The Journal of The Royal Astronomical Society of Canada

Journal

Le Journal de la Société royale d'astronomie du Canada

PROMOTING ASTRONOMY IN CANADA

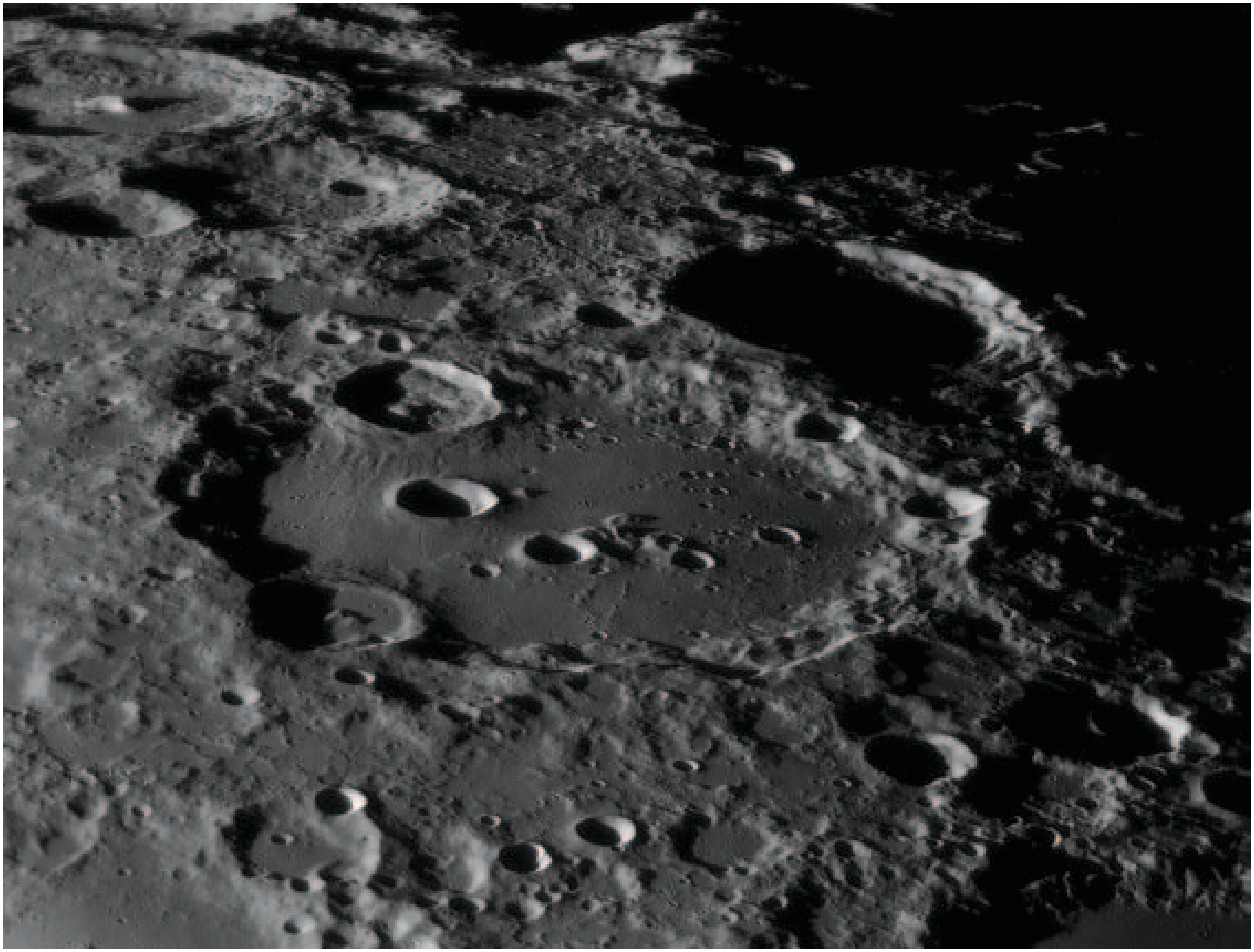
August/août 2012
Volume/volume 106
Number/numéro 4 [755]

Inside this issue:

A Giant Island Universe –
The Pinwheel Galaxy

Astrophotographers take note!

This space is reserved for your B&W or greyscale images; a new feature in the *Journal*. Give us your best shots!



"Clavius"

Mike Wirths continued his domination of seeing from his site in northern Mexico to capture a fabulous image of the crater Clavius. Mike uses an 18-inch Starmaster Dob with a Carl Zambuto primary mirror on an altitude/azimuth mounting with a drive system. His choice of imager is a Lumenera Infinity 2-2 monochrome camera through a red/infrared filter. In Mike's words, it was "another great night of seeing ... with nary a puff of wind." He estimated the seeing at 8-9/10.

Clavius, located in the lunar highlands, is the third-largest crater on the Earth-facing side of the Moon; its size allows it to be seen by eye when the Moon is at first quarter. A hint of its diminished central mountain system appears above and right of the middle crater in the sequence of five that arcs across Clavius' floor.

Journal

August/août 2012 | Vol. 106, No. 4 | Whole Number 755

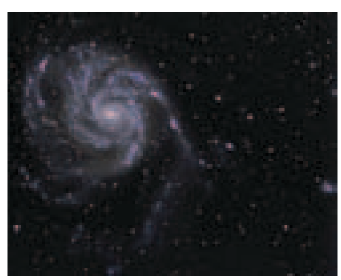
Royal Astronomical Society of Canada
Société Royale d'Astronomie du Canada

contents / table des matières

Feature Articles / Articles de fond

Columns / Rubriques

Departments / Départements



Front cover *— "The Pinwheel Galaxy"*
Stuart Heggie provides us with this interesting image of the Pinwheel Galaxy (Messier 101 to the cognoscenti*). M101 is a face-on spiral galaxy in Ursa Major, one of our closer neighbours at 6 megaparsecs distance. It is notable for the large number of HII regions (coloured reddish-purple here) and its size—about 70 percent larger than the Milky Way. Stuart caught the galaxy from Flesherton, Ontario, with an AP155EDF telescope and a T-10XME camera. Exposure was 14×5 min in L and 3×10 min in each of RGB.*

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.

The *Journal* of The Royal Astronomical Society of Canada is published at an annual subscription rate of $93.45 (including tax) by The Royal Astronomical Society of Canada. Membership, which includes the publications (for personal use), is open to anyone interested in astronomy. Applications for subscriptions to the *Journal* or membership in the RASC and information on how to acquire back issues of the *Journal* can be obtained from:

The Royal Astronomical Society of Canada
203 – 4920 Dundas St W
Toronto ON M9A 1B7, Canada

Internet: nationaloffice@rasc.ca
Web site: www.rasc.ca
Telephone: (416) 924-7973
Fax: (416) 924-2911

Canadian Publications Mail Registration No. 09818
Canada Post: Send address changes to 203 – 4920 Dundas St W, Toronto ON M9A 1B7

Canada Post Publication Agreement No. 40069313
We acknowledge the financial support of the Government of Canada through the Canada Periodical Fund (CPF) for our publishing activities.

International Meteor Conference

2012 September 20-23
La Palma Island, Canary, Spain

Every year, the International Meteor Organization (IMO) organizes the International Meteor Conference (IMC). This meeting deals with all aspects of meteor observation, including the underlying physics, and is attended by more than 100 amateurs and professionals. This year the IMO will hold its 31st IMC on La Palma, Canary Islands, Spain, in collaboration with the Astro Travels agency and the "Cabildo" island authority, which will sponsor this event.

Besides its two days of conference presentations, IMC 2012 will include an excursion to the Roque de los Muchachos Observatory (ORM) with a visit to three of its largest facilities, among which the Gran Telescopio de Canarias (GTC) is the largest optical telescope worldwide (10.4 m diameter). The registration fee for the conference is only 155 EUR and includes accommodation in the four-star apartment-hotel Las Olas on an Atlantic black-sand beach, full-board buffet, the excursion, participation at the Conference, proceedings, and other surprises.

The geographic location of the Canary Islands might be of particular interest for participants from the west side of the Atlantic who attend this, the first IMC to be held in Spain. The exceptional natural beauty of the "La Isla Bonita" provides a stunning backdrop to the conference and argues for a few extra days of holiday.

Several attractive tours are available before the start of the Conference; they are outlined on the IMO Web site: **www.imo.net/imc2012**

We are looking forward to seeing you in La Palma this September,

Ovidiu Vaduvescu (Astro Travels La Palma and former Toronto RASC member) and Paul Roggemans (IMO Belgium)

News Notes / En manchettes

Compiled by Andrew I. Oakes
(copernicus1543@gmail.com)

Exploration mission focussed on Jovian system

Jupiter and its moons are the targets of the European Space Agency's (ESA) "next large science mission," said the agency in a May 2012 announcement. A space probe to the Solar System's largest planet is planned for launch in 2022 from the European spaceport in Kourou, French Guiana, on an Ariane 5 rocket.

Called the *Jupiter Icy moons Explorer (JUICE)*, the probe will take about eight years to reach Jupiter, arriving in 2030 and spending three years studying the gas giant and several of its larger moons. The mission is aimed at providing scientists with a better insight into how gas giants and their orbiting worlds form and the potential for Jupiter's icy moons of hosting life.

Jupiter's Europa (icy), Ganymede, and Callisto (rock-ice) are three moons of interest, as they may have internal oceans potentially hosting living organisms. (The fourth Galilean moon, Io, is volcanic.)

JUICE is the first "large-class" mission to be chosen as part of ESA's *Cosmic Vision 2015-2025* program. The undertaking will address two key themes of *Cosmic Vision*: What are the conditions for planet formation and the emergence of life? How does the Solar System work?

While in the Jovian system, *JUICE* will continuously observe Jupiter's atmosphere and magnetosphere and the interaction of the Galilean moons with the gas-giant planet.

The space probe will visit Callisto (the most heavily cratered object in the Solar System) and will twice fly by Europa. It will make the first measurements of the thickness of Europa's icy crust and will identify candidate sites for future *in situ* exploration. In 2032, the spacecraft will enter orbit around Ganymede

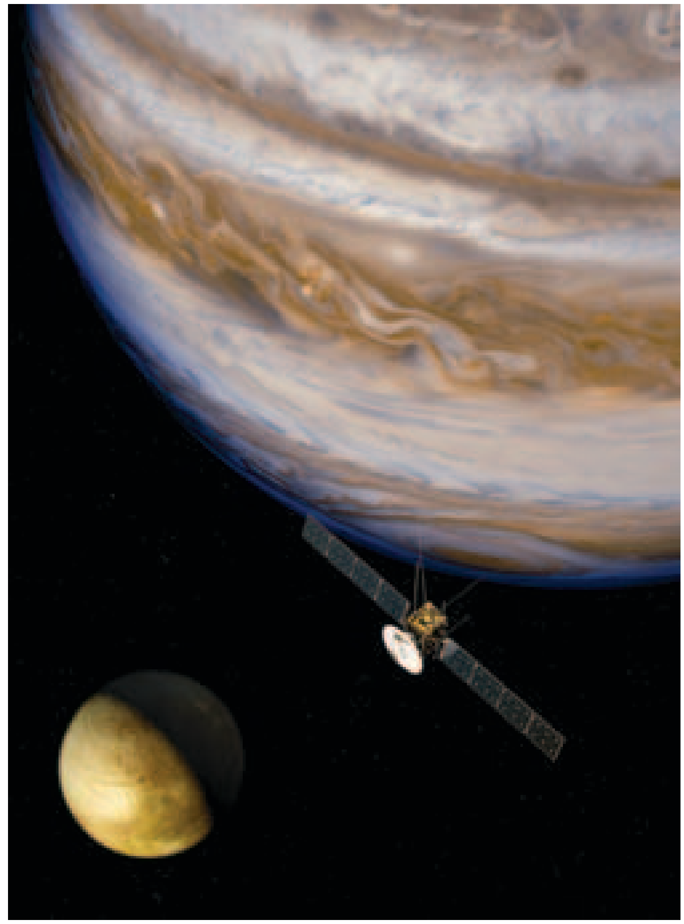


Figure 1 — The Jupiter Icy Moons Explorer. Image: ESA/AOES

to study the icy surface and internal structure of that moon, including its subsurface ocean. Ganymede is the only moon in the Solar System known to generate its own magnetic field, and *JUICE* will observe the unique magnetic and plasma interactions with Jupiter's magnetosphere in detail.

In addition to *JUICE*, there were two other candidate space missions in competition for ESA selection—the *New Gravitational-wave Observatory (NGO)* and the *Advanced Telescope for High-Energy Astrophysics (ATHENA)*. In addition to the two

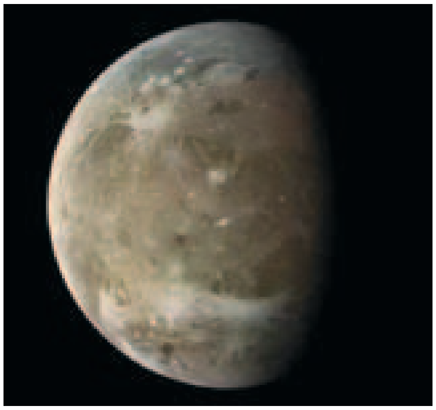


Figure 2 — Galileo's view of Jupiter's moon Ganymede, acquired 1997 February 27. Image: NASA/JPL

Cosmic Vision aims being addressed by *JUICE*, two others were postulated: What are the fundamental laws of the Universe, and how did the Universe begin and what is it made of?

A second call for missions is expected in 2013.

Filament ablaze with billions of new stars

A McGill University-led research team has discovered a giant, galaxy-packed filament ablaze with billions of new stars.

Using the *Herschel Space Observatory*, the team observed a filament connecting two clusters of galaxies that, along with a third cluster, will someday smash together and give rise to one of the largest galaxy superclusters in the Universe.

According to a McGill media release in May 2012, the filament is the first structure of its kind spied in a critical era of cosmic buildup when colossal collections of galaxies called superclusters began to take shape. The glowing galactic bridge offers astronomers a unique opportunity to explore how galaxies evolve and merge to form superclusters. "We are excited about this filament, because we think the intense star formation we see in its galaxies is related to the consolidation of the surrounding supercluster," said Kristen Coppin, a postdoctoral fellow in astrophysics at McGill and lead author of a paper that appeared recently in *Astrophysical Journal Letters*.

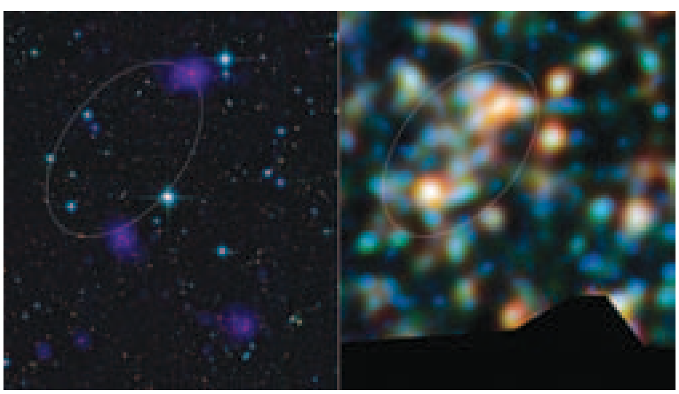


Figure 3 — The Herschel Space Observatory-discovered giant, galaxy-packed filament connects two clusters of galaxies that, along with a third cluster, will smash together in several billion years creating one of the largest galaxy superclusters in the Universe. The clusters are seen in visible and X-ray light (purple) on the left. Herschel's observations in infrared light appear on the right, with coloured regions indicating greater infrared emissions. A white oval outlines the 8-million-light-year-long intergalactic filament in each image—a filament that in visible light does not stand out because dust obscures the star-formation activity in distant galaxies. Image: ESA/NASA/JPL-Caltech/CXC/McGill University.

"This luminous bridge of star formation gives us a snapshot of how the evolution of cosmic structure on very large scales affects the evolution of the individual galaxies trapped within it," noted Jim Geach, a co-author of the paper.

The newly discovered intergalactic filament, containing hundreds of galaxies, spans eight million light-years and links two of the three clusters that make up a supercluster known as RCS2319. This emerging supercluster is an exceptionally rare, distant object whose light has taken more than seven billion years to reach us. Previous observations in visible and X-ray light had found the cluster cores and hinted at the presence of a filament. It was not until astronomers trained *Herschel* on the region, however, that the intense star-forming activity in the filament became clear.

Dust obscures much of the star-formation activity in the early Universe, but telescopes such as *Herschel* can detect the infrared glow of this dust as it is heated by nascent stars. The amount of infrared light suggests that the galaxies in the filament are producing the equivalent of about 1000 solar masses of new stars per year. For comparison's sake, our Milky Way galaxy produces about one solar mass worth of new stars per year. Researchers suggest the fast pace of star formation in the filament is due to the fact that galaxies within it are being crunched into a relatively small cosmic volume under the force of gravity.

By studying the filament, astronomers will be able to explore the fundamental issue of whether "nature" or "nurture" matters more in the life progression of a galaxy. The galaxies in the RCS2319 filament will eventually migrate toward the centre of the emerging supercluster. Over the next seven to eight billion years, astronomers think RCS2319 will come to look like gargantuan superclusters in the local Universe, such as the nearby Coma cluster.

First instrument for *James Webb Space Telescope (JWST)* ready

The Mid InfraRed Instrument (MIRI), the first instrument to be completed for the *James Webb Space Telescope (JWST)* is now with the European Space Agency (ESA), which will hand it over to NASA for the next stage of the new telescope's construction and testing. The *JWST* is an infrared space observatory with a collecting area more than two-and-a-half times larger than ESA's *Herschel Space Observatory*, which to date is the largest infrared scientific telescope so far flown to space (see News Notes item immediately above).

The European consortium that built the instrument delivered it to ESA in May 2012, marking an important completion milestone for the *JWST* project. The handover came at the end of a rigorous testing and calibration for the MIRI.

The MIRI, which comprises a camera and spectrometer, will operate at infrared wavelengths and at an extremely low temperature of -266 °C—just 7 °C above absolute zero. The low temperatures are required to keep the instrument's own infrared emission from overwhelming the faint signals from astronomical targets of interest in the distant Universe. MIRI will be capable of penetrating thick layers of dust obscuring regions of intense star birth. It will see galaxies near the beginning of the Universe, and it will study sites of new planet formation and the composition of the interstellar medium.

The transfer of MIRI to NASA will itself mark the start of the Integrated Science Instrument Module (ISIM) integration process, a major milestone for NASA on the way to completion of *JWST* and its eventual launch.

ESA is also leading the development of another of *JWST*'s four instruments: the Near-Infrared Spectrograph (NIRSpec), which will obtain spectra of more than 100 galaxies or stars simultaneously to study star formation and chemical abundances of young distant galaxies.

The other two science instruments will be the Near InfraRed Camera (NIRCam) and the Fine Guidance Sensor/Near InfraRed Imager and Slitless Spectrograph (FGS-NIRISS).

Designed to work primarily in the infrared range of the electromagnetic spectrum, the *JWST*'s instruments will have some capability in the visible range.

The *JWST*'s launch into space is planned for 2018.

Symposium held in advance of Transit of Venus

In preparation for the 2012 June 5 transit of Venus, the University of Toronto (with a group of supporters and organizers) sponsored a special day-long information-packed symposium for educators, professional and amateur astronomers, and academics of history and philosophy of science.

Held on 2012 April 28, the collaboratively planned event—it included the participation of the Toronto Centre of The Royal Astronomical Society of Canada—was presented under the title "*Transit of Venus: Past and Present—A Symposium and Related Exhibit*."

Professor Craig Fraser, Acting Director, Institute for the History and Philosophy of Science and Technology, University of Toronto, officially opened the symposium, which featured a variety of invited speakers:

- Professor Jay M. Pasachoff, Field Memorial Professor and Director of the Hopkins Observatory, Williams College, Williamstown, Mass., *"The Transit of Venus"* [keynote address];
- Randall Rosenfeld, Archivist, The Royal Astronomical Society of Canada, *"Perceiving New Worlds: The Transit of Venus across the Centuries,"* which included the performance of the speaker's originally composed piece of music played on a 17th-century replica flute, honouring the Transit of Venus;
- Professor Bernard Lightman, York University, *"Proctor, Airy, and the Transit of Venus 1874"*;
- Professor Victor Davies, composer, on his opera *"Transit of Venus,"* based on the play by Maureen Hunter;
- Professor Michael Reid and Mubdi Rahman, Department of Astronomy and Astrophysics, and the Dunlap Institute of Astronomy and Astrophysics, University of Toronto, *"Planetary Transits in High School Astronomy/Space Science"*;
- Professor Ralph Chou, University of Waterloo, and The Royal Astronomical Society of Canada's Toronto Centre, *"Observing the Transit Safely and Effectively"*;
- Professor James Graham, Inaugural Director, Dunlap Institute of Astronomy and Astrophysics, University of Toronto, *"Transits in the Modern Era"*; and
- Paul Greenham, Ari Gross, Erich Weidenhammer, Institute for the History and Philosophy of Science and Technology, University of Toronto, *"On the Astronomical Instruments in the University of Toronto Scientific Instrument Collection."*

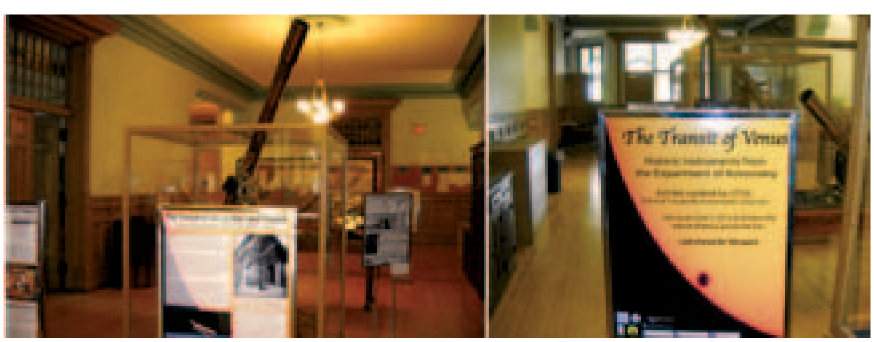


Figure 4 — Scenes from the Transit of Venus Symposium at the University of Toronto.

A feature of the symposium was a tour of the astronomical instrument exhibit at the Institute for the History and Philosophy of Science and Technology, located at Victoria College, University of Toronto. The exhibit was mounted to commemorate the 2012 Transit of Venus and reflected on the role played by the University in the 19th-century transit events. ✶

Andrew I. Oakes is a long-time unattached member of the RASC who lives in Courtice, Ontario.

Feature Articles
Articles de Fond

Castle Frederick Observatory

by Roy Bishop
Halifax Centre, The Royal Astronomical Society of Canada
Professor Emeritus, Department of Physics, Acadia University
Wolfville, Nova Scotia, Canada
(RLB@eastlink.ca)

Abstract

Castle Frederick Observatory, established by the hydrographer J.F.W. DesBarres, existed in Nova Scotia from 1765 until 1773. New information confirms its location, a second image of the observatory has been located, and the design and the nature of the observatory are addressed. Also an original portrait of DesBarres, possibly a self-portrait and apparently never before reproduced, is presented.

Introduction

Joseph Frederick Wallet DesBarres (1721-1824) is one of the most interesting individuals of the latter half of the 18th century. Educated in Switzerland, DesBarres's teachers included two members of the famous Bernoulli family. "His training was such that later, DesBarres would meet few equals on this side of the Atlantic." (Kernaghan 1985). He became a British subject and in 1753 enrolled in the Royal Military Academy at Woolwich, near London, England. In 1756, he arrived in North America as an engineering officer with the Royal American Regiment at the beginning of the Seven Years War. He took part in the battle at Louisbourg in 1758, at Quebec the following year, and at St. John's in 1762. His colleagues included two other remarkable men, James Cook and Samuel Holland (Beaglehole 1974).

With the conclusion of the war in 1763, at the request of the British Admiralty, DesBarres spent a decade (1764-1773) carrying out the most extensive and accurate survey of the coasts of mainland Nova Scotia and Sable Island done in that century. During those years, he also became a major landowner in central and northern Nova Scotia, accumulating some 70,000 acres. DesBarres then returned to England where, from 1774 to 1782, he published his surveys and those of Holland, William DeBrahm, George Gauld, James Cook, and Michael Lane. Under the sponsorship of the British government, during the dozen years between the Seven Years War and the American War of Independence, these men had surveyed much of the Atlantic coast of North America, from southern Labrador to the mouth of the Mississippi, "by far the largest surveying operation ever conducted by a European power overseas." (Hornsby 2011). The genesis of *The Atlantic Neptune* [as DesBarres entitled folios of the charts he published] occurred on Sunday, 1770 August 12 at the Simeon Perkins house in Liverpool, Nova Scotia, where Holland met DesBarres and proposed that they combine their surveys for publication (Hornsby 2011).

In 1784, King George III appointed DesBarres Lieutenant Governor of the then separate province Cape Breton. His first act was to found and name the city of Sydney. Later, in 1804 at the age of 82, he undertook an active 8-year term as Lieutenant-Governor of Prince Edward Island. He died in Halifax, Nova Scotia, at the age of 102, and is interred there in St. George's Anglican Church.

Only two biographies of DesBarres merit consideration (Webster 1927 and 1933, Evans 1969). For accounts of DesBarres as a mapmaker see MacPhee (1985) and Hornsby (2011). Concerning his talent as an artist and publisher: "Certainly the most astonishing single contribution to the pictorial description of early Canada was made by J.F.W. DesBarres… [His prints] are among the finest and most beautiful pictures of Canada ever made." (Spendlove 1958). "The charts [produced by DesBarres] became a standard guide for navigation in waters off the eastern coast of North America. The production, compilation, printing and engraving of *The Atlantic Neptune* must surely be regarded as one of the most remarkable products of human ingenuity, determination and industry to appear during the 18th century." (Thomson 1966). "The artistic excellence of the views alone gives [*The Atlantic Neptune*] high rank. This feature is solely due to DesBarres, who drew with great sensitiveness and had an exquisite sense of colour." (Stevens 1937). For a description of the printing of *The Atlantic Neptune* and the subsequent history of the copper plates used to produce it, see Terrell (1995). For aspects of DesBarres's *magnum opus* concerning Nova Scotia, see Owen (2000). For views of pages of *The Atlantic Neptune* held by the Royal Museums Greenwich, England, see http://collections.rmg.co.uk/collections.html#!csearch;searchTerm=The+Atlantic+Neptune

One account of Castle Frederick Observatory exists and has been reprinted (Bishop 1977, 1990). It includes a summary of DesBarres's life, in more detail than given in this introduction, and describes the web of circumstances surrounding his observatory.

The Location of Castle Frederick Observatory

At the beginning of the decade of his survey of the coasts of Nova Scotia, DesBarres established a home on the lands he had acquired in Falmouth, Nova Scotia, about 8 km southwest of Windsor. Located in a beautiful area at the base of the granite highlands of central Nova Scotia, he called his property *Castle Frederick*. It was here that he "caused an astronomical observatory and a dwelling house to be erected on this granted land with suitable drawing offices and accommodations for his assistants, who were young gentlemen of the Navy, several of them of birth and expectations, and with whom he uninterruptedly devoted the intermediate winter months in collating the observations collected on the coasts during the milder seasons and in composing fair charts thereof for the use of the Royal Navy and the benefit of national commerce." (DesBarres 1817, Figure 4 of Bishop 1977).

By 1770, his Castle Frederick property consisted of some 5000 acres, and a population of 93 was recorded on the estate, including tenants and employees of French Acadian, English, Scottish, Irish, German, and American origins (Duncanson 1990). Mary Cannon, a capable person in her own right, stayed with DesBarres at Castle Frederick and presented him with four daughters and a son during these years (Kernaghan 1981). When DesBarres returned to England in October 1773 to publish his charts, Mary Cannon remained at Castle Frederick, where she managed his various properties for several decade-

Figure 1 — Watercolour of Castle Frederick. Diameter 80 mm (Courtesy of the Library and Archives Canada)

Figure 1 shows a watercolour presumed to be by DesBarres and of his observatory and residence at Castle Frederick. The original was in the possession of DesBarres descendants in England, who donated it to the Library and Archives Canada in 1959 (Acc. No. 1959-4-1, C 8468). In 1977, I wrote: "Although there is disagreement among long-term residents of the immediate area as to which of two sites is the location of DesBarres's home, only one site is consistent with several details in the small painting which was found among his papers." Three pieces of evidence, one old and two new, confirm that conclusion.

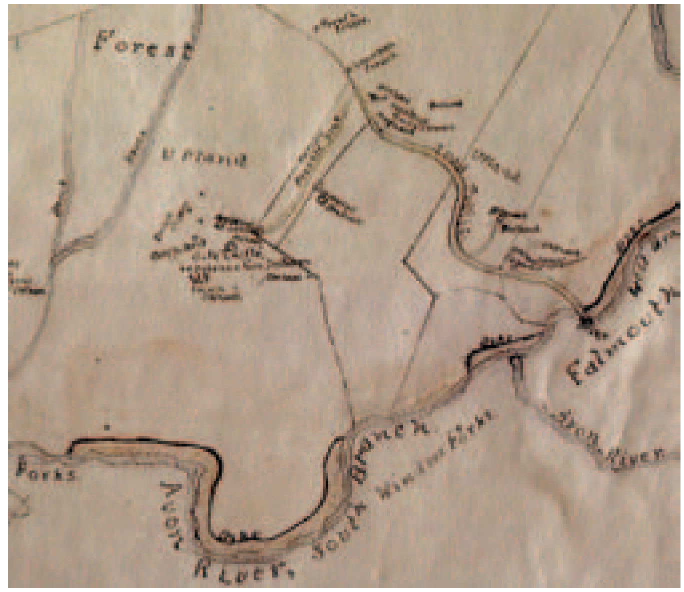


Figure 2 — Part of a 1911 map by E. Bessie Lockhart. "Site Castle, residence Gov. DesBarres" is left of centre. (Courtesy of the Nova Scotia Archives)

It was during conversations in 1977 with Eva Bessie Lockhart (1890-1985, B.A. Acadia University 1916) that I discovered the likely site of DesBarres's "dwelling house." Ms. Lockhart was born at Castle Frederick, in a house built for DesBarres's daughters, 100 metres from the site identified in my 1977 paper. She knew her paternal grandmother, Anne Cannon (1818-1898), who had looked after those daughters in their old age. Ms. Lockhart stated that it was common knowledge in her family where DesBarres's original dwelling house was located. Moreover, in 1911, when she was a student at the provincial teachers' college in Truro, Nova Scotia, as part of a course project, Ms. Lockhart drew a map entitled "Present Condition of Original Castle Frederick" (Figure 2). Her map places "Site Castle, residence Gov. DesBarres" at the location shown in Figure 3 (Lockhart 1911).

William Frederick DesBarres Bremner (1904-1985), a 6th-generation descendant of DesBarres and a life-long resident of the Castle Frederick area, had in his possession a

Figure 3 — Remnants of the cellar and foundation of DesBarres's Castle Frederick dwelling house in 1977. The author is seated on a foundation stone.

map of that area drawn by one William Anson and dated June 1830. That date was six years after DesBarres's death and after his daughters had inherited his Castle Frederick lands. Figure 4 shows the portion of the Anson map that includes the DesBarres property. Although DesBarres's residence is not labelled as such on the Anson map, the location of the four buildings shown on the DesBarres property and the curve of the road leading to them are consistent with Ms. Lockhart's site for DesBarres's residence. The other purported location of DesBarres's residence (the buildings nearest the upper-left corner of Figure 5 and labelled as "Residence W.F.D. Bremner" on Figure 2) is 450 m from Ms. Lockhart's site, and is blank on the 1830 map.

Figure 4 — Part of Anson's 1830 map. Four buildings on the DesBarres property appear upper left of centre. (Courtesy of the Bremner family, Castle Frederick, Nova Scotia)

During the years 1987-1990, archaeological excavations occurred at Castle Frederick. The excavations at Ms. Lockhart's site of DesBarres's dwelling house indicate that "the entire structure must have been approximately 27 metres long and 9 metres wide at its widest point. Artifacts include fragments of Batavian porcelain, Chinese export and European porcelains, English White Salt-Glazed stoneware, … gunflints, architectural remains, and a precision nut and bolt—perhaps from a

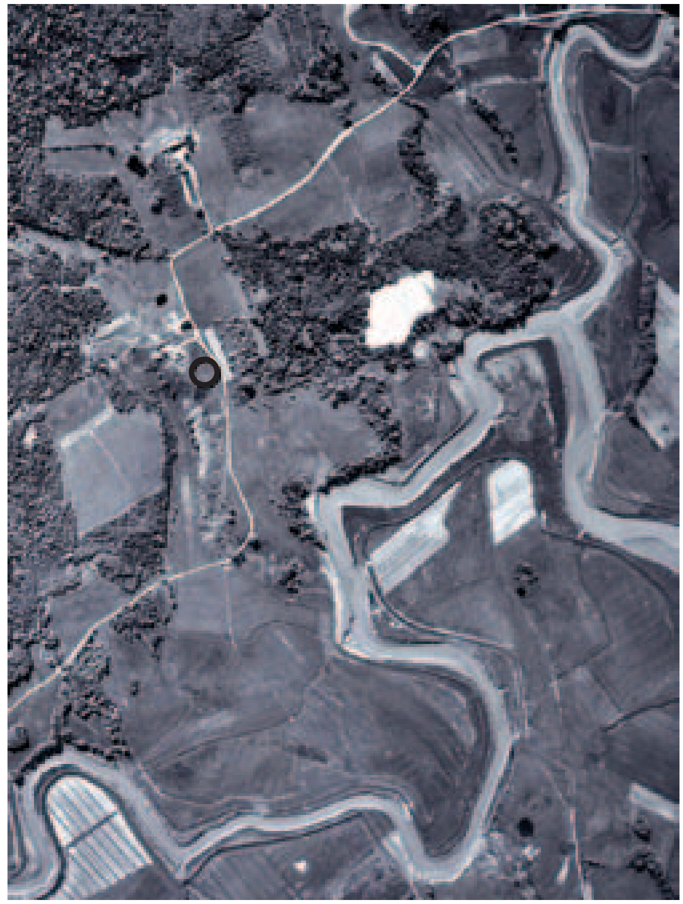


Figure 5 — An aerial photo of the Castle Frederick area. The foundation of DesBarres's dwelling house is within the small black circle, upper left of centre. (Courtesy of Maritime Resource Management Service, Amherst, Nova Scotia)

tripod for a survey instrument." "We have only identified one site [amongst several in Nova Scotia and New Brunswick] with which to compare the collection from DesBarres's castle: John Wentworth's mansion in New Hampshire, occupied from 1768 to 1775. The range of artifacts from Governor Wentworth's mansion appears to duplicate the finds from Castle Frederick, indicating that DesBarres was indeed an affluent member of society and had access to a great variety of objects with which he furnished his house and table." (Lavoie 1991).

In 2010, the Bremner family, the current owners of the Castle Frederick lands, entered into a Stewardship Agreement with the Archaeological Land Trust of Nova Scotia to ensure the protection of six archaeological sites on that property, including the site of DesBarres's dwelling house, see www.altns.ca/castlefrederick.htm or http://museum.gov.ns.ca/arch/PDF/ArchNSNewsletter2010.pdf

Ms. Lockhart's statement (verbal in 1977 and her map of 1911), the Anson map of 1830, and the archaeological results published in 1991 confirm the site of DesBarres's dwelling house (Figure 3), at latitude N 44.9369°, longitude W 64.2148° (GPS measurement). As indicated in Figure 1, the observatory was nearby.

Images of Castle Frederick Observatory

What evidence indicates that Figure 1 depicts Castle Frederick? DesBarres's handwritten words match the scene displayed in the image—he "caused an astronomical observatory and a dwelling house to be erected on [his] granted land" at Castle Frederick. Why else would the small building with the curious roof have been given the same prominence as the large building on the right?

Figure 6 is a pencil sketch of the same scene held by another DesBarres descendant, apparently by the same artist, and presumably showing the site at a later date when a third building was present and more fences were on the property. The third building may have been the one "with suitable drawing offices and accommodations for his assistants."

Figure 6 — Pencil sketch of Castle Frederick (Courtesy of Sarah Micklem, Essex, England)

What evidence indicates that DesBarres was the artist? The style and format of the watercolour are similar to some of DesBarres's coastal scenes in his Atlantic Neptune (Figure 7). Another is the similarity of the flags in Figures 1 and 8. Furthermore, until recently, both the watercolour and the pencil sketch (Figures 1 and 6) were in the possession of DesBarres's descendants.

Figure 7 — Two coastal views by DesBarres, from The Atlantic Neptune *(Courtesy of the Killam Memorial Library, Dalhousie University)*

Figure 8 — A ship entering Louisbourg Harbour, part of a coastal view by DesBarres, from The Atlantic Neptune *(Courtesy of the Killam Memorial Library, Dalhousie University)*

The Design of the Observatory

Prior to the mid-18th century, observatories typically consisted of towers on buildings, with access to the sky provided by windows and open observing decks. One of the first observatories having a moveable dome was King George III's Kew Observatory, erected for the 1769 transit of Venus. (Donnelly 1973).

In 1768, the great British civil engineer John Smeaton (1724-1792) designed a portable wood-and-canvas observatory. For the 1769 transit of Venus, William Wales and Joseph Dymond took two such observatories to the shore of Hudson Bay, and James Cook took one to Tahiti (Wales 1770, Broughton 2003, Beaglehole 1974). From a comment by Wales in his journal, it appears that the roofs of his observatories may have rotated on a circular track. DesBarres had spent the years 1753-1756 at the Royal Military Academy near London being trained as an engineer and surveyor. One wonders if he encountered Smeaton.

Figure 9 is an enlargement from Figure 1. In the original watercolour, the observatory measures only 7 mm from its base to the top of its roof. Thus the detail displayed in the painting is on a scale of 0.2 mm, requiring of the artist a fine brush, good eyesight, a steady hand, and a determination to record that curious building for posterity. The tree trunk in front of the left side of the observatory was superimposed after the entire building was painted, for the left side of the building, a mirror image of its right side, is faintly visible. The style of the building, with its curved roof and a central door bordered by walls apparently constructed of horizontal boards or logs, indicates that the floor plan may have been octagonal. Dark patterns on the roof hint at a cover for an

Figure 9 — Castle Frederick Observatory, an enlargement from a black and white copy of Figure 1 (Courtesy of the Library and Archives Canada)

opening to view the sky. The pencil sketch (Figure 6) displays less detail, although the door has a curved top, a feature not apparent in Figures 1 and 9. How large was the observatory? Comparing the observatory to the dwelling house (Figure 1), and noting Lavoie's figure of 27 metres for the latter, indicates that the observatory may have been fairly spacious inside.

A Proper Astronomical Observatory?

An astronomical observatory can be defined simply as a place built for astronomical observations. Sometimes the definition is further elaborated by distinguishing "surveying stations"—temporary structures used in conjunction with terrestrial mapping—from more permanent "astronomical observatories" that have celestial measurements as their raison d'être. Milham (1937, 1938) takes that position: "The surveying stations or temporary astronomical observatories in connection with the early boundary surveys and in connection with the survey of the coast… are not considered to have been astronomical observatories in any proper sense."

Yet labelling is not always easy. Carlyle Beals (1899-1979), Canada's Dominion Astronomer (1947-1964) and the fourth Director of the Dominion Observatory, said of that institution:

> *This observatory, for some years the largest and most important in Canada (1905-1918) was founded for the express purpose of standardizing and co-ordinating topographical and geodetic surveys, and while one of its telescopes was devoted to what might be termed astronomical research such activities were not the primary purpose of the institution. It would appear therefore that there is a certain parallel between this observatory and the more modest one built by DesBarres, so that if one of them is a 'proper' observatory, so is the other. While the Dominion Observatory has now ceased to exist as such, during its palmy days the various directors and staff members would have been quite upset if anyone had questioned the 'propriety' of their institution.* (Beals 1978).

In England "in 1675, the Royal Observatory at Greenwich was founded specifically to make the lunar-distance method [of navigation at sea] practicable."(Howse 1996).

The Greenwich List of Observatories lists only five observatories in the Western Hemisphere prior to 1800: two in Jamaica (1732, 1743) and three in present-day Nova Scotia, Canada (Howse 1986). Of the latter three, one is DesBarres's observatory (1765). Another was at Louisbourg (1750), associated with the Marquis de Chabert (Donovan 1977, Brooks 1979, Donovan 1980). The third was also at Louisbourg (1765), associated with Samuel Holland (Brooks 1990). Like DesBarres, at that point in their careers, Chabert and Holland were surveyors. Chabert was employed by France, Holland and DesBarres by England.

Although not mentioned in *The Greenwich List of Observatories*, in 1639 an observatory was erected in Mauritia (near Recife), Brazil, for the astronomer and biologist George Marcgrave (Gudger 1912). According to Gudger: "This was in all probability the first astronomical observatory ever erected in the southern hemisphere and in the new world." Also, Charles Mason and Jeremiah Dixon erected temporary observatories during the survey (1763-1767) of their eponymous line between Maryland and Pennsylvania. The renowned American clockmaker, surveyor, professor of astronomy, and first director of the United States Mint, David Rittenhouse, is associated with two observatories; the first erected for the 1769 transit of Venus, and the second at his home in Philadelphia c. 1782-1796. Also, an observatory existed at the College of William & Mary in Virginia c. 1785 (Milham 1937, 1938, and King 1955).

Aspects of Castle Frederick Observatory distinguish it from those of Chabert, Holland, and Mason and Dixon. Unlike a surveying station, it was not located in the survey area, and DesBarres did not tie his surveys to the position of his observatory. Also, surveying stations served their purpose within weeks or months. Castle Frederick Observatory lasted eight years, its use only then terminated by increasing troubles with the American colonies that resulted in DesBarres being recalled to England to prepare charts of those coasts. Of special note, Castle Frederick Observatory appears to be the earliest observatory in the Western Hemisphere for which images survive (Figures 1 and 6). That happenstance is not surprising given DesBarres's artistic talent as displayed in his monumental *Atlantic Neptune* and the appreciation of some of his descendants for their extraordinary ancestor. In his history of Canadian astronomy, Richard Jarrell considers Castle Frederick to be the oldest astronomical observatory in Canada that stands with full documentation (Jarrell 1988).

"A large number of questions relating to eighteenth-century chart-making remain unanswered." (Evans 1966). In

DesBarres's case, questions do indeed come to mind. Why did DesBarres locate the observatory so far from the areas of his survey? Why did he equip it with "astronomical instruments" of such nature that the British Admiralty complained that "many of these instruments purchased were not absolutely necessary to enable Mr. DesBarres to perform the services on which he was employed"?

We do not know how, or even if, DesBarres determined the longitude of various points in his survey area. For land-based surveys, the usual method of longitude determination in that century was by observations of eclipses of Io, the inner Galilean satellite of Jupiter (*e.g.* see Holland 1768). Another method, known as "lunars" and adaptable to ships at sea, made use of the changing angle between the Moon and the Sun or another star. In 1769, DesBarres ordered a copy of the *Nautical Almanac*, first published only two years earlier. Included with it were tables of predictions for the Moon's position that originated with the German astronomer Tobias Mayer (DesBarres 1769, Howse 1996). He also ordered a copy of the French publication *Connoissance des Temps* that gave predictions for eclipses of Io (Van Helden 1996), but it was unavailable. Another item ordered that year was the *British Mariners Guide*, authored by the Astronomer Royal, Nevil Maskelyne, which gave instruction in the then new lunar method of determining longitude, but it was out of print (DesBarres 1769).

Thus DesBarres certainly was aware of the latest techniques for longitude determination, but apparently was having difficulty obtaining all that he needed to actually carry out such measurements. Also, there is no record of DesBarres taking a portable observatory and a pendulum clock (necessary for longitude determinations) on his survey, or even that he had a suitable clock. Lack of such evidence and Samuel Holland's offer of 1770 August 12 to give DesBarres his clock-based astronomical observations are consistent with the Admiralty's complaint about his "not absolutely necessary" astronomical instruments, suggesting that DesBarres had not established points of longitude (Hornsby 2011). (Chronometers, which greatly facilitated the determination of longitude, became available only after DesBarres and Holland had finished their surveys.)

Did DesBarres have an interest in astronomy above and beyond his formal training as a surveyor? On this point the historical record is silent. Indeed, there is a glaring absence of information on all aspects of DesBarres's private life. The late W.F. Clyde DesBarres told me that when he was young, a trunk-full of old documents belonging to his family was intentionally destroyed. That might account, at least partially, for gaps in the story of DesBarres. Evans (1969) remarked: "Time and again in telling the story of his life I have cried out for some flesh to put on the bones of his public actions, but usually long searches have turned up nothing more concrete than a wisp of additional information."

As an example of "a wisp of additional information," DesBarres spent two years, 1766 and 1767, charting the coasts and treacherous shoals of "the Graveyard of the Atlantic," Nova Scotia's Sable Island. Early in the afternoon of 1766 August 5, the central track of an annular solar eclipse swept directly across Sable Island, an event that would have left an impression on DesBarres if he was near there that day. Later that year, he ordered from London a book, *Cassini's Elements of Astronomy*, and "a Large Reflecting Telescope wth Some Equatorical [*sic*] Parts" (DesBarres 1767).

There is more evidence that astronomy may have held a special interest for DesBarres. In the second year of his hydrographic survey, the Royal Society of London published a letter from the famous London telescope maker, Peter Dollond. In it, Dollond described a refracting telescope he had built having a novel, triple-lens objective of 3¾ inches aperture and 42 inches focal length, a large aperture for a refractor of that era (Dollond 1765). James Short F.R.S., an outstanding telescope maker of that century, examined Dollond's telescope and said in his introduction to Dollond's letter: "I have tried it with a magnifying power of 150 times, and I found the image distinct, bright, and free from colours." That is the sort of performance one expects of a modern apochromatic refractor. "[Dollond's triple achromats] took powers of 350, or 90 to the inch of aperture, without 'breaking down'." (King 1955). Several Dollond telescopes of this type were used for the most widely-observed astronomical event of that century, the 1769 June 3 transit of Venus (Warner 1998). Also, England's Astronomer Royal had "a treble object glass telescope of Dollond, of 3½ feet" installed at the Royal Greenwich Observatory (Maskelyne 1774).

What has that bit of telescope history to do with Castle Frederick Observatory? Among the voluminous DesBarres papers is an invoice listing "a 3½ ft. Achromatic Telescope with Triple Object Glass, with Rack, Stand, and finder" that was shipped from London to DesBarres in Halifax (DesBarres 1769). Here was DesBarres in the sixth year of his coastal survey ordering another astronomical telescope, a state-of-the-art refractor. Included in the order were "dark Glasses," common accessories in that era for observing the Sun (Warner 1998). The invoice is dated 1769 April 4, barely two months before the 1769 transit of Venus.

Yet there is no record that DesBarres observed the transit. An item in the historical record indicates why he may have failed. Near Philadelphia where David Rittenhouse and others observed the transit, the sky had been overcast with frequent heavy rain for several days, but it finally cleared less than two days before the transit (Smith 1769). The usual northeasterly track of weather systems in these latitudes makes it likely that on the day of the transit DesBarres was under the weather system that had plagued Rittenhouse. Also, in 1882 and again in both 2004 and 2012, clouds prevented observations of the three subsequent transits of Venus that would otherwise have been visible from Nova Scotia. Limited statistics, but it appears that Nova Scotia is not a good location from which to observe transits of Venus!

Figure 10 — Joseph F.W. DesBarres, c. 1785, pencil and watercolour (10 cm x 12 cm), possibly a self-portrait (Courtesy of the late Dorette DesBarres Bate, Ottawa)

Portraits of DesBarres

Anyone fascinated by the story of DesBarres would like to see a picture of the man. Unfortunately photography did not exist in DesBarres's time. During the past 35 years, I have located four different portraits. I designate these A, B, C, and D, with version #1 being the original or a reproduction of the original, and #2 being an approximate copy of #1 by a different artist:

A1 — See Figure 10. In 1978 the original was in the possession of Dorette DesBarres Bate (1902-1989) of Ottawa, a lineal descendant of DesBarres. Regarding this portrait, Ms. Bate said: "I have an idea, from something my father* said perhaps and because with a magnifying glass I compared it with the water colour on the chart [from *The Atlantic Neptune*, in Ms. Bate's possession], that J.F.W. did a nice little oval portrait of himself." (Bate 1978). The small size of the portrait, its format, its pencil and watercolour style, and its delicate colouring indicate that Ms. Bate was likely correct.

*Dr. Frederick William Wallet DesBarres (1867-1964), a legendary figure in theology and history at Mt. Allison University, Sackville, New Brunswick.

A2 — The frontispiece in Evans's 1969 biography of DesBarres, and held by the Library and Archives Canada. A2 also appears in Webster 1933 (p. 61).

B1 — Opposite p. 55 in Evans, and appears to be the same person depicted in A1. I came across the original of B1, in England, as part of a 1979 display commemorating *The Atlantic Neptune* at the National Maritime Museum in Greenwich. It was on loan from Sarah (Mrs. David) Micklem of England, a lineal descendant of DesBarres.

C1 — Figure 1 in Bishop 1977, from a copy at the Nova Scotia Archives. In 1978, I discovered the original (a pastel) in the home of Dorette DesBarres Bate (see A1). In 1989, Ms. Bate donated it to the Library and Archives Canada. C1 appears in Hornsby 2011 (p. 210), although Hornsby misspells Ms. Bate's first name.

C2 — A copy by J. Gambardella. Appears in Webster 1933 (p. 18), on the dust cover of Evans 1969, and in Duncanson 1990 (p. 23).

D1 — On the reverse of the image B1 in Evans. I am not convinced that D1 depicts the same person as A1, B1, and C1.

Despite the dearth of documentation concerning his private life, from clues and pieces of circumstantial evidence in the historical record, Lois Kernaghan (1985) has assembled a fascinating literary portrait of DesBarres. I close with a few lines from her assessment:

> *Superbly educated, he had many talents and used them well. He was an opportunist and an optimist, eager to turn situations to his own advantage. His cultivated air and personal magnetism drew many admirers, as did his keen intellect, lively conversation and ability to live life with gusto. The true genius, however, is usually eccentric, and DesBarres was no exception. He was brilliant but impetuous. We may like to think of DesBarres as pompous, quibbling, sometimes distasteful, and even perhaps insecure, but the fact remains that he is a larger-than-life folk figure in our history, and that the enigma of his private career will continue to fascinate us. Like William Dyott, Charles Baker and countless others [contemporaries of DesBarres] who have been spellbound by his personality, we would all feel honoured to be his guests at dinner.*

Acknowledgements

Dr. C. Bruce Fergusson (1911-1978), Provincial Archivist of Nova Scotia (1956-1977), played a seminal role in this work. Documentation provided by the Library and Archives Canada and the Nova Scotia Archives was invaluable. Special thanks to the Bremner family of Castle Frederick for preserving artifacts from the DesBarres era, to Dr. Randall Brooks for several articles concerning DesBarres, to Peter Broughton for helpful advice, to Sarah Micklem for Figure 6, to Randall Rosenfeld, Archivist of The Royal Astronomical Society of Canada, for bringing Hornsby's magnificent book to my attention, to the late Dorette DesBarres Bate for permission to photograph the original portrait reproduced in Figure 10, to the late Arthur

Covington for his keen interest in Castle Frederick Observatory, and to John Duncanson, Allister Jakeman, Larry Loomer, Raymond Magarvey, and Dr. W.J. Noble (all deceased) for the inspiration of their great interest in antiquarian matters. ✶

References

Bate, D.D. (1978). Letter to the author, dated 1978 January 31.

Beaglehole, J.C. (1974). *The Life of Captain James Cook*. London: Adam & Charles Black.

Beals, C.S. (1978). Letter to the author, dated 1978 January 13.

Bishop, R.L. (1977). An Eighteenth-Century Nova Scotia Observatory. *JRASC, 71*, 425-442, December.

Bishop, R.L. (1990). J.F.W. DesBarres: an Eighteenth-Century Nova Scotia Observatory, *Profiles of Science and Society in the Maritimes Prior to 1914*, ed. P.A. Bogaard, 64-81. Fredericton, New Brunswick: Acadiensis Press.

Brooks, R.C. (1979). M. de Chabert and the 1750 Louisbourg Observatory. *JRASC, 73*, 333-348, December.

Brooks, R.C. (1990). Time, Longitude Determination and Public Reliance upon Early Observatories, *Profiles of Science and Society in the Maritimes Prior to 1914*, ed. P.A. Bogaard, 163-192. Fredericton, New Brunswick: Acadiensis Press.

Broughton, P. (2003). *Historic Transits of Venus from a Canadian Perspective*. Available at www.rasc.ca/committees/history

DesBarres, J.F.W. (1767). DesBarres Papers, M.G. 23, F1, Series V, vol. 6, p. 1252, Library and Archives Canada.

DesBarres, J.F.W. (1769). DesBarres Papers, M.G. 23, F1, Series V, vol. 6, p. 1254, 1255, Library and Archives Canada.

DesBarres, J.F.W. (1781). DesBarres Papers, M.G. 23, F1, Series V, vol. 2, p. 282, Library and Archives Canada.

DesBarres, J.F.W. (1817). DesBarres Papers, M.G. 23, F1, Series V, vol. 23, p. 5486, Library and Archives Canada.

Dollond, P. (1765). An Account of an Improvement made by Mr. Peter Dollond in his New Telescopes, *Phil. Trans. Roy. Soc. London, 55*, 54-56.

Donnelly, M.C. (1973). *A Short History of Observatories*. University of Oregon Books.

Donovan, K. (1977). The Louisbourg Observatory: Most Likely Canada's First. Unpublished manuscript, Fortress of Louisbourg National Historic Park.

Donovan, K. (1980). Canada's first astronomical observatory, 1750. *Canadian Geographic, 100*, No. 6, 36-43, December 1980.

Duncanson, J.V. (1990). *Falmouth—A New England Township in Nova Scotia*. Belleville, Ontario: Mika Publishing.

Evans, G.N.D. (1966). Hydrography: A Note on Eighteenth-Century Methods, *Mariners Mirror, 52*, 247-250.

Evans, G.N.D. (1969). *Uncommon Obdurate: the Several Public Careers of J.F.W. DesBarres*. Toronto: University of Toronto Press.

Gudger, E.W. (1912). George Marcgrave, The First Student of American Natural History, *The Popular Astronomy Monthly, 81*, 250-274, September 1912.

Holland, S. (1768). Observations made on the Islands of Saint John and Cape Briton [*sic*], to ascertain the Longitude and Latitude of those Places . . . , *Phil. Trans. Roy. Soc. London, 58*, 46-53.

Hornsby, S.J. (2011). *Surveyors of Empire: Samuel Holland, J.F.W. DesBarres and the Making of The Atlantic Neptune*. Montreal & Kingston, London, Ithaca: McGill-Queen's University Press.

Howse, D. (1986). The Greenwich List of Observatories: A World List of Astronomical Observatories, Instruments and Clocks, 1670-1850, *Journal for the History of Astronomy, 17*, part 4, No. 51.

Howse, D. (1996). *The Lunar-Distance Method of Measuring Longitude*. In The Quest for Longitude, W.J.H. Andrewes editor, 150-162. Cambridge, Mass., Harvard University.

Jarrell, R. (1988). *The Cold Light of Dawn: A History of Canadian Astronomy*. Toronto: University of Toronto Press.

Kernaghan, L.K. (1981). A Man and his Mistress: J.F.W. DesBarres and Mary Cannon, *Acadiensis, 11*, No. 1, 23-42, Autumn 1981.

Kernaghan, L.K. (1985). 'A most eccentric genius': The Private Life of J.F.W. DesBarres, *Nova Scotia Historical Review, 5*, #2, 41-59.

King, H.C. (1955). *The History of the Telescope*. Cambridge, Mass., USA: Sky Publishing Corporation.

Lavoie, M.C. (1991). *Archaeological Evidence of Planter Material Culture in New Brunswick and Nova Scotia*. In *Making Adjustments*, Margaret Conrad editor, 218-233, Fredericton, New Brunswick: Acadiensis Press.

Lockhart, E.B. (1911). *History of Castle Frederick*, Nova Scotia Archives, Communities MG4, No. 30.

MacPhee, S.B. (1985). DesBarres and His Contemporaries as Mapmakers, *Nova Scotia Historical Review, 5*, #2, 15-27.

Maskelyne, N. (1774). Observations of Eclipses of Jupiter's first Satellite made at the Royal Observatory . . . , *Phil. Trans. Roy. Soc. London, 64*, 184-189.

Milham, W.I. (1937). Early American Observatories, Part II, *Popular Astronomy, 45*, 523-540, December.

Milham, W.I. (1938). Early American Observatories: Which Was The First Astronomical Observatory in America? Williamstown, Mass.: Williams College.

Owen, J.V. (2000). Margins for Errors, Manuscript Notations in *The Atlantic Neptune, Mercator's World*, July/August 2000, 42-45.

Smith, W. (1769), Account of the Transit of Venus over the Sun's Disk, as observed at Norriton, in the County of Philadelphia, and Province of Pennsylvania, June 3, 1769, *Phil. Trans. Roy. Soc. London, 59*, Part II, 289-326.

Spendlove, F.St.G. (1958). *The Face of Early Canada*. Toronto: Ryerson Press.

Stevens, H. (1937). *Notes Biographical and Bibliographical on The Atlantic Neptune*. London: Son and Stiles.

Terrell, C. (1995). A sequel to The Atlantic Neptune of J.F.W. DesBarres: the story of the copperplates, *The Map Collector*, #72, Autumn 1995, 2-9.

Thomson, D.W. (1966). *Men and Meridians: The History of Surveying and Mapping in Canada*, Vol. 1. Ottawa: Queen's Printer.

Van Helden, A. (1996). *Longitude and the Satellites of Jupiter. In The Quest for Longitude*, W.J.H. Andrewes editor, 86-100. Cambridge, Mass., Harvard University.

Wales, W. (1770). Journal of a Voyage, made by Order of the Royal Society, to Churchill River, on the North-west Coast of Hudson's Bay . . . , *Phil. Trans. Roy. Soc. London, 60*, 100-136.

Warner, D.J. (1998). Telescopes for Land and Sea, *Rittenhouse, 12*, No. 2, issue 46, 33-54.

Webster, J.C. (1927). *Proc. Trans. Roy. Soc. Can.*, 3rd Ser., 21, Sec. II, 21-40.

Webster, J.C. (1933). *The Life of J.F.W. DesBarres*. Privately printed.

So, What's Up with the Casinos?

by Rick Huziak, Saskatoon Centre
(rickhuziak@shaw.ca)

There are six Saskatchewan Indian Gaming Authority (SIGA)-run casinos in Saskatchewan that have up-shining tepees of light as their visual calling card:

- Bear Claw (White Bear First Nation, near Carlyle)
- Dakota Dunes (Whitecap Dakota First Nation, south of Saskatoon)
- Gold Eagle (North Battleford)
- Living Sky (Swift Current)
- Northern Lights (Prince Albert)
- Painted Hand (Yorkton)

It has been a while since casino lighting has been in the news, but that doesn't mean that we have forgotten about it. The casino light tepees continue to shine into the nighttime sky. In the case of the rural casinos Bear Claw and Dakota Dunes, light tepees still shine over acreages, parks, and other natural areas. More than once at Pike Lake Provincial Park, kids at public star nights I've given have run to the river to see the Northern Lights, only to be disappointed when they realize that the tepee lights of the Dakota Dunes have just been turned on! For the urban casinos, the light tepee is the major light-pollution marker over each of their respective cities, easily seen for dozens of kilometres. At the Gold Eagle Casino, a rapidly flashing LED sign and the light tepee create glare and distraction that could be dangerous to motorists when they approach the casino on the Yellowhead Highway from the south.

When SIGA announced that their six casino designs would include light tepees that "*could be seen for one hundred miles all around*," the Saskatchewan Light-Pollution Abatement Committee (SLPAC), a committee of the Saskatoon and Regina Centres of the RASC, voiced opposition, citing light-pollution concerns for local residents. Since the first casino, Dakota Dunes, was situated in a rural setting, it was decided that a new environmental non-governmental organization (ENGO), eventually called the Rural Environment Preservation Association of Saskatchewan (REPAS), would be formed to fight the Dakota Dunes Casino lighting directly. It was thought better that a local citizen's group, directly affected, should lead the challenge against the lighting. REPAS members consisted mostly of residents of the community of Pike Lake, the Hamlet of Beaver Creek, and of the Rural Municipality of Corman Park, with members of SLPAC consulting. As one of their first actions, REPAS bought the "dakotadunescasino.ca" domain name, and made it a light-pollution Webpage.

After exhaustive and non-productive lobbying and petitioning of SIGA, provincial government MLAs, federal government MPs, and the Saskatchewan Law Reform Commission, REPAS challenged the *Saskatchewan Environment Management and Protection Act* (EMPA, 2002), citing that "a pollutant was being intentionally discharged into the atmosphere that caused a nuisance." The challenge contended that the lights had introduced a disruption to faunal populations and the reduction of enjoyment of the properties of surrounding residents. To challenge the *Act*, the offense already had to have been committed, so we had to wait until the Dakota Dunes light tepee was turned on. Our submission also pointed out that there was a potential hazard to migrating birds, moths, bats, and other fauna. According to EMPA, the government had 90 days to respond to our challenge.

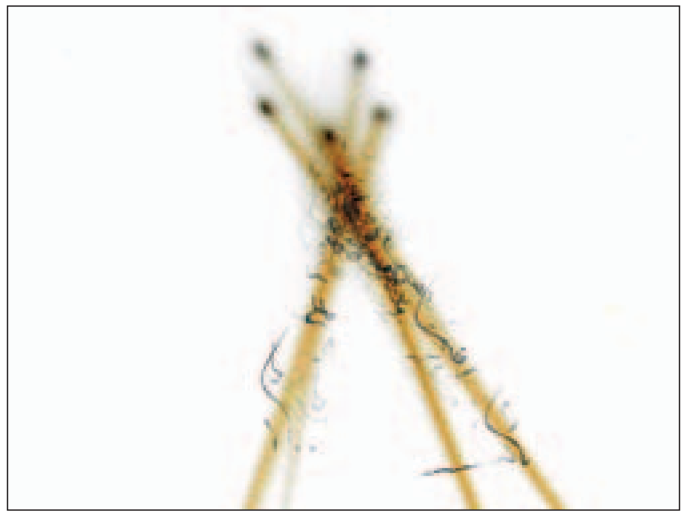


Figure 1 — More than 160 dying warblers can be seen, caught in these lights of the old Painted Hand Casino. Photo has been reversed and contrast enhanced to show bird flight trails. Photo by Ken Armbruster and used with permission.

True to our prediction, during the time that the province's environmental lawyers were evaluating our challenge, a flock of migrating yellow warblers flew into the tepee beams of the Painted Hand Casino in Yorkton (at the casino's former location) and, according to newspaper reports and eyewitness accounts, thousands of birds flapped around in the intense 2-billion-candlepower beams until they died of exhaustion or from mid-air collisions. Despite this, the Ministry of Environment ruled that we did not have a case, citing from the *Oxford English Dictionary,* that light was not a particle and thus did not fit the EMPA definition of *particulate* pollutants. They failed to comment on how or why the birds had died.

Our legal counsel was livid, stating: "Laws should not be static and are meant to adapt to new circumstances as situations present themselves." With no government recognition of the negative effects of light tepees, the Painted Hand Casino was allowed to be built only 100-metres from Yorkton's Ravine

Ecological Preserve; no one seemed to recognize that this could be an issue (except for the preserve curators!). The SLPAC and REPAS considered a re-challenge under the *Migratory Birds Convention Act and Regulations*, but just ran out of steam, since we had other projects that needed attention and lacked sufficient funds for a full-up court challenge.

We may not have eliminated the light tepees, but some progress has been made through our lobbying. After Dakota Dunes Casino was built and the controversy over the lights and bird deaths erupted in the media, some lessons appear to have been learned. The remaining five casino parking lots were redesigned with full cut-off (FCO) lights that do not pollute the sky. (Dakota Dunes still uses the original side-facing halogen lights.) The light tepees seem to have been turned down in intensity to what appears to be approximately 25 percent or less of their maximum intensity. And, in response to a promise made to Saskatchewan Environment, tepee lights, at least at the Painted Hand Casino, are mostly off for the weeks surrounding the fall bird migration. (We are uncertain if other casinos participate in the fall migration lights-off period, nor do we know if the spring migration is also honoured.)

It may be a bit ironic that my last talk regarding light-pollution abatement for the 2011 Saskatchewan Waste Reduction Council Fall Forum was given in the meeting hall at the Living Sky Casino in Swift Current. I don't think any of the staff or management saw the irony. ✶

Resources

Light Pollution Web page: www.dakotadunescasino.ca

Saskatchewan Law Reform Commission Report: www.lawreformcommission.sk.ca/LightPollutionAbatementBP.pdf

Bird deaths in the news: www.cbc.ca/news/canada/saskatchewan/story/2008/09/11/casinos-birds.html

This article has been revised from one originally published in the *Dark Sky Monthly* series, *Saskatoon Skies*, February 2012

Rick Huziak is no stranger to many Journal *readers, having authored a column on variable-star observing for many issues. He has been active throughout Saskatchewan, lobbying against light pollution for several years.*

Eyeballs, Dunnies, and the Universe; A Visit to SNOLAB

by Katrina Ince-Lum, Toronto Centre
(roocnu@wepaddle.com)

I can see clearly now, the rain is gone,
I can see all obstacles in my way
Gone are the dark clouds that had me blind
It's gonna be a bright (bright), bright (bright)
Sun-Shiny day.

– Johnny Nash

We arrived at the security gate in a mini-bus under the cover of pre-dawn darkness. I was surrounded by bleary-eyed but excited amateur astronomers from the RASC Toronto Centre and the Orillia Astronomy Club, psyched for our coming adventure as we waited for the boom to rise. A few months earlier, Gordon Michener of the Orillia Astronomy Club advised Blake Nancarrow of the Toronto RASC that he had arranged a visit to SNOLAB, and there were still a few spaces available if anyone was interested.

I had not slept at all the night before in anticipation to our visit, as the Sudbury Neutrino Observatory (SNO), an underground facility located in the depths of the Vale Creighton Mine specializing in astroparticle physics, is not a place where one can just turn up at the gate for a tour. This was a wonderful and unique opportunity to see experimental physics in action.

I was interested in documenting the physical effects that day. My curiosity started with questions such as why are contact lenses not allowed, and what would bathroom facilities be like? How would it feel going that far underground? We were given explicit instructions about what we could bring, what we were going to wear, and where we were going, and I had imagined that my eyeballs were going to deform under the pressure of a deep mine. All I knew was that that morning, going to SNOLAB, I'd be wearing my glasses and not my contact lenses. The real reason, as I later found out, was far more ordinary.

After being ushered into the main administration building, we signed in, changed into bulky mining garb complete with hardhats, headlamps, heavy boots, and safety glasses and were ready to be briefed by Samantha Kuula, Communications Officer with SNOLAB and our guide. We had a set time to get to the cage, our mode of transportation for the two kilometre descent into the mine that gave access to the laboratory. This is not your standard elevator, whereby one can push a button at any time and expect the car to arrive. This single-cable conveyance—the cage—is the only form of transportation in and out of the mine: for miners, scientists, all the science equipment, the mined rocks, and everything that was ever assembled in the Lab, and of course, for us.

While waiting for the cage, I could hear a series of metallic hollow taps by the operator; a kind of code that indicates to the hoisting engineer where the cage is needed. Miners passed us on the way to work, all dressed similarly to the members of our group. SNOLAB enjoys a good working relationship with Vale in the Creighton mine.

Descending two kilometres under the ground was not completely uneventful: rattling; jammed inside a rectangular box; hurtling downward about four CN Tower lengths in five minutes; jammed shoulder to shoulder with approximately 40 other people. One person didn't make it down; someone else lost her hearing—we had to go back up to the surface. The second attempt down into the mine was uneventful, but because it was a slightly unpleasant experience, I decided to count the number of times my ears popped to pass the time. One person lifted his arm to hold his nose to clear his ears, inadvertently elbowing a neighbour in the face.

Figure 1 — Squeaky clean and ready for SNOLAB

Security and safety was drummed into us from the time we arrived: not to stop at any time crossing the street above ground; to give way to mining cars or machinery underground; to know where any one person was at any time through a wall-tag system; to keep safety glasses and headlamps on when in the mine. Once underground, we were oriented to two different refuge rooms. The first one was painted silver in honour of Stephen Hawking's visit a few years ago. We were told that this was the kind of room in which the Chilean miners would have been trapped (during their 2010 ordeal), but that we were located three times deeper, in much more stable rock, thankfully.

The walk from the cage, through the mine to our destination, clutching our double-bagged lunch, was about the same distance horizontally as we had just traveled vertically, except that now there was no high-speed conveyance to carry us along. The mine corridors were dark and smelled slightly of sulphur; the ground was uneven, with puddles along the way. It was also surprisingly windy—and it was now clear to me why contact lenses are not permitted. A mine was not a place to be blinded by a speck of dirt; I had to wipe grit from my eyes on a number of occasions. We walked on either side or in the middle of the car tracks, headlamps pointed to the ground to avoid tripping.

We arrived at the boot-washing station where the transition to an environment cleaner than a CLASS2000 clean room began. In short order, we went from a dirty and dusty mine to a spotless venue with very low levels of dust and equally low levels of background radiation.

After leaving the boot-washing station, we entered a bright, plastered corridor, where we were required to remove boots, hardhats, and belts, and the outer bag of our lunch. (What was my tuna sandwich going to be like after hours of non-refrigeration and walking through a hot mine? Squishy but fine, as it turns out.) We hung our mining garb—to be put on again later—and were segregated by gender, going onward to separate change rooms, where we removed our remaining clothing. After an obligatory wash-up (which included washing our hair) in a pass-through shower, making sure not to slip backwards to the "dirty" side, we emerged squeaky clean, where we were provided with disposable clothing. That done, we proceeded, at last, into SNOLAB.

One advantage to working in a clean-room environment in a mine two kilometres underground is that one does not have to think about what to wear. Another benefit, as Samantha pointed out, was the egalitarian work environment. Everyone in this underground hierarchy, from the cleaner to the most eminent scientist, was dressed in similar garb. It wasn't all rosy though: we weren't able to run down the street to the local Tim Hortons for a coffee on a whim or retrieve something we'd forgotten on the surface—and we had to shower each time we left and then returned to the clean environment.

I wondered if we'd encounter absolute darkness or very low lighting while two kilometres underground, so I arranged to bring a small tripod for my camera. In the end, however, there was plenty of light throughout our visit, from the focussed beams of the headlamps on our hardhats that pierced the darkness in our two-kilometre walk through the hot, dark, dusty, and sometimes wet mine to the bright airy spaces of SNOLAB.

Because of the increased pressure on our bodies at the mine's depth, we were advised that we'd sleep well that night, and I can say that was true for me.

The world's deepest flush toilet and septic treatment plant is located at SNOLAB. The bathroom was thankfully ordinary

Figure 2 — A view of the Halo Supernova Experiment with Dr. Clarence Virtue explaining its operation to the tour.

and I could not resist the urge to use it! The septic system is monitored and maintained by on-staff chemists, with special bacteria in the tanks to break down solid matter, using dog food to feed bacteria when they're not getting enough to eat. It is self-contained, and totally odour free.

And what of SNOLAB? What is here? A bright, airy, and of course, clean space, filled with small and large plastered rooms excavated out of 90,000 tonnes of rock. The astrophysicists who work here come from 18 different universities from all over the world, trying to figure the very thing that's always interested me: what is the Universe, and what is it made of? We only know the constituency of 5 percent of the Universe, and so scientists are working feverishly to find out what the rest is composed of. Most of it remains a mystery. "WIMPS (Weakly Interacting Massive Particles, which are currently hypothetical, but if we find them, may explain dark matter) are here, and we're slamming into them as our Solar System rotates in our galaxy," postulated Mikhail Batygov, another of our guides.

The experiments that we saw included:

SNO+; the 1 million litres of heavy water from the original SNO experiment had been removed and returned to Atomic Energy Canada after ten successful years of detecting neutrinos. Apparently they were effective in collecting every single drop of heavy water, taking six months to gradually remove it under tight security, employing special rail cars and the cage, and using an eyedropper to collect the last drop of heavy water—in the end, collecting more than they originally had! SNO+ will refine the original neutrino study, making precision measurements of the solar-neutrino spectrum.

To conduct the new neutrino experiments, SNO+ will use a spherical container of a new liquid scintillator of linear alkyl benzene within a chamber flooded with ultrapure water, which causes the sphere to float and shield the detector. Both heavy water and ultrapure water must be handled carefully. Heavy water is approximately 10 percent denser, but otherwise is physically and chemically very similar to normal water. It is not radioactive, but contact with heavy water can cause sterility; ultrapure water will draw iron from blood.

We saw only the top part of the spherical detector through a hole in the floor; scientists were winched in and out of this hole wearing a harness.

PICASSO (Project in Canada to Search for Supersymmetric Objects): an experiment to detect dark-matter candidates such as WIMPs. PICASSO uses millions of tiny droplets of a superheated liquid in which any slight perturbation will cause an explosive transformation of the liquid into a gas. Events are detected by the sound they create.

HALO (Helium and Lead Observatory): a lead-encased supernova detection experiment that uses Helium-3 to detect neutrinos from supernovae explosions. HALO is part of a world wide monitoring network. According to Dr. Clarence Virtue "The only way we can look into a supernova is to see the neutrinos that come out...99.9 percent of the energy from supernovae is emitted as neutrinos."

DEAP (Dark Matter Experiment using Argon And Pulse-shape discrimination): a prototype dark-matter detector that uses liquid argon to detect the elastic scattering of dark-matter particles. Ionizing radiation passing through the argon will cause it to first become excited, and then relax by emitting scintillation light at 128 nm.

Keep an eye on this exciting laboratory for more science yet to come. The mine has been expanded, and is now far more than a place to characterize the basic properties of solar neutrinos. SNOLAB now looks at neutrino properties, supernovae, dark matter, seismology, and possibly extremophiles, one of the keys to assessing the possibility of life beyond planet Earth. There are already occasions to sing about new discoveries and more are on the way. It was a truly amazing place to visit, although I cannot help but wonder how disruptive having visitors must be for them. I'm extremely thankful for the opportunity to have explored this unique realm.

And for the record, my ears popped 17 times on the way down and 11 times on the way up. ✶

Katrina is a member of the Toronto Centre, a past winner of the Bert Winnearls award, and is a former councillor. She was responsible for initiating the Toronto Centre's Solar Observing session and spends way too much time on Twitter promoting local astronomy events. She can be reached at roocnu@wepaddle.com or roocnu@Astro_yyz

Was This 1681 Medal a Lucky Charm or a Star Map?

by Robert S. McIvor
(robertmcivor@ymail.com)

1. Introduction

Comets have been recorded on coins for a very long time. Not every comet was recorded on coins, of course, only a few truly spectacular appearances that either aroused alarm or happened to coincide with significant political events. The most famous comet in the distant past was probably the one recorded shortly after Julius Caesar was assassinated on March 15 in 44 BC. His successor, Augustus, used the comet for propaganda purposes and struck a silver coin, called a denarius, that displays the comet and its prominent tail with words inscribed in Latin "DIVVS IVLIVS" or "divine Julius" (Figure 1). The coin played to the public imagination that the comet transported the soul of Caesar into the heavens. Augustus and many others observed the comet for seven consecutive evenings and a description in his own words was preserved by Pliny the Elder in *Natural History*.

Figure 1 — Roman denarius depicting the comet of 44 BC and inscribed to the divine Julius.

In the late Middle Ages, several comets were depicted on medals; Carl Sagan showed a number of examples in his book on the subject in 1985. A Dutch medal of 1577 depicts the comet of that year, "flying above the clouds" according to Sagan, and the reverse describes it in Latin as "the star of offended divinity." This was the comet Tycho Brahe studied so intently to demonstrate that it was not only above the clouds but well beyond the orbit of the Moon. A Dutch medal of 1686 displays a comet over the city of Hamburg and the reverse reads in Latin "not all that terrifies, harms." A German medal of 1744 depicts the comet of that year and its reverse quotes the *New Testament* text at Romans 11:34 in German: "Who hath known the mind of the Lord?"

Each medal was struck the year the comet appeared and in some cases while the comet was still visible. This strongly suggests that the designs on the medals were prepared by someone who had actually observed the individual comets, an inference that is credible even though the identities of the artists are unknown. The inscriptions attest to the anxiety the comet aroused, but whether they refer to a divine emperor, an offended divinity, or a sacred text, they have nothing whatever to do with the *science* of comets.

2. The Silver Medal of 1681

The focus of this article is a silver medal that was struck

Figure 2 — The German silver medal of 1681.

in early 1681. Its images are still well-defined after three centuries (Figure 2), supplied courtesy of its present owner, astronomer Donald Yeomans. The medal weighs 6.73 grams and measures 27.5 millimeters in diameter. It is roughly the size of a Canadian or American quarter. The obverse depicts a tailed comet in the sky, and the inscription at the bottom refers to December 1680 and January 1681 when the comet was visible. The reverse is inscribed with words that rhyme in German and random letters are capitalized.

This tiny medal is all we have to work with. It would have been nice (as well as thoughtful) if the artist behind the artwork had left written notes so subsequent generations—like us—would fully understand what he had in mind. But the fact is we do not know who the artist was or what was in his mind, except what the medal reveals through his artwork. All we know is that this medal was struck in early 1681, and it depicts a tailed comet. Was this medal intended to be a lucky charm or a star map? We are left to our own devices how to investigate. *That* is the challenge!

3. Similar Specimens

Two specimens of this medal were listed for sale in German catalogues in 2007. *Griechische Munzen Katalog 52* offered a bronze specimen and identified it as No. 2265 in the Brettauer listing of German medals. *Sammlung Deutsche Kupfermunzen Katalog 45* listed a silver specimen similar in quality and design to the one displayed here. This second catalogue quotes comments by two numismatic experts, who confirmed that the medal originated in Germany, in either Hamburg or Silesia, and it was struck to commemorate a comet appearance that was a "sensational event observed in all of Germany."

4. An Astronomer Describes the Medal in 1890

Edward S. Holden (1846-1914), professor of mathematics at the U.S. Naval Academy and director of the Lick Observatory, was a founder of the Astronomical Society of the Pacific, its first President, and the first Editor of its journal. "I have in my possession," he wrote in 1890, "a silver medal of the great comet of 1680. The medal was struck in the Low Countries, at some (unknown) monastery, probably while the comet was still visible, and it was distributed as a kind of amulet or charm against its evil effects." His article displays both sides of the medal.

He went on to inform his readers that:

> *The great comet was discovered November 30, 1680, by Kirch, and was observed until March 18, 1681. It will be noticed that the obverse bears two dates: Anno 1680, 16 December, and 1681, January. If I should hazard a guess at these dates, I should assume December 16 was the date the comet was first seen at the monastery, and that the medal was struck in January 1681. At this time, the comet was in the constellations Aquila, Sagitta, and Cygnus. I find that I cannot accurately identify all the stars as laid down.*

Holden translated the German inscription on the reverse as "This star threatens evil things: but trust! God will turn these to good." He also explained why some letters were capitalized by pointing out that each capital letter has a value. One M = 1000; one D = 500; one C = 100; one L = 50; six V's (at 5 each) = 30; and I = 1, for a total of 1681, which is, of course, the year the medal was produced.

Holden offered his own assessment of the medal:

The mental image which we may form of the monkish artist, with his rhyming motto, his logogriph of 1681, ***his erroneous designs of the star groups made indoors while the constellations were shining outside***, (my emphasis) *may serve to recall to us something of the spirit of a time only two centuries ago. It must be remembered, too, that it was for this very comet of 1680 that Sir Isaac Newton computed an orbit by his own methods, which showed that it revolved about the sun in a conic section, peacefully obedient to the law of gravitation. The medal, then, seems to mark a distinct division between two epochs in the history of astronomy (and in the history of human belief), and, therefore, to have a value quite apart from and above its numismatic rarity.*

5. A Second Astronomer Displays the Medal in 1991

Donald Yeomans works for NASA, and he published a book on comets in 1991 that contains a wealth of historical detail. This comet of 1680 was a real attention-getter and it was painted by artists in England, Holland, and Germany. Yeomans reproduces the artwork of Friedrich Madeweiss "showing the path of the comet through the constellations." He also displays both sides of this silver medal of 1681 and explains that "on the obverse is an illustration of the comet on a stellar background."

He describes the historical context of the comet of 1680:

> *This first telescopic discovery of a comet was made by the German astronomer Gottfried Kirch on the morning of November 14. It remained a morning object until the first few days of December, when it entered solar conjunction. On December 18 it was seen at noon in the Philippines, less than 2 degrees from the Sun. John Flamsteed, at Greenwich, first detected its tail in the evening sky on December 20, with the head being observable two days later as it exited the solar glare. Extensive observations were made by many European observers. In the British colony of Maryland in North America, Arthur Storer noted its tail was 15 to 20 degrees in length on November 29. The Chinese reported the comet first on November 23 in Crater. It had a white tail more than 1 degree long pointing toward the west. On December 21, the Chinese observed it coming out of solar conjunction with a darkish-white color and a tail over 60 degrees long pointing to the northeast. The last observations were made by Isaac Newton on March 19, 1681.*

A view of the comet recreated using the planetarium program *Starry Night* is shown for 1680 December 29 in Figure 3.

6. Astronomy or Theology?

Professor Holden did not disclose how he learned that the medal had been produced at a monastery. Perhaps he suspected such a connection because of the religious nature of the inscription. I am not at all convinced it was produced at a monastery. In any event, I have little interest in the inscription. I cannot tell if it came from a Catholic, a Lutheran, an Anabaptist, or even none of the above. I cannot decide if the author was God-fearing or comet-fearing or comet-fearing and God-trusting, so I am content to leave the interpretation of the inscription to someone trained in the nuances of medieval theology.

It strikes me as odd that Holden devoted only two sentences—a mere 26 words—to the comet side of the medal but two whole paragraphs to the inscription side. He could identify some of the stars on the medal but he does not disclose which ones. His reference to Aquila, Sagitta, and Cygnus provides a clue. I suspect that he allowed himself to be distracted by the inscription. He could have and should have devoted more time and text to the star patterns on the comet side of the medal. I am sure I am not alone in wanting to know whether the star patterns can be identified and I also want to know if

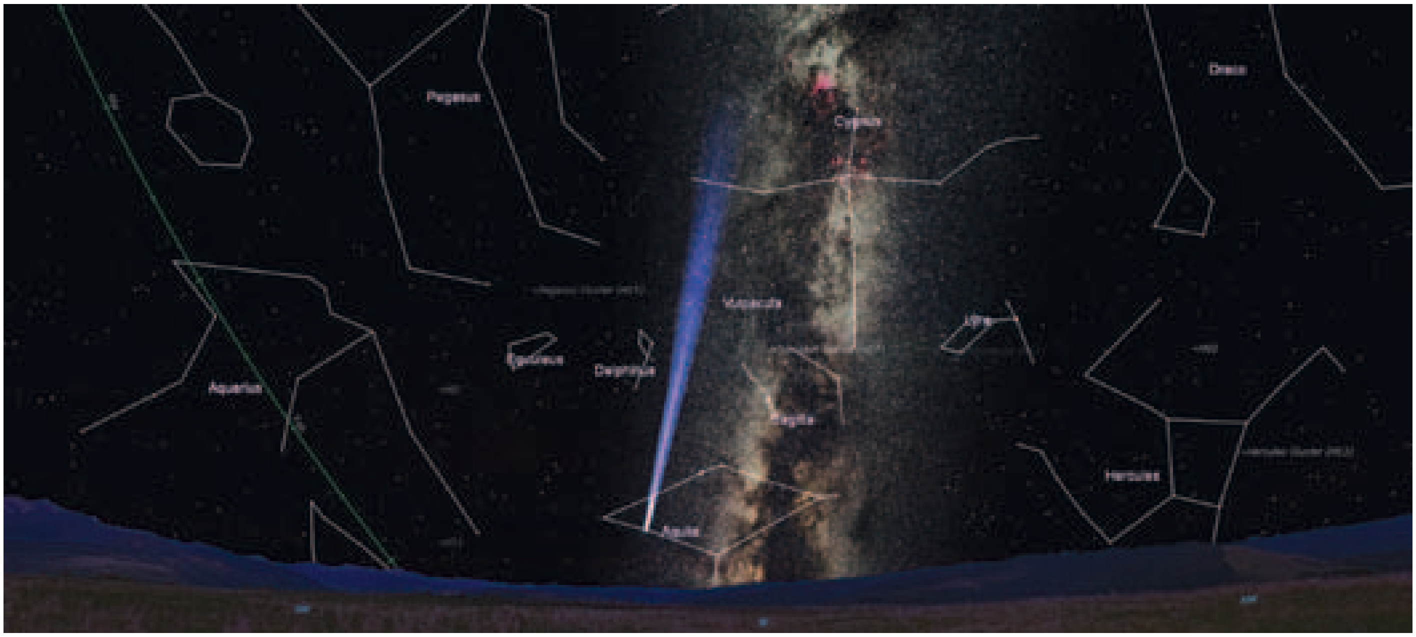


Figure 3 — A Starry Night recreation of the appearance of the comet on the evening of 1680 December 29.

we can use the coin to plot the sky position of the comet for a particular date and with what precision. When I first saw this medal, my immediate instinct was that it displays a comet on a star map. It certainly *looks* like a star map or *made to look* like a star map!

I have quoted Holden's comments that imply that the artwork on the medal was prepared by a monk who rarely looked up at the night sky. Does this artwork display "erroneous designs of the star groups" as Holden suggests, and was it composed "indoors," or, was it meticulously prepared by a skilled observer who carefully watched this comet over a period of several weeks? The contrast between these options could hardly be more stark. Either this artwork was composed by an inward-looking recluse mumbling rhymes and muttering numbers in his cell, or it was prepared by an upward-looking observer at home under the stars and paying close attention to a comet overhead. Which is it? Monk or astronomer? Indoors or outdoors? Erroneous or authentic star groups? We have defined the issue.

7. Investigating a Possible Star Map

I became aware of this medal through Yeomans' book, and I later noticed specimens in some coin auctions in 2007. I have written articles on astronomical coins, and so I became intrigued by the comet side of this medal. I did what I suspect most people do when faced with this challenge—I compared the patterns on the medal against several modern star atlases over a couple of evenings. The three central stars are easily matched with the three stars in a row in Aquila, but I could make no further progress. I returned to the issue two years later and started afresh by researching the numismatic history of this medal.

Through the Internet, I managed to access the proceedings of the Numismatic Society of London in 1839. Its president was Edward Hawkins (1780-1867), who was a Fellow of the Royal Society and a Fellow of the Society of Antiquaries. He was Keeper of Antiquities and Coins in the British Museum for four decades. Some of his research was published in 1885 under the title *Medallic Illustrations of the History of Great Britain and Ireland*.

In his address to the society in July 1839, he referred to this medal of 1681:

> *The comet of the 16th December, 1680, and January 1681, is recorded on a circular medal in my possession, and struck in Germany. According to Halley's stated positions of the comet of 1680, it appears that on the 16th December, the date on the medal, the comet's longitude was 291½ and latitude 18. Now in this point of the heavens are the constellations Aquila, Sagitta, Delphinus, &c. Hence the three stars in a line, as represented on the medal, are those of Aquila, commonly called the Tailor's Yard.*

The Great Comet of 1680 was observed by several giants of modern astronomy, including Edmond Halley (1656-1742) of Halley's Comet fame, Astronomer Royal John Flamsteed (1646-1719), whose star catalogue was published a decade after his death, and Sir Isaac Newton (1642-1727), who computed the comet's orbit around the Sun. Halley observed it in December 1680 below the constellation of Aquila; Flamsteed monitored its sky position daily by measuring its distance from Altair in Aquila; and Newton continued his observations until 1681 March 19.

Since this comet was observed in December 1680 in Aquila, and the coin has the date December 1680, I agree with

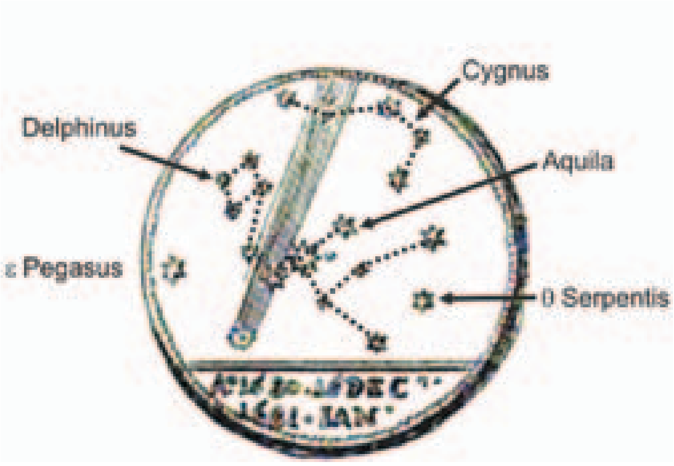


Figure 4 — An enlarged copy of the medal identifying the stars and constellations in the medal's stellar background.

Hawkins that the three stars "in a line" on the medal are probably the three brightest stars in Aquila (β-α-γ Aquilae) that form a straight line. It is a rather modest beginning because it does not make any of the other stars obvious. It should, but it doesn't! Where are the stars of Sagitta above Aquila? Was the author a novice in cartography? Did the author select some stars for his map and ignore others to suit his plan? We have generated more questions.

The identification of β-α-γ Aquilae will kick-start our investigation. These stars were called the "Tailor's Yard," as Hawkins noted, because they form a line five degrees in length [the name is also frequently associated with the stars of Orion's belt]. This crude measurement will provide a yardstick for estimating the approximate sky area depicted on the coin. Bear in mind that *any* depiction of the sky onto a *flat* surface, especially a flat surface only 25 mm in diameter, is bound to involve some distortion. Nevertheless, using this trio of stars to set a scale of 5 degrees, we can estimate that the radius of the sky area on this medal is somewhat above 20 degrees. I have cast my net wide.

If we draw several diameters across an image of the coin, we can establish its centre. It coincides with a tiny bump of silver in the middle of the coin immediately below the star that I have identified as γ Aquilae. Using a modern star atlas and γ Aquilae as the centre for a compass, I measured a radius of 20 degrees and marked off this circular area of sky. I tried but could not identify the star patterns on the medal. I increased the radius to 25 degrees and studied a larger sky area. Failing again, I increased the radius to 30 degrees and thought I could recognize the star patterns at 31 degrees (Figure 5). I could match all 19 dots on the medal with 19 stars in five constellations (Figure 4), but the scale is severely distorted across the breadth of the coin and some obvious patterns are missing. The matches can be summarized as:

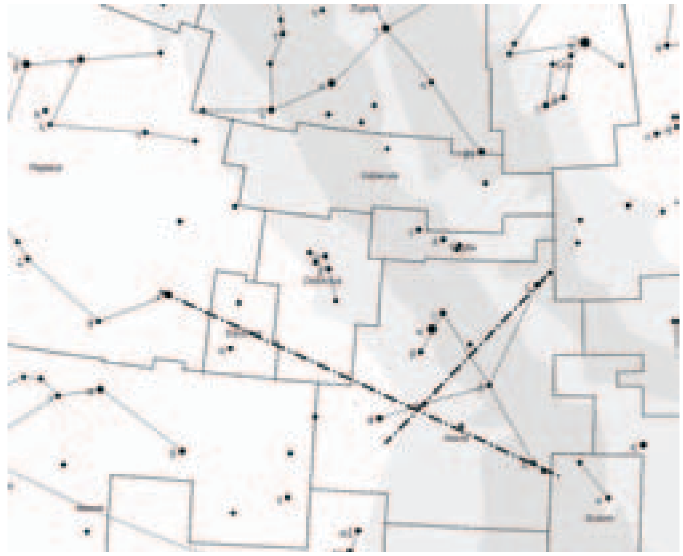


Figure 5 — A chart of the sky around Aquila showing the two lines, ε Peg to λ Aql and ζ Aql through σ Aql that intersect at the sky position of the comet on 1680 December 29.

– one star in Pegasus:	ε
– seven stars in Aquila:	α β γ λ ζ μ σ
– one star in Serpens Caput:	θ
– five stars in Cygnus:	β η γ ε ζ
– five stars in Delphinus:	γ α δ β ε

8. Why *These* Stars?

Two sets of three stars on this map forms straight lines: β-α-γ Aql and β-η-γ Cyg. There is a semi-circle of five stars that loops from λ Aquila up to ε Cygnus and all five stars—λ Aql, θ Ser, ζ Aql, β Cyg, and ε Cyg—are positioned along the Milky Way. Whoever composed this artwork sighted stars along straight lines, hopped from star to star in a loop, and knew the Milky Way and its markers. He displays the habits of a seasoned star observer. The comet tail is about half as wide as β-α-γ Aquilae, which suggests a width of two degrees, matching the recorded observations. The comet's tail on the medal is some 35 degrees long and stretches from southern Aquila to ε Cygnus, very similar to the *Starry Night* depiction in Figure 3.

There are two faint stars on the map, μ and σ Aquilae, and we wonder why they were included when brighter stars were ignored (such as the stars in Sagitta). It is possible that the author was using these two faint stars to track the comet's changing position. If we draw a line from ε Peg to λ Aql, and a second line from ζ Aql through either μ Aql or σ Aql, the lines will intersect at the comet's position (Figure 5) on 1680 December 29. This location is between the positions of θ Aql and η Aql, had they been drawn on the coin. The fact these stars are missing suggests that the comet was so close and the altitude so low that the comet's brilliance may have overcome the stars. I have drawn these two lines on a star chart and they intersect at a position that is 10 degrees from α Aquila (Figure 5). Flamsteed used a telescope at Greenwich Observatory to track this comet, and he measured its position at 11 degrees and 10 minutes from α Aquila two days later, on 1681 January 1 (Merian 1691).

The second inscribed date on the medal is shown as 1681 - 1AN. The name of the month begins with the numeral 1, not the capital letter "J" for January as expected. The designer seems to be using another letter/numeral device to denote a specific date: 1681 January 1, but this cannot be, as the rapidly moving comet was considerably higher in the sky on that date, to the southeast of Delphinus. However, the plotted position is very accurate for the evening of December 29, if my identification of the stellar pattern is correct.

9. The Author of the Star Map

I have demonstrated how this numismatic artwork resembles a star map and why I think the author was an experienced observer. He obviously knew that a medal of 25-mm diameter offers a limited work space, so he kept his map uncluttered by including only those stars that served his purpose. Four of his stars can create two lines that intersect to accurately plot the position of the comet on the night of 1680 December 29. "X marks the spot." I think it was an impressive achievement on such a tiny canvas.

We know he was a passionate sky observer because he was outdoors in December and early January in a country that normally experiences cold winters. Temperatures near Hamburg, Germany, hover around freezing during winter months, yet this dedicated observer braved the elements to track the comet's path. He knew that a really bright comet was a once-in-a-lifetime event, so he choose the cold outdoors to observe it over indoor warmth and a good night's sleep. Readers in northern climates may appreciate this argument more than readers in sun-drenched California!

It is worth noting that the artist plotted stars without constellation figures. A fellow German, Johann Bayer, a lawyer and an amateur astronomer, published a popular star catalogue in 1603 with about 1000 stars outlined with constellation figures. It was superseded in 1729 by John Flamsteed's catalogue, which plotted over 3000 stars using more accurate sky positions derived from observations through a telescope. Flamsteed's catalogue retained the constellation figures used by Bayer—figures that are in use to this day in astronomy journals and magazines.

10. January 1681

We can piece together what likely happened in late December 1680 and early January 1681. Our designer attempted his observations late in December and early in January as soon as the declining evening light would allow, perhaps frustrated by the frequent cloud that haunts Europe at this time of year. The choice of December 29 may have been dictated by the weather; other nights may not have been clear enough to see the horizon-hugging nucleus of the comet. Whatever his reason, when he was satisfied with the observation and had constructed his star chart, he reduced the field to a circle 25 mm in diameter, composed a rhyme in German for the reverse, capitalized certain letters to provide numbers that total 1681, constructed the proofs, and sent it for casting. He may have supervised the production of the medal to ensure it displayed the star pattern as accurately as possible and especially the comet that dominated the evening sky on those magical nights at the end of 1680.

11. Conclusion

It fires the imagination to realize that someone in 1681 managed to create a star map on a Lilliputian scale and inscribe it onto a metal canvas 25 mm across to preserve his observations for countless generations. The remarkable thing is we still don't know who he was. ✶

References

Bayer, Johann (1603). *Uranometria.*

Flamsteed, John (1729). *Atlas Coelestis.* London.

Halley, Edmond (1705). *A Synopsis of the Astronomy of Comets*. London.

Hawkins, Edward (1839). *Proceedings of the Numismatic Society of London*. Oxford.

Holden, Edward S. (1890). Medal of the Great Comet of 1680. *Publications of the Astronomical Society of the Pacific*, *2* (8), 124-125.

McIvor, R.S. (2004). The Star on Bar Kokhba's Coins. *The Celator Coin Journal*, *19*, (2).

McIvor, R.S. (2011). A Supernova on Ancient Coins. *The Celator Coin Journal*, *25*, (2).

Merian, Matteus (1691). *Theatri Europaei, Zwolffter Theil*. (Merian assembled observations of this comet.)

Pliny the Elder (circa AD 75). *Natural History*, book II, paragraph 94.

Sagan, Carl & Ann Druyan (1985). *Comet*. New York, NY: Random House.

Westfall, Richard S. (1980). *Never At Rest: A biography of Isaac Newton*. Cambridge: Cambridge University Press.

Yeomans, Donald K. (1991). *Comets: A Chronological History of Observations, Science, Myth, and Folklore*. New York, NY: John Wiley.

Robert McIvor retired from a career in insurance. He has a degree in theology from the University of London and is interested in the history of astronomy and numismatics, including the history of celestial cartography and astronomical information preserved on ancient coins.

Figure 1 — Winnipeg Centre's Sheila Wiwchar made the most of a partly cloudy night with this photo of the haloed Moon as it rose through cirrus clouds in early May. Lunar haloes form when light from the Moon is refracted by hexagonal ice crystals. The angle of refraction is 22° or smaller, leading to a bright inner edge to the ring at that angle, where the minimum deviation occurs. No light is bent at a greater angle, and so the inside of the ring is dark. Light rays that have less deflection contribute to the bright region outside the ring.

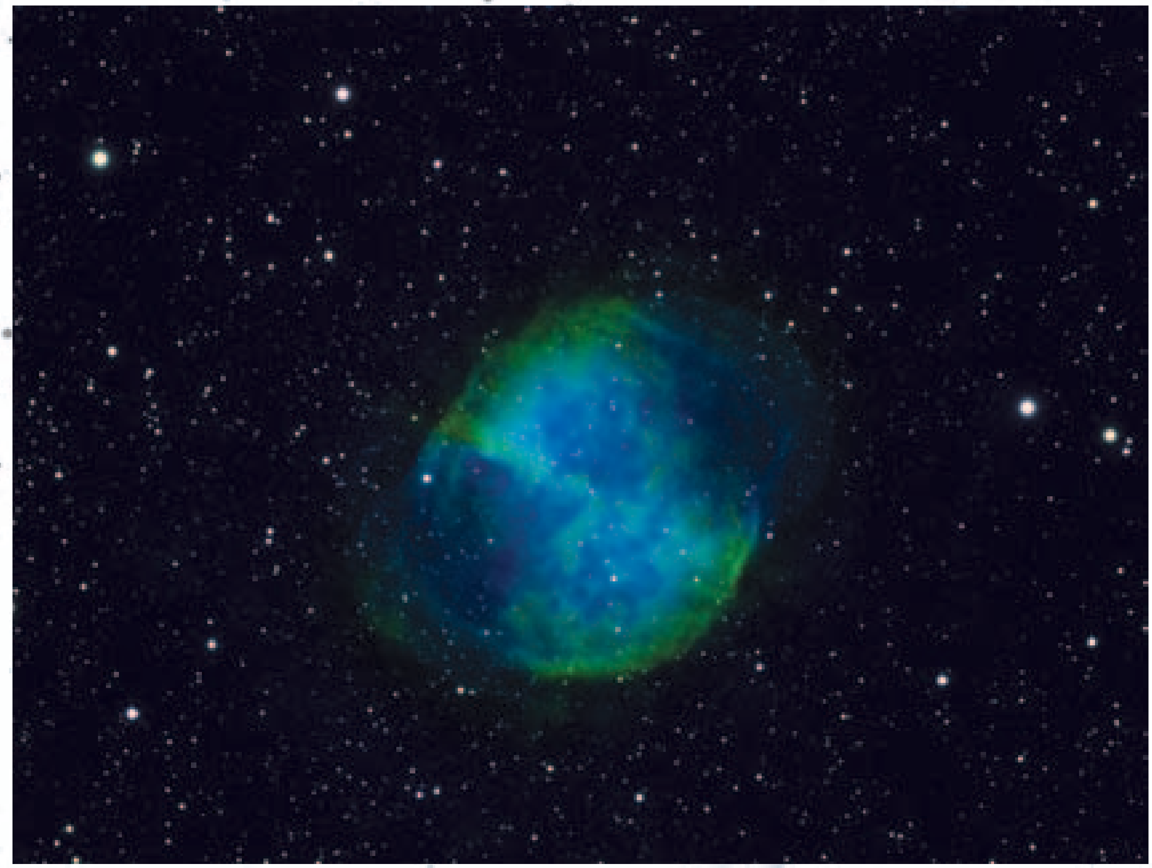


Figure 2 — The Dumbell in the Hubble palette. Narrow-band imaging—a "hot" topic in astroimaging—can present unfamiliar views of familiar objects, such as this image of M27 (the Dumbell Nebula) by Steve Altstadt of the Winnipeg Centre. Steve used 5-nm narrow-band filters in the light of Hα, OIII, and SII, colouring them green, blue and red respectively to duplicate the "Hubble palette." The distribution of each of the elements can be determined by examining the colour changes in the image. Exposures were 3×10 min in each colour, binned 3×3, and the 3×10 in luminance, binned 2×2.

Figure 3 — "The Rosette." Brian McGaffney of Nutwood Observatory sent us this image of the Rosette Nebula, which perfectly complements the wide-angle view provided by John McDonald in Figure 4. The Rosette is a large Hα region with an embedded star cluster, NGC 2244, in its central void. The structure lies about 5200 light-years distant; the nebula has a mass of about 10,000 Suns. Brian used an SBIG STL 6303e camera on a Televue 127IS 'scope. The exposure (Hα+L, Hα+RGB), using 10-minute subs, totalled about 10 hours over two nights.

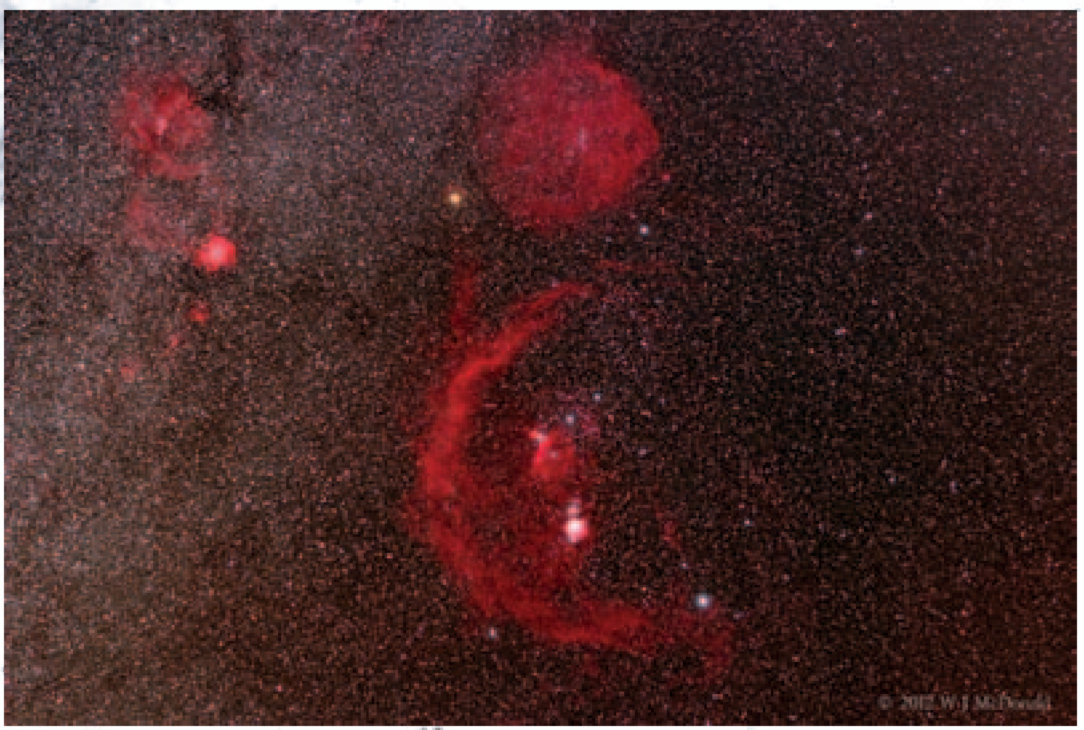


Figure 4 — "Glorious Orion." The Orion Nebula complex is a favourite target of amateur astronomers, but few can improve on this view of the constellation's extended hydrogen clouds shown in this image by Victoria's John McDonald. Visible here are the Orion Nebula, the Horsehead Nebula, the Rosette Nebula, and Barnard's Loop. John captured the photons using a 28-mm f/3.5 lens on a Canon T3i camera from the Painted Pony Resort near Rodeo, New Mexico, during the Alberta All Star Party. Exposure was 23×120 s in white light, 9×600 s in Hα at ISO 1600 and 15×300s in Hα at ISO 3200 for a total of 216 minutes.

Gears and Periodic Errors

by Rick Saunders, Halifax Centre
(ozzzy@bell.net)

Most modern mounts use a worm-and-gear (also called worm-and-wheel) type of drive on each axis. These allow for a full 360-degrees of rotation, non-reversibility of the drive, along with a great amount of gear reduction.

The reduction in a worm-and-gear drive is dictated by the number of teeth in the driven gear. A 360-tooth gear will show 360:1 reduction while a 180-tooth gear will have a reduction of 180:1. As in the transmission of a car in low gear, motor torque is greatly multiplied by low gear ratios, allowing a small motor to easily turn a large and heavy telescope. A telescope has to be able to track the sky accurately at approximately one revolution per day, but a motor alone could not turn accurately at a speed that slow. The large amount of reduction in a worm drive allows the motor to turn at a usable speed while keeping the tracking rate slow.

Figure 1 shows the worm and gear setup from a Mathis Instruments mount. The worm is the small steel *driving* gear and the worm gear is the large bronze *driven* gear. Due to the non-reversibility of the gears, the worm gear cannot drive the worm, which is perfect for telescope use (and also why they're used in guitar tuners). This means that when the drive is stopped, even an out-of-balance condition will not cause the axis to slip unless the clutch is loose or a gear actually strips.

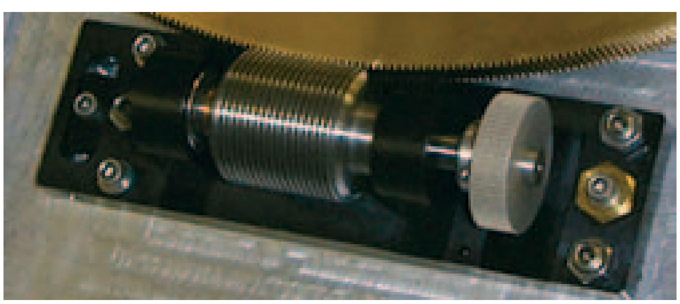


Figure 1 — Worm and gear from a Mathis Instruments mounting.

A favourite discussion in the on-line forums is the topic of periodic error (PE)—a tracking error caused by slight inaccuracies in the mount's RA worm. This makes the mount speed up and slow down very slightly through each rotation of the worm in a repeatable fashion; hence the term "periodic." The change in speed causes a target to wobble back and forth in right ascension as shown in Figure 2.

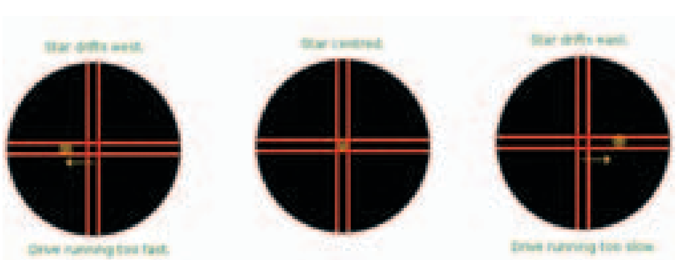


Figure 2 — Crosshair-view images of periodic error in Right Ascension

PE can be caused by many different types of inaccuracies in the worm. Figure 3 shows two worms that have machining errors compared to one that is perfect (left graphic). The centre worm itself is round but is being driven off centre which will cause it to strike the gear alternatively closer and further from the centre of the gear's rotation. The graphic on the right is a worm that is out-of-round, or egg-shaped.

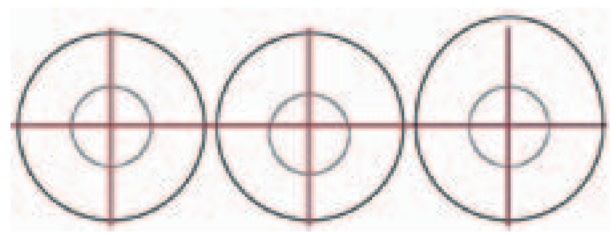


Figure 3 — A schematic of a normal gear construction (left) and two machining errors (centre, eccentricity; right, oval-shaped worm gear) that will affect tracking.

Both of these types of machining errors will cause the mount's RA axis to speed up and slow down alternately with the period of the worm.

A greater problem is a worm that is "bumpy", as is shown in Figure 4. The left hand example shows a smooth worm (red) striking the gear (black). As the worm turns it will turn the gear smoothly. The right side of the graphic shows a poorly polished or lapped worm striking the gear. This will cause the gear to jerk quickly while turning, either speeding up or slowing down rapidly with a period much shorter than a full worm rotation.

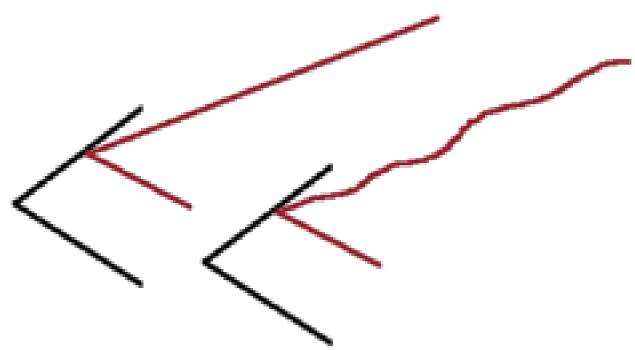


Figure 4 — schematic showing smooth (left) and bumpy gears; the first will give few tracking errors while the latter will have a very uneven periodic error.

Figure 5 shows the actual PE curve of a modern popular German equatorial mount with a peak-to-valley amplitude of about 26 arcseconds. This sounds like a lot but is not unheard of with today's telescopes. The PE curve is superimposed on a perfect sine curve that shows that the mount's gears are quite smooth. The spikes are most likely due to seeing. The important thing in the graph is not the amount of PE but that the curve almost perfectly matches the sine curve. On this mount, an auto-guider will be able to correct perfectly any drift in a guide-star.

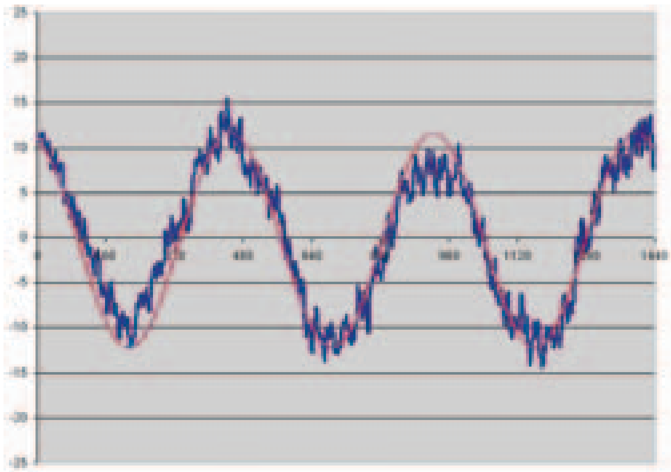


Figure 5 — Example of a large but relatively smooth periodic error.

The PE curve displayed in Figure 6 shows just how bad a modern mount can be. This is also from a popular mount that is touted by the manufacturer as being well-suited for imaging. I have tried to fit a sine curve over this mount's PE curve, but it was not as simple a task as in the previous example. This mount would not be very useful for imaging without some work.

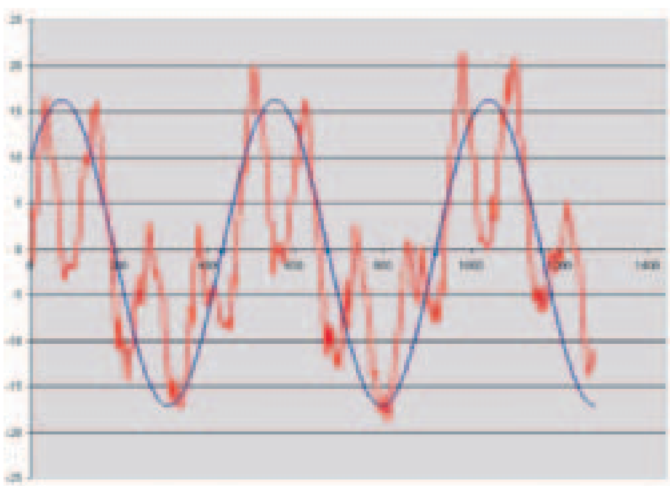


Figure 6 — Example of a large and very erratic periodic error.

Today, just about everyone is guiding their images, so normally any PE will be guided out. The amplitude of the PE curve isn't generally an issue, but the shape of the curve is critical. Figure 6 shows many areas where the curve is so steep that an auto-guider may not be able to correct for the changes quickly enough.

Even if it displays a bad PE curve like Figure 6, a mount may still be usable for imaging. Most mounts these days come with some form of periodic error correction (PEC) built into their firmware. PEC has always been a rather dark art to me, and I never really did get it to work properly on my HEQ5. I don't even try on my CGE, as it isn't needed. The theory of how PEC works is quite simple. Start the mount's PEC "learn" routine and let the mount run over three or four worm revolutions (see calculation below) while guiding on a star. While in learning mode, the PEC system records all guiding done by you or an autoguider. Once stored, the PEC system reverts to "playback," repeating any guiding corrections that were recorded during the training session, speeding up and slowing down as needed to smooth out the curve.

There may be a problem using PEC while auto-guiding in that the guider, during its calibration phase, is doing its calculations with no knowledge of any worm rotation speed changes. If the mount is being guided during times of very slow or very fast worm rotation, as dictated by the PEC routines, then guider error could be introduced. This may or may not be an issue, but SBIG has in the past stated that PEC should be turned off when using their guiders.

So how good is PEC? Generally quite good from the examples I've seen, where people have taken their time and used the available software tools correctly. With very good mounts, PEC can reduce error to the point where an auto guider isn't needed for short(ish) exposures, making the system good for survey or patrol duties. Generally it's not good enough for long-exposure imaging with mounts that normal humans can afford.

There are several software tools available to help with determining the amount of PE a mount exhibits and to smooth out the PEC routines. If the plan is to use both PEC and an auto guider, it would be in your best interest to check the on-line forums to see if there will be any issues.

Figure 7 shows a Fourier analysis of the Figure 5 curve. A Fourier analysis is used to break apart the periodic wiggles in the tracking and turn them into a myriad of sine curves that, when added up, reproduce the curve being analyzed. Each sine curve in the Fourier analysis represents a frequency; some are very quick corrections, others are slower, and still others are quite leisurely. The various frequencies can be plotted on a graph (the frequency of the frequencies), where the most common corrections show up as "spikes" or high spots in the chart, as in Figure 7. The centre of a spike represents the period of that curve. This type of chart shows the PE generated by all of the gears between the motor and the worm-gear individually. As can be seen in the graph, the analysis of the Figure 5 curve shows really only two periods:

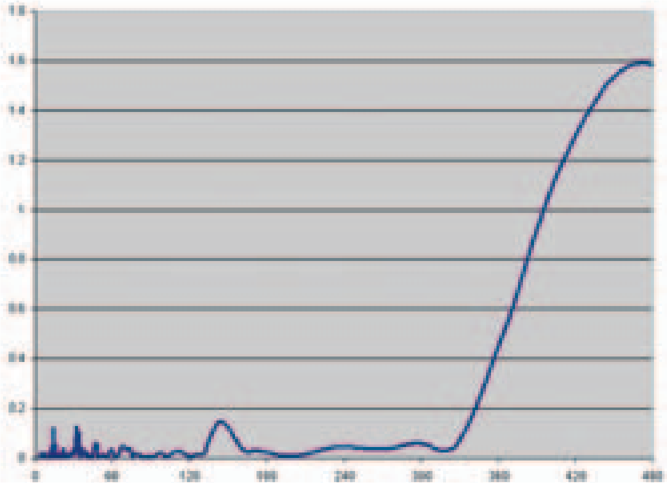


Figure 7 — Fourier curve showing the relative frequency of the periods of guiding errors in the gear of Figure 5.

a large hill on the right side with a period that peaks near 480 seconds and a smaller hump at about 150 seconds that is probably due to some error in the transfer gears between the motor and worm.

Figure 8 shows a typical worm-gear setup. Places where periodic errors are generated are in the worm and gear, the transfer gears, and in the gearbox of the motor. Errors generated in the gearbox usually show up as the "noise" at the far left of the Fourier analysis graph. Unless they are very bad, the PE from the gearbox and transfer gears normally does not have a deleterious effect on tracking. Fixing transfer gear PE could be difficult. Dirty or sticky bearings in the worm's shaft may also add to the noise in the Fourier analysis.

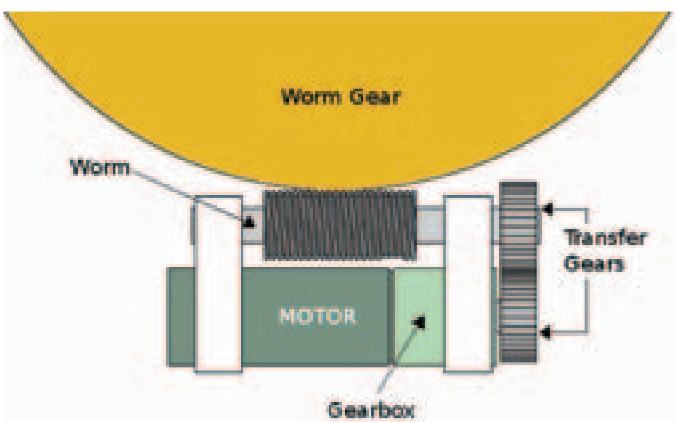


Figure 8 — A schematic of a standard worm-gear setup.

A low periodic-error value in the specifications of a mounting may be an indication of the quality of the gears used in its manufacture. A mount maker with some integrity would state the maximum allowable PE that one of their mounts displays before the gears are rejected, but not all manufacturers are that forthcoming; at best, you can expect to see the average PE. It should also be kept in mind that different samples of similar mounts from a single manufacturer may show differing PE, though all will be within the acceptable range of the maker's quality-assurance specifications. ✶

Rick Saunders became interested in astronomy after his father brought home a 50-mm refractor and showed him Saturn's rings. Previously a member of both Toronto and Edmonton Centres, he now belongs to the London Centre, and is mostly interested in DSLR astrophotography.

Calculating worm period

A PE curve will have an amplitude equal to the greatest excursion of the star from centre, and a period that can be calculated using the following relationship:

Period = 86164 / number of teeth in the worm gear

So, a gear with 180 teeth will have a worm period of 479 seconds, while a gear with 360 teeth will have a period of 239 seconds. A telescope mount's documentation will generally tell how many teeth are on the worm gear and (possibly) the average periodic error that the manufacturer specifies for the mount.

Fifty Years of Astrophotography

by Klaus Brasch, Unattached Member
(krbrasch@earthlink.net)

As a life-long "amateur" or lover of all things astronomical, few activities have given me more pleasure than photographing celestial objects. To be sure, there are many far better images taken by professionals, or from space, or by advanced amateurs so skilled they rival the *Hubble Space Telescope*. That's not the point however. To me astrophotography has always been, as my late friend, great astro-imager, and accomplished golfer, Mike Mayerchak, used to say "… a lot like golf; you play mainly to best yourself." That's been my perspective as well.

My venture into the hobby began as a teenager in the late 1950s as a newly minted member of the Royal Astronomical Society of Canada. In those heady *Sputnik*-era days, we were all excited about the prospects of space travel and hoped somehow to become part of that. Most amateurs then had only modest, often homemade telescopes and did mainly visual work. An 8-inch reflector was a large instrument, and few of us could afford one.

My first decent telescope was a homemade effort that my father and I built in his basement workshop. I paid the then-hefty sum of $15 for a 3-inch f/13 war-surplus achromatic lens and found a scrap aluminum optical tube and some metal end-pieces from an old X-ray machine to serve as the lens cell and draw-tube holder. We even built a plumber's-nightmare "equatorial" mount out of iron pipe fittings with a 45° angle joint for the polar axis, conveniently close enough for our latitude in Montreal. The counterweight was made of lead that we found at a scrap-metal yard. We melted it in an old pot on an outdoor electric element and poured it into a tin can to solidify, blissfully unaware of how poisonous lead fumes are! We even tried building a tripod out of broken hockey sticks, which I had in abundance. That proved way too wobbly however, so we invested in much costlier hardwood (Figure 1).

Figure 1 — My late father and a friend observing the 1963 total eclipse of the Sun near Plessiville, Québec, with our homemade 3-inch refractor on its plumber's-nightmare mount.

Figure 2 — My first astro-camera (left) with wax paper focussing screen and leaf shutter. The now-classic Asahi Pentax single-lens reflex camera was used later for both regular and astro-photography.

As to cameras, most commercial models were way beyond my pocket book or entirely unsuitable for astronomical purposes, as were most films of the day. That did not stop me though, and I again resorted to improvisation. My dad found an old-style leaf shutter just wide enough to accept a 1.25-inch-diameter cardboard tube and glued it to the body of a cheap Bakelite camera that held an eight-exposure roll of paper-backed Kodak 828 Tri-X film. Then, as now, the real challenge was focussing at the telescope. No "live view" LCD screens, computers, or any other focussing aids existed in those days, just range finders or ground-glass screens, none of which my improvised camera possessed. Instead of ground glass, I Scotch-taped a piece of wax paper to the film plane of the open camera, and that did the trick. After marking the focus point on the eyepiece draw tube, I removed the camera and wax paper, loaded the film, and reattached my not-so-high-tech toy, ready to shoot the Moon (Figures 2 and 3). Despite the fact that those first pictures were as grainy as sand paper, I was hooked for life!

Eventually I graduated to a 6-inch refractor, the primary instrument at the Montreal Centre's old observatory on the McGill University campus. My good friend Geoff Gaherty

Figure 3 — First image of the Moon, shot in 1959 on Kodak Tri-X film with my modified toy camera and the 3-inch refractor shown above.

Figure 4 — The crater Copernicus and surroundings shot with my camera and Tri-X film at the prime focus of a 6-inch refractor at the Montréal Centre of the RASC circa 1960.

and I spent many happy nights there, observing and sketching the Moon and planets. After much trial and error, I finally obtained an image of the Copernicus region that was to be my pride and joy for many years (Figure 4). It looks pretty dismal by today's digital standards, but I was overjoyed.

After graduating with a biology degree from Concordia University (Sir George Williams then), I went on to graduate school at Carleton University in Ottawa. Perennially short of money, I sold all optical equipment, and my astrophotography career went into prolonged eclipse for many years.

Thankfully it emerged again in 1979. While on sabbatical leave in southern California from my faculty position at Queen's University in Kingston, I rediscovered the joys of photographing the heavens. Southern California was astronomy heaven then, with several major observatories and important telescope manufacturers, including Cave Optical, Meade, and Celestron. I had my eyes on one of those exciting new orange C8s, which were affordable, portable, and seemed ideal for astrophotography. On a visit to the Celestron facility in Torrance, I learned that one of their classic C10 telescopes was for sale. Only about 300 of these superb f/13 Schmidt-Cassegrain telescopes were made in the 1960s, and they were primarily intended for lunar and planetary observing. Mine had been fully modernized by its previous owner, with coated optics, a solid wedge and tripod, and an orange-coloured tube rather that the original blue and white (Figure 5). I hauled it all over to dark mountain sites in the Los Angeles area (there were still dark sites there in 1980), including the legendary Mt. Pinos. I also acquired an Olympus OM-1 35-mm camera, favoured by many astrophotographers for deep-sky work. After shooting my first image of the Orion Nebula with the then "fast" Ektachrome 400 film (Figure 6), I was hooked once again.

A few years later, I was offered an exciting research position at an American university, and I moved south permanently. Trips to the Texas Star Party became an annual pilgrimage, and I got into astrophotography in earnest. Fortunately, some really good films, like Panatomic X, "hypered" Kodak Technical Pan, and Fujichrome 400, had become available, featuring relatively low reciprocity, fine grain structure, and an acceptable dynamic range. The classic Celestron C10 proved to be a formidable instrument for lunar and planetary work, especially with fine-grained black-and-white films (Figure 7). As inevitably befalls most astronomers, however, I was eventually overcome by a severe case of aperture fever and traded up to a fine C14.

Figure 5 — The classic Celestron 10 Schmidt-Cassegrain (circa 1965 vintage) as it appeared in 1980, fully refurbished, painted, and mounted on a C14 wedge and tripod. Only about 300 of these superb f/13 telescopes were made.

Film-based astrophotography probably reached its peak in the late 1990s thanks to the availability of several excellent colour films, light-pollution filters, and image digitization. The short-lived Kodak PPF-Pro 400 colour-negative film was among the best. My favourites were Ektachrome 200 slide and Fujichrome Provia colour-reversal films, which are both still used by devotees of emulsion-based photography. Not only were these films very finely grained and red sensitive for emission objects, but by taking several exposures, and scanning and digitizing them, it became possible to stack and process them for maximum effect. Two of my best film-based images are shown in Figures 8 and 9.

Although film held its own in terms of resolution and contrast for several years more, by the late 1990s, astronomical CCD cameras had come down enough in price that many amateurs could afford them. I held out for a while longer, because they were still not cheap and were rather cumbersome. In addition to requiring long, multiple exposures through colour filters, they needed dedicated computer software and hours of image processing. I preferred the ease and portability of single-lens reflex cameras, especially for field trips to dark sites. Nonetheless, I always told myself "The day they come out with a DSLR that's as good and easy to use as my trusty old Olympus OM-1, I'll go over to the dark side." Well, that day arrived in 2005 with the Canon 20D. "Digital testosterone" one reviewer labelled it, with an 8.2 Megapixel CMOS APS sensor and a host of other refinements. Canon even issued a limited-production model 20Da, intended specifically for the amateur astronomy market, with enhanced red sensitivity so lacking in conventional models. My 20D was custom modified for even greater red sensitivity, and the first image I took with it of the

Figure 6 — A 10-minute exposure of the Orion Nebula taken in 1981 at the prime focus of the C10 on Ektachrome 400 slide film, push-processed to ASA 800. The slide was later digitized and processed in Photoshop.

Figure 7 — Prime-focus shot of the Moon with the C10 on Kodak Panatomic-X and subsequently digitized and processed in Photoshop. Panatomic-X and Technical Pan were two of the best black-and-white films for lunar and planetary work.

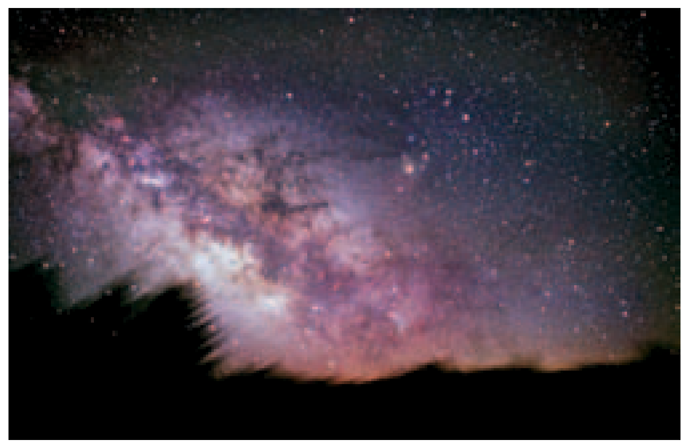


Figure 8 — The Milky Way rising over the Mojave Desert. This 10-minute exposure was taken in 2003 with a 28-mm wide-angle lens at f/4 on Fujichrome Provia 400, digitized and processed in Photoshop.

Figure 9 — A 25-minute exposure of M42 taken in 2000 with Kodak PPF-400 color-negative film and a Celestron 14 at f/7. The image was reversed into a slide, scanned, digitized, and processed in Photoshop. *Note the fine grain, excellent resolution, and dynamic range of this film compared to Figure 6.*

Figure 10 — Digital image of Copernicus and surroundings taken in 2003 with a Nikon Coolpix 995 on my C14 at f/30 with eyepiece projection. A sequence of 10 images was stacked and processed in RegiStax. *Contrast this with Figure 4 taken 50 years earlier under similar lunar phase.*

Figure 11 — The Orion Nebula complex imaged with a TMB-92 f/5.5 apo refractor and a Hutech-modified Canon 50D coupled with an IDAS LPS-V3 filter. This is a composite of several exposures at ISO 400-800 totaling 20 minutes, stacked in RegiStax *and processed in* Photoshop CS3.

Figure 12 — M33, the Pinwheel Galaxy, imaged with a C11 HD at f/6.2 and a modified Canon 50D. This is a composite of several exposures at ISO 800-1600 totalling 35 min, stacked in RegiStax *and processed in* Photoshop CS3.

Orion Nebula convinced me that, alas, film had gone the way of the dinosaurs (and I loved dinosaurs!).

Digital imaging, of course, required a whole new set of skills about which someone nearing retirement like I was could be quite apprehensive. Specialized image-stacking software, dark framing and flat fielding, newer (and more difficult to master) versions of *Photoshop*, costly narrow band-pass filters, special focussing aids, field flatteners … the list goes on. Not to mention that my treasured Canon 20D was soon superseded by even better models with higher resolution, easier focussing, less internal noise, and of course, higher cost. Since this seems to happen at regular two-year intervals with no end in sight, I soon realized that I had been sucked into an astro-imaging black hole!

In the end though, it's all been worth it. Never in my wildest dreams 53 years ago did I imagine that someday I could capture with modest-size telescopes astronomical images that superseded the best emulsion-based photos taken with giant telescopes only a couple of decades earlier. Thanks to webcams and digital video cameras, it is now possible to capture hundreds of lunar and planetary images in just a few seconds. After that, with outstanding software like *RegiStax*, you can select only the best images and combine them into high-resolution, diffraction-limited images of astounding clarity (Figure 10). It is almost like post-facto adaptive optics.

The sky is literally the limit for digital deep-sky imaging. My current modified Canon 50D can be used up to ISO 1600 without bothersome image granularity. In addition to live-view focussing, programmable noise reduction, and continuous shooting mode, it lets you adjust white balance, image quality, and a host of other features on the fly. The only downside is that this remarkable camera is already four years old and effectively obsolete! Of course, the next generation of cameras will feature even higher resolution, less noise, full video imaging, and even more refinements.

Probably the biggest boon for deep-sky imaging is the availability of special light-pollution filters and narrow-band-pass filters selective for H-alpha, H-beta, OIII, and SII. By combining them with multiple short exposures and stacking those with appropriate software, you can capture remarkable deep-sky images even from urban and suburban settings. Ideally, of course, you want really dark, pollution-free skies as far from big-city lights as possible. I have been fortunate in that regard to have lived near or visited remote sites in the American southwest, Australia, and the Atacama region of Chile. For more details about the latter see Brasch (2011). Astro-friendly skies were also a big factor when my wife and I decided to retire to Flagstaff, Arizona, "The world's first dark-skies city," and home to Lowell and the US Naval Observatories, Anderson Mesa, and soon Lowell's 4.3-metre Discovery Channel Telescope. We built a backyard observatory on our property, where I have obtained some of my best celestial images (Figures 11 and 12).

It has been a long but rewarding journey since I took my first pictures of the Moon in 1959. While I thoroughly enjoyed my professional career as university teacher and researcher, astrophotography has been and continues to be a fulfilling and creative outlet for me.

Acknowledgements

First and foremost, I thank my wife Margaret for her support, patience, and friendship for so often leaving her an "astronomy widow," while I went chasing clear skies in obscure places. I thank my oldest astro-friends, Geoffrey Gaherty and Terence Dickinson, for taking much of the journey with me, and Alan Dyer for frequent technical advice and support. Lastly, I thank my many friends in Flagstaff and at Lowell Observatory for sharing their passion for astronomy with me. ✶

Reference

Brasch, K. (2011) *Chilean Imaging Odyssey*, Sky & Telescope, October 2011.

After 34 years in research and university administration, Klaus Brasch now serves as docent and lecturer in the public program at Lowell Observatory. His astro images have been widely published in books and magazines and he has translated several French astronomy books into English, including Great Observatories of the World, New Atlas of the Moon, *and* Space Probes.

Astronomical Art & Artifact

William Wales and Joseph Dymond, Astronomical Observations During the 1769 Transit of Venus from Hudson's Bay—the Toronto Manuscript

R.A. Rosenfeld, RASC Archivist
(randall.rosenfeld@utoronto.ca)

Abstract

This paper presents for the first time a summary but critical codicological and palaeographical description of the Toronto manuscript (MS) of *Astronomical Observations By Order of the Royal Society, at Prince of Wales's Fort, on the North-West Coast of Hudson'[s] Bay. By William Wales & Joseph Dymond* (Toronto, Thomas Fisher Rare Book Library, MSS gen 38.040, post-1769, August 25). The manuscript contains the two astronomers' record of observations of the 1769 Transit of Venus (ToV), and other related astronomical phenomena. Analysis reveals that while the external features (material aspects) of the Toronto MS are consonant with a later-18th-century origin, the hand of the MS is not identical to the one that wrote the Sydney NSW MS of Wales's *Journal* on the Resolution (Sydney, State Library of New South Wales, MS safe 1/84, 1772-1774), indicating that the Toronto and Sydney MSS cannot both be autograph originals in William Wales's hand.

"Hudson's Bay" was the standard name in the 17th and 18th centuries for the large salt-water body and associated landforms now called "Hudson Bay," centred at long. 85 W, lat. 60 N. The historical usage is adopted for this paper.

Paper Artifacts of the Transits of Venus

Transits of Venus, in common with other notable celestial events, are inscribed in scientific instruments of memory. Or, rather, it is the human perceptions of the phenomena—however carefully prepared for, systematically observed, and scrupulously recorded—that are noted, and once published or otherwise disseminated, take on the identity of the phenomena (become the phenomena) in everyday scientific and popular discourse. Material records of observations are of unquestionable importance, although not all records are of equal importance, as not all observations are of equal value. Manuscript (MS) sources of 18th-century scientific activity in what is now Canada are of such rarity, however, that even MS copies of reports that were published at the time and still exist in multiple print copies have a high value as part of the cultural patrimony of Canada, however meagre their contribution to the fund of previously unrecorded scientific data.

One such paper artifact of the 1769 ToV is the manuscript recording astronomical observations made at Prince of Wales's Fort on Hudson's Bay by the Royal Society expedition manned by the astronomers William Wales (*ca.* 1734-1798), and Joseph Dymond (1746-1796) (Wolf 1959, 164-166; ODNB Carlyle/Howse, Wales, William; DCBO Williams, Wales, William; Orchiston 2007; Anon. BEA, 320; Reid 2008), and now part of the Tyrrell *fonds* in the Thomas Fisher Rare Book Library of the University of Toronto, MSS gen 38.040 (Fig. 1 and 2).[1] Little is known from published sources about Dymond, who was a former assistant to the Astronomer Royal, Nevil Maskelyne, but considerably more is known about Wales. Information on his life prior to, during, and after the ToV mission is readily available from the sources cited, as are accounts of the scientific success of Wales and Dymond's work on behalf of the Royal Society. James Cook's words of 1774 expressing his opinion of

Figure — 1 Fol. 1r (iii) of the Toronto MS of Wales and Dymond's astronomical observations during their 1769 ToV expedition. Reproduced by permission of the Thomas Fisher Rare Book Library.

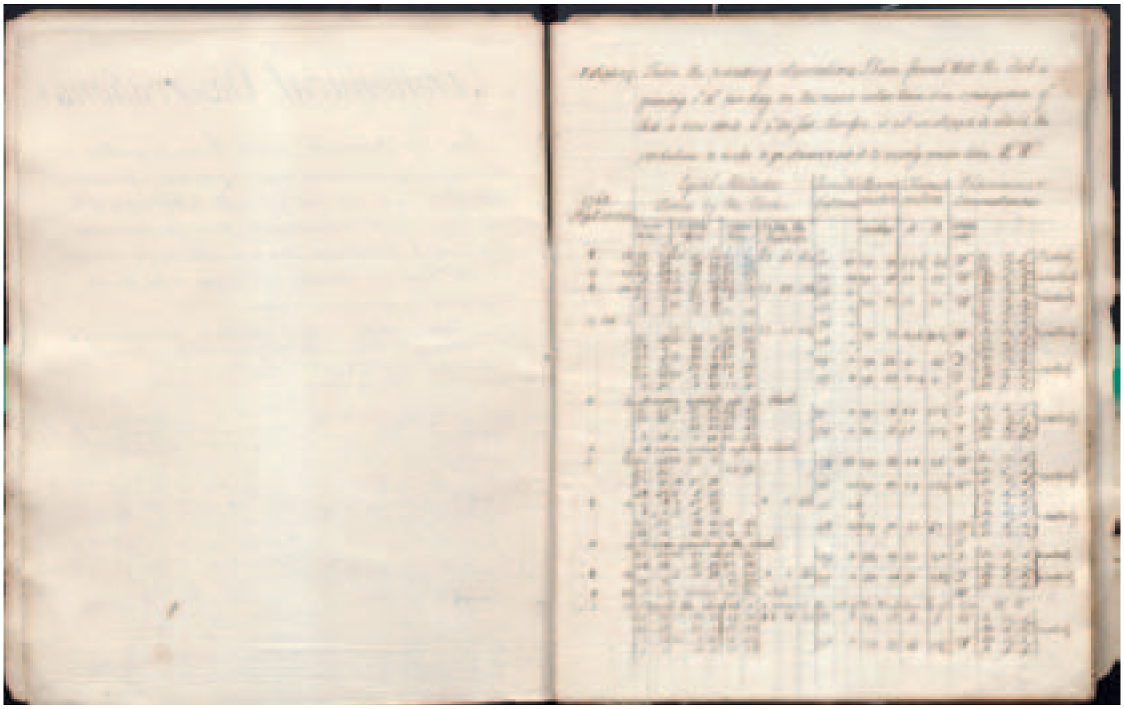


Figure — 2 Fol. 2r (iv) of the Toronto MS of Wales and Dymond's astronomical observations during their 1769 ToV expedition. Reproduced by permission of the Thomas Fisher Rare Book Library.

Wales's competence suffice to show the astronomers' quality: "For M^{r} Wales, whose abilities [*sic.*] is equal to his assiduity, lost no one observation that could possibly be obtained" (quoted from Beaglehole 1992, 423).

Wales and Dymond published three reports of their work in the Royal Society's *Philosophical Transactions* of 1769 and 1770, the first covering their astronomical observations, the second presenting a narrative of their travels (which possesses a high anthropological—but, alas, not astroarchaeological—interest), and the third tabulating meteorological data they had systematically acquired (Wales & Dymond 1769; Wales 1770; Dymond & Wales 1770). The Toronto MS is textually identical to the published report of Wales and Dymond's ToV and other astronomical observations (Wales & Dymond 1769).

The Toronto MS was acquired by the David Dunlap Observatory of the University of Toronto in 1950 by gift from Dr. Joseph Tyrrell (see the provenance information in the section Codicology: 10 below). Helen Hogg referred to the MS in her Out of Old Books column in this *Journal* in 1950, apprising readers of Tyrrell's gift, and subsequently twice in her astronomy column in the *Toronto Star* in 1957 and 1977 (Hogg 1957; Hogg 1977).[2] Don Fernie published several short pieces that referred to the MS, the first in his well-received book on astronomical voyages in 1976 and the second in a science periodical in the late 1990s (Fernie 1976, 17-23; Fernie 1998). An attempt at a fuller handling of the MS was produced by Griffin-Short in 2008, whose chief aim seems to have been to correct perceived shortcomings in Hogg's and Fernie's treatments: "Both Dr. Hogg and Dr. Fernie used the pages as window dressing; neither expressed any interest in the MS itself"! (Griffin-Short 2008, 70). Such a charge is ill-conceived, for neither Hogg's nor Fernie's pieces were meant as technical descriptions of the external features (palaeographical and codicological) of the MS, and both clearly acknowledged the importance of the MS—Hogg by direct statement in 1950, and Fernie by twice publishing the only images to date (a decision for which he deserves both thanks and credit—his selection of folios for reproduction was a highly intelligent one, given the choices). Nor should Hogg or Fernie be criticized for not exploiting the internal features of the MS (its text), for through reading it, they both doubtless soon discovered it hardly differed from the published version, in which case quoting from the latter would be kinder to readers outside of Toronto who were likely to have access to the *Philosophical Transactions*, should they have wished to verify any readings or interpretations. It is unfortunate that Griffin-Short chose not to reproduce any images from the MS, nor even ductus graphs showing her recreation of the sequence of penstrokes, certainly odd decisions when presenting palaeographical arguments. Other factors rendering her script analyses significantly less useful than they might be are the lack of verifiable references to temporally appropriate script comparanda, the lack of precise citations to the letter forms of the MS, the missing of significant variations in the letter forms, misapprehensions as to what are and are not standard 18th-century English script practices, and an apparent ignorance of established palaeographical nomenclature.

It is to Griffin-Short's credit, however, that among the questions she asks of the MS one at least is cogent, namely "Is it in Wales' hand, or might in be in Dymond's?" (Griffin-Short, 2008, 70). An important question that wasn't asked is the utterly basic one: what *is* this manuscript? Is it the primary record of the scientific observations? Or is it secondary or tertiary record constructed from the primary records by the project scientists themselves or under their commission? Could it have been prepared for the Royal Society's printers? Or was it meant as an archival copy, and if the latter, made by or for whom? A less important although not trivial question is: where and when was the MS produced?

These questions will be addressed in the conclusion, after the presentation of the evidence from the summary palaeographical and codicological analysis of the Toronto MS (a full analysis featuring the graphical representation of the ductus of all the letter forms and their variants, and similarly the different ruling schemata, and the comparison of both to those in other English scientific MSS *ca.* 1760-1770, is not attempted here). The hand of the Toronto MS is also compared to the hand in Sydney, State Library of New South Wales, MS Safe 1 / 84, 1772-1774, *Journal* on the Resolution, 21 June 1772-17 Oct. 1774, attributed by Reid (2008, 173) as well as the museum to William Wales.

Palaeography of the MS (*n.b.* the features chiefly used for this analysis occur on fols. 1r (iii), 17r (xix)-19r (xxi), although the findings were checked against features in the rest of the MS)

1. **General aspect:** the English Round Hand is more disciplined than not, and the letter forms are reasonably stable. The forms of the letters lack the balanced proportion of those in the best writing masters' copybooks (Banson 1702; Bickman 1741?), but what they lack in easy elegance, they make up for in studied clarity. The use of ligatures is light, and abbreviations are few. The pen nib is cut to render the minimum contrast between thick and thin strokes (in palaeographical terms there is minimal "shading"). The hand does not appear exceptional for the period, except in the matter of the angle of the vertical strokes to the lines of ruling, which is noticeably more inclined to the vertical (*i.e.* closer to 90°) than usually encountered.

2. **Angle of vertical strokes to ruling lines:** *ca*. 54°-66° (estimated from measurements of text ascenders).

3. **Characteristic forms** (refer to Fig. 3):

   "**b**"—the ascender is almost never looped

   "**c**"—the shoulder of the letter is relatively short for the period

   "**d**"—the Uncial form appears casually interspersed with the Caroline form

   "**f**"—neither the upper nor the lower loop occupy more than 1/3 the vertical length of the letter

   "**m**"/"**n**"—shoulders frequently do not meet the preceding minims

   "**s**"—tall "s" occurs infrequently, certainly less than average for manuscript and printed books of the period

   "**t**"—the cross bar is either absent to the left of the ascender, or only extends vestigially

   "**&**"—the form is unusual, with a descender curving to the left in place of a foot, and with the vertical angle of the form inclined to the left at an equivalent ("mirror image") angle to the other graphic forms

Comparison of the Hands of the Toronto and Sydney MSS

There are strong divergences between the letter forms of the Toronto MS, and those of the Sydney MS (*n.b.* the features chiefly used for this analysis occur on pp. 1, 2, 171, 177-179, 351, 353 of the Sydney MS, although the findings were checked against features in the rest of that MS. Please refer to Fig. 3):

"**b**"—the ascender of "b" is looped, unlike in the Toronto MS

"**f**"—the loops of "f" occupy more than 1/3 the vertical length of the letter, approaching at times 1/2 the vertical length

"**m**"/"**n**"—the shoulders regularly meet the preceding minims

"**s**"—tall "**s**" occurs more frequently than in the Toronto MS

"**t**"—the cross bar regularly extends to either side of the ascender

"**W**"—the form displays prominent curved upper serifs, particularly on the left, unlike the form in the Toronto MS

The general aspect the MSS differs as well. The proportional minim height is lower in the Sydney MS than in the Toronto MS, leading to more oblate letter forms in the former. Descenders are noticeably longer in the Sydney MS than in the Toronto MS. The scribe of the Sydney MS cut his pen nib to create a very noticeable contrast between thick and thin strokes, in contrast to the scribe of the Toronto MS who favoured greater uniformity (less shading). The angle of vertical strokes to ruling lines is *ca*. 38°-48° (estimated from measurements of

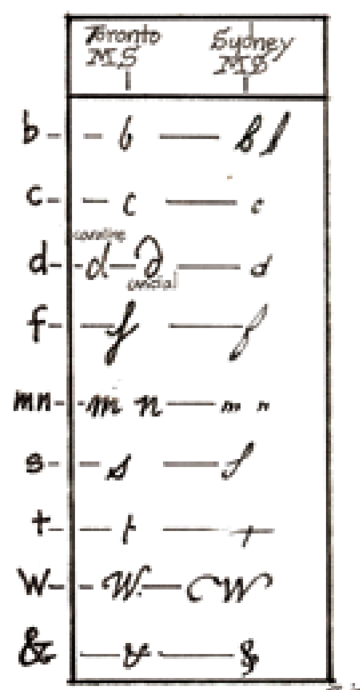


Figure — 3. Letter forms of the Toronto MS compared to those of the Sydney MS.

text ascenders), which approaches a 20° difference between the two MSS.

Codicological description

Toronto, Thomas Fisher Rare Book Library, MSS gen 38.040, post-1769, August 25

1. **Construction:** note book consisting of a single quire of 14 folded bifolios, with 20 folios of text and tables, and occasional notes on versos. See diagram of foliation (Fig. 4).

2. **Binding:** the outer bifolium (same quality of paper as the other bifolia) serves as a cover. The stitching of the binding is now entirely missing. The holes are now easily visible. See the diagram of stitching (Figure 5). The binding holes were probably made with a binding awl, or quill knife (Figure 6).

3. **Paper:** thick, cream-coloured paper, in a good state of preservation. Its macro features contributing to its general aspect are consonant with paper of the mid-18th century. **Mold Pattern**: the chain lines are *ca*. 2.43 cm apart, and the laid lines are *ca*. 0.1 cm apart. **Watermark**: large circular watermark (*ca*. 8.9 cm in diameter) present on some folios (*e.g.* 7v, 12v, 13v-14r, 14v, 19v, 20v-21r, 21v-22r, 22v). Details of the design and legend (outermost circular field) are difficult to discern in white light. The field for the legend is double bordered, top and bottom. Occupying the centre field is a seated figure of Britannia, holding a trident and a sceptre (?); a shield with the Union Jack is also present. At the top and outside of the outermost circular field carrying the legend is a crown. British watermarks featuring this or similar designs were quite frequent in the 18th century, and were found on paper used in government offices, but by no means limited to "official" use (*Correspondence of Adam Smith* 1987, 378).

4. **Dimensions:** the bifolia are 31.35 cm in length, and 20.3 cm in height (measured at the central opening at fol. 12v [XIVv]-13r [XVr]). Pages are *ca*. 15.68 cm in length, and 20.3 cm in height (measured at the same place).

5. **Foliation:** Arabic numbers are entered at the top right, beyond the rulings (with the exception of fols. 7r, 11r, 12r, and 20r), in a grey-pigmented material. The numbers are in the hand of the main manuscript text. Some of the numbers have been partially cut off by post-production trimming (one wonders why this would be necessary with such an informal binding?). The pigment is probably graphite, or just possibly a crayon compound. It is unlikely to be lead. Whatever the composition of the pigment, it was probably in "stick" form, and held in a copper-alloy *porte-crayon* (Figure 6). Alternatively, the stick of pigment may have been encased in wood.

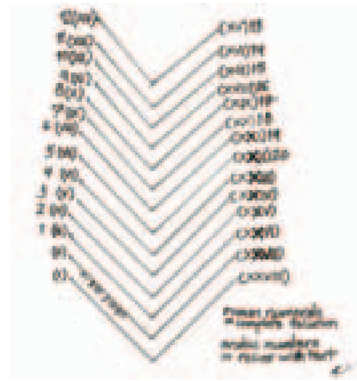


Figure — 4. Diagram showing the arrangement of the sheets in the Toronto MS.

6. **Ruling:** guide marks to aid in the placement of the horizontal lines (rows) are pricking marks (small holes) or indentations. The pricking marks were produced by either the end of a penknife, the point(s) of a divider, a pricker (a specialised awl with a relatively thin metal shaft with a fine point), or a parchment runner ("pricking wheel," a toothed wheel freely rotating on an axle attached to a handle) (Figure 6). **Ruling Patterns**: *ca*. 82% of the inked folios contain tables predominantly with numerical data, and *ca*. 18% contain text. Not surprisingly, the information fields to be accommodated determine the nature of the tables, which in turn set the ruling patterns. In a break with traditional codicological practice, no close analysis of the patterns will be provided here; it would try the patience of readers, and serve no useful purpose (for a typical example of the layout of a page with tabular data, see Figure 1; for a typical example of the layout of a page with text, see Figure 2). After their creation, the guide marks were joined up by ruling lines, made by "pencil" (see section 5 above) and straight-edge (either a plane scale, a plain scale and protractor, a parallel rule, an unmarked rule, or a square, any of which could have been made of boxwood, copper-alloy, or silver; see Figure 6). Particular care was not always taken to align the ruling lines with the guide marks (*e.g.* fol. 8r), or to produce parallel or consistently spaced lines, or to begin and end all lines at the same place. Some major ruling lines were then inked (sometimes following the "pencil" lines very approximately). Vertical lines dividing columns or (sub-columns) one from the other were often treated thus, as well as the horizontal line at the top of a table (or its continuation onto subsequent folia), into which the names of the columns were entered.

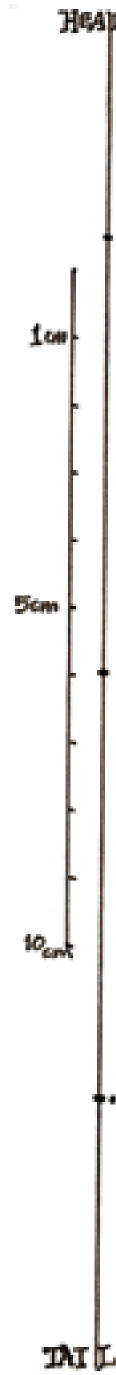


Figure — 5. Diagram showing the location of the sewing stations of the binding of the Toronto MS.

7 **Ink:** the appearance now is of a consistent brown colour throughout, a feature diagnostic of gallo-tannate ink (full chemical analysis would be necessary to confirm this identification). Fortunately, there are no signs of gallo-tannate destruction of the text support, or loss of legibility of the text. If Wales or Dymond wrote the MS on expedition, ink, or materials sufficient for its onsite manufacture, may have been available at the fort, or the astronomers may have carried it from Europe in powdered form (Leekey 1750, 8). The widths of the pen knibs used throughout are consistent. The pens were most likely made from the shed flight feathers of Canada Geese (they were very popular for superior pens in Great Britain and possibly the rest of Europe, and were harvested from the shores of Hudson's Bay; see Wilkes 1799?, 34, 56, and Finlay 1990, 4. It seems reasonable to assume Wales and Dymond would have made use of the local supply). Alternatively, though less likely, the two astronomers could have used metal pens, which did exist at the time (Hambly 1991, 39, col. pl. XIX).

8. **Module:** this can be described as the average space the letters occupy. It is a figure that indicates a tendency rather than a precise value. There are different ways of expressing module. Gilissen's (1973) formula, with its affectation of precision, will not be used here. Rather, the maximum range of the size of certain representative letters ("n" and "o") will be given, sampled from several pages.

   Fol. iir (title page), display script: ascender height= 2.2 mm-4.9 mm; descender depth=3.1 mm 7.5 mm; minim height=2.4 mm-4.6 mm; minim width "n"=3.9 mm-5.7 mm, "o"=2.0 mm-3.5 mm.

   Fol. 1r, display script: minim height=6.4 mm-6.6 mm; minim width "n"=5.8 mm-6.1 mm, "o"=4.5 mm-5.3 mm.

   Fol. 9r, tabular script (bottom table, column 9): minim height=1.0 mm-1.4 mm; minim width "n"=1.3 mm-1.6 mm, "o"=1.0 mm-1.4 mm.

   Fol. 17r, text script ("Remarks" page): minim height=1.2 mm-2.1 mm; minim width "n"=1.5 mm-2.3 mm, "o"=1.1 mm-1.59 mm.

9. **Corrections:** the scribe did not make his corrections through expunctuation. He appears to have preferred the use of a penknife and pounce (dried and powdered resin), the 18th-century version of Wite out. The technique consisted of: i) carefully scraping the area of the mistake to remove paper fibres bearing ink; ii) rubbing pounce into the area; and iii), recompressing and smoothing the remaining fibres by applying pressure with a burnisher, such as the handle of a penknife (Fisher 1757, p. 29). Areas so treated appear somewhat whiter than the rest of the paper, and the normal pattern of chain and laid lines from the paper mold is obscured. Ink written over the scraped and re-pounced surface displays a greater tendency to dispersion compared to ink written on the unaltered surface.

Figure — 6. Tools similar to those used to make the Toronto MS. Reproduced by permission of the Specula astronomica minima.

10. **Provenance:** on the front cover (fol. ir) at the lower left is a note in pencil reading: "JB Tyrrell/June 1928/£3.10". In the upper centre of the same page is an inscription in ink: "Presented to the/ David Dunlap Observatory/ by J.B. Tyrrell./ Toronto/ May 26th 1950." There are no internal indications in the text pointing to the earlier history of the manuscript. The Tyrrell in question is Joseph Burr Tyrrell (1858-1957), the well-known Canadian geologist, palaeontologist, orchardman, fur-trade historian, and accomplished self-mythologizer (Robertson 2007). He proved an astute collector of antiquarian materials related to the annals of Canadian exploration and subsequently a generous patron to the library of his *alma mater*. Tyrrell visited the site of Wales and Dymond's theatre of ToV operations, Prince of Wales Fort, on more than one occasion, and he was most impressed by the substantial remains (Robertson 2007, 197). Such a personal connection to the site may have provided reason enough for Tyrrell's purchase of a MS recording observations made at that very place 160 years previously. Preserved with the MS is a Kraft envelope sent by "J. Patterson/ 97 Walmer Rd/ Toronto, Ont." to "Dr. Frank. S. Hogg/ David Dunlap Observatory/ Richmond Hill, Ont.," inscribed in ink, and pencilled in a different hand "Wm Wales records of 1768/ Very Important." The sender may have been RASC member John Patterson (1872-1956), former Controller of the Meteorological Service of Canada (1929-1946; Anon. 1955, 710; CE, Morley Thomas, John Patterson), and the recipient was RASC member Prof. Frank Hogg (1904-1951), director of the David Dunlap Observatory (1946-1951; Chant 1951).

Conclusion

Who, then, wrote the Toronto MS? Could it have been Wales, or Dymond? In the ideal case, one would have plenty of examples of the handwriting of both for comparison. Among the collections of The Royal Greenwich Observatory at the Cambridge University Library, there are indeed manuscripts apparently in Wales's hand. Reid is familiar with them, and believes that the Sydney MS was also penned by Wales (2008, 173). If that is so, then the Toronto MS was not written by William Wales, as a comparison of features of the respective scripts decisively establishes (see the section above on the Comparison of the Hands of the Toronto and Sydney MSS. A thorough study of Wales's orthography could also serve to confirm or question this conclusion). It was not Reid's aim to provide a palaeographical description of the Sydney MS, as a tool to determine whether it could have been written by Wales, but he does provide good functional reasons for believing that Wales was the scribe. The Sydney MS is a private record of the voyage of the Endeavour as an astronomer might write such a work; besides containing the data of the astronomical observations, it also holds a multitude of quotidian observations concerning many things, including the behaviour of the crew. It was not a document compiled for formal publication. Until a proper palaeographical analysis of Wales's hand from a MS presenting clear internal evidence that he was indeed its scribe is made available, it will be impossible to assert with absolute confidence that he wrote any extant MS.

What, then, *is* the Toronto MS? Leaving the question of scribal identity aside for the moment, could it be the primary record of Wales and Dymond's astronomical observations, that is, the logbook into which observations were entered direct from the telescope or quadrant? Counting in favour of that interpretation is the fact that nearly 25 percent of the MS openings are blank, which could be seen to imply that the size of the text was not even approximately known before writing began. One might imagine that anyone setting out to make a copy of a text would chose a blank book with roughly the right number of pages, in order not to be profligate with paper. Counting against the Toronto MS being the primary record of Wales and Dymond's astronomical observations are the discipline of the layout, the cleanness of the entries, the striking rarity of mistakes requiring correction, the generally un-shopworn appearance, and the fact that a single hand is evident throughout, even entering the observation signatures of both astronomers. To these objections can be added the striking consistency of the colour of the ink, indicating completion of the writing over a shorter rather than a longer period. If this were the original logbook, the composition of the ink would have varied in response to changing atmospheric conditions, for during the severe weather encountered at the fort during the winter of 1768-1769 (Wales 1770, 124), they most probably would have had to add brandy to the ink to try to prevent it from freezing (as recommended by both Mather 1737, 31, and Wilkes 1799, 51), and such changes of ambient humidity, temperature, and chemistry may very well have affected the intensity of the colour. In short, there is simply not enough information to decide if this is the original logbook, or not. Chances are that it isn't.

The characteristics noted above would, however, accord with the MS being a secondary or tertiary record constructed from the primary records (whatever physical form they may have taken), written either by one of the project scientists themselves, or by another under their commission.

Could the MS have been a copy prepared for the typesetters of the printers of the *Philosophical Transactions*? Possibly, but there are no signs of compositors' notes, and MSS copies intended for printers enjoyed a notoriously low rate of survival. The state of the MS seems to speak against this possibility. The fact that the MS is presently unbound is not evidence that it was in the hands of the printers, for we don't know when the stitching was removed.

It is difficult to marshal evidence against the MS being a retrospective copy produced for archival purposes. Reid's handling of the broader MS evidence implies that the Toronto MS is not in Wales's hand, but that doesn't mean Wales didn't own it; he could have had someone else produce the copy. Contrary to popular belief, the printing press did not kill the commercial production of manuscript books; there were times and conditions when it was economically attractive to commission a MS copy of a printed work (Danish court Chamberlain W.H.R.R. Giedde's collection of later 18th-century chamber music is a perfect example; Rosenfeld 2009). That means that anyone in the 18th-century could have copied Wales and Dymond's report from the *Philosophical Transactions*. The few corrections on the versos of the folios could have been corrections made against the published version. In the absence of any library stamp, bookplate, or signature, it is impossible to say who owned the MS, let alone who might have commissioned it.

Can we say when and where the MS was made? The answer is no. The possibilities include production at the Fort late in Wales and Dymond's residence there, or onboard ship during the return trip to England, or anywhere in Europe or the New World where someone desired to have a MS copy of Wales and Dymond's observations.

It is not inconceivable that most of these questions will remain unresolved by the time of the next transit of Venus in 2117. Urania's sister Clio has a fine disregard for a mere mortal's sense of time. ✶

Acknowledgements

I wish to thank Lee Robbins, Librarian of the Department of Astronomy & Astrophysics of the University of Toronto for help in locating Thomas Fisher Rare Book Library, MSS gen 38.040, and Anne Dondertman, Acting Director, Thomas Fisher Rare Book Library, University of Toronto, for granting permission to photograph, study, and reproduce several images from the MS, and the staff of the Thomas Fisher Rare Book Library for being so accommodating.

References

Manuscripts, Books, and Articles

Anon. (1955). *Nature 175* (April 23), 710.

Anon. (2007), Dymond, Joseph. In T. Hockey, *et al*. (Eds.), *Biographical Encyclopedia of Astronomers*, I. (320). New York-Dordrecht-Heidelberg-London: Springer.

Banson, W. (1702). *The Merchant's Penman.* London: John Stuart[?].

Beaglehole, J.C. (1992). *The Life of Captain James Cook*. Palo Alto: Stanford University Press.

Bickham, G. (1741?). *The Universal Penman.* London: R. Sayer.

Chant, C.A. (1951). Frank Scott Hogg, 1904-1951, *JRASC 45, 1,* 1-3.

Dymond, J. & Wales, W. (1770). Observations on the State of the Air, Winds, Weather, &c. Made at Prince of Wales's Fort, on the North-West Coast of Hudson's Bay, in the Years 1768 and 1769, *Philosophical Transactions 60*, 137-178.

Fernie, J.D. (1976). *The Whisper and the Vision: the Voyages of the Astronomers*. Toronto: Clarke, Irwin & Company.

Fernie, J.D. (1998). Marginalia: Transits, Travels and Tribulations, IV, in *American Scientist 86, 5*, 422-425

Finlay, M. (1990). *Western Writing Implements in the Age of the Quill Pen*. Wetheral, Carlisle, Cumbria: Plains Books.

Fisher, G. (1757). *The Instructor....* London: W. Johnston.

Gilissen, L. (1973). *L'Expertise des écritures médiévales: Recherche d'une méthode avec application à un manuscrit du XIe siècle. Le Lectionnaire de Lobbes* (Codex Bruxellensis 18018). Ghent: E. Story-Scientia.

Hambly, M. (1991). *Les instruments de dessin 1580-1980.*Paris: Ars Mundi.

Hogg, H.S. (1957). With the Stars: 1769 Astronomical Trip Into Canadian Arctic Had Valuable Results, in *The Toronto Star, September 21*.

Hogg, H.S. (1977). The Stars: Venus is Bright and High, in *The Toronto Star, February 19*

Leekey, W. (1750?). *A Discourse on the Use of the Pen*. London: R.Ware.

Mather, W. (1737). *The Young Man's Companion: or Arithmetic Made Easy....* London: R. Ware-J. Clarke-T. Longman.

Orchiston, W. (2007). Wales, William, in T. Hockey, *et al*. (Eds.), *Biographical Encyclopedia of Astronomers*, II. (1189-1190). New York-Dordrecht-Heidelberg-London: Springer.

Reid, F.L. (2008). William Wales (*ca*. 1734-1798): Playing the Astronomer, in *Studies in the History and Philosophy of Science 39*, 170-175.

Robertson, H. (2007). *Measuring Mother Earth: How Joe the Kid Became Tyrrell of the North*. Toronto: McClelland & Stewart.

Rosenfeld, R.A. (2009). 'Giedde Online:' a Valuable Resource for Scholars and Players of the Baroque Flute (125-129). In A. Powell, (Ed.), *Traverso: the Second Decade, 1999-2008*. Hillsdale, NY: Pendragon Press.

Sheehan, W. & Westfall, J. (2004). *The Transits of Venus*. Amherst, NY: Prometheus Books.

Smith, Adam (1987). The Correspondence of Adam Smith. In E.C. Massner & I.S. Ross, (Eds.), *The Works and Correspondence of Adam Smith*, *Vol. 2*. Oxford: Clarendon Press.

Wales, W. & Dymond, J. (1769). Astronomical Observations Made by Order of the Royal Society, at Prince of Wales's Fort, on the North-West Coast of Hudson's Bay, *Philosophical Transactions 59*, 467-488.

Wales, W. (1770). Journal of a Voyage, Made by Order of the Royal Society, to Churchill River, on the North-West Coast of Hudson's Bay: of Thirteen Months Residence in that Country; and of the Voyage Back to England: in the Years 1768 and 1769, *Philosophical Transactions 60*, 100-136.

Wilkes, J. (1799?). *The Art of Making Pens Scientifically*, 2nd ed. London: J. Vigevena.

Wolf, H. (1959). *The Transit of Venus: A Study of Eighteenth-Century Science*. Princeton, NJ: Princeton University Press.

Wulf, A. (2012). *Chasing Venus: The Race to Measure the Heavens*. New York: Alfred A. Knopf.

Web sites

Canadian Encyclopedia: Morley Thomas; John Patterson www.thecanadianencyclopedia.com/articles/john-patterson (accessed 2012 May 25)

Dictionary of Canadian Biography Online: G. Williams; Wales, William www.biographi.ca/009004-119.01-e.php?&id_nbr=2203. (Accessed 2012 May 27)

Oxford Dictionary of National Biography: E.I. Carlyle/D. Howse; Wales, William www.oxforddnb.com/view/article/28457. (Accessed 2012 May 27)

Transit of Venus Project: R.A. Rosenfeld; Return to the Sources www.transitofvenus.nl/wp/2012/05/13/return-to-the-sources. (Accessed 2012 May 13)

[1] The recent discussions of Wales & Dymond in Sheehan & Westfall 2004, pp. 165, 189-190, and Wulf 2012, pp. 127-130, 141-142, 147-148, 155-156, 175, 195, and 201, whatever their merits, add nothing to previous treatments; and they must be used with caution on some points (ToVP Rosenfeld, Return to the Sources).

[2] I wish to thank Eric Briggs of the Toronto Centre for alerting me to Prof. Hogg's articles.

Cosmic Contemplations

Guide-Free, Diffraction-Limited Imaging with Emccds

by Jim Chung, Toronto Centre
(jim_chung@sunshine.net)

"Lucky imaging" is a term coined by David Fried in a 1978 paper in which he discussed the probability of obtaining a sharp short-exposure image through poor-sky-seeing turbulence. In 2007, the University of Cambridge and Caltech demonstrated this technique with the 5-metre Hale telescope at Palomar. Using an EMCCD (electron multiplying) camera with adaptive optics and short exposures of less than 100 milliseconds, they obtained diffraction-limited performance in the visible spectrum rivalling that of the *Hubble Space Telescope*. In several past columns, I've demonstrated how imaging developments in microscopy can be easily transferred to amateur astronomical applications. Microscopy imaging has driven the commercial development of EMCCD technology, such that it is currently within the reach of well-heeled amateur astronomers, and will continue to disseminate more widely with time. Not personally belonging to the former group, I relied upon the generosity and quick willingness of Rob Grant and Kevin Foster of Princeton Instruments in arranging the loan of one of their current EMCCDs, the PhotonMAX 1024B.

An EMCCD differs from a conventional CCD in that the electron signal is multiplied on board the imaging chip prior to readout, in a process similar to a photomultiplier. Secondary electrons are generated for each signal photon/electron when higher-than-typical (20-40V) clock voltages needed for electron transfer are applied. This accelerates the charge-carrier

Figure 1 — The PhotoMAX EMCCD camera.

Figure 2 — The long mounting plate (a) needed to adapt the camera to the Celestron telescope (b).

electrons to high enough velocity to generate additional electron carriers via impact ionization in a special portion of the CCD's serial register.

A CCD generates "read noise" from its circuitry, particularly when faint signals are preamplified prior to conversion from analogue to digital values; typically, a well-designed CCD has a read noise value of 13 e^- rms (root mean square). This means that single photon signals cannot be detected, because the signal does not rise above this read-noise floor. One solution is to increase the signal with a prolonged exposure, but this requires an expensive tracking mount with guiding corrections that will also be subject to variations in atmospheric turbulence or seeing. An EMCCD reduces the read noise to 1 e^- rms while increasing the signal by 1000×, allowing a concomitant reduction in exposure time that obviates the need for a tracking mount. Similar in fashion to amateur planetary imaging, the short exposure allows the freezing of good seeing, so that stacking selected good frames with the requisite software allows an amateur to obtain diffraction-limited results regardless of seeing conditions.

The PhotonMAX utilizes a back-illuminated frame transfer 1024×1024 CCD with large 13-μm pixels and a QE (quantum efficiency) of 90%. A powerful thermal-electrical cooler lowers operating temperatures to -55 °C, resulting in a dark current of only 0.08 e-/pixel/second. The camera was designed to allow real-time intracellular imaging of very faint light signals. This includes techniques such as fluoresce-*in-situ* hybridization (FISH), where fluorescently labelled antisense strands of DNA display the location of genes on individual chromosomes, helping to determine whether translocation events can account for genetic anomalies.

Fortunately, the PhotonMAX came equipped with a standard C-mount lens thread. Among my collection of astro odds and ends, I found a C-thread to T-thread adaptor that allowed me to mount a 2-inch to T-thread adaptor and connect the EMCCD to my 8-inch Celestron SCT.

I purchased a piece of 3×24×1/2-inch-thick aluminum plate and used a table saw to cut a 45° bevel on each side to make a very long Losmandy-style dovetail bar. This long bar was required to mount both the SCT and the EMCCD in tandem as shown in Figure 2.

Because I live in the city, I was unable to demonstrate sub-second imaging in visible light, but the EMCCD was perfectly responsive with narrowband imaging. Using only 30-s subexposures (although shorter exposures would have been preferable, as there is evidence of some horizontal star blooming) I managed to image the Dumbbell Nebula in under 10 minutes, unguided, at a focal length of 2000 mm. Figure 3 is the result—a false-colour image using hydrogen alpha (Hα) and oxygen III (OIII) narrowband filters.

As CCDs have become more affordable, and so, hopefully, will EMCCDs. There are some inherent disadvantages to the EMCCD that may be a barrier to mass-market production. There can be a variable number of electrons produced during the EM process that can lead to an increase in overall shot noise and reduction in the effective QE. High dynamic range can only be maintained at low frame rates. The sensors are only made by two manufacturers and are expensive and currently limited to a maximum of 1024×1024 pixels. High power consumption requires very substantial thermal-electric cooling. New developments in the field of sCMOS (scientific CMOS) low-light imaging may be the technology that reaches amateur astronomers first, since these chips offer some of the virtues of EMCCD and have the advantage of being lower in cost, having much faster frame rates (planetary applications?), high resolution (6.5-µm pixels), and larger arrays (5.5 megapixels). These types of imagers will be a boon to the young urban amateur astronomer who doesn't have much spare time to devote to imaging nor lives in an area with a large percentage of clear nights. I returned the PhotonMAX after only a week and I still miss it! ✶

Jim Chung has degrees in biochemistry and dentistry and has developed a particular interest in astroimaging over the past four years. He is also an avid rider and restorer of vintage motorcycles, which conveniently parlayed into ATM projects. His dream is to spend a month imaging in New Mexico away from the demands of work and family.

Figure 3 — The Dumbell Nebula, imaged through the EMCCD camera.

Rising Stars

The Distance from Computer Science to Astrobiology is "0" in Mike Gowanlock's Universe

by John Crossen, Buckhorn Observatory
(johnstargazer@xplornet.com.)

Mike Gowanlock is travelling numerous roads on his journey to a Doctorate in Computer Science from the University of Hawaii.

The computer-science aspect that Mike is involved in is high-performance computing. He's devising new methods that will decrease the time necessary to carry out computationally intensive simulations. In his endeavours, he's acting both as the scientist (astrobiologist) and the computer scientist, searching for faster solutions to increasingly complex problems. The journey is not yet complete, but his travels have already taken him along some fascinating pathways.

In addition to his pursuit of a Ph.D., Mike is also a Research Assistant with the NASA Astrobiology Institute. The project for his research assistantship came out of the challenge of overlapping disciplines and their respective sets of terminology. Integrating that terminology into a common vocabulary is a big undertaking. Mike's job is to measure the degree of interdisciplinary thinking present in papers authored by scientists who are funded by the NASA Astrobiology Institute—but that's just one aspect of his work. Knowledge from many fields is required to perform scientific research.

Mike's expertise on habitability within the Milky Way Galaxy comes from his M.Sc. work at Trent University. Initially, one of Mike's computer-science professors at Trent, Dr. Sabine McConnell, suggested that he consider working with her and Trent's Dr. David Patton on an astrobiology project for his Masters thesis. Titled *A Model of Habitability within the Milky Way Galaxy*, the work was published in the international, peer-reviewed journal *Astrobiology* in the November 2011 edition. Mike sums up the study with these words:

> *If you wondered where the most habitable places in the galaxy might be, using Earth as a model, you would look for conditions similar in temperature that would allow for liquid water on a planet's surface, conditions that would be conducive to the possibility of life. To begin with, you have to have a star that hosts planets.*
>
> *As metallicity increases over time due to the continual birth and death of stars in certain areas of the galaxy, chances for the development of planets increase. Metallicity refers to the abundance of elements heavier than hydrogen or helium, in other words, the stuff that planets are made of.*

Figure 1 — Mike Gowanlock.

Is there life on Mars? "Not that we know of," says Gowanlock, "but we're following the trail of water. We have reason to believe basic life is widespread," he continues, "but complex life (like a plant involved in the process of photosynthesis, for example) may not be common at all."

Mike's M.Sc. paper laid the groundwork for his on-going involvement in astrobiology. According to Mike, "I've been working on implementing a more sophisticated model of the Milky Way that will allow us to probe habitability in the inner region of the galaxy. This is an area that was not modelled in our previous work."

"Our previous work suggested that the inner region of the galactic disk contains the greatest number of habitable planets conducive to complex life, as based on estimates of planet formation rates and considering the dangerous effects of supernovae sterilizations. We did not attempt to model the innermost regions of the galaxy in this model. The innermost region that we modelled was at 2.5 kpc from the galactic centre."

In the pursuit of his Doctorate, Mike continues to work with Trent U. colleague, Dr. David Patton and is widening the scope of his original study.

> *Astrobiology is a relatively new field, and I think that the field benefits from the fact that many of the discoveries made are of great interest to the public. Advancements made in astrobiology are beginning to answer some of the most fundamental questions regarding life in the Universe. These are questions that civilizations have pondered for millennia, which we are now finally able to study through scientific means.*

Furthermore, advancements in the field seem to be occurring rapidly. For example, after the first exoplanets were found, many researchers focussed their efforts on the field of planet formation. This exciting field is trying to understand how planets form around other stars. Between theoretical models of the formation of planetary systems and observational studies, we are finding that there are many different configurations in which planetary systems are found. These studies captivate the public's imagination.

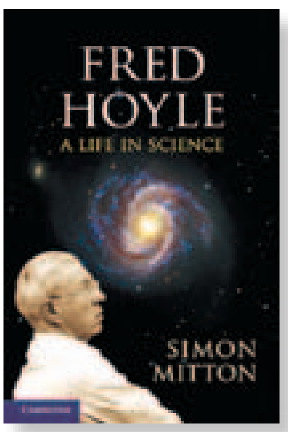
I think of exoplanet searches as a key component of astrobiology. The Kepler mission is giving us incredible information pertaining to the frequency of planets around other stars. One of the main goals of these searches is estimating the frequency of Earth-sized planets. Of particular interest is the habitability of these other planetary systems; a key component of such an assessment is determining the distance that these planets orbit their host stars such that water can remain in a liquid state on the planet's surface.

If it had not been for my Trent U. Professors Sabine McConnell and David Patton, I'd likely be working in something radically different. I have to say, I'm very happy with how my academic career has developed thus far. Looking back, I can't imagine focussing my efforts in work unrelated to astrobiology. ✶

John Crossen has been interested in astronomy since growing up with a telescope in a small town. He owns www.buckhornobservatory.com, a public outreach facility just north of Buckhorn, Ontario.

Reviews / Critiques

Fred Hoyle: A Life in Science, by Simon Mitton, pages 369+xi, 16 cm × 23 cm, Cambridge University Press, 2011. Price £20. Paperback (ISBN: 978-0-521-18947-7).



In *Fred Hoyle: A Life in Science*, Simon Mitton has assembled an engaging biography of one of the most productive, influential, and controversial astrophysicists in recent British history. From his birth in 1915 to his death in 2005, Fred Hoyle devoted most of his life to the pursuit of a variety of high-profile scientific investigations, almost all of which were ground breaking, of an astronomical nature, and directly linked to subsequent work in the field. Even his war service working on improvements to naval radar ranging was an important contribution to the ultimate Allied victory.

Mitton's *A Life in Science* is arranged in somewhat unusual fashion. Initially, it is ordered temporally to describe Hoyle's origins, childhood experiences, and education, continuing the thread through his experiences as an undergraduate student, graduate student, and postdoctoral fellow at Cambridge. Much of Hoyle's life will be of interest to readers wishing to learn more about the vagaries of the British educational system of the early 20th century, a system in which intelligence and ability were not necessarily a guarantee of success or acceptance. After that, the ordering is roughly by research topic, in order to provide details of how Hoyle's work in those areas evolved over the years.

Mitton does a good job of placing Hoyle's scientific and later administrative efforts into the context of what was happening at the time, to the point that I developed a deep appreciation for the philosophy and methodology that Hoyle followed in order to seek the shortest path to advancing knowledge in astrophysics. He was a strong adherent of allowing bright minds to find and pursue unhindered those areas that interested them most, which is not always the case in science. My impressions of Hoyle and his work during my younger days were often formed from a distance in the context of the sometimes negative or derogatory reactions generated in other astronomers of my acquaintance, and I was happy to learn more of the positive details of the controversial sections of Hoyle's career: his ongoing feud with Martin Ryle, the founding and operation of the Institute of Theoretical Astrophysics (IOTA) at Cambridge, and his years as a media icon.

The human side of Hoyle is also described, from his long-term goal of climbing all of Britain's peaks to his never-ending quest to find adequate finances to support his education, career, family, and research. I found myself growing closer to Hoyle and his ideologies the more I read. It was also interesting to discover how he was responsible for introducing Julie Christie to a potential career in the cinema as a result of finding actors for his *A is for Andromeda* series on the BBC. My years in Canada left me unaware of Hoyle's lengthy media career in Britain, where he was a household name for many years on matters of science and astronomy.

Hoyle's prolific publication record focussed on a selection of somewhat diverse topics. His early work on the accretion theory of star formation with Ray Lyttleton is little cited these days, and he is much better known for his work with Willy Fowler and Margaret and Geoffrey Burbidge on the seminal papers on the origin of the elements in the 1950s, the famous

B²FH paper (Burbidge, Burbidge, Fowler, and Hoyle—an arrangement determined by alphabetical ordering rather than by importance of input) and others that have been reprinted frequently by *Reviews of Modern Physics*. It was Fred Hoyle who also introduced the concepts of steady-state cosmology, which seems like only a minor historical blip in the present era where Big-Bang cosmology is the mantra. His later years saw him becoming equally controversial with Chandra Wickramasinghe in the Diseases from Space publications.

A less generous author might have included editorial content discussing the pros and cons of Hoyle's ideas, but Simon Mitton has wisely left readers to judge Hoyle's life for themselves. It worked for me, given that my own career has witnessed the same obstacles and concerns encountered on a regular basis by Fred Hoyle throughout his life. University, business, and government politics are no different in North America than they were (and are) in Britain, and readers should be interested in learning what the life of a typical scientist is actually like. In Hoyle's case that involved original research, a moderately heavy teaching and administrative load, considerable involvement with the media, and the development of active collaborations with some of the finest scientific minds of his era. Hoyle's frequent struggles with journal editorial boards and astrophysicists holding conflicting views may be the signature of a scientist whose work has a lasting impact on the field.

If there are any weaknesses in *A Life in Science*, they lie in the astronomical descriptions, curiously enough. There are places in the text where it is not clear that Mitton is familiar with the intricacies of the astronomical phenomena that he is describing. While explaining about the number of sunspots, for example, it is not clear that the numbers being referred to are actual counts of spots on the Sun's surface or references to Wolf numbers, which are quite different. He also refers to the colour-magnitude diagram of a star cluster as a "run of colour against magnitude among the stars," which seems to mix the coordinates. Later, there are some confusing statements about stellar populations. Nowadays, for example, we would probably describe the "ordinary stars in the solar neighbourhood" as disk population rather than Population I. The distinctions are typically subtle, and might easily be overlooked by the casual reader.

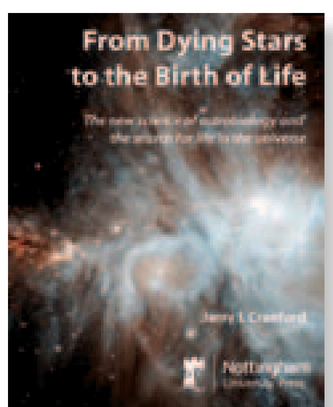
In general, however, I recommend *Fred Hoyle: A Life in Science* wholeheartedly. It is a good read that provides many interesting insights into the life of a well-known British astrophysicist of the last sixty years. There is much that one can learn from the rich life experiences of Fred Hoyle that are relevant to our own lives. ✶

David G. Turner

David Turner is Professor Emeritus of Astronomy and Physics at Saint Mary's University in Halifax, and specializes in the study of open clusters and variable stars. He is also a life member of the RASC, and best known for his work deciphering the meaning behind the chancel ceiling stars of St. John's Church Lunenburg. He was also the editor of this Journal *for many years.*

From Dying Stars to the Birth of Life

The new science of astrobiology and the search for life in the universe, by Jerry L. Cranford, pages 237+ix, 19.5 cm × 25.5 cm, Nottingham University Press, 2011. Price £24.99 (CDN $40.79). Hardcover (ISBN 978-1-907284-79-3)



The title and attractive cover of this book promise an engaging read. The story of how we came to understand stellar evolution and its relationship to the development of life on Earth, and possibly on other celestial bodies, is one that needs to be told in an accessible way. It is a big, fascinating story that parallels the development of science itself.

The author is an amateur astronomer of many years and a self-proclaimed amateur astrobiologist with a great love of his subject. He has set out to synthesize and simplify an enormous amount of scientific information. His objective is to relay that information to the interested lay reader in an engaging way. It is a daunting task! To his credit, his passion for the subject shines through. He avoids the use of technical and scientific jargon in an effort to make a complex subject understandable to non-science readers.

The book follows a logical chronological sequence. There is good use of background information to support and develop the concepts presented in the book. All the pertinent information is there. The book is divided into eight chapters of varying length. Each chapter is further divided into sections. The introductory and concluding chapters are short. The six main chapters organize the content of the book into the following big ideas:

- The history of astronomical science, cosmology, and stellar evolution
- The origins of life on Earth
- The co-evolution of Earth systems, the biosphere, and mass extinctions
- The search for extra-solar planets and extra-terrestrial life
- Interstellar travel and communications, and UFOs

But there are some major problems. Regrettably, the book suffers from a lack of judicious editing. It is verbose with run-on sentences and too-long paragraphs. The author is prone to editorializing, which does not add anything of value. There are large and unrelieved blocks of text that in some cases are several pages in length. The notable over-use of bold and italic text and unnecessary use of combined bold, italic, underlined text is distracting. Quotation marks are inappropriately used to emphasize words and phrases. There are more effective ways for a writer to make a point.

Additionally, the book suffers from poor layout and design. The text is presented in a single column of justified text. This layout hinders readability by stretching words and spaces to fill the entire single-column layout. The lack of visual breaks slows the reader considerably. The eye loses track of its position across the page. Coupled with overly long sentences and paragraphs, the reader is soon lost and must retrace his or her steps to start again. Too-long chapter titles and headings and the use of all-capped fonts for titles and headings further detract from the book's readability.

There is a lack of visible structural elements in the presentation of the content. By this I mean that there are no neat and obvious visible divisions of content. It is hard for the reader to browse the book and identify particular subjects. Content needs to be broken up into easily digested portions that are delineated by adequate and concise titles, headings, and sub-headings. Sections would be better delineated if separated by white space and highlighted with summarizing introductory sentences, relevant illustrations, callout boxes, bulleted lists, and other tools to effectively present information. The reader should be able to flip though the pages of a chapter and see immediately by the images, titles, headings, and callouts, what the chapter contains. Instead, the reader is confronted with large, solid blocks of text that give no hint of content. It is off-putting and does not encourage involvement in what should be a lively and engaging read.

Some chapters contain more illustrations than others; most are publicly available from sources such as NASA and Wikipedia. Sadly, some are of low resolution and poor quality (example: Figure 2-36 on page 50; Figure 3-13 on page 81). This presents a visual hodge-podge with no uniform style.

There are a few minor punctuation and spelling errors. A personal nitpick for me is the word "Earth." When referring to the planet upon which we live, it is almost always capitalized. It is not capped when one speaks of earth in the context of soil, or the ground we walk on.

The book lacks a foreword by a recognized scientist to introduce it to the reader. There is a briefly annotated list of 27 of the author's recommended sources, entitled *Further Suggested Readings*. There is no glossary of terms, or any bibliography or list of cited references. The index is a brief (single column, large font, few entries) nine pages.

If this book was stringently edited and restructured with an effective layout, it would be much shorter and far more engaging to read. In an unfortunate disconnect, the binding and cover make it look like a textbook, but the content is clearly intended for the interested lay reader. It has a wonderful story to share with its audience. It is a shame that the lack of proper editing and design makes this book such a challenge to plough through. ✶

Mary Lou Whitehorne is Past President of the RASC and a retired astronomy educator, author, and curriculum developer. She thinks hot upper-main-sequence stars are cool. She holds the Chant Medal, and the Simon Newcomb and Las Cumbres Awards. Asteroid 144907 Whitehorne is named in her honour.

Second Light

Second Light: A Massive Starburst Galaxy 1.1 Billion Years After the Big Bang

by Leslie J. Sage
(l.sage@us.nature.com)

The *Hubble* Deep Field was a long observation of a spot in the sky, using the *Hubble Space Telescope*. The purpose was to search for galaxies in the early Universe. It was followed up at several different wavelengths, including the sub-millimetre, where the signature of active star formation at high redshifts is seen (Hughes *et al.* in the 1998 July 16 issue of *Nature*). The brightest sub-millimetre source in the *Hubble* Deep Field (HDF850.1) has remained mysterious till now. No counterpart is known at any other wavelength, and no redshift had been determined, but Fabian Walter of the Max Planck Institute of Astronomy, in Heidelberg Germany, and his colleagues have now measured its redshift to be 5.18, which is strikingly bigger than almost all other sub-millimetre-bright galaxies (see the 2012 June 14 issue of *Nature*).

Dust heated to ~30-40 K by massive young stars radiates with a peak emission around 100 microns. At a redshift of ~5, this peak is observed at ~600 microns. The Submillimetre Common-User Bolometer Array (SCUBA) instrument on the James Clerk Maxwell Telescope on Mauna Kea (of which Canada is a significant partner) has detectors at 450 and 850 microns, so it was obvious to David Hughes and his collaborators 15 years ago that an observation of the *Hubble* Deep Field would likely yield something very interesting. Little did they know just how interesting it would turn out to be!

Much effort was expended for over ten years in looking for a counterpart for HDF850.1 (as the source was named) and searching for a spectral line—any line—that would give a hint of how distant it was. Astronomers were quite perplexed that HDF850.1 would not give up its secrets, as many other sub-millimetre-bright galaxies had at least radio counterparts, and most of them were in the redshift 2-3 range.

Walter and his colleagues performed what is known as a "full frequency scan" in the 80-115 GHz range to search for lines. (Gary Welch of Saint Mary's University and I did this for the radio source NRAO 150 more than ten years ago—we never did find a line, so the result has not been published.) They found two lines from carbon monoxide, which is the most abundant molecule in the Universe after hydrogen. In the absence of a known redshift, multiple lines are needed in order to determine which molecule is being seen. The unique spacing of the lines seen at 93.2 and 111.8 GHz strongly suggested the J=5-4 and J=6-5 transitions of CO at a redshift of 5.18. On the assumption that this was correct, Walter then tuned the radio receivers to 307.4 GHz, corresponding to a line emitted by singly ionized carbon atoms (the rest wavelength is 158 microns), which is known to be strong in starburst galaxies. The line was there, so the redshift of 5.18 was confirmed. At this redshift, the Universe was just 1.1 billion years old.

Walter then was able to estimate the amount of gas giving rise to this emission, and it's an extraordinary ~30 billion solar masses, which is about one-quarter of the total mass of the galaxy. In the Milky Way, molecular gas is about one percent of the total mass. Stars form from molecular gas, and there is a lot available in HDF850.1; Walter calculates that gas is being turned into stars at a rate of about 850 solar masses per year. The rate in the Milky Way is a few solar masses per year. The reason it is not visible at other wavelengths is that the copious amounts of dust associated with the gas effectively absorb optical and ultraviolet light. It's just like a flashlight inside a thick fog—you do not have to be very far from the flashlight before all the light is absorbed or scattered, making the light invisible.

But HDF850.1 gets even more interesting. It is part of a group of 13 galaxies (including a quasar) at the same redshift, making it one of the most distant proto-clusters known. The reason this is interesting is because it takes time to grow a cluster.

In the early Universe, as sampled by the microwave background, the distribution of gas deviated from uniformity by just one part in 100,000. Those tiny deviations grew over time as the regions where the density was higher than average accumulated gas and grew—through gravity—into filaments where galaxy formation occurred. In simulations of this process, clusters and superclusters of galaxies form where two or more filaments overlap. Where the initial density was somewhat less than average, voids developed. They became intergalactic space.

The process of gravitational accretion of mass happens slowly at first, so it is striking to see such a large group of galaxies, including a full-blown quasar, existing just a billion years after the Big Bang. Clusters did not become common until a redshift of about 1, when the Universe was about 6 billion years old. The peak densities of quasars and sub-millimetre-bright galaxies happen in the same redshift range of z~2-3, when the Universe was 2-3 billion years old.

Gradually we are building up a picture of the early Universe. Personally, I cannot wait till the *James Webb Space Telescope* is launched (probably in 2018 or so), as it will reveal yet more wonders. I suspect that one of the first big projects it will do is a deep observation of the *Hubble* Deep Field to see what new surprises await us there. ✶

Leslie J. Sage is Senior Editor, Physical Sciences, for Nature Magazine *and a Research Associate in the Astronomy Department at the University of Maryland. He grew up in Burlington, Ontario, where even the bright lights of Toronto did not dim his enthusiasm for astronomy. Currently he studies molecular gas and star formation in galaxies, particularly interacting ones, but is not above looking at a humble planetary object.*

Astrocryptic Answers

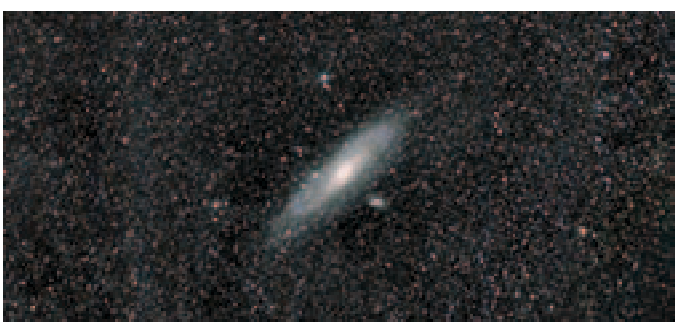
by Curt Nason

1 T	R	2 A	N	3 S	I	4 T	■	5 Y	O	6 U	N	7 G
I	■	U	■	E	■	I	■	E	■	R	■	E
8 M	U	S	I	C	■	9 T	E	L	E	S	T	O
E	■	S	■	O	■	L	■	L	■	A	■	T
10 S	C	I	E	N	C	E	■	11 O	M	E	G	A
■	■	E	■	D	■	S	■	W	■	■	■	I
12 I	N	S	E	C	T	■	13 Z	K	O	14 P	A	L
M	■	■	■	O	■	15 T	■	N	■	I	■	■
16 P	L	17 A	I	N	■	18 U	N	I	C	O	R	19 N
E	■	T	■	T	■	R	■	F	■	N	■	O
20 T	E	R	R	A	C	E	■	21 E	V	E	N	T
U	■	I	■	C	■	I	■	N	■	E	■	E
22 S	M	A	R	T	■	23 S	A	T	U	R	N	S

Errata

We goofed, as several of you have informed us. The photo of the Andromeda Galaxy (identified as IC342) on page 116 of the June issue should be attributed to Dalton Wilson. Here is the correct caption:

Figure 7 — The Andromeda galaxy is a familiar object to RASC members, but this wide-angle shot by Dalton Wilson places it within its environment and gives it a majesty that higher magnifications subdue. Dalton trapped enough photons for this image using a Canon 40D with a Nikkor 105-mm lens; exposure was 21×240s (3h 6m) in January this year. ✶



Transit Tales

Randall Rosenfeld and Walter MacDonald have arranged a collage of images and stories from the June 5 Transit of Venus, at http://rasc.ca/transit-2012-results.

Society News

by James Edgar, Regina Centre
(jamesedgar@sasktel.net)

The May 20 partial solar eclipse in the western part of the country was a precursor to the June 5 Transit of Venus. Lots of people were out at events showing off the partially blocked Sun. I'm now writing this on the eve of that very transit—the last one for many years. One wag wrote "I'll be celebrating my 171st birthday next time around!" I know there are numerous outreach events planned, and I trust you had good weather for that once-in-a-lifetime event! (Well, twice, if you happened to see the 2004 transit…)

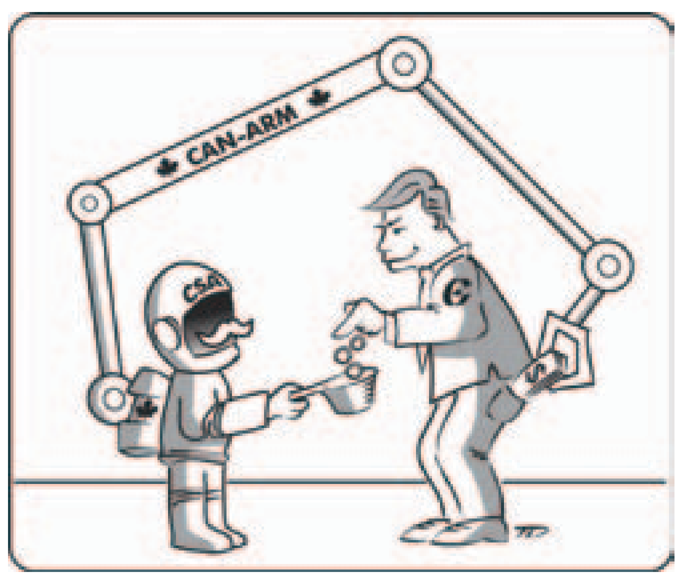
Last issue I wrote of the Society having to hire a new Membership and Publications Coordinator, and here I'm doing it again. Julia didn't stick around, and we've hired Fatima Riaz to work at National Office.

As a result of our having to write new By-Laws, we find there is much else in need of revision that ties in with them—a revised RASC Manual, which includes a new Policy Manual, the GA Manual, the Web site—making a large list. One small detail is that we can begin to officially use the term Annual General Meeting. Our By-Laws have only used the term Annual Meeting up to now, but many people over the years have been overheard in dusty corridors using the initials "AGM"—now you can use it without flinching!

Don't forget to plan an Education and Public Outreach event at a location near you—it's our mandate, and what keeps us active. What better place or way to attract new members? ✶

It's Not All Sirius—Cartoon

by Ted Dunphy



THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

Executive committee and appointed officers for 2012/13 | Comité exécutif et membres attitrés pour 2012/13

Honorary President	Jim Hesser, Ph.D., Victoria
President	Glenn Hawley, B.Sc., B.Ed., Calgary
1st Vice-President	Colin Haig, B.Sc., M.Sc., Hamilton
2nd Vice-President	Chris Gainor, B.A., M.Sc., Ph.D., Victoria
Secretary/Recorder	James Edgar, Regina
Treasurer	Denis Grey, B. Math., M.B.A., Toronto
Past President	Mary Lou Whitehorne, Halifax
Editor of Journal	Jay Anderson, B.Sc., MNRM, Winnipeg
Editor of Observer's Handbook	David M.F. Chapman, M.Sc., Halifax
Editor of The Beginner's Observing Guide	Mary Lou Whitehorne, Halifax
Editor of Observer's Calendar	Paul Gray, Halifax
Executive Director	Deborah Thompson, CAE, Toronto

Centre addresses/Adresses des centres

The most current contact information and Web site addresses for all Centres are available at the Society's Web site: www.rasc.ca

Belleville Centre
c/o Greg Lisk, 11 Robert Dr
Trenton ON K8V 6P2

Calgary Centre
c/o Telus World of Science, PO Box 2100
Stn M Location 73
Calgary AB T2P 2M5

Charlottetown Centre
c/o Brian Gorveatt,
316 N Queen Elizabeth Dr
Charlottetown PE C1A 3B5

Edmonton Centre
c/o Telus World of Science
11211 142 St
Edmonton AB T5M 4A1

Halifax Centre
PO Box 31011, Halifax NS B3K 5T9

Hamilton Centre
c/o Mr. A. Blanchard, 2266 Lakeshore Rd W
Oakville ON L6L 1G8

Kingston Centre
PO Box 1793, Kingston ON K7L 5J6

Kitchener-Waterloo Centre
305 - 20 St George St, Kitchener ON N2G 2S7

London Centre
c/o Peter Jedicke, 82 Barrydale Cres
London ON N6G 2X4

Mississauga Centre
PO Box 98011, 2126 Burnhamthorpe Rd W
Mississauga ON L5L 5V4

Centre francophone de Montréal
C P 206, Station St-Michel
Montréal QC H2A 3L9

Montréal Centre
18455 Meloche St
Pierrefonds QC H9K 1N6

New Brunswick Centre
c/o Paul Gray, 1068 Kingsley Rd
Birdton NB E3A 6G4

Niagara Centre
c/o Dr. Brian Pihack
4245 Portage Rd
Niagara Falls ON L2E 6A2

Okanagan Centre
PO Box 20119 TCM
Kelowna BC V1Y 9H2

Ottawa Centre
1363 Woodroffe Ave, PO Box 33012
Ottawa ON K2C 3Y9

Prince George Centre
7365 Tedford Rd
Prince George BC V2N 6S2

Québec Centre
2000 Boul Montmorency
Québec QC G1J 5E7

Regina Centre
PO Box 20014
Regina SK S4P 4J7

St. John's Centre
c/o Randy Dodge, 206 Frecker Dr
St. John's NL A1E 5H9

Sarnia Centre
c/o Marty Cogswell, 6723 Pheasant Ln
Camlachie ON N0N 1E0

Saskatoon Centre
PO Box 317 RPO University
Saskatoon SK S7N 4J8

Sunshine Coast Centre
5711 Nickerson Rd
Sechelt BC V0N3A7

Thunder Bay Centre
286 Trinity Cres
Thunder Bay ON P7C 5V6

Toronto Centre
c/o Ontario Science Centre
770 Don Mills Rd
Toronto ON M3C 1T3

Vancouver Centre
1100 Chestnut St
Vancouver BC V6J 3J9

Victoria Centre
3836 Pitcombe Pl
Victoria BC V8N 4B9

Windsor Centre
c/o Greg Mockler
1508 Greenwood Rd
Kingsville ON N9V 2V7

Winnipeg Centre
PO Box 2694
Winnipeg MB R3C 4B3

Journal

Great Images

The Leo Dwarf Galaxy is a relatively bright object but hides in the glare of Regulus, one of the brighter stars in the sky. The Leo Galaxy is one of a dozen small companions of our Milky Way, and one of the youngest, though star formation seems to have ended a billion years ago. This image was captured by Lynn Hilborn in April and May using a TEC 140 telescope and an ML 8300 camera at his Whistlestop Observatory near Grafton, Ontario. Exposure was 29×5 minutes in L and 10×2 minutes in each of R,G, and B.