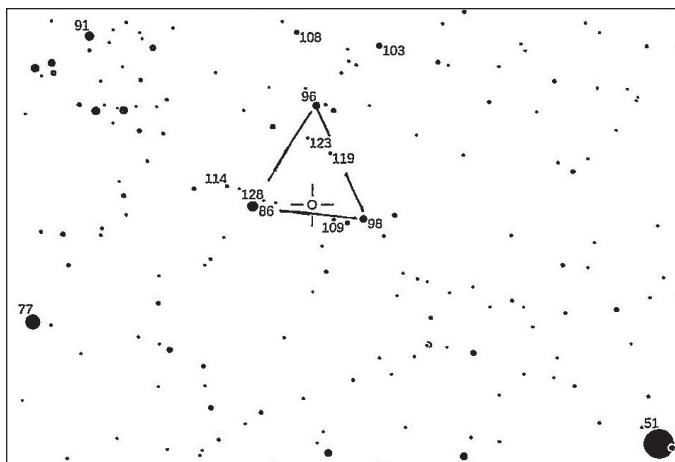


Figure 2 — SS Cygni (SS Cyg)

## SS Cygni (SS Cyg) (October)

SS Cygni is a dwarf nova of the U Geminorum type and one of the most observed variables in the AAVSO database. It was discovered by Louisa D. Wells of Harvard College Observatory from her study of the College's plate collection in 1896. Being one of the brightest stars of the class (visual magnitude 12.4 at quiescence) and located in the Milky Way with a rich field of comparison stars, it is no wonder that SS Cyg is so popular with observers.

Like all dwarf novae, SS Cyg consists of a main-sequence star in close orbit with a white dwarf primary. As the white dwarf draws material from the main sequence star into a surrounding accretion disk, the accumulated material eventually explodes. The exact trigger of the explosion is uncertain. Two competing models are: (1) instabilities in the disk or (2) a sudden transfer of mass from the secondary. Although the orbital period of the two SS Cyg stars is only 6.5 hours, the times between outbursts are non-periodic and vary from 30 to 70 days. The outbursts themselves vary between wide and narrow duration with no discernable pattern.

Most of what we know about dwarf novae behaviour comes from the work of amateur astronomers. SS Cyg has been the subject of more than 50 AAVSO Alert Notices—including the first one in 1974. Amateur observations have been correlated with X-ray, ultraviolet, infrared and radio observations.

SS Cyg can be found at coordinates 21h 42m 43s, +43°35'10", about 0.5° northeast of the star 75 Cygni (SAO 51167) labelled as 51 on this chart. It lies in an easily discernable triangle of ninth magnitude stars. Figure 2 is not inverted with north up and east left. SS Cyg is the highlighted open circle. Chart courtesy AAVSO.

## Z Andromedae (Z And) (October)

Williamina Fleming discovered Z Andromedae while investigating spectrum plates at Harvard College Observatory in

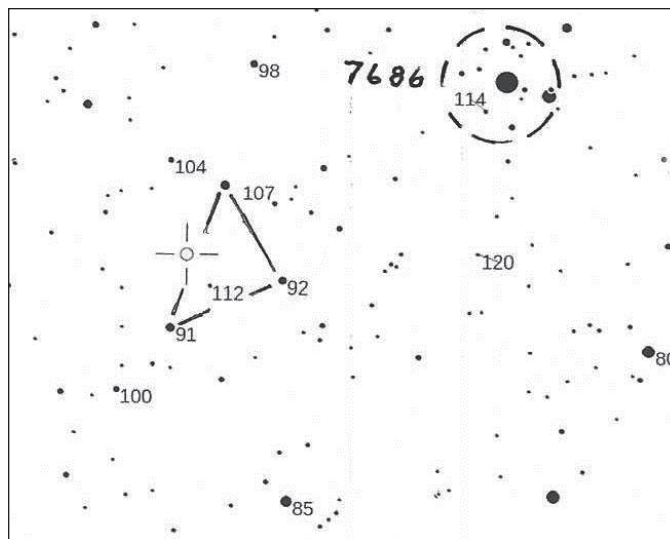


Figure 3 — Z Andromedae (Z And)

1901. She noted that the star had a strange spectrum, similar to that of several novae. Further work by Annie Jump Cannon isolated emission lines of hydrogen and helium. The full spectrum revealed the presence of a low-temperature, M-type giant star coupled with emission lines of an excited second star. Z And is considered the prototype of these *symbiotic* stars. Any binary system can provide fundamental information about the stars, such as mass and radii. Being embedded in a nebula, symbiotic stars also provide clues about processes in the gas cloud. With the development of astronomical satellites in the 1980s, astronomers could collect data in wavelengths not available to ground-based observers. They now include X-ray, UV and IR data in their models.

During its quiescent phase, Z And exhibits small amplitude variations around visual magnitude 11 over irregular intervals around 685 days. Then every 10–20 years, the star's brightness increases from visual magnitude 11 to magnitude 8 as the dwarf accumulates mass from the red giant's stellar wind and becomes unstable. During outburst, the star gets bluer and its spectrum is dominated by the hot dwarf star and the surrounding nebulosity.

You can find Z And at 23h 33m 40s, +48°49'06". It lies along one side of a triangle of 9th magnitude stars, about 40' south-east of 6th magnitude SAO 53088, the brightest of 20-odd stars that make up the open cluster NGC 7686. Figure 3 is not inverted with north up and east left. Z And 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

## Galaxies and Starbirth



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

Galaxy collisions are literally one of the biggest events that happen in the Universe.

The sizes and masses of the collisions are mind-blowing, but collisions are relatively frequent in our Universe with a typical galaxy experiencing several collisions over its lifetime. Because of this frequency, collisions are thought to be an essential part of how galaxies grow. However, for a galaxy like our Milky Way, most of these collisions are blandly referred to as minor collisions, where the galaxy colliding with the Milky Way is significantly smaller (10% of the Milky Way mass or less). These minor collisions stand in contrast with the main event: major mergers, when two equal-mass galaxies collide with each other. If these are gas-rich star-forming systems like the Milky Way, the crash of the two galaxies together leads to a frenzied rush of star formation called a starburst. The newly formed stars include high-mass stars that give off vast amounts of radiation and end their lives in supernova. Supernovae and starlight disrupt the natural process of star formation and usually leads to the end of star formation. But where does the reservoir of star-forming gas go after a collision? Does it get driven out of the galaxy by the radiation of the high-mass stars? Or does it stick around, somehow unable to form another generation of stars? New observations with the Atacama Large Millimetre/submil-

limetre Array (ALMA) have found the missing gas, but the discovery raises some puzzling new questions.

Our Milky Way Galaxy is a typical massive, star-forming galaxy—a proper citizen in the Universe. Like similar galaxies, it is composed primarily of dark matter (about 75% of its mass) with stars (23%) and gas clouds (2%) making up most of the remaining material. The galaxy is actively forming new generations of stars, where the gas cools down to temperatures as low as 10 K before gravitationally collapsing into new stellar systems, i.e. the stars and their planets. We can see this process happening around us where we observe stellar systems in various stages of this formation. This star formation process is an active lifecycle: some of the newly formed stars are high mass and disrupt the parent cold gas cloud through stellar winds, supernovae, and radiation. The heated gas moves to other parts of the galaxy where it cools again and can start the star-formation process anew.

The process of star formation gives galaxies their representative shapes and colours, which arise from the collective light of billions of individual stars. The types of light from stars is almost entirely determined by the mass of the star at the time when it was formed. High-mass stars give off huge amounts of radiation, but their surface temperatures are also relatively high, leading to a strong blue colour and lots of high-energy radiation being emitted. Medium-mass stars, like our Sun, give off much less light and the temperature is cooler, leading to yellow / white colours. Finally, the cool surfaces of the lowest-mass stars barely emit light at all and are visibly red. Some stars are exceptions to these rules, such as red giants at the end of a star's life where the star's brightness increases

dramatically. Paired with these general trends about stars comes a consequence about lifetimes. The highest-mass stars consume their nuclear fuel at a disproportionately faster rate than lower-mass stars, so they run out of fuel quickly. A star that is 10 times the mass of our Sun will have a lifetime about 1000 times shorter, so that the highest-mass stars only last a few million years. All these properties of stars give insights into the light that galaxies emit. Blue light from galaxies comes from high-mass stars, and those stars must have been formed in the relatively recent cosmic past. The presence of this light means that the galaxy is forming stars steadily, requiring a supply of cold gas to power that ongoing star formation. In the absence of star formation, the high-mass stars will end their lives and there will be no ongoing star formation to replace the missing high-mass stars.

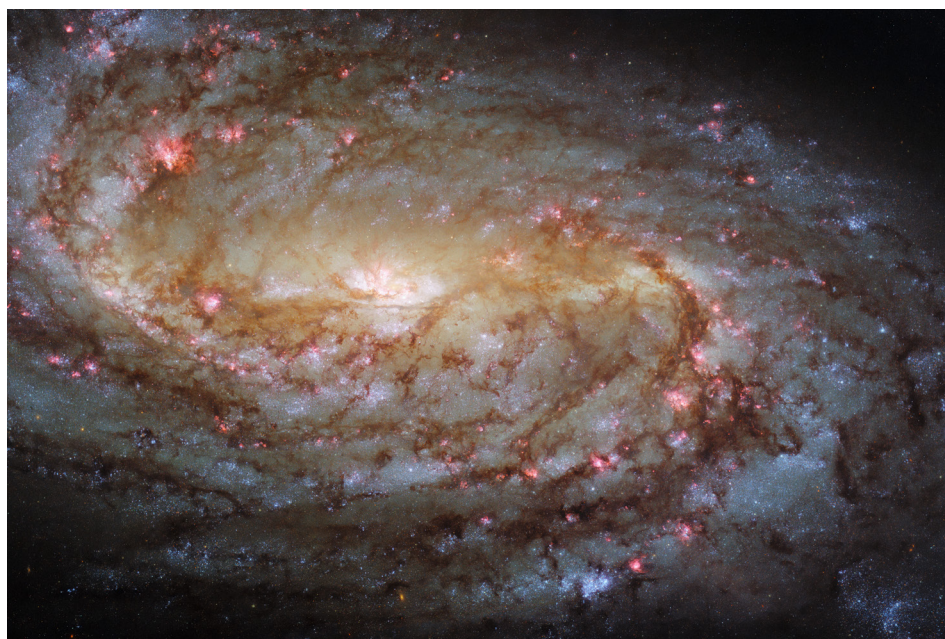


Figure 1 — Optical image of NGC 2903, a typical star-forming galaxy. This galaxy shows the characteristic blue light associated with recent star formation and the strong dust lanes in dark features associated with a substantial amount of dense molecular gas. Credit: ESA/Hubble & NASA, L. Ho, J. Lee and the PHANGS-HST Team

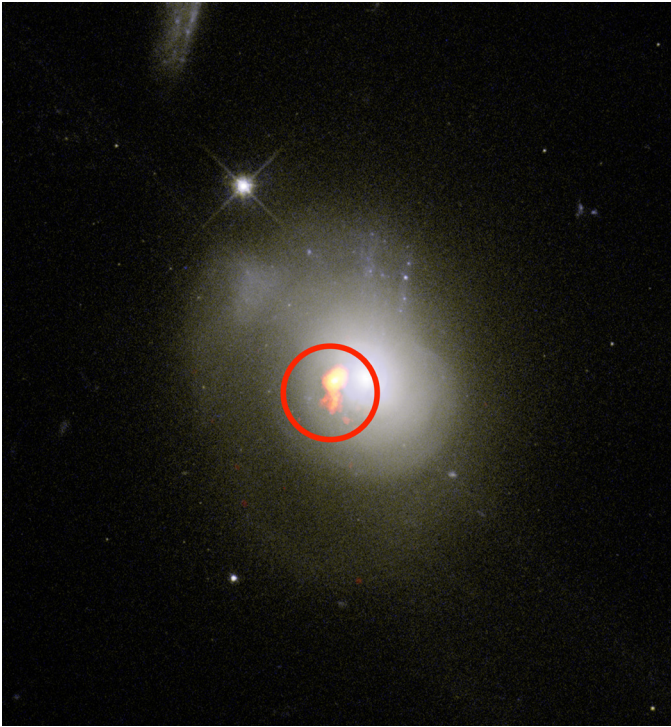


Figure 2 — A post-starburst galaxy system with the image of the cold gas seen by ALMA highlighted by a circle. This system shows the characteristic colour of an aging stellar system. The rings and shells of stars are also a signature of a recent collision where the stars from the two galaxies have not completely merged together into a quiet galactic system. Image Credit: (ESO/NAOJ/NRAO) / S. Dagnello (NRAO/AUI/NSF)

The medium-mass stars will continue to produce light steadily until they too run out of fuel, die, and not be replaced. As time progresses from when star formation ceased, a galaxy will give off progressively less light and that light will be redder.

This picture describes a galaxy in isolation. If galaxies formed stars at a steady rate, most galaxies would run out of gas in about 2 billion years—an aeon but still only about 15% of the age of the Universe. These galaxies must be fed with fresh supplies of gas to drive their ongoing star formation. The source of this fuel is gas that is still falling into galaxies from the dark spaces between these systems. This inflow of matter can come in a steady rain of gas, but sometimes that infalling material comes in a larger chunk that has already formed a small, gas-rich galaxy. The Large and Small Magellanic clouds are examples of such dwarf-galaxy systems that are being pulled into the Milky Way and will eventually merge with our own system. We see another galaxy, called the Sagittarius Dwarf, is soon to collide with the far side of the Milky Way disk. Galaxy collisions are frequent and play a vital role in our understanding of galactic evolution.

The major merger events occur when two galaxies of similar mass collide with each other. For example, the Milky Way and Andromeda Galaxies are destined to collide in about 4

billion years. When these galaxies collide, the stars and stellar systems slide through each other and only pull on each other through gravity. In a galaxy collision, typically about one pair of stars will actually collide. The gas in the systems, however, will smash together triggering a huge burst of cooling and star formation. We know that, after a starburst, the galaxy will typically stop forming stars even though the total amount of stars formed is not 100% of the original gas mass. Until recently, we did not know where exactly the gas went after a starburst. Post-starburst galaxies are characterized by giving off most of their light from medium-aged stars, showing that star formation stopped a while ago but that the stars are still aging away.

The two likely outcomes for what happens to gas in post-starburst galaxies are that the gas gets blasted out of the galaxy or it gets retained and is somehow sterile and not forming stars. Recent ALMA observations have shown that at least some of the gas mass remains in the system and is sterile. ALMA is particularly good at finding the cold molecular gas that forms stars by looking for light from the carbon monoxide molecule. By examining several galaxies that appear to be post-starburst based on their stellar light, an international team led by Dr. Adam Smercina found a surprisingly large amount of cold molecular gas in these galaxies (Figure 2). This raises the question: why is that gas no longer forming stars? The raw material is there but something is preventing the star formation. Looking more closely, the key difference between that gas and the star-forming gas in our own galaxy is how fast the gas is moving. The post-starburst systems all have gas that appears to be stirred up under pressure and moving quickly around the galaxy. The study proposes that these high-speed gas motions are too violent to allow stars to form. If a star were to start forming, the pressure forces and turbulence in the surrounding material would pull apart the forming system. Such a discovery gives more clues as to the nature of star formation in all systems, meaning that just having cold gas is not enough to form stars. Keeping the star-formation engine running also requires having that gas be low enough pressure that the beginnings of stars can continue to build up without being destroyed. It remains unclear how this strong gas pressure could be maintained over a long time and the next steps will try to understand how these internal motions can persist instead of just fading away.

In total, we now have a clearer picture of this missing link of galaxy evolution, connecting how ordinary galaxies transition through the post-starburst stage to become the red galaxies we see. ★

*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.*

# Imager's Corner

## Layers and Blends



by Blair MacDonald, Halifax Centre  
([b.macdonald@ns.sympatico.ca](mailto:b.macdonald@ns.sympatico.ca))

The idea for this column came from answering some questions about layers.

When you use a processor that supports layers and blend modes, there are several layer-based approaches that work very well on astrophotos. In some cases, these layer-based approaches are merely alternate implementations of standard techniques, but in others they offer something that you cannot implement, at least in a single step, without them. Over the next several editions we will look at several of the more useful techniques and show how they can ease and improve several common processing tasks.

Now for the most part, to use these techniques you need image processing that supports layers and blend modes. With packages such as *PixInsight* you can implement different blend modes between images using *Pixel Math*. Please check out <https://pixinsight.com.ar/en/info/articles/7/pixelmath->

[blending-modes.html?fbclid=IwAR19uZUEBU\\_-S0CMUIp-WEP6Z5nwJjbCawWUu5KV44WcgFgkHnN3Of\\_ViIec](https://pixinsight.com.ar/en/info/articles/7/pixelmath-blending-modes.html?fbclid=IwAR19uZUEBU_-S0CMUIp-WEP6Z5nwJjbCawWUu5KV44WcgFgkHnN3Of_ViIec) to see how to implement blend modes in PixInsight. It is also a great reference to explore the math that implements each of the different blend modes.

In this column, we will look at a simple but powerful technique that can be used to selectively enhance areas of your images called layered, masked stretch or LMS. This is an adaptation of an HDR process that has been around for years. The original technique was used to combine images of different exposures, but the LMS approach is intended to combine two different stretches of the same data set. The idea is to stretch the image for all the faint detail and ignore what happens to the brighter areas of the image. Next create another copy of the same data and apply a stretch that best shows the brighter areas ignoring what happens to the faint stuff. I usually use this technique after I have done my initial stretch, colour correction, noise reduction, and sharpening. It greatly improves image contrast in the brighter areas without losing all the faint detail that we work so hard to get in those initial stretches.

As an example, let's take a look at one of my not-so-great shots of M42 (Figure 1). Even in the unprocessed data the

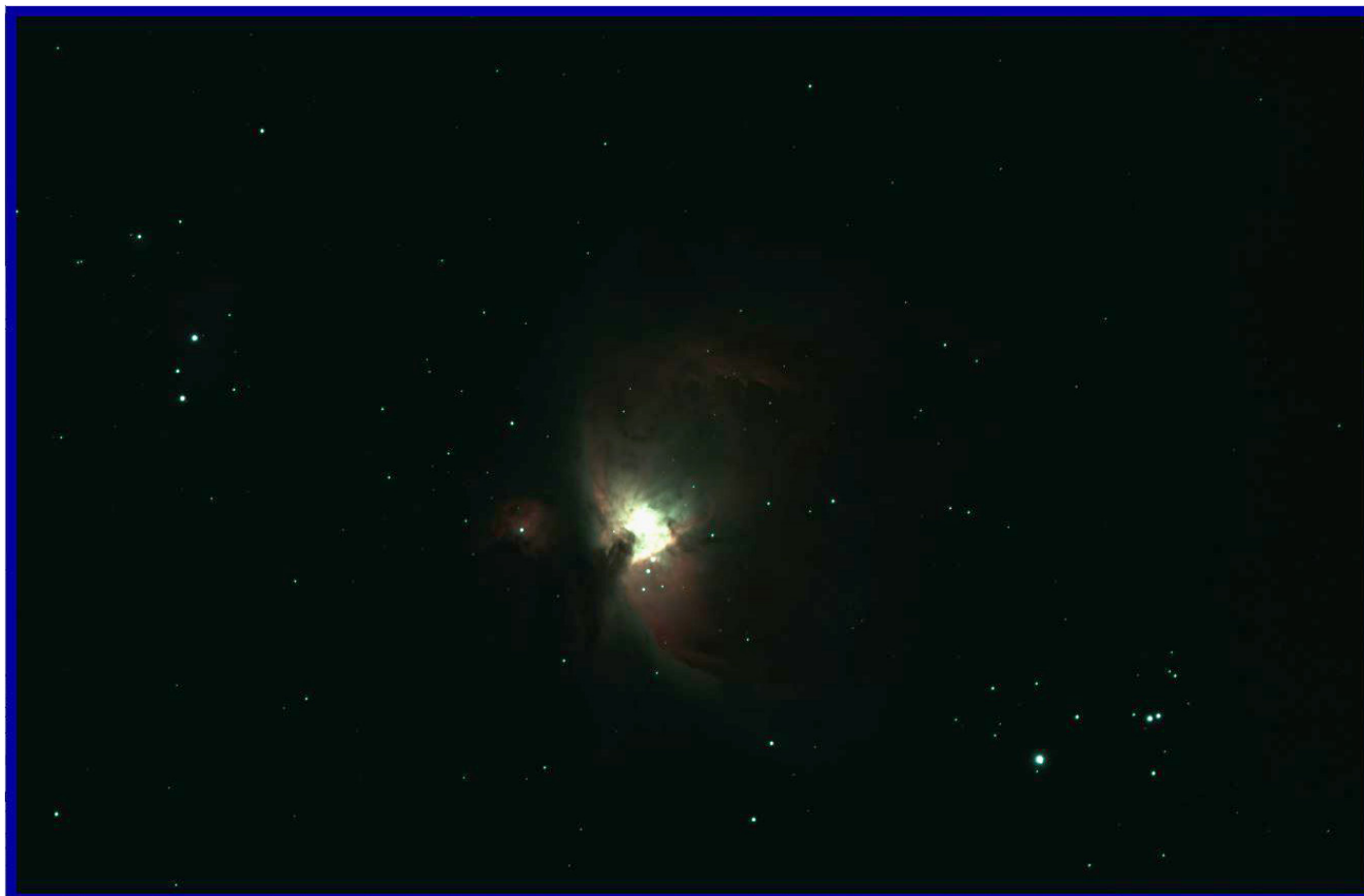


Figure 1 — Original, unprocessed M42 image

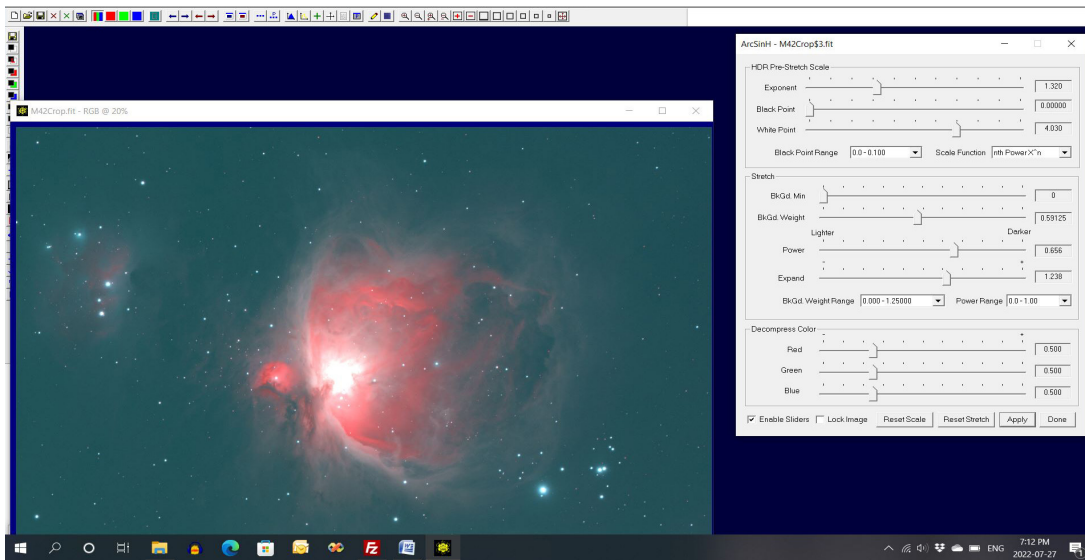


Figure 2 — Arcsinh stretch applied to the data, keeping as much of the core as possible

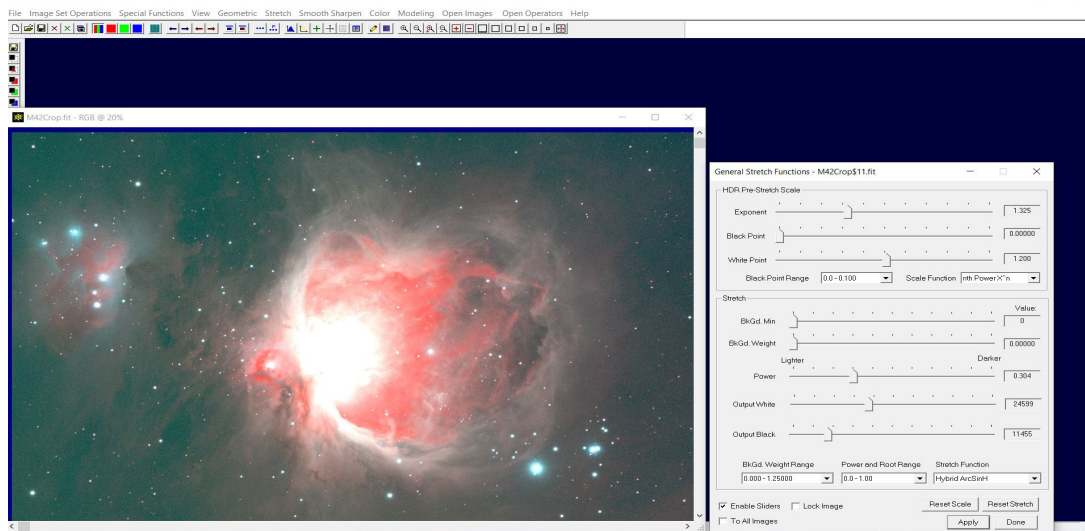


Figure 3 — Second hybrid arcsinh stretch is used to make the faint gas and dust visible at the expense of losing all the remaining core detail

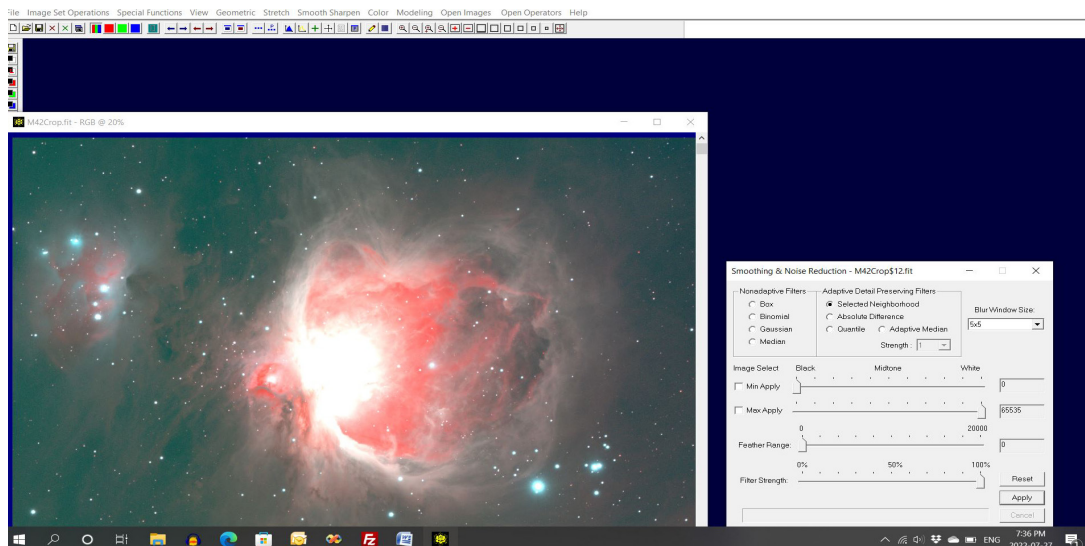


Figure 4 — Noise reduction is applied to tame the noise in the darker areas that was made worse by the second stretch

core of M42 is completely blown out, so the goal of the processing is to preserve the detail left in the core while bringing out the dim gas and dust surrounding the nebula.

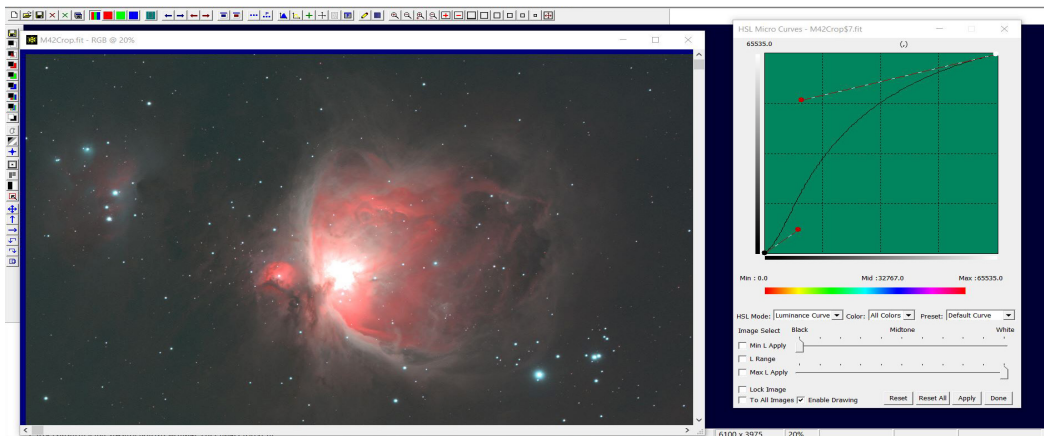
The first step in the process is an initial arcsinh stretch, but any favourite stretch will do as long as it brings out more of the faint detail without blowing out the core any more than it already is (Figure 2).

Pushing the stretch any further will reveal more of the faint background dust and gas, but at the expense of blowing out the core even more. So let's save the image so far and use an additional stretch to show the faint gas surrounding the main nebula complex.

Figure 3 shows the next step in the process, taking the noise down a bit with your favourite smoothing filter as the extreme stretch exaggerates the noise in the darker parts of the image.

Save this image for the base layer of the final image stack. For this example we will call it bottom.fit.

Now that we have an image with lots of gas and dust visible, we can return to the original image after the initial stretch and apply a much gentler curve stretch to brighten the core area of the nebula without blowing out the core any more than the initial stretch did.



As you can see from Figure 5, this yields a more detailed core at the expense of all the faint gas and dust in the image shown in Figure 4. To increase the contrast a bit, a levels adjustment is used to raise the black point a bit.

Save the image in Figure 6 as top.fit.

Now the LMS magic happens. Make an image stack with the bright image (bottom. fit) on the bottom and top.fit at the top of the stack. Make a luminance mask from the bottom image and apply it over the top image. Set the blend mode of the top layer to normal to produce the result as shown in Figure 7.

This generally produces an image that has the detail of both the top and bottom images, but lacks contrast and sharpness. To restore the sharpness to the resulting combination, blur the mask enough to remove all the fine detail.

Figure 5 — Image after second gentle stretch

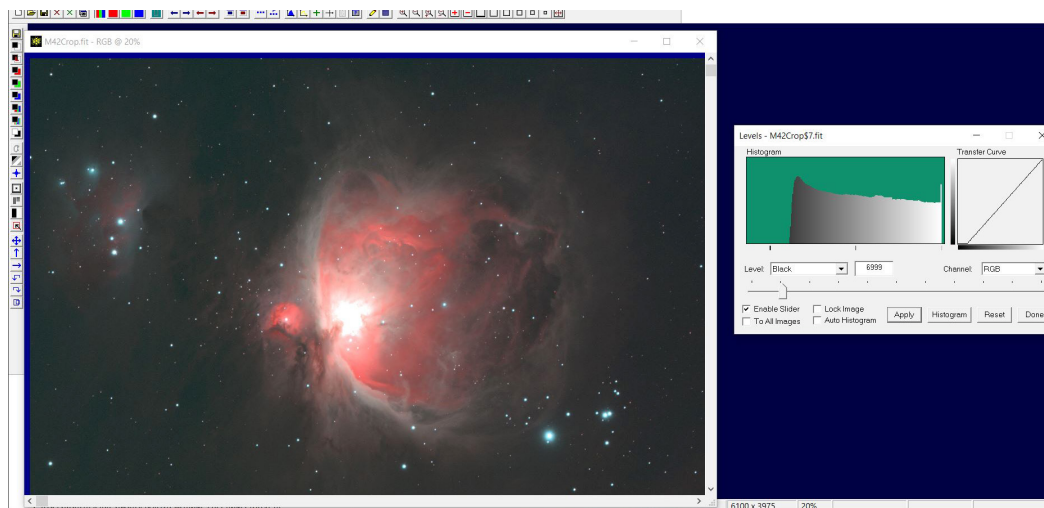


Figure 6 — Contrast boosted final second image

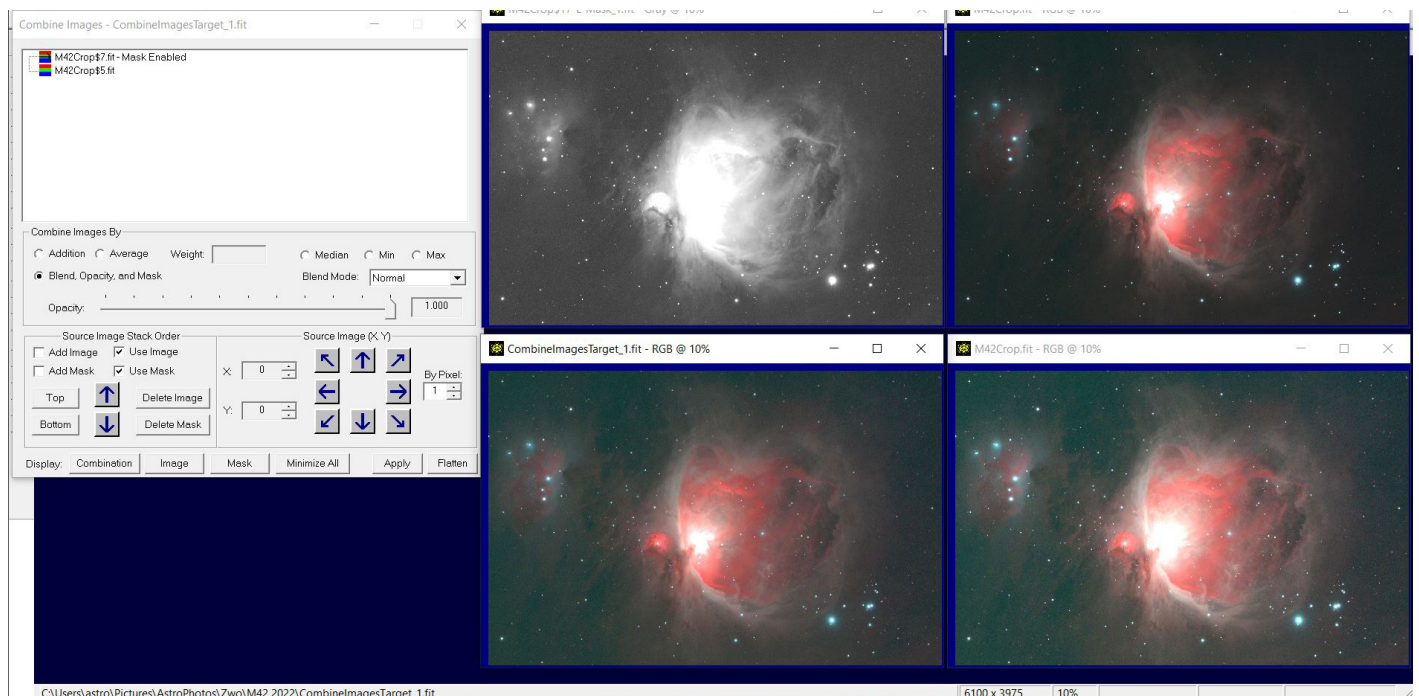


Figure 7 — The bottom image is in the lower right, the top image is in the upper right with the mask in the upper left. The resulting combination is shown in the lower right.

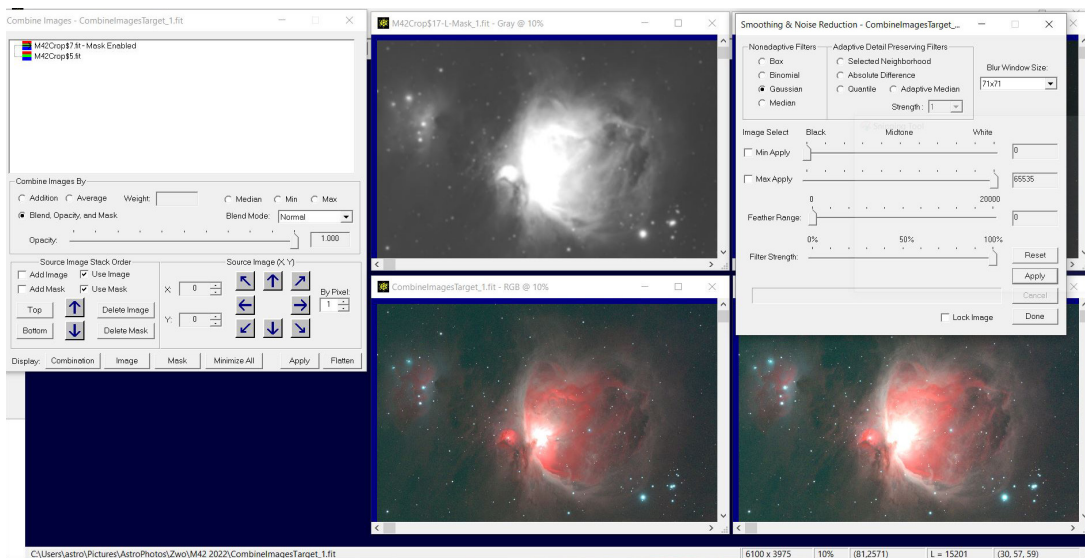


Figure 8 — Blurring the mask will restore much of the sharpness and contrast to the blended image

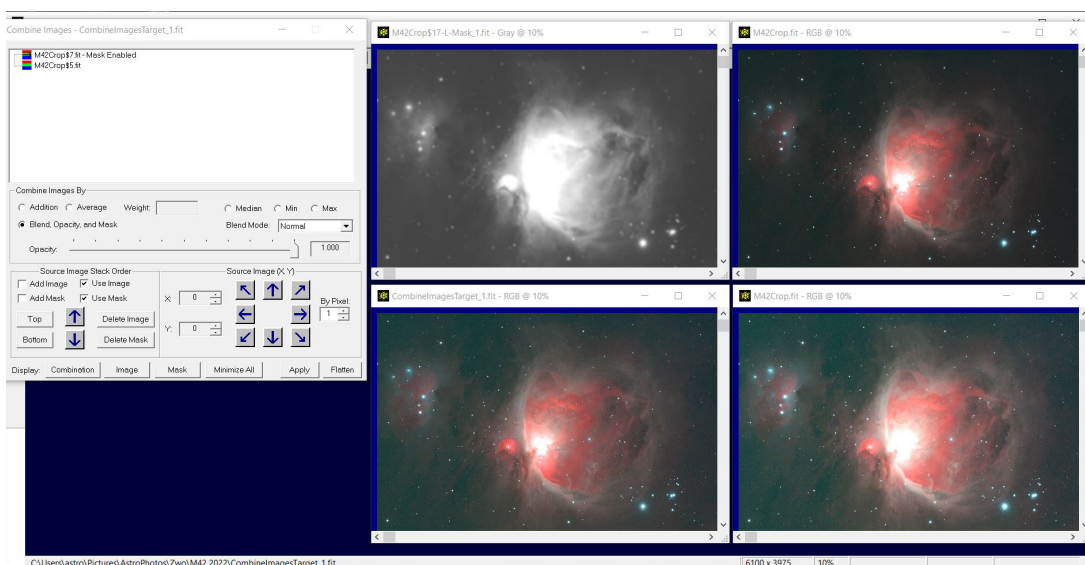


Figure 9 — Final image stack with blurred mask

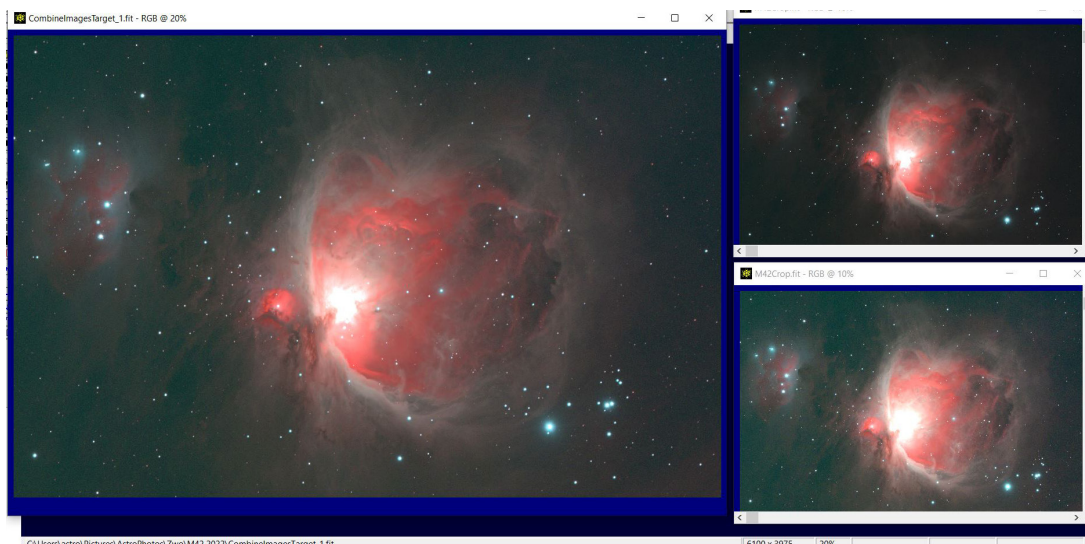


Figure 10 — Final flattened stack ready for setting the black point and the last colour tweaks

Figure 8 shows the blurred mask with most of the detail removed. Here I've used a Gaussian low-pass filter with a pixel radius of 71.

The layer stack shown in Figure 9 is merged producing the image shown in Figure 10. As you can see by comparing the flattened stack to the top and bottom images shown on the right in Figure 10, the combination maintains the best of both images. The faint gas and dust from the bottom image is clearly visible, while the core detail is restored from the top image.

All that remains is to set black point of the combined image and do any final colour tweaks.

After levels are used to set the black point (Figure 11), the image is slightly green so the *Image Plus* equivalent of HLVG is used to set the final colour.

If there is some area of an image that you want to add contrast or brighten compared to the rest of the image, the LMS process is ideal, as you can use a blurred painted mask as opposed to a mask made from the brighter layer. Blur the mask well and it will blend in the brightened areas without any of the blurring that the mask can cause if you only apply it to a simple contrast boost. Keep in mind that the blurring is critical to getting the image to blend well and some experimentation is required to get it just right.



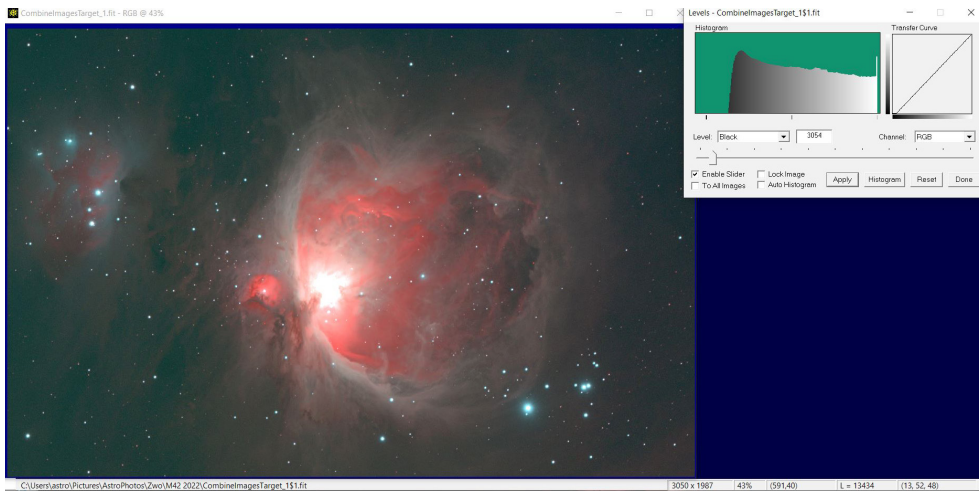


Figure 11 — Using levels to set the final black point of the combined image

Figure 12 — Final image after fixing the slight green cast



Remember, this column will be based on your questions so keep them coming. You can send them to me at [b.macdonald@ns.sympatico.ca](mailto:b.macdonald@ns.sympatico.ca). Please put "IC" as the first two letters in the topic so my email filters will sort the questions. ★

*Blair MacDonald is an electrical technologist running a research group at an Atlantic Canadian company specializing in digital signal processing and electrical design. He's been an RASC member for 20 years, and has been interested in astrophotography and image processing for about 15 years.*

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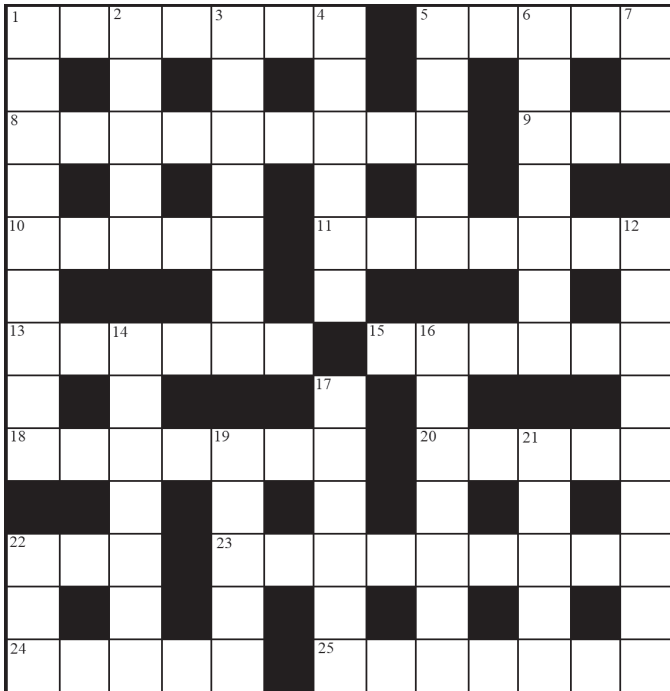
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# Astrocryptic

by Curt Nason



## ACROSS

1. I spy around 509 Romans back of the compass (7)
5. From the west, Orion's leg at infrared shows a bright star (5)
8. Worrisome asteroids are close to heartbreaking (4,5)
9. This Moon is unseen in three directions (3)
10. Interplanetary vehicle made of slate (5)
11. Two men and a place for two Centres in the west (7)
13. Meteor burst seen from far away (6)
15. Such CCDs worked better from a company with zero lighting (6)
18. Alien caught in sting operation by telescope circles (7)
20. Bend backwards around the east to spot a star (5)
22. Romer first turned round to the lion (3)
23. Aphrodesian sports a dark band between bows (9)
24. A rather namby-pamby first name for a double star aficionado (5)
25. MIT astronomer's editor said, "Leave it in, my boy." (7)

## DOWN

1. Hawaiian survey team rallied Spartans around the head of research (3-6)
2. Ten beams of high energy from a pulsar (1-4)
3. Where the Sun springs up (3,4)
4. Harris echoes an old name for Alpheratz (6)
5. Tycho's family was readjusted at this facility (5)
6. Al Green sang about the relativity of spacetime (7)
7. Cattle call like a one-quarter Moon (3)

12. Ran a blade around the bull's eye (9)
14. Flashes appear remote to the last second (7)
16. Stale fruit from the Julian calendar (3,4)
17. Transit ends in the regression of nodes (6)
19. Where Galileo confused the laity (5)
21. Two points about a poem that describe ecliptic crossings (5)
22. The Spanish sunrise (3)

## Answers to previous puzzle

**Across:** 1 JAMES VAN ALLEN (anag); 8 NEREIDS (N+anag); 9 MODEM (anag+m); 10 SOUTH (2 def); 11 FINDERS (2 def); 12 MAYALL (hom); 14 ACROSS (2 def); 17 NEBULAE (n(anag)e); 19 SPICA (hid); 21 GRAIN (2 def); 22 IMAGING (I'm aging); 23 MAGNETOSPHERE (Magneto+sphere);

**Down:** 1 JANUS (2 def); 2 MERCURY (mer(Cu)ry); 3 SAIPH (anag); 4 AL-SUFI (anag); 5 ALMANAC (2 def); 6 LADLE (anag); 7 NEMESIS (anag); 12 MONOGEM (2 def); 13 LALANDE (anag); 15 OLIVINE (hid); 16 MEXICO (2 def); 18 BRAGG (hom); 19 SCARP (anag+p); 20 ANGLE (anag-r)

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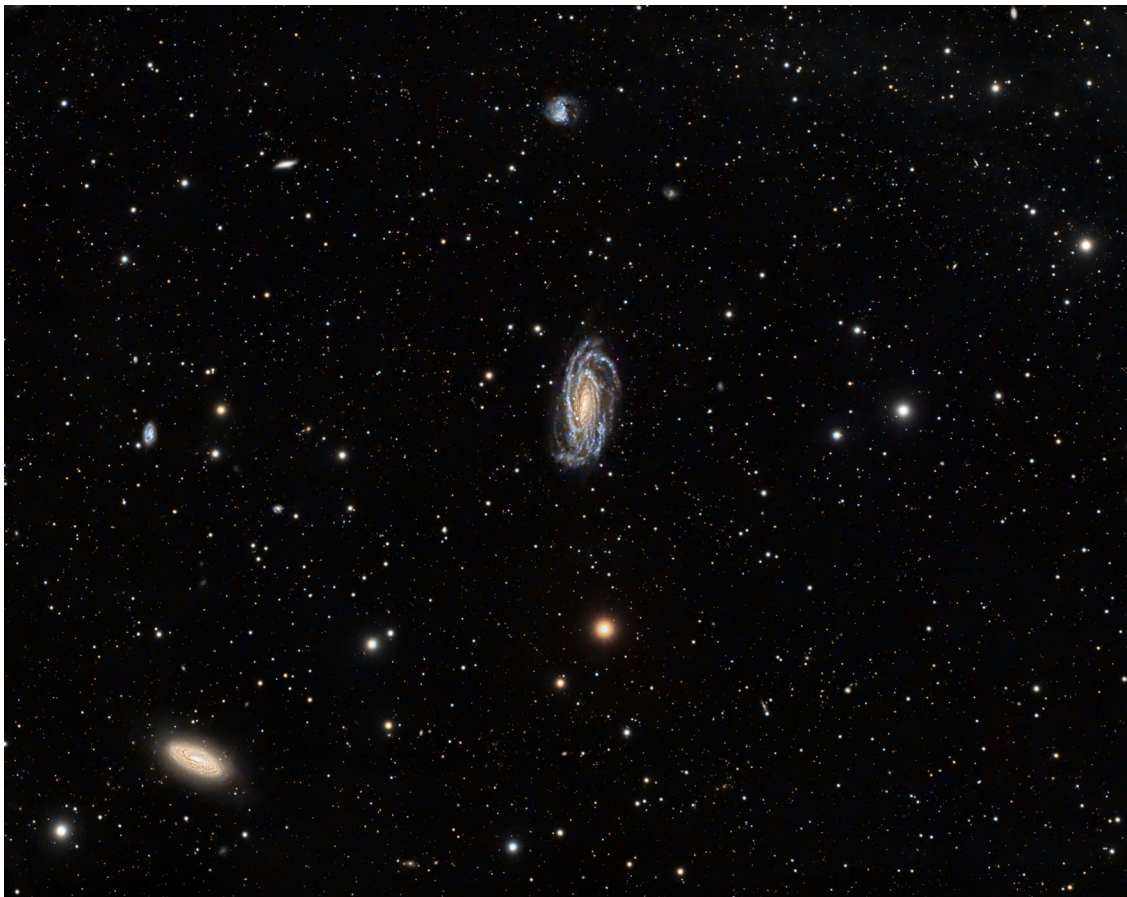
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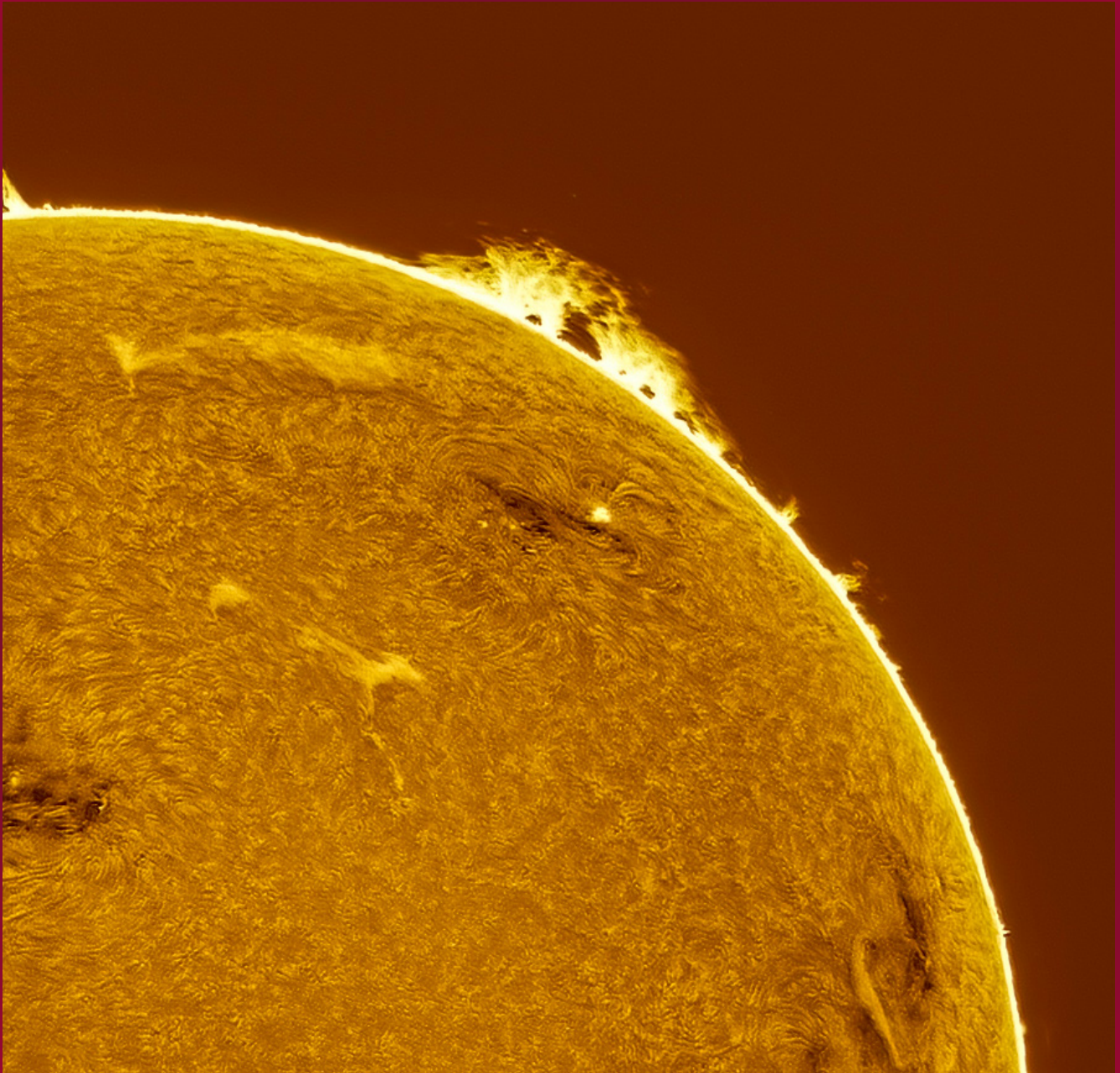


## Great Images

by Ron Brecher



Ron Brecher imaged NGC 5033, the large spiral galaxy at the centre of this image and NGC 5005, seen at lower left. "The two form a gravitationally bound pair around 40 million light-years away, but are not yet close enough to distort each other," Ron says. He used a Sky-Watcher Esprit 150 f/7 refractor and QHY600M camera with Optolong UV/IR filter, a Takahashi FSQ106 @ f/5 (530mm), QHY-367C Pro One-shot colour with Optolong UV/IR filter. Acquisition, focusing, and control of Paramount MX mount were done with N.I.N.A. and TheSkyX. Focus with Optec Direct-Sync motors and controller. Equipment control with PrimaLuce Labs Eagle 4 Pro computer. All pre-processing and processing in PixInsight. Acquired from his SkyShed in Guelph, Ontario. Total integration was 28hr05m.



# Journal

*Here comes the Sun. Andrea Girones imaged our modest star from her backyard in Ottawa with a Lunt 40-mm H $\alpha$  dedicated solar scope, tracked on a Star Adventurer tracker. She used an ASI174MM camera and a 2.5 $\times$  Powermate. Acquisition with Firecapture and processed with Autostakkert!, IMPPG and Photoshop.*