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Journal

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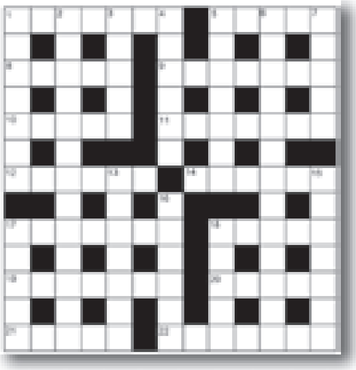

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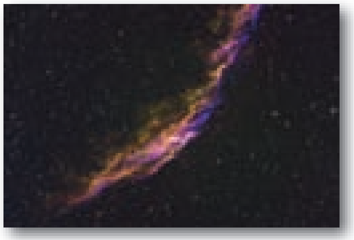

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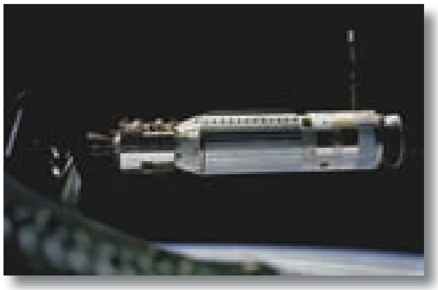

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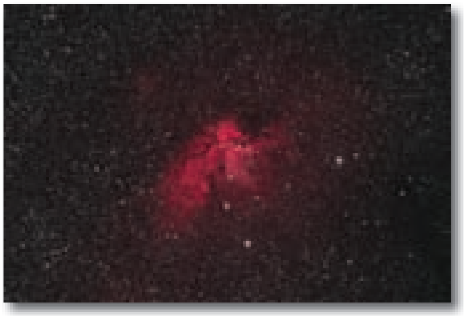
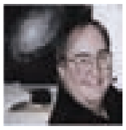


On the Front Cover:
Stuart Heggie returns in this issue with a photograph of NGC 7380 in Cepheus. Stuart used an SBIG STL 11000 camera on an AP 155 EDF telescope at f/7. Exposures were 7 x 5 min luminance, 5 x 5 min in each of RGB, and 5 x 30 minutes in Hα. NGC 7380 was discovered by Caroline Herschel on 1787 August 7, while being free from recording duties when her brother William was absent. Sir William Herschel included his sister's discovery in his catalogue.

COLUMNS



News Notes

by Andrew Oakes (copernicus1543@gmail.com)

Vertical Structures Seen in Saturn's Rings

NASA's *Cassini* spacecraft has uncovered "towering vertical structures" in the planet's flat rings, according to the *Cassini* Imaging Central Laboratory for Operations (CICLOPS)/Space Science Institute in Boulder, Colorado. The images of the vertical structures were made possible as Saturn neared equinox. They are attributable to the gravitational effects of a small nearby moon.

The search for ring material extending well above and below Saturn's ring plane has been a major goal of the imaging team during *Cassini*'s "Equinox Mission," the two-year period containing exact equinox — that moment when the Sun is seen directly overhead at noon at the planet's equator.

This novel illumination geometry occurs every half-Saturn year, or about every 15 Earth years. It lowers the Sun's angle to the ring plane and causes out-of-plane structures to cast long shadows across the rings' broad expanse, making them easy to detect.

The 8-kilometre-wide moon Daphnis orbits within the 42-kilometre-wide Keeler Gap in Saturn's outer A ring, and its gravitational pull perturbs the orbits of the particles forming the gap's edges. Scientists have estimated, from the lengths of the shadows, that wave heights from the perturbation reach enormous distances above Saturn's ring plane — as high as 1.5 kilometres — making these waves twice as high as previously known vertical ring structures, and as much as 150 times as high as the rings are thick. The main rings — named A, B, and C — are only about 10 metres thick.

The findings were presented in a paper authored by *Cassini* imaging scientists, and published June 2009 online in the *Astronomical Journal*.

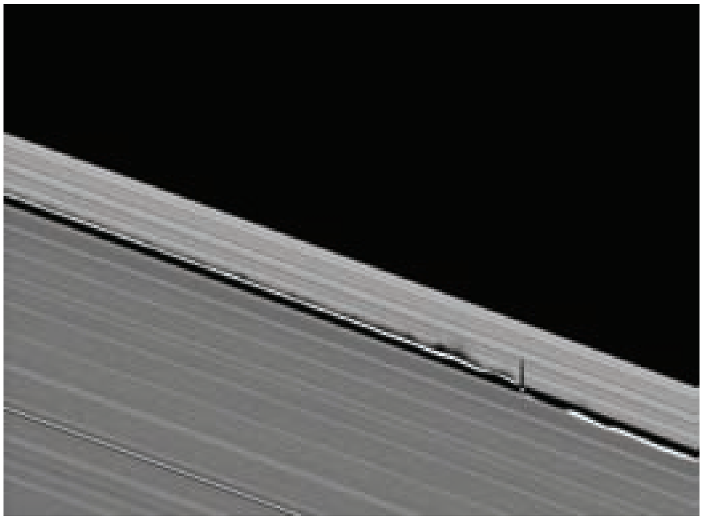


Figure 1 — Looming vertical structures, seen here for the first time and created by Saturn's moon Daphnis, rise above the planet's otherwise flat, thin disk of rings to cast long shadows in this *Cassini* image. Photo: CICLOPS/Space Science Institute, Boulder, Colo.

Journal

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CFHT Legacy Survey - Most Distant Supernovae Found

The Canada-France-Hawaii Telescope Legacy Survey (CFHTLS), which completed image-taking in January 2009, ending nearly a six-year project, has resulted in the discovery of four ancient supernovae. Two of the four newly discovered supernovae occurred about 11 billion years ago, 2 billion years earlier than the previous record holder.

The discovery surfaced in one of the components of the CFHTLS — the Supernova Legacy Survey — that observed four areas of the sky, each the size of one square degree. Each of the "deep" fields was obtained and searched for new supernovae every few nights around new Moon for half a year over each year of the duration of the survey.

An international team of astronomers, led by Jeff Cooke (University of California, Irvine), examined the results. One of the Keck telescopes was later used to look more closely at the spectrum of light each object emitted, and confirmed they were indeed supernovae.

The CFHTLS Supernova Program aims primarily at measuring the equation of state of Dark Energy. It is designed to precisely measure several hundred high-redshift supernovae.

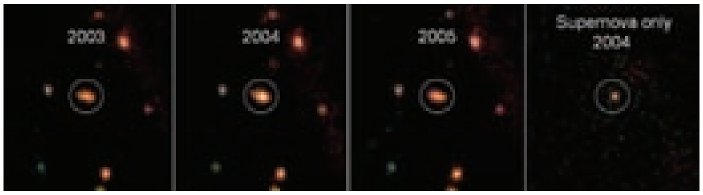

Figure 2 — The above frames show the host galaxy containing one of the newly discovered supernovae. The galaxy visibly brightens in 2004 and then returns to normal. This suggested that in 2003 the supernova was not detected; it appeared in 2004 and had mostly faded in 2005. The last frame subtracts galaxy light from the images in the years that the supernova was not detected to reveal only the supernova.

Petrie Lecturer for 2009

Canadian-born astrophysicist Scott D. Tremaine from the Institute for Advanced Study in Princeton, New Jersey, was the Petrie Lecturer of the Canadian Astronomical Society (CASCA) for 2009. The Petrie Lecture is an invited discourse by an outstanding astrophysicist that is held at Annual Meetings of the Society, in memory of the significant contributions to astrophysical research by the late Robert M. Petrie.

Widely regarded as one of the world's leading astrophysicists for his contributions to the theory of Solar System and galactic dynamics, Tremaine is credited, along with Peter Goldreich, for correctly predicting that shepherd moons created some of Saturn's and Uranus' thin rings. In addition, along with colleagues at the University of Toronto, Tremaine also showed that short-period comets originated in the Kuiper belt, a disk of small ice-and-rock bodies orbiting the Sun beyond Neptune's orbit.

In 1986, Tremaine became the first director of the Canadian Institute for Theoretical Astrophysics at the University of Toronto, a position he left in 1997.

The astrophysicist has an asteroid named in his honour [*Tremaine 3806* 1981 EW32, see *Minor Planet Circular 27458*], which was discovered on 1981 March 1. The citation provided by P.M. Goldreich noted Tremaine's seminal contributions to Solar System and galactic dynamics, and his co-authorship with James Binney of the leading monograph on galactic dynamics.

Tremaine's lecture titled, "Stellar dynamics at the centres of galaxies," was presented during CASCA's annual meeting on 2009 May 28.

First Canadian Private Space Explorer

Guy Laliberté, founder of *Cirque du Soleil* and the ONE DROP Foundation, will be the first Canadian private space explorer to visit the *International Space Station*. The Canadian Space Agency will advise Laliberté, who will meet with Canadian Astronaut Robert Thirsk while at the *International Space Station*.

During his 12-day stay at the *International Space Station,* described as a "humanitarian mission," Laliberté will share information about water issues in the world and raise awareness for ONE DROP Foundation initiatives that promote *Water for all, all for water.*

"Canada's leadership role in space exploration is at the forefront of our mandate," said Dr. Steve MacLean. "This humanitarian mission, imagined by a leading entrepreneur and artist, demonstrates the talent, imagination, and dedication that Canadians are recognized for worldwide."

This year is considered a year of celebration for Canadian space exploration, which began almost 25 years ago. Canadian veteran astronaut Robert Thirsk began a six-month stay (May 2009) on the *ISS,* marking a space milestone, where, for the first time, six astronauts will be living and working together in the world's largest

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orbiting microgravity scientific laboratory. In June, Julie Payette visited the *ISS*, and took the ONE DROP foundation's emblem with her to space as part of her official flight kit, to highlight the importance of protecting this precious resource.

Hubble Space Telescope Captures Jupiter Collision

NASA scientists interrupted the checkout and calibration of the *Hubble Space Telescope* in late July to aim the then-recently refurbished observatory at a new expanding spot on the giant planet Jupiter.

The *Hubble Space Telescope (HST)* took a picture of the spot, caused by the impact of a comet or an asteroid, on 2009 July 23. The image represents the sharpest visible-light picture taken of the impact feature. The observations were made with *HST*'s new camera, the Wide Field Camera 3 (WFC3), which was not yet fully calibrated at the time.

Discovered by Australian amateur astronomer Anthony Wesley, the spot was created when a small object plunged into Jupiter's atmosphere and disintegrated. After it was discovered, the spot continued to change day to day in the planet's cloud tops. The world's largest telescopes were quickly trained on Jupiter to record the potentially new science unfolding 600 million kilometres away. The only other time such a feature has been seen on Jupiter was 15 years ago, after the collision of fragments from Comet Shoemaker-Levy 9. ◆

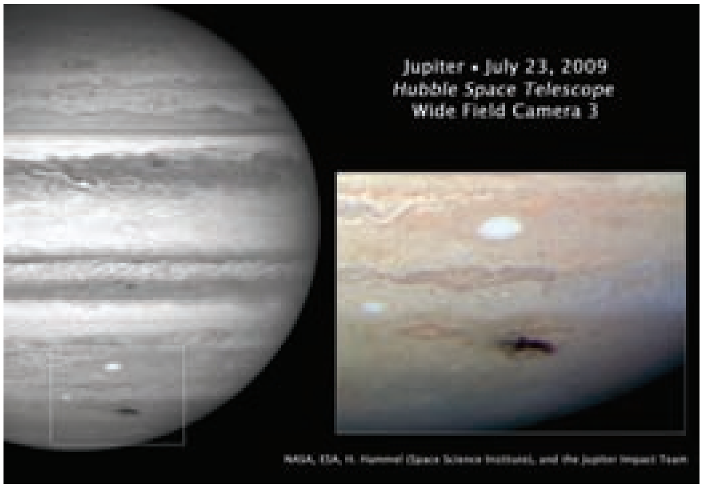

Figure 3 — Recent impact observations made with *Hubble*'s new camera, the Wide Field Camera 3 - a natural-colour image of Jupiter as seen in visible light. Photo Credit: NASA/*Hubble Space Telescope* (Space Telescope Science Institute, Baltimore)

Andrew I. Oakes is a long-time Unattached Member of RASC who lives in Courtice, Ontario.

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The 1904 Shelburne (Ontario) L5 Chondrite Fall, Revisited

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Abstract: The century-old Shelburne, Ontario, L5 chondrite fall has been reinvestigated as part of a program to revisit Canadian meteorite falls to further understand their fall circumstances, the recovery and distribution of fragments, and to refine and expand the meteorite description, where warranted. Shelburne was a particularly well-observed fall on 1904 August 13 at 8 p.m., being reported from many locations within a 130-km radius in enough detail to estimate its entry to have been nearly vertical. An assessment of possible orbits derived from the fall circumstances indicates that the meteoroid had a low initial velocity of ~14 km/s in order to have had an Apollo-type orbit that is usual for meteorite delivery. Two substantial fragments of Shelburne were recovered from area farms in 1904: the 5.6-kg Shields fragment and the 12.6-kg Johnston fragment. The Shields fragment was soon purchased by the Field Columbian Museum of Chicago, where much of it is still curated. The Johnston fragment was initially studied in Kingston at the School of Mining, but its specific fate is unknown; it is, however, the likely source of most of the Shelburne fragments found in public and private meteorite collections worldwide. Two previously unidentified ordinary chondrite fragments in the Miller Museum collection at Queen's University, Kingston, are confirmed to be remnants of the Johnston fragment. A visit to the Shelburne fall area with limited ground searching did not produce new fragments, but the engagement of public interest turned up a previously unknown piece of fragment in the possession of one of Shields' descendants. In a survey of the worldwide distribution of the Shelburne meteorite, some 11.1 kg of the original 18.2 kg of the meteorite can currently be accounted for. Aside from documenting the history and current distribution of the Shelburne meteorite, this study also provided an opportunity to bring community history to life, and to introduce astronomy and the study of meteorites to new audiences.

The Shelburne 1904 Fall Event

On the evening of Saturday, 1904 August 13, startled viewers as far as 130 km from Shelburne, Ontario, reported seeing a brilliant, huge ball of fire fall nearly perpendicularly shortly before sunset. The fall was not seen in Shelburne itself, a village of some 1300 inhabitants, as a recent rainstorm had left the immediate area shrouded in dense cloud. However, witnesses there reported seeing a strong flash light up the northern sky a bright red, briefly illuminating the surrounding countryside. This was followed by sounds heard over an area of 50-km radius, "like the boom of two cannon in succession, then a rally, like drum beats, musical in tone but [with] the vibrations last[ing] much longer than usual" (*Shelburne Free Press,* 1904a). Although the peculiarities of the musical sounds were widely discussed, it did not take long to realize that they were caused by the fireball exploding as it shot overhead.

Two fragments of the meteorite were soon recovered a few kilometres north of Shelburne (at location 43°07´N, 80°12´W) — a 5.6-kg fragment that fell less than a metre from John Shields' farm house and a 12.6-kg fragment that fell in Thomas Johnston's oat field. Although there was widespread belief that other fragments had been produced by the explosion, none were found.

We decided to reinvestigate the century-old Shelburne L5 chondrite fall as part of an ongoing program to revisit Canadian meteorite falls in order to further understand their fall circumstances, the recovery and distribution of their fragments, and to refine and expand their technical descriptions, where warranted (*e.g.* Plotkin 2006; McCausland *et al.* 2006). A reassessment of the fall circumstances also affords the possibility for a 'forensic' study (*e.g.* Beech *et al.* 2007) to recover more information on the meteorite's origin. As an added benefit, we welcomed the opportunity to engage public interest — not only in the study of meteorites, but also more broadly in the linkages between science and community history. Our investigation involved a reassessment of contemporary accounts of the fall event, an assessment of the subsequent distribution of Shelburne fragments, public outreach, visits to potential Shelburne fragment owners, and limited ground searching of the fall area. An expansion of the Shelburne meteorite description is the subject of a companion investigation (van Drongelen 2007; van Drongelen *et al.* manuscript in preparation).

Observations of the Fireball

The Shelburne fireball was well observed and, just as importantly, the many observations were collected in reports published in the fledgling scientific literature of Canada, in the newly-formed *Journal of The Royal Astronomical Society of Canada* (Borgström 1905a) and in the 1904 *Report on Activities of the Geological Survey of Canada* (Johnston 1906).

Figure 1a (adapted from Borgström 1905a) shows the locations of observers of the Shelburne event. The August 13 evening fireball was reported by 25 observers from 21 locations within a 130-km radius of Shelburne. The more-detailed and informative reports give the fireball a steep angle to the horizon, implying that the fireball likely had a steep trajectory. A full account of these observations, including incidences of simultaneous sound during the fireball and whistling noises near the fall location, can be found by consulting Borgström (1905a) and Johnston (1906). Excerpts from several observations in these sources are reproduced for the given locations below:

1) Lake Rosseau: The meteor came into sight with a great flash of light and sparks flew from it as from a rocket. It descended

nearly vertically and reached the horizon a little west of south from the place. [T.M. Robinson]

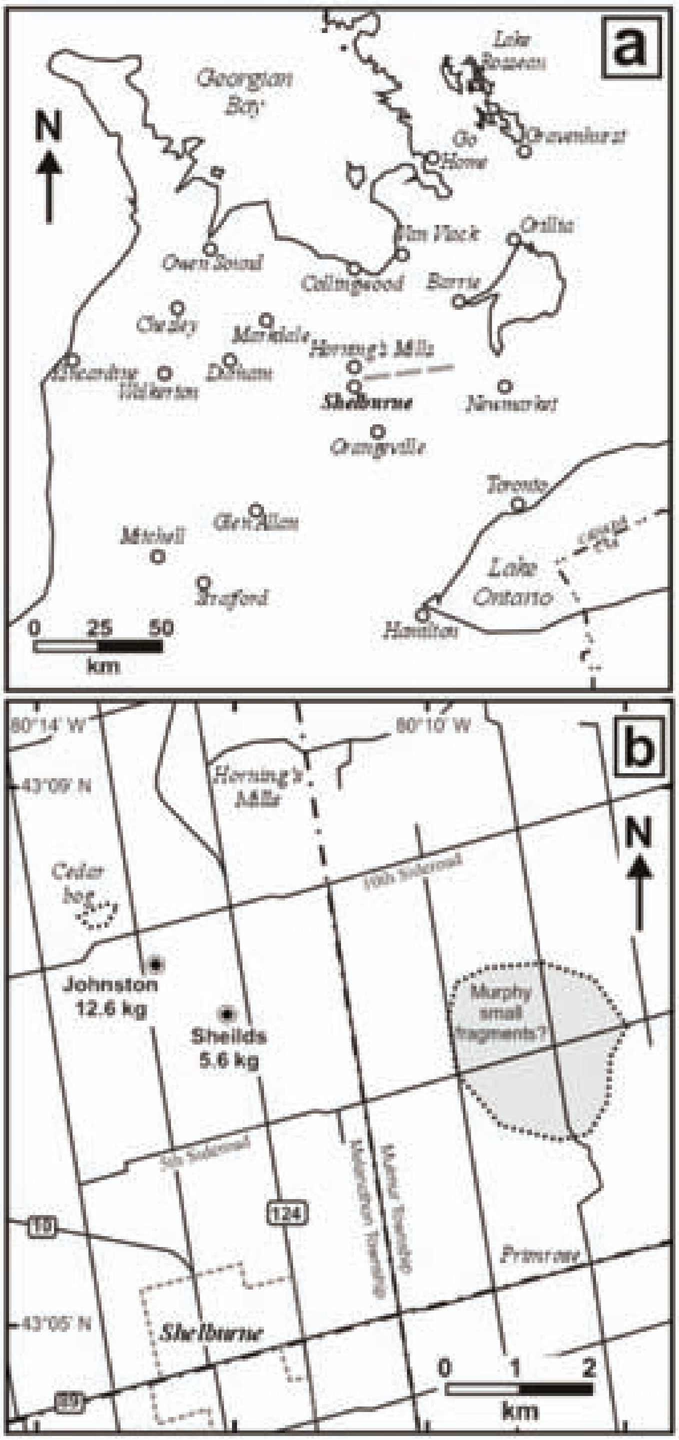

Figure 1 — Fall circumstances of the 1904 Shelburne L5 chondrite: a) locations of observer reports in southern Ontario, as documented by Borgström (1905) and Johnston (1906). The dashed line shows a possible easterly ground track for the fireball's steep entry that is most consistent with the observer reports (adapted from Borgström 1905); b) locations of the two known fragments north of Shelburne and of possible other small fallen fragments reported by R. Murphy (see #10, text), shown with reference to map NTS 41 A/1 Dundalk, 5th Edition (NAD-83 coordinates).

2) Go Home: ...The meteorite appeared to move nearly vertically, tending a little, perhaps 10°, to the west. [Dr. C.A. Chant, U of Toronto, at Georgian Bay]
3) Gravenhurst: It was a ball of fire that made a flash like lightning and was going to the southwest, with an altitude of 30°-40°. One of the persons spoke of a hissing sound, which the others do not appear to have heard. The sky was cloudless, with distant lightning in the south and north. [T.M. Robinson, Meteorological Station, Gravenhurst]
4) Newmarket: A person in Newmarket saw the meteor a little after 8 o'clock. It came from the east and passed west a little towards the north. It appeared to be a little north of here, and was very low, almost seeming to strike the ground just west of here. ...He noticed no noise. [Geo.A. Carefoot]
5) Toronto: Mr. R.J. Collins, Secretary of the Royal Astronomical Society [of Canada], reports that the meteor was seen by several parties in Toronto and that their observations seem to indicate that the meteorite fell nearly vertically or a few degrees to the north-northeast of the perpendicular.
6) Glen Allan: The meteor appeared north-northeast and [was] observed as moving slightly to the west. [J.L. McPherson, B.A., quoted in letter from Dr. Chant]
7) Stratford: The meteor appeared north by northeastward of Stratford and was going downward towards the northwest ...One person described it as a "red ball with a long tail" another said that "it seemed to go straight down." [J.H. Lennox]

A useful feature of the observations from Shelburne and immediate area is the descriptions of the sounds of fireball breakup: many observers tell of hearing several reports, indicating that it is possible that more than two fragments of Shelburne reached the ground (Borgström 1905a; Farrington 1906):

8) Shelburne: Two men...say that they perceived no fire-ball but only a flash of light of a reddish colour, which lighted up everything around. The flash was followed by several explosions, separated from one another by short intervals and more distinct than thunder.
9) Horning's Mills: Mr. T. Ostic was standing on a little hill about three miles north of the place where the meteorites were found, and observed, at about 8 o'clock, a sudden light over the northern sky. Immediately after the light, he heard a whistling noise, and then four cracks like the striking of a drum, but loud like gunshots.
10) Primrose: "I saw the flash of light, then followed three reports, which were not like thunder. I heard something strike the ground only a few rods away. I heard other pieces fall in the neighboring [sic] field. None of these were found. The explosion seemed to be in the northeast. The time from this explosion to when I heard the pieces strike the ground would be about two to three minutes. The place is about three miles east of where the [known] pieces were found." [R. Murphy]

In summary, it appears from these observations that the Shelburne fireball had a steep entry from the east or northeast, and that it had multiple audible fragmentations. The implications of these observer reports will be taken up below.

Recovery of the Shelburne Meteorite Fragments

The first fragment found, weighing 5.6 kg, fell on the farm of John Shields, east half of lot 8, concession 2, Melancthon Township (Figure 1b). Shields reported (*The Shelburne Free Press* 1904a; Borgström 1905a, Farrington 1906; Johnston 1906) that he and his family had heard sounds like a muffled drum beat and a crash, followed by a dull thud at the rear of his house. His immediate thought was that an old shed there had fallen. Going out to investigate, he saw the shed intact, but noticed that the east end of the back (north) side of the house as well as the floor and roof of the east end of the veranda were splattered with mud. A further search revealed a small excavation ~30-cm wide in the soil less than a metre to the north of the veranda (Figure 2). A small heap of wet earth lay to the southeast of the hole, between it and the mud-spattered veranda. Somewhat later, Shields dug into the hole and found the meteorite buried ~45 cm into the soft clay-rich soil. He noted that it could not have been hot when it fell, for it had carried a large burdock leaf with it into the ground, which was still green and uncharred when dug up (Borgström 1905a; Farrington 1906). The meteorite was then brought into town and put on display in the window of Jelly and White's hardware store, a local meeting point (Figure 3), where it was viewed by hundreds of persons.

Figure 2 — Fall location of the Shields fragment, view looking west. Mr. John Shields (left) is holding his 5.6-kg meteorite. Looking on is likely Dr. Leon Borgström (right), who visited Shelburne in the early fall of 1904. Note the plank inserted into the plunge pit created by the meteorite between Mr. Shields and the veranda at left. Image courtesy of L. Pesonen (U. Helsinki).

Although Shields received requests from many interested parties for pieces of the meteorite, he was initially averse to breaking it up or selling it in whole or in part (Johnston 1906). Later, however, following a personal visit in February 1905 by O.C. Farrington, the Curator of Geology at the Field Columbian Museum of Natural History in Chicago, he sold it intact to the Field for $465 (Borgström 1905b). After the Field Museum cut off fragments for research and exchange, the main mass was reduced to its present 2.9 kg (Farrington 1916; Horback and Olsen 1965; C. Nunez, personal communication).

Two weeks after the fall, on August 30, a second fragment of the meteorite — twice as large, at 12.6-kg mass — was found on the farm of Thomas Johnston, on the west half of lot 10, concession 2, about 1 km northwest of the first fragment location (*The Shelburne Free Press* 1904d; Borgström 1905a; Johnston 1906). Johnston's son George had been home at the time of the fall, and felt certain that something had fallen into their oat field. Not wanting to tramp down his crop in search of the meteorite, he waited until the grain was ripe. When he set about harvesting it, his binder passed over a freshly made hole near the foot of a crescent-shaped knoll. Together with his brother-in-law, William Fleming, he dug up the meteorite, which had buried itself about 60 cm into the light soil. Once again, the meteorite was brought into town and put on display at Jelly and White's hardware store.

Figure 3 — Jelly and White's hardware store, where each Shelburne fragment was on public display shortly after being found.

Records of the subsequent history of this larger specimen are somewhat sketchy. Two weeks after discovering it, Johnston sold the meteorite to a district manager of the Bell Telephone Company for $200, who in turn sold it to Leon Borgström for $276 (Johnston 1906; *The Orangeville Citizen* 1906). Borgström, a young Finnish geologist/chemist then affiliated with the School of Mining in Kingston, had a keen interest in meteorites, having recently obtained his Ph.D. from the University of Helsinki with a dissertation on the Hvittis (Finland) and Marjalahti (Karelian Republic, Russia) meteorites. After his study of the Johnston fragment (Borgström 1905a), he sold a 1.7-kg slice to the Natural History Museum of London in late May 1905 (Borgström 1905b; C. Smith, personal communication) and at least 1.44 kg (and probably the lion's share) of it to the Foote Mineral Company of Philadelphia (C. Francis, personal communication; Appendix). Many fragments of the Shelburne meteorite that are distributed in various university and museum collections today are from the Johnston fragment via the Foote Mineral Company (personal communications).

Borgström was a key figure in the Shelburne meteorite story. Chasing the Shelburne fall was likely what brought him to Kingston; the new mineral analysis laboratory at the School of Mining (to become part of Queen's University in 1915) was just the kind of facility needed to do state-of-the-art meteorite bulk chemical and mineralogical analyses (Borgström 1905a). Meeting with the owner of the first fragment, John Shields, in the fall of 1904, Borgström attempted to purchase it either for a Canadian museum or for himself. He also wrote to L. Fletcher, the Keeper of Mineralogy at the British Museum (Natural History) to offer to serve as an agent on the British Museum's behalf, if Mr. Shields ended up asking more than Borgström or the Canadian museums were willing to pay (Borgström 1904).

Although Borgström was disappointed when Shields sold his specimen to the Field Museum without any warning (Borgström 1905b), his success in purchasing the larger Johnston specimen must have more than made up for that loss. During the late fall of 1904 and early winter of 1905, Borgström set to work in Kingston describing the Shelburne meteorite, reporting on its fall circumstances, its bulk appearance and density, bulk chemistry, and characteristic mineralogy (Borgström 1905a,c). During this time he also lightheartedly mentioned in a letter to Fletcher that he was able to introduce to his friends in Kingston, a new sport, skiing, "...which surely will have a great future in this snowy country" (Borgström 1905c)! By June of 1905, Borgström was finished with Shelburne, taking passage back to Europe after a visit to the US Geological Survey in Washington (Borgström 1905d), where he would have had the opportunity to sell Shelburne to the Foote Mineral Co. of Philadelphia.

Renewed Shelburne Investigation

We began our Shelburne investigation in July 2007 with a visit to the Dufferin County Museum and Archives in Rosemont, several kilometres east of Shelburne, where we examined contemporary newspaper accounts of the meteorite's fall and recovery, and examined old town plats to determine where the Shields and Johnston houses were located. This was followed by visits to the editors of the Shelburne and Orangeville newspapers, asking them if they would publish a story that we had prepared about the meteorite. In the story, we pointed out that other fragments had likely fallen on nearby farms, described what they might look like, explained that researchers associated with the Royal Ontario Museum in Toronto were interested in the possibility of recovering additional fragments for their ongoing research, and invited readers to contact us if they thought they might possibly have a fragment. We indicated that we would come to Shelburne shortly to meet with anyone who wished us to examine any suspected meteorite they might have. As with Dresden (Plotkin 2006), the newspaper editors were very interested in the story and happy to run it in their newspapers (*The Orangeville Citizen,* 2007: *The Orangeville Banner,* 2007).

The newspaper stories quickly drew more than a dozen responses. A few weeks later, we went to Shelburne and met with 18 persons to examine their specimens. Prior to meeting anyone on our first day there, we went to the location of the Shields house at 44° 7.3´N, 80° 12.1´W, took photos and measurements, and walked the fields between this house and Johnston's house to examine the undulating terrain of the fall area. We examined, to no avail, the discarded rocks along fence lines in the area between the two found fragments and also a large rock pile behind the Shelburne Golf and Country Club, located directly east across the concession road from the Shields house.

The first person we visited was the one we thought would be our best bet — Mary Cornfield, John Shields' great-niece, who had written us saying she had a piece of the meteorite that had been handed down through her family as a part of its history. In addition to her 29-g fragment (Figure 4a), she also had a cast of the complete Shields meteorite and two offprints from the Field Museum, its 1903 catalogue of meteorites, and Farrington's 1906 publication on the Shelburne meteorite (Figure 4b). The fragment, cast, and offprints were given to Shields in appreciation for the sale of his meteorite to the Museum (Borgström 1905b), and stand as an enduring contribution of the Museum to the Shields family and to the people of Shelburne.

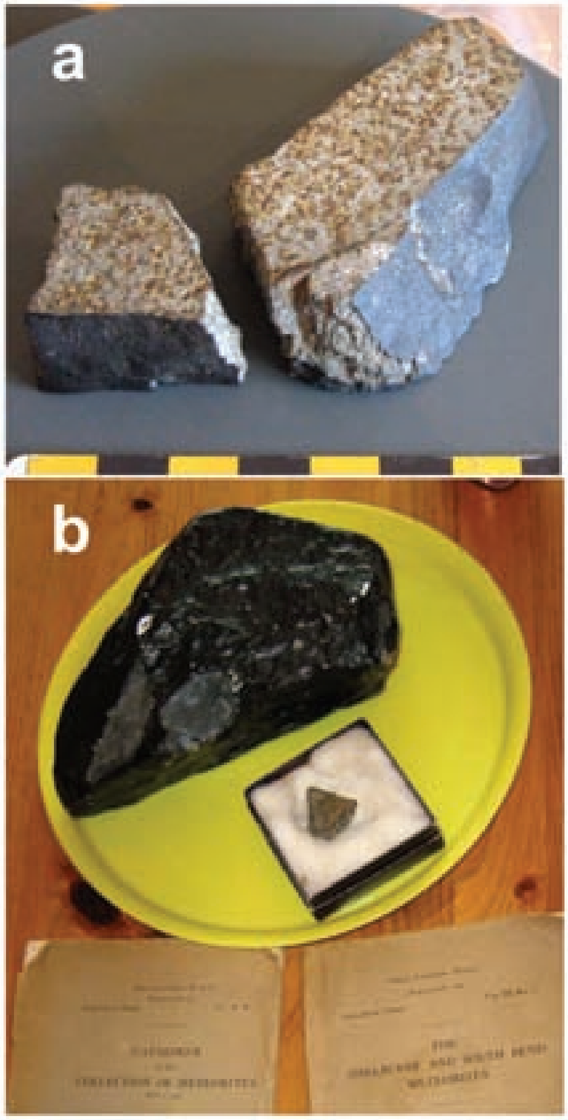

Figure 4 — Portion of the Shields fragment remaining with his descendant, Mary Cornfield: a) 29-g Cornfield 1.9-cm thick Shelburne slice (left) in comparison with the 1.75-cm thick 80-g UWO slice, with scale in cm; b) items given to the Shields family by the Field Columbian Museum and passed down through generations — a plaster cast of the 5.6-kg Shields fragment, a 29-g slice from that fragment, and two relevant publications by the Museum.

After meeting with another person who had contacted us, we went a few kilometres north to Horning's Mills, to examine a rock in a stone fence in front of a house there. According to the story behind this, the original owner of the house was a stonemason who had built the fence from local stones, which included one that had been "authenticated" as being a meteorite. Alas this stone and many others in our subsequent meetings turned out to be a cemented siltstone conglomerate that seems to be commonly mistaken to be meteoritic in the Dufferin County region.

We then went to a farm across the road from the Johnston house to examine a stone there that was unusual, but non-meteoritic. The 84-year-old owner of the property, a bright and interesting lady who knew a lot about the history of the area, told us an intriguing story about how Johnston and a neighbour on the next concession road to the west had both seen or heard a fragment of the meteorite fall into a cedar bog between their houses. Hearing this gave us the idea of later carrying out a search there. Our visit to the Johnston farm itself turned up a low knoll along its western boundary that likely is the fall location for the larger fragment. On the following morning, we participated in a public event at the Dufferin County Museum and Archives to examine stones brought in by individuals who thought they might have fragments of the Shelburne meteorite. Unfortunately no new fragments of the meteorite surfaced among the eighteen examined.

In September, a small party, including ourselves, Roberta Flemming from UWO, and Ian Nicklin from the Royal Ontario Museum, returned to the Shelburne area to search rock piles and to do a pilot ground search of the cedar bog, 1 km to the northwest of the Johnston fragment's approximate fall location (Figure 1b). The search was designed to find a large (>10 kg) fragment, given the heavy forest cover and the bog's location towards the heavy end of the strewnfield northwest of the larger Shelburne fragment. We used a proton precession magnetometer to detect the presence of shallowly buried high-magnetic-susceptibility bodies as would be expected for a metal-bearing L chondrite, and followed up with poke poles and local excavation where it was deemed useful. Over two days we determined that this method was not going to deliver a new Shelburne fragment: quite apart from the passage of a century since the fall event and the low area coverage offered by a party of four, our main problem was that the ground in the area consists of glacial till containing small boulders at a depth of about a metre. Some of these terrestrial boulders contain significant magnetic mineralogy that was detectable by the portable magnetometer, leading to false meteorite "hits." A more dedicated survey would likely turn up multiple anomalies, all of which would have to be excavated to determine if they were magnetite-bearing metamorphic rocks or meteorites.

Later in 2007, we visited the Archives and the Miller Geological Museum at Queen's University in Kingston to follow up on the fate of the Johnston fragment. Miller Curator Mark Badham noted the presence in the collection of two Shelburne plaster casts and also of two unknown ordinary chondrite fragments. The casts proved to both be of the Johnston fragment that Borgström had described, and were probably the ones made by Borgström himself during his 1904-5 investigation (Figure 5a). The two unknown ordinary chondrite fragments both had fusion crust and cut surfaces with oxidation staining of the metal, a good match in appearance with the UWO and David Gregory Shelburne fragments (Figure 5b). Notably, one of the Queen's unknown ordinary chondrite fragments was found to uniquely match a portion of the exterior surface and metal veining evident on the Johnston meteorite cast, showing conclusively that this fragment — and probably the other one — are remnants of the Shelburne meteorite studied by Borgström.

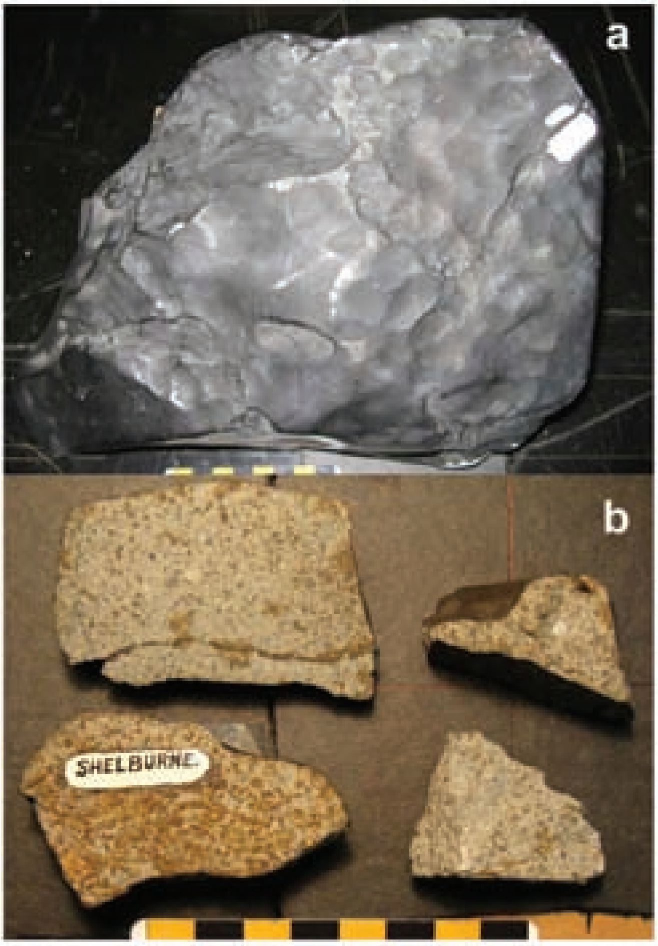

Figure 5 — Shelburne meteorite at Queen's University: a) plaster cast of the 12.6-kg Johnston fragment studied by Borgström in 1904-5, with cm scale at bottom; b) two previously unidentified Shelburne Johnston fragment slices at Queen's (top pair; a 93-g slice with distinctive metal vein and a 42-g slice), compared with the labelled 80-g UWO slice (bottom left) and the 30-g Gregory piece (bottom left).

Distribution of the Shelburne L5 Chondrite

The current distribution of the 18.2-kg Shelburne fragments is summarized in the Appendix (a more-detailed account is available from the authors by request). The Shelburne meteorite is well distributed in the world's collections. A measure of its availability and usefulness is its appearance as a reference meteorite in several synoptic chemical studies of ordinary chondrites (*e.g.* Jarosewich and Dodd 1985; Schoenbeck *et al.* 2006). In total, 11.1 kg can presently be located and 13.5 kg can be accounted for historically. Of the original 5.6-kg Shields fragment, 5.2 kg can be accounted for in the historical records and catalogues of the Field Museum (Farrington 1916; Horback and Olsen 1965), and 3.9 kg can be located today at the Field and in other collections. For the 12.6-kg Johnston fragment, a total of 5.8 kg can be tied confidently to having come from it, with at least 1.4 kg of this having passed through the Foote Mineral Co. A further 0.97 kg of Shelburne fragments have an unknown provenance but likely also come from the Johnston fragment. Of the original 18.2 kg of Shelburne, 7.1 kg is missing today. Some of this (up to hundreds of grams) has been consumed for research or been lost to cutting, but the rest is unaccounted for.

Origin of the Shelburne L5 Chondrite

Given the time of the Shelburne fall — August 3 — it was perhaps natural that persons should think it was somehow related to the annual Perseid meteor shower. Others thought it, like other meteorites, might possibly be "chunks of matter that break away from the tails of comets and, in striking out for 'fresh worlds to conquer,' run up against our own planet" (*The Shelburne Free Press* 1904b). There was no mention at all of the possibility that meteorites might originate from asteroids. Although Ernst Chladni, who played a seminal role in helping found meteoritics as a science (Marvin 2007), had proposed (Chladni 1794) that meteorites might be portions of celestial bodies broken off by collisions, and Robert Gregg, a first-rate English mineralogist, proposed (Gregg 1854) that asteroids were these celestial bodies, it was not until a century later — in the 1950s — that a small number of scientists began to study asteroid-meteorite relationships intensively. Even as late as 1963, John A. Wood, a meteorite geochemist at the Smithsonian Astrophysical Observatory, observed (Wood 1963) that there were "...perhaps as many opinions as to the origin of meteorites as there are students of meteorites."

There are currently thirteen meteorites with well-determined pre-atmospheric orbits that clearly tie them back to an origin in the main belt of asteroids (*e.g.* Spurný *et al.* 2009; Jenniskens *et al.* 2009), all determined from instrumentally observed meteorite-dropping events over the last 50 years. More generally, other well-observed events (*e.g.* Brown *et al.* 1996) and systematic fireball observing programs (*e.g.* Halliday *et al.* 1989) have established that the aphelia of the orbits for large meteoroids typically lie in the main belt. It is obviously not possible to determine a specific atmospheric trajectory and prior orbit for Shelburne from historical observations alone, but it is nevertheless possible to use the existing observations to better understand its entry circumstances and possible origin.

Borgström (1905a) concluded from his compilations of the visual observations that the fireball had "...shot with great velocity through the atmosphere nearly perpendicularly or slightly inclined towards the west." Farrington (1906) noted from his examination of the vertical plunge pit at John Shields' yard that the incoming meteorite must have had a moderately steep angle at arrival to clear a 12-foot high shed wall 6.5 feet to the north of the plunge pit. He concluded that the arrival had been steep and from the northwest, judging from the generally southeast distribution of spattered mud on John Shields' house and veranda and using the southeasterly trending line between the two fragment fall locations. An opposing approach from the southeast is suggested by the location of the larger Johnston fragment a kilometre to the northwest of the Shields fragment, but this trajectory was ruled out by Farrington based on the geometry of the Shields' veranda roof being 12 feet above and less than 2 feet south of the Shields pit (Farrington 1906). These ground observations pertain more to the passage of the fragments through the lower troposphere, however, with their initially steep trajectory having been modified by slowing to terminal velocity (Borgström 1905a) and by winds.

The reported observation by R. Murphy (#10, above; Borgström 1905a) of falling debris in the Primrose area is of interest here — it suggests that a number of small fragments may have fallen ~5 km to the east of the two known large fragments (Figure 1b). If true, the resulting strewnfield has plausible dimensions and mass distribution (*e.g.* Brown *et al.* 1996) and implies an approach of the fireball from the east, producing fragments on the ground with increasing mass towards the west. Wind can also be an important contributor to strewnfield distribution, however, with small 1-g to 10-g fragments tending to be distributed some kilometres downwind of the larger fragments. Several anecdotal descriptions (Borgström 1905a) report the afternoon and early evening to have been humid with thunderstorm activity, implying a generally westerly airflow that is common for this region in August, and consistent with summer season mid-latitude tropospheric winds coming from the west to northwest (Beer 1974). Archived 8 a.m. daily continental weather maps bracketing the fall event (NOAA Central Library Data Imaging Project) are consistent with moderate upper-level westerly winds for southern Ontario at the time of the event (J. Anderson, *pers. comm.*). Wind from the west at the time of fall may account for the distribution of the possible smaller fragments near Primrose with respect to the larger two; the strewnfield distribution unfortunately may not then offer much constraint on the steep fireball trajectory. On the whole, the location of the larger 12.6-kg Johnston fragment 1 km to the northwest of the 5.6-kg Shields fragment nevertheless favours an approach from the east.

Assuming that Shelburne was derived from the main belt of asteroids, such that it would have had a pre-entry orbit similar to those for other ordinary chondrites (Halliday *et al.* 1989; Brown *et al.* 1996), the time of the Shelburne event and its observed steep trajectory may be used to crudely estimate its initial velocity (*e.g.* McCausland *et al.* 2006). Steep entries from the northwest, northeast, east, southeast, and the vertical have been assessed (Table 1), and show that Shelburne likely had a low initial entry velocity of ~14 km/s, to have had a plausible Apollo-type pre-entry orbit with aphelion in the main belt asteroids, and a Tisserand number >3, representing an asteroidal, rather than cometary orbital affinity (Bottke *et al.* 2002).

Given the steep entry and early evening local-time arrival, the perihelion value, *q*, of the solved orbits is the best constrained parameter, varying between 0.88 and 1.01 astronomical units for reasonable entry velocities. Aphelion (Q), orbital eccentricity *(e)*, and especially inclination *(i)* tend towards larger, unlikely values with higher entry velocities. Possible orbits calculated for an initial velocity of 12 km/s result in aphelion inside of Mars' orbit, with Q<1.52 AU, Mars' semi-major axis. No particular distinction can be made between vertical or steep trajectories that approach from the east or southeast and those that approach from the northwest, as they all result in plausible moderate-inclination (~12°) Apollo-type orbits given a ~14 km/s initial velocity.

These orbits are of a similar type to that derived for the Dresden meteorite at 14 km/s (McCausland *et al.* 2006) and would also tend to favour delivery from the inner main belt of asteroids via the 3:1 mean-motion resonance with Jupiter at a = 2.5 AU or the $\nu6$ sidereal-motion resonance with Jupiter and Saturn at 15° to 16° inclination for a = 2.246 AU (Bottke *et al.* 2002). Bottke *et al.* (2009) have argued that the L-chondrite meteoroids are derived from the catastrophic breakup of an asteroid 470 million years ago, and are now dominantly delivered by the 3:1 mean motion resonance. To the extent that it can be determined, the Shelburne L5-chondrite delivery is consistent with the conclusion that the L chondrites are derived from the Gefion asteroid family (Bottke *et al.* 2009).

The observed fragmentation of Shelburne into at least two major individuals and the estimated initial velocity of ~14 km/s offers an independent estimate of Shelburne's initial and final (landed) mass: as calculated for a Mg olivine-rich body, a meteoroid arriving at a minimum initial velocity of ~14 km/s will fragment due to atmospheric ram pressure, if it is more massive than 55 kg (Beech *et al.* 2007). The initial-mass-to-final-mass ratio by atmospheric ablation for a Mg olivine-rich body is ~3:1 for an initial velocity of 14 km/s (Beech *et al.* 2007), thus yielding a minimum final mass of ~18.3 kg for the Shelburne meteorite.

Alt	*Azm*	*vel*	RA	*Dec*	*a*	*e*	*i*	ω	Ω	*Q*	*q*	*T*
90	090	12	240.9	44.1	1.15	0.129	5.9	202.1	141.2	1.30	1.01	4.77
90	090	14	240.9	44.1	1.47	0.312	12.2	187.6	141.2	1.93	1.00	3.18
75	090	12	256.7	43.3	1.11	0.117	5.3	225.9	141.2	1.24	0.98	4.98
75	090	14	256.7	43.3	1.36	0.278	12.1	204.6	141.2	1.76	0.99	3.64
80	060	12	246.9	50.1	1.10	0.096	6.5	214.8	141.2	1.21	1.00	5.05
80	060	14	246.9	50.1	1.33	0.240	13.4	193.0	141.2	1.65	1.01	3.83
75	120	12	270.1	25.2	1.10	0.137	1.8	243.5	141.1	1.25	0.95	5.04
75	120	14	270.1	25.2	1.43	0.339	7.6	222.0	141.2	1.92	0.95	3.29
75	300	12	222.4	50.1	1.14	0.108	6.8	178.4	141.2	1.26	1.01	4.85
75	300	14	222.4	50.1	1.38	0.271	12.9	168.5	141.2	1.76	1.01	3.58

Table 1 — Representative possible orbits for the Shelburne meteoroid.
Fall location: 44.12 deg N; 80.20 deg W (Fig. 1). Fall time, date: 8 p.m. local time, 1904 August 13. Symbols are: *alt,* altitude of the radiant (in degrees), *azm,* azimuth of the radiant, *vel* is entry velocity in km/s, RA and *Dec* are the apparent right ascension and declination of the radiant, *a* is the semi-major axis in AU (astronomical units, with Earth distance from Sun =1), *e* is the eccentricity, *i* is the inclination of the orbit with respect to the ecliptic, ω is the argument of perihelion, Ω is the longitude of the ascending node, *Q* is the aphelion distance in AU, *q* is the perihelion distance, and *T* is the Tisserand parameter (Bottke *et al.* 2002).

Higher initial velocities would also produce fragmentation, but with more-efficient ablation, thus requiring a much larger initial mass to achieve the 18.2-kg final Shelburne mass. At 14 km/s, greater initial masses are possible and would imply the existence of undiscovered fragments with significant kg-scale mass on the ground or a more efficient ablation than is being accounted for in the calculations. It is most noteworthy here that, assuming the Shelburne meteorite is adequately represented by an Mg olivine body, the estimated initial velocity of ~14 km/s and the observed fragmentation during Shelburne's entry leads to a plausible minimum mass for Shelburne that agrees well with the 18.2 kg that has been found.

Conclusions

Renewed investigation of the 1904 Shelburne, Ontario, meteorite fall has led to the discovery of several previously undocumented fragments, and also to a refined understanding of its fall circumstances. Based on available observational constraints, the Shelburne L5 chondrite likely arrived via an Apollo-type orbit as a >55-kg meteoroid with a low initial entry velocity of ~14 km/s.

Our investigation of the Shelburne event served as a useful public outreach opportunity, not only for the Shelburne community but also for the Dufferin County Museum and Archives. The Museum itself had recently purchased a small 1.4-g fragment of Shelburne, so our study also acted as a focal point for the Museum's own investigation of the 1904 Shelburne meteorite event. Similar opportunities for deeper investigation and outreach can be found with other Canadian meteorite falls and finds.

Acknowledgments

We thank Ian Nicklin, Royal Ontario Museum, for initially suggesting the reinvestigation of the Shelburne meteorite fall and for his participation in the cedar bog field search along with Roberta Flemming, University of Western Ontario. Wayne Townsend, Director of the Dufferin County Museum and Archives, generously hosted our public meteorite event. Many people assisted in the investigation of Shelburne's history and distribution, including Roseann Ruckledge (Dufferin County Museum and Archives), Clarita Nunez (Field Museum), Caroline Smith and James Hatton (NHM, London), Mark Badham and Gillian Barlow (Queen's University), Carl Francis (Harvard), Ian Nicklin (ROM), Richard Herd (GSC, Ottawa), Lauri Pesonen (U. Helsinki), Franz Brandstaetter (NHM, Vienna), Ansgar Greshake (Berlin), Joseph Boesenberg (AMNH, New York), Linda Welzenbach (Smithsonian), and Chris Herd (U. Alberta). We enjoyed fruitful discussions on the Shelburne meteorite with Katrina van Drongelen and Kim Tait (ROM). David Gregory kindly provided access to his Shelburne fragment for comparison studies. We thank Wayne Edwards (NRCan) for assistance with setting up the orbit calculations. Editor Jay Anderson and two anonymous reviewers offered helpful comments that improved this work.

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Appendix

The following list of all known occurrences of the Shelburne meteorite is given in order of decreasing total mass. A more-detailed accounting is available from the authors by request. This compilation is based on the current (fifth) edition of the *Catalogue of Meteorites* (Grady 2000) with departures from that work representing updates found in this study, and new entries marked with an asterisk.

Location	**Mass (total)**
Field Museum of Natural History, Chicago	4.67 kg
Natural History Museum, London	1.79 kg
United States National Museum, Washington, DC	730.00 g
*Royal Ontario Museum, Toronto	721.00 g
Harvard University, Cambridge	474.25 g
Vatican Collection, Rome	409.85 g
University of California at Los Angeles	355.00 g
DuPont Collection, Palatine, Illinois	281.00 g
Museum of Natural History, Paris	254.68 g
Naturhistorisches Museum, Vienna	245.00 g
Max-Planck Institut für Chemie	242.00 g
Yale University, New Haven	165.00 g
*Queen's University, Kingston	135.45 g
Museum für Naturkunde, Berlin	133.20 g
Geological Survey of Canada, Ottawa	119.90 g
*University of Western Ontario, London	80.20 g
Monnig Collection, Texas Christian University, Fort Worth	62.60 g
*Arizona State University, Tempe	57.80 g
American Museum of Natural History, New York	51.00 g
*David Gregory, private possession	30.30 g
*Mary Cornfield, private possession	29.00 g
Academy of Sciences, Moscow	26.00 g
*University of Griefswald	22.00 g
*University of Bonn	16.5.0 g
*Delft University of Technology, Netherlands	10.00 g
Institut für Planetologie, Münster	7.40 g
*University of Alberta, Edmonton	5.97 g
*Dufferin County Museum and Archives, Rosemont	1.40 g
Total accounted for:	**11.11 kg**

Selenology and The Bomb

by Peter Goetz, Calgary Centre (Peter.Goetz@cnrl.com)

In 1945, Harvey Nininger, a self-taught scientist and avid collector of meteorites, suggested that rocks blasted free from the lunar surface by a nuclear-tipped missile might fall on Earth to be collected as tektites (fused bits of rock that were thought to be of lunar origin). From his suggestion, it is clear that the weapons of mass destruction, so recently used by the United States and Germany in WW II, had entered the public's consciousness. In attempting to win that war, both sides had produced so-called "wonder" weapons. The Germans had placed quantities of conventional explosives on their unconventional V-2 ballistic missiles, while the Americans had opted for conventional bombers that carried unconventional atomic bombs.

Although the 22,000 tons of TNT or 22-kiloton equivalent yield of the "Fat Man" bomb developed to attack Japan was sufficient for Nininger's purpose, its 5-ton weight could not have been lifted by any missile available at the end of WW II. The United States had in fact only just begun a programme to develop its own ballistic missiles. The first American (nuclear-tipped) missile did not reach service until 1955, when the Army's Jet Propulsion Laboratory released the Corporal Short Range Ballistic Missile (SRBM) armed with a 1000-pound W7 fission warhead. A year later, in 1956, Secretary of Defense Harold Brown assigned the role of strategic offense to the Air Force, which produced the thermonuclear-warhead-equipped Thor Intermediate Range Ballistic missile (IRBM) in 1958 and the Atlas Intercontinental Ballistic Missile (ICBM) in 1959. Rebuffed in their attempt to produce long-range nuclear weapons, the Army created the Ballistic Missile Agency (ABMA) to develop a Super Jupiter launch vehicle to be used for the military conquest of outer space and the placement of an outpost on the Moon.

In parallel with their development of strategic missiles, the Air Force also produced space-launch vehicles for the deployment of spy satellites. The development of these satellites was initiated in 1956 with the award of a contract to Lockheed Missile Systems to develop Weapon System 117L. Code-named "Pied Piper," WS-117L consisted of two satellite reconnaissance systems: one designed to transmit line-scanned images of negatives developed in orbit and another to send back undeveloped film by means of a capsule ejection system.

Orbited under cover as *Discoverer* satellites in *Thor-Agena* second-stage vehicles, success was finally achieved with the 13th launch on 1960 January 10. The next day an empty "film bucket" was retrieved by Navy frogmen after it had descended by parachute into the Pacific. The Air Force, in contrast, chose electronic image transmission because it was interested in real-time reconnaissance. The first "Satellite and Missile Observation System," SAMOS, was launched into space in late 1960 as part of a second-stage Agena rocket, boosted by an Atlas ICBM. Lockheed's Agena space vehicle was the first practical second-stage addition to IRBMs and ICBMs, transforming these missiles into space-launch vehicles. The Agena vehicle incorporated both boost and manoeuvring engines. These gave it enough power to break the bonds of Earth's gravity, paving the way for lunar missions.

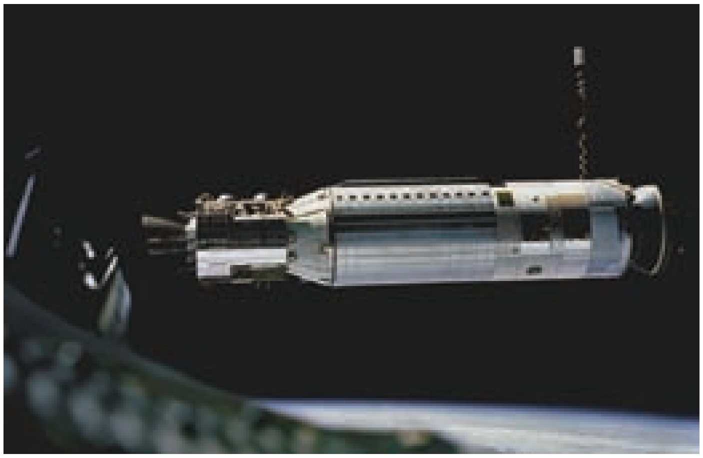

Figure 1 — A view of an *Agena* target vehicle, used in the *Gemini* flights in the 1960s. NASA image.

Anticipating the ability to reach the Moon with the technologies then being developed, W. Kellogg of the "Research and Development Corporation" published a study in 1956 entitled "Observing the Moon from the Moon's Surface." RAND was a non-profit think tank spun off from the Douglas Aircraft Company to evaluate scientific and technological issues. Kellogg's report followed up Harvey Nininger's earlier ideas by suggesting various observations that could be made by an unmanned instrument carrier capable of landing a payload on the Moon and relaying information back to the Earth. Some of the observations discussed were measurements of the lunar atmosphere, its magnetic field, and seismic activity. In addition, the creation of a visible flash on the Moon with an atomic explosion was considered.

The following year, another proposal to "nuke the Moon" was put forward by Kraft Ehricke, designer of the Agena second-stage vehicle, and Nobel Prize-winning cosmologist George Gamow. They jointly proposed a small probe named *Cow* (after the nursery rhyme) that was to fly around the Moon and return to Earth a week after it was launched. A later second probe was to be preceded by an atomic explosion that would have raised a cloud of vapourized rock. The second probe was intended to fly through the cloud, collect samples, and return them to Earth. Although the lunar sample return mission never got off the ground, it was ultimately implemented as *Project Stardust* — an interplanetary probe launched in 1999 that rendezvoused with Comet Wild 2. While flying through the comet's tail, the probe exposed aerogel collectors that trapped particles of cometary and interstellar dust. These particles were subsequently returned to Earth in a re-entry capsule, to the great benefit of planetary science.

In February 1957, Edward Teller, co-inventor of the hydrogen bomb, suggested a slightly different idea to gain knowledge of the Moon's composition. He proposed exploding a megaton-range thermonuclear warhead just above the Moon's surface. At the time, Teller's Lawrence Livermore Laboratory was developing the compact, 326-kilogram W47 warhead for the Polaris Submarine-Launched Ballistic Missile. The output of a thermonuclear explosion is 80 percent high-velocity neutrons, 19 percent gamma rays, and 1 percent vapourized bomb components. The gamma rays from the thermonuclear explosion would have irradiated the Moon's surface, causing it to fluoresce in response. The fluorescence of the lunar surface could then have been monitored from orbit or from Earth, and its spectral characteristics used to determine the Moon's chemical composition.

Although Teller's idea was never implemented, a number of successful space missions have since capitalized on his concept. In January 2005, the *Deep Impact* interplanetary probe, designed and built by JPL, was launched into an orbit on course for Comet Tempel 1. On July 4 of the same year, the probe deployed a 360-kilogram impactor that slammed into Tempel 1 with a velocity of 10.3 kilometres per second. The collision released energy equivalent to the explosive yield of almost 5 tons of TNT. Special High-Resolution Infrared Spectrometers on board the probe recorded the thermal spectra from the heat generated by the collision, which was then used to determine Tempel 1's composition.

Figure 2 — A spectacular image of comet Tempel 1 taken 67 seconds after it obliterated *Deep Impact's* impactor spacecraft. NASA/JPL-Caltech/UMD image.

The *Mars Rover* missions, launched in 2003, successfully landed a pair of mobile rovers on the surface of Mars. In addition to a camera platform mounted on a vertical mast, each *Rover* carries a number of analytical tools in a robotic arm. A panoramic camera and a miniature "Thermal Emission Spectrometer" are used to view surrounding scenes in infrared wavelengths to determine the types and amounts of different minerals as a basis for choosing science targets. A "Mossbauer Spectrometer" that emits neutrons from two cobalt-57 sources identifies minerals that contain iron. An "Alpha Particle X-Ray Spectrometer" that emits high-energy gamma rays from a curium-244 source is also used to evaluate the concentration of major elements in rocks and soil.

Although a variety of proposals to reach the Moon were being formulated in the mid- to late-1950s, the United States had yet to launch a satellite into Earth orbit. This idea to do so was first made public by President Dwight D. Eisenhower, who approved a plan to orbit a scientific satellite as part of the International Geophysical Year (IGY) during 1957-1958. The Soviet Union followed suit with plans to orbit its own satellite. A national crisis erupted in the U.S. on 1957 October 4 when the Soviets successfully launched *Sputnik* as its contribution to IGY. This created the illusion of a technological gap, and provided the impetus for increased aerospace spending and the creation of new federal agencies to manage air and space research and development.

Figure 3 — Mars Rover. NASA image.

A direct result of *Sputnik* was the creation of the National Aeronautics and Space Administration on 1958 July 29. NASA absorbed its predecessor, the National Advisory Committee for Aeronautics (NACA), and three major research facilities — Langley Aeronautical Laboratory, Ames Aeronautical Laboratory, and Lewis Flight Propulsion Laboratory. Headquarters for NASA were temporarily set up at the Dolley Madison House in Washington, D.C., with T. Keith Glennan as its first administrator. Glennan had been president of the Case Western University in Cleveland, Ohio, and one of the commissioners of the United States Atomic Energy Commission (AEC). Although it might not have seemed obvious at the time, NASA gave the United States a major advantage over the Soviet Union in the space race. It now had a single organization with a specific set of goals, whereas the Soviet space program was hampered by competition between a set of loosely coordinated organizations.

In addition to NACA, Glennan attempted to incorporate other organizations into NASA, notably the Space Science Group of the Naval Research Laboratory in Maryland and the Army's Jet Propulsion Laboratory and Ballistic Missile Agency. The Army reacted aggressively to this request. Glennan had assumed that the Army was in the rocket business for military purposes and that space was just a sideshow, but after Secretary Brown limited the range of Army missiles to 200 miles in a 1956 pronouncement, the reality was the other way around. Nevertheless, the Army's case for hanging on to ABMA and JPL was weak, and Glennan managed to acquire both these organizations. On 1958 October 21, President Eisenhower transferred the ABMA's scientists and engineers to NASA. The Army lost 100 million dollars worth of facilities and equipment, about 4000 civilian employees, and Wernher von Braun, the former wartime director of Germany's V-2 project. It also lost Super Jupiter,

Figure 4 — Dr. Wernher von Braun in 1954, then Chief, Guided Missile Development Operation Division at Army Ballistic Missile Agency (ABMA) in Redstone Arsenal, Alabama. NASA image.

which NASA renamed Saturn in preparation for its use as the *Apollo* Program's booster.

One year prior to its transfer to NASA, JPL's Director, William H. Pickering, presented plans for a space extravaganza intended to overshadow the recent Soviet success with *Sputnik*. The program was called "Red Socks" and its main objectives were to "impress the world" with a series of lunar flights and to refine space-guidance technology. Because of its military connections, JPL was well aware that the necessary technology to accomplish its lunar missions was in development with projects such as the Army's Jupiter re-entry vehicle, the Navy's Microlock radio ground-tracking system, and the Air Force's Thor-Agena space launch vehicle.

The Red Socks program proposed the launch of nine different lunar probes. For the purpose of expediency, the first probe would likely have been carried aloft by a Thor-Able two-stage launch vehicle and then inserted into a trans-lunar trajectory by means of a small Altair third stage. The initial use of a Thor-Able launch vehicle would have allowed the probe to reach the Moon as early as June 1958 but would have limited the probe's weight to 6.75 kilograms. The remaining probes would likely have been launched with the aid of a Thor-Agena rocket combination. This more powerful vehicle would have allowed a weight increase to 54 kilograms for the succeeding probes.

While the objective of the second probe was to take close-up pictures of the Moon's dark side and return them to Earth in a re-entry vehicle, the objectives of the seven following missions were vague. To further define the program, Pickering subsequently proposed exploding a nuclear warhead on the Moon's surface. In this manner, lunar rocks hurled to our planet by the explosion might be acquired. (If he heard, Harvey Nininger must have been delighted.) The explosion was also expected to produce "beneficial psychological results" in certain quarters. The atomic warhead for the lunar mission was to be delivered by a somewhat fanciful 72-metre-tall "Inter-Spatial Ballistic Missile" or ISBM, that was never built.

The minimum nuclear yield thought necessary to propel rocks to the 2.4 kilometres-per-second velocity required to escape the Moon's gravity field was 11 kilotons. This could have been provided by a W34 tactical warhead based on a boosted fission device produced by the Los Alamos Nuclear Laboratory. The physics package for this warhead weighed only 65 kilograms! Saunders Kramer, a Lockheed Missiles and Space Division employee, determined that such a warhead would have enough time to explode before being crushed on impact with the lunar surface. The use of piezoelectric crystals to generate an impact signal to detonate pre-armed warheads in ballistic re-entry vehicles was common practice by this time, and Kramer found that such a proposition was indeed practical for the lunar mission. Warhead arming would have been accomplished by a radar altimeter as the space probe descended toward the lunar surface.

Project Red Socks ultimately received no government support but, in December 1957, JPL and the ABMA were asked to orbit an Earth satellite. *Explorer 1,* with technology very similar to the proposed Moon probe, was launched into orbit on a Redstone missile 81 days later, on 1958 January 29. After a false start with *Pioneer,* JPL accomplished a modified Red Socks mission as part of the *Ranger* space program, beginning with the lunar landing of *Ranger 7* on 1964 July 31. The 366-kilogram *Ranger* lunar probes were carried into space by means of Atlas-Agena launch vehicles.

Figure 5 — *Ranger 7* spacecraft, launched on 1964 July 28 and arriving at the Moon three days later. The spacecraft carried six television cameras, sending back high-resolution photographs of the lunar surface until its impact in an area between Mare Nubium and Mare Cognitum. NASA image.

In the continuing spirit of inter-service rivalry, the United States Air Force Special Weapons Center initiated its own top-secret Project A119 in 1958. This was ingenuously entitled a "Study of Lunar Research Flights." Project A119's real aim was to intimidate the Soviets and their allies with the surprise detonation of a nuclear or thermonuclear warhead on the surface of the Moon. The project was formulated during a one-year period by a small group of scientists at the Armour Research Foundation at the Illinois Institute of

Technology, which provided scientific consultancy to the Air Force.

This group included many well-known scientists. Leonard Reiffel, the project's chief scientist, was the *Apollo* lunar mission's scientific instrumentation manager; Gerard P. Kuiper had a successful career in planetology and his doctoral student, Carl Sagan, became a well-respected science popularizer. Relying on a delivery accuracy of "a couple of miles," it was decided to explode the warhead on the Moon's night side, close to the terminator. The debris cloud from the explosion would have been back-lit by the Sun, and its visibility maximized.

In planning the lunar location for detonation of the nuclear warhead, Project A119's participants probably took into account the results of Operation Argus, a clandestine series of nuclear tests conducted in the South Atlantic during the late summer of 1958. Argus consisted of three kiloton-range bursts at altitudes of 200 km, 240 km, and 539 km. The tests were used to evaluate the effects of nuclear explosions outside of the atmosphere — how the release of charged particles and radioactive isotopes would interact with the Earth's magnetic field and potentially interfere with radar tracking, communications, and satellite electronics. Argus inadvertently demonstrated that a nuclear fireball does not form outside the atmosphere. Therefore, to make such an event visible, it would be necessary to choose a location where atomic debris might be illuminated as it expanded into space.

Unfortunately, many of the reports produced for Project A119 were destroyed in 1987 by the Armour Foundation. The main report is available through the Freedom of Information Act. Reiffel has never discussed these once-classified reports, but it is clear his team concluded that, properly placed, a nuclear explosion could be made visible from Earth. The project's reports also described methods for studying the thermal characteristics of the lunar surface exposed to the explosion, and the detection of a metallic core if seismometers had been placed on the Moon's surface ahead of the explosion. Rock composition and the presence of a magnetic field were also to be examined.

Gerard Kuiper's task for this project was to calculate the size of crater created by a nuclear surface burst. On the terminator, it is unlikely that such a crater would have been visible from Earth, since even a megaton-range explosion would have blasted a hole no more than half a kilometre in diameter. Kuiper's graduate student, Carl Sagan, prepared other scientific investigations related to the project: "Possible Contribution of Lunar Nuclear Weapons Detonations to the Solution of Some Problems in Planetary Astronomy" and "Radiological Contamination of the Moon by Nuclear Weapons Detonation." Sagan was also tasked with modeling the expanding dust cloud to be produced by the nuclear explosion in the vacuum of space. This model was central to predicting if the cloud would be visible from Earth.

Despite its thin scientific veneer, it was clear that the main aim of the project was a political statement. The Air Force wanted a spectacular cloud of dust, clearly visible to America's adversaries. In appraising the scientific value of this project, Reiffel made it clear there would be a huge cost in contaminating the lunar surface with radioactive debris, but the Air Force was mainly concerned with how the explosion might play to the public on Earth. Reiffel, in his report, noted that the reaction of the public to a surprise atomic explosion on the Moon would most likely be negative. As the mission was mainly a public-relations exercise, this factor helped contribute to its demise in January 1959. Nevertheless, *Air Intelligence Digest* reported a concern in November 1959 that the Russians might be preparing their own project to nuke the Moon. In fact, they were.

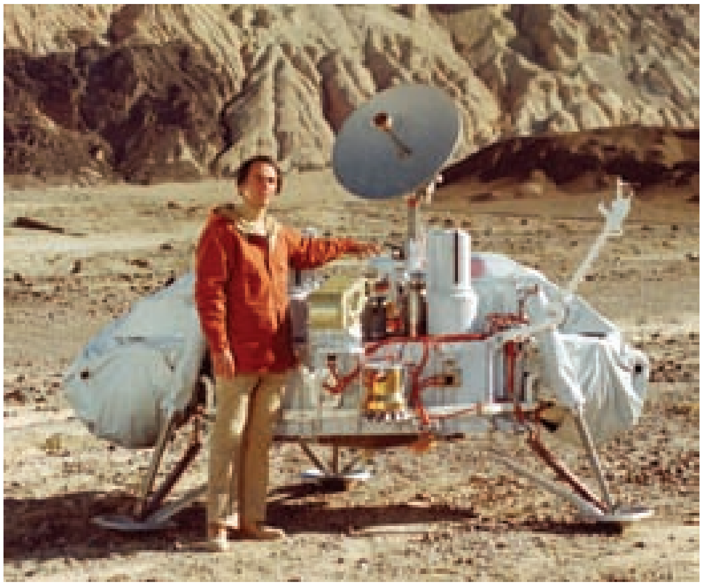

Figure 6 — Carl Sagan with a model of the *Viking* Mars lander. NASA image.

The cancellation of Project A119 was inevitable after the United States and the Soviet Union concluded a nuclear-test moratorium in December 1958. The moratorium was supposed to lead to a total test ban but, lacking a formal agreement, the Soviet Union resumed testing on 1961 September 1, followed almost immediately by the United States. Despite the resumption of testing, a nuclear Moon mission was rendered remote on 1961 May 25, when President John F. Kennedy announced before a special joint session of Congress the dramatic goal of sending an American to the Moon and returning him safely to Earth before the end of the decade. The "Partial Test Ban Treaty," which prohibited any nuclear explosion within the atmosphere or in space, entered force in 1963, and, four years later, the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and other Celestial Bodies" closed forever the page on nukes in space.

Suggestions for Further Reading

Burrows, William E. 1999, This New Ocean: The Story of the First Space Age (Random House: Toronto)

Rhodes, Richard 1996, Dark Sun: The Making of the Hydrogen Bomb (Simon & Schuster: New York)

Rhodes, Richard 1995, The Making of the Atomic Bomb (Simon & Schuster: New York)

Ulivi, Paolo 2004, Lunar Exploration: Human Pioneers and Robotic Surveyors (Springer-Verlag: Heidelberg)

Peter Goetz has a Ph.D. from Carleton University in the Earth Sciences and is a practicing petroleum geologist in Calgary, Alberta. He is also active as an amateur astronomer. A visit in 2000 to the Titan II museum in Green Valley, Arizona, triggered Peter's interest in nuclear and thermonuclear processes. His research in this area has led to the publication of a number of popular magazine articles on nuclear weapons; he is currently completing a book that details the historic development of American nuclear-weapon systems. This article is a condensed version of a lecture given at the University of Calgary's Rothney Observatory on the occasion of the 40th Anniversary of Apollo 11*'s Moon landing.*

The Joys of Winter Stargazing

by Ray Khan, Mississauga Centre (khanscope@gmail.com)

If you are like me, on some winter nights, you might look out the window and secretly pray that it will be cloudy. Why? In my case, it's so I won't feel guilty about having to go outside and observe in the cold, because — lo and behold — the clouds have appeared, or are going to appear as soon as my equipment is set up to start observing the night sky. Never mind that the weather forecast predicts a clear night — surely, the Weather Network must be wrong tonight, I tell myself. Truth is, this has happened on the odd occasion, and now it is a useful memory to play back at convenient times, especially when it's nice and warm inside and -7 outside.

It is remarkable just how many excuses one can come up with to avoid stargazing in the winter: "It's my turn to baby-sit the kids tonight" (of course, you actually have to have kids to pull this excuse) or "I have to get up for work early tomorrow." (But it's true, really!!!)

Or perhaps you really can't miss the next episode of CSI. on television.

With that in mind, I would like to offer some practical solutions to winter stargazing, even though summer skies are currently on your mind and winter far away. I find the winter sky to be inspiring and refreshing to observe. Some of the best and most memorable observing I have done has been during the cold season. The skies tend to be clearer, and, if the air is calm, stars appear to be brighter, and there are usually a few planets that can be observed on any given evening, especially as evenings begin early. Regardless of whether you are observing from your backyard or driving to a location, a little preparation goes a long way.

First, you will want to layer your clothing. Thermal underwear, available in most ski shops, is a good place to start, for both your legs and upper body. A pair of comfortable pants and a sweater should follow, and, over those, to minimize bulk, I recommend some of the thermal clothing that cross-country skiers wear. It allows for flexibility and movement. Over the pants, a windproof shell is useful for keeping the wind at bay. Complete your ensemble with a long winter coat.

A wool hat, earmuffs, and scarf are also essential, for if your head gets cold, your entire body feels the impact. If you prefer a hoodie, those are good too, though they tend to twist and get in your way. Wool-lined Sorel-brand boots are my personal favourite to keep my toes warm, especially when supplemented with thick thermal-wool socks. Thin gloves with thermal lining are great, especially when you need nimble fingers to make adjustments to various bits and pieces of hardware. If they aren't warm enough, try gloves and mitts together, removing the mitts when a finer touch is needed for tweaking instruments. If you tend to be sensitive to the cold, you can even purchase compact chemical heating packets, which can be placed within your shoes and gloves.

Bring a good-size thermos to carry your favourite hot beverage, especially useful if you are travelling to a distant observing location. In my case, I always determine the location of the *en route* 24-hour Tim Hortons when I plan to be out late, as they provide for a quick refuelling stop on the way out and back. I would suggest abstaining from alcoholic drinks, as they will dilate your pupils, among other things.

In the cold of winter, it is a particularly good idea to plan your observing session ahead of time. With one of the many software programs available to amateur astronomers (a Google search will even turn up some that are free of charge), you can decide which objects to observe, and note the time (from the warmth of your home) at which they are best viewed. You don't want to be heading out to observe Saturn, for example, only to find out that it is not rising till after 2 a.m., when you want to be back home by 11 p.m. Further, less time is wasted trying to figure out what to observe, and more time is actually spent observing.

One of the other benefits to winter observing is that, because it gets dark early, you can start observing sooner, cover a lot of objects, and still be back at a reasonable time — important if you happen to be driving some distance to a dark-sky site. And, if you're driving to an unfamiliar location, it is usually a good idea to go observing with a buddy. Carry booster cables — the battery you use with your telescope may also bring your vehicle to life again in difficult circumstances. If your power needs are significant, don't use your car battery — low temperatures bring low battery capacity, and you can use it up in the course of a winter night.

I recall a friend who, several years ago, went stargazing by himself to a ski resort. It was a great spot, as the surrounding hills blocked the light from the surrounding townships. As luck would have it, his car slipped into a ditch as he was entering the site. He did not have a cell phone, and ended up walking quite a distance to a rural home late at night to obtain assistance.

I remember more fondly an observing session in 1997, when I decided to go to a provincial park, the Forks of the Credit, where I knew other amateur astronomers would be observing and photographing Comet Hale-Bopp, one of the brightest comets of the last century. As it is just about an hour northwest of Toronto, it was a relatively easy drive. It was a cold, clear, and crisp winter night, with no wind, and I was simply enthralled by the experience of observing under ideal conditions with fellow amateur astronomers.

At about 1:30 a.m., we had finished observing and photographing the comet, which was then setting below the horizon. Everyone else had left the site. I recall how cold my hands were advancing the 35-mm film in my camera, being careful to make sure it did not tear because of the cold temperatures. Those were the days, before the advent of the digital camera!

Realizing that the comet would reappear in the dawn sky, I decided to stay the night and capture images of it in the early morning twilight, as it climbed above the horizon before the Sun rose and erased it from the pre-dawn sky. Fortunately, there was a 24-hour Eddie Shack donut shop just a few minutes away, so I went there, refilled my thermos with hot chocolate, and bought some donuts to carry me through the night. I was starting to feel a bit drowsy at this point, so I got into my truck, and turned the heater and radio on, left the window open a slight crack, and dozed off to sleep for an hour or so.

When I awoke, I checked the car dashboard clock and it was around 3 a.m. I climbed from the truck and was struck at how glorious the night sky was. I then observed the morning sky while lying down on a blanket on the warm hood of my truck with a pair of binoculars in my hands. It was almost a surreal experience, enhanced by the quiet around me and a night sky blanketed with stars. When the comet reappeared above the horizon in the early morning, I took some more images with my camera. Finally, as the dawn crept in, I decided to call it a "night" and head home for a well-earned sleep.

Today, several years later, I still recall this as being one of my most memorable winter observing experiences.

Owning a dog can also be another handy way to familiarize yourself with the winter sky. When it's time to walk Fido, even in the city, you can see the outlines of the brighter constellations, especially Orion, the Hunter, the Pleiades, and, of course, the brighter planets — Venus, Jupiter, Mars, and Saturn. Dog-walking time is a time to note the apparent motion of these objects over the course of a month or season. Of course, you will want to be sure to observe the bright star, Sirius ("the Dog Star") and point it out to your four-legged companion, so that he or she too can enjoy the sky. A great way for both of you to learn the night constellations!

The International Year of Astronomy has resulted in many astronomical events and activities at many different venues and locations and more is yet to come. Telescopes for public viewing will be set up at many of these upcoming events, and even though the temperatures may chill, the clarity of winter skies is sure to bring on many Galileo Moments.

Ray Khan is an amateur astronomer who resides in Toronto and manages Khan Scope Centre, a retail astronomy shop.

Twelve RASCals Remember the First Lunar Triumph

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

When a majestic tree crashes in a dense forest and no one is there to witness its sudden fall, some philosophical humans might deem it a non-event. But sentient beings who see such a thunderous crash consign it to a long-term memory by associating it with contemporaneous events in the passage of our lifetime. So it was with our Moon in the summer of 1969, when the largest TV audience ever for a space event — an estimated 600 million people,[1] representing one-fifth of the Earth's population — watched a very extraordinary event.

It is somewhat of an understatement to say that the Moon has intrigued humanity since early men and women looked up into the night sky and wondered what causes it to move. And on 1969 July 20, now just over 40 years ago, two representatives of humanity set foot on that Moon for the first time, contributing to a human triumph of truly epic proportions. To put this experience into a recent-era perspective, the date comes some 150,000 years from the first appearance of *Homo sapiens* tramping across the plains of East Africa, and up to 5 millennia after the passing of great ancient civilizations such as those of Sumer, Babylon, Egypt, and Rome.

During that summer week in 1969, most humans witnessed, heard, or read about the Moon landing via the then-current communication technology — television, radio, and print. But since that summer adventure, billions of men and women have been born, so that the first Moon landing and lunar walkabout represent an intriguing story of exploration that is not a personal, real-life story, but only a fairly recent piece of history to be read about or viewed as a film documentary.

Those who lived through the *Apollo 11* voyage have vivid memories of this extraordinary event occurring at a special period in their lives — an event that they will never forget and will take to their graves. Wernher Von Braun, a celebrated NASA executive and rocket engineer who worked on the *Apollo* program and many other space initiatives, evaluated his sense of the importance of the event during a pre-launch press conference when he observed: "I think it is equal in importance to the moment in evolution when aquatic life came crawling up on land."[2]

Walter Cronkite, the iconic giant of TV news anchors, who covered the early manned space flights and died at 92, just three days before the 40th anniversary, concluded a few years ago that 1969 is the one date that will be best remembered from the 20th century. "Five centuries from now," Cronkite said, "I believe the 20th-century date that will be remembered is the year the human race first journeyed from the Earth to the stars." [3]

Figure 1: Buzz Aldrin on the moon, standing next to the LEM landing leg on 1969 July 20. The reflected light from the gold thermal cover on the LEM can be seen on the shaded side of the white space suit. The lunar surface just beyond the LEM leg is smoothed by the engine exhaust and appears brighter. Image: NASA.

The entire *Apollo 11* mission lasted 195 hours and 17 minutes, of which the Moon landing and surface reconnaissance consumed only 21 hours.

Many members of the RASC, now older by 40+ years, were part of that assortment of Earth-bound humanity who had the special opportunity to witness this history-making drama as it unfolded. To see what they recalled of the first astronauts' Moon landing and walk during this anniversary year, a call went out on the RASC list server for members to share their recollections of the *Apollo 11* voyage, now some two generations past.

RASCals were asked:

1. How did you witness the event (TV, radio, other)?
2. Where were you?
3. Did it have any impact on you?
4. How old were you then?
5. Any special memories?
6. Any outcomes that resulted for you?
7. Disappointments — Then? Now?

The responses revealed a unique time and age, which now remains a personal memory. What follows are the collected reminiscences of 12 RASCals arranged in a Question & Answer table. Many were youngsters at the time, and some recall requiring parental permission to stay up late to watch. Imagine the youthfulness and their awe!

1. Douglas B. George

A-1: TV

A-2: My Aunt's place in Montreal in their basement rec room; both families were there.

A-3: Sure, I was a space cadet already.

A-4: 7 years old

A-5: I thought the guy took a long time to step off the ladder!

A-6: Hard to say, but I was already into space stuff.

A-7: Nope

2. Kim Mysyk

A-1: TV

A-2: In my living room alone, in the little two-bit, one-horse town I grew up, south of "Winterpeg."

A-3: Yes - big time! I was into astronomy at the time and also into geology, but this was the impetus that really got me interested in becoming a geologist. It was extremely exciting to think that we were actually going to get analyses and find out something about the geology of the Moon!!

A-4: 16.5 years old

A-5: Thinking about what an incredible event I was witnessing, I was in awe and found it truly mind-boggling!

A-6: I went into geology at University.

A-7: Then: Thinking what a sad fact it was, that this incredible event was so irrelevant to most people in the town.
Now: Would have been nice to have some follow-up on the lunar geology.

3. Geoff Gaherty

A-1: In the morning, I wandered down to the hotel bar and there, on the TV, were Armstrong and Aldrin walking on the Moon.

A-2: It was pretty much an accident that I saw the Moon landing. I was flying from California to Kenya on a combined honeymoon and research trip. Our flight from London to Nairobi via Frankfurt was delayed five hours by an "industrial dispute" at Heathrow. As a result, we landed in Frankfurt just late enough that, had we taken off, the pilots would have just exceeded their safe flying time. So, instead they got us all off the plane at 3 a.m. and bused us into a hotel in town for the night.

Figure 2 — The Earth's (Moon's?) most expensive footprint. Image: NASA.

A-3: I was totally entranced! I'd been a science-fiction reader for 16 years and an amateur astronomer for 12 years, and this was a dream come true!

A-4: 28 years old

A-5& 6: We headed on to Nairobi later that morning, and I still have a copy of the Nairobi newspaper with the Moon-landing story in it.

A-7: My major disappointment is that we haven't been back to the Moon since 1972. *Apollo 17* was the first flight with a real scientist aboard, and Harrison Schmitt learned an enormous amount on that flight, but the cancellation of the last two *Apollo* missions was a major scientific tragedy.

4. Ian Levstein

A-1: I have a clear memory of sitting in the family room with my Mom as we watched the event live on TV.

A-2: On 1969 July 20, I was living in the northern Toronto suburb of Downsview.

A-3: Indeed, yes. Each week for three years I was transported to other worlds whenever *Star Trek* aired. In July 1969, I was thrilled when science fiction became science fact. It was now just a matter of time before we moved beyond the Moon to Mars and then beyond our own galaxy and it might just happen in my lifetime. I persuaded my Mom to buy me a pair of binoculars that week and the heavens never again looked quite the same.

A-4: I was 15.5 years old and going into grade 11 at William Lyon Mackenzie Collegiate Institute.

A-5: I sat for hours waiting for Neil Armstrong to stand on the Moon and, as it was rather late in the evening, Mom kept telling me it was time to go to bed and it'd be on the news in the morning, but I wanted to stay up. It was summertime and there was no school the next day, so I won!

A-6: The Moon landing was the impetus behind my love of astronomy.

A-7: No regrets then. Now though, I'm disappointed that space travel has become so difficult. It's terrific that US-Soviet relations finally came together (at the time, we were never sure)...and it has worked out well for the *ISS* [the *International Space Station*], but there are just too many politicians who would prefer to divert funds away from the space program.

5. Paul Campbell

[Paul wrote as a preamble to his answers: "OK, I'll dive in but my honest answers may differ from some on the list. I think that should be OK."]

A-1: TV

A-2: At home in Littleton, Colorado. I got to stay up late to watch it.

A-3: Don't get me wrong, I knew the landing was history in the making and that was cool but, in the long term, it didn't have much of an impact. Soon after, I lost interest in all things space and astronomical. Sad to say, I was one of the ones who lost interest in watching the Moon landings since they seemed so commonplace.

A-4: 14 years old

A-5: Not really, except I got to stay up late.

A-6: It wasn't the space missions that drew me to astronomy. It was reading about the expanding Universe that blew my mind. Sad to say I didn't know about that until my adult life, and it's actually something we knew some half-century before the Moon landing. To be honest, the only way I know about *Shuttle* launches is because our local list server lights up. I think the best outcome of the space missions has been the *Hubble* telescope and its repairs. If it weren't for the manned missions, the ***Hubble*** would have been a dud.

A-7: We need a larger *Hubble* up there.

6. Brian Fenerty

A-1: TV

A-2: I was in the dining room (during dinner service) of the then-named *Olde Englande Inne* on Lampson Street, Esquimalt, Victoria, B.C., where I was staying. The owner of the top-rated period-character small hotel brought in a large TV and placed it on a dining table to the right of the dining room's fireplace for all hotel guests to watch the full approach and landing. (What, a TV in that quaint dining room? Never done, old chap! No modern contraption in that top-star period dining room ever before, to my knowledge — but the owner could, of course, do what he wanted, and did.) Waiters and waitresses in old-fashioned English dress helped us watch, over delicious, specially made steak and kidney pie, and other delicacies. The hotel's suits of armor (empty) standing in various corners looked on, too. Delightful blend of the past and the future!

A-3: Confirmed for me what serious science-fiction writers (*Analog*[4] *etc.*) were saying that we fledglings in the nest called Earth really needed to do.

A-4: Younger

A-5: In the days just before the landing, prompted by Victoria newspaper's article with sky map, I went over to nearby Saxe Point Park overlooking open water for a good distance, and located the pinpoint of light that was *Apollo 11* on its way outbound and watched it for many minutes before it set. Next night was able to see it again, fainter and further outbound. Due to need for certain twilight conditions and clear western horizon, most of North America did not see these extremely rare outbound, beyond-Earth-orbit views.

Figure 3 — Aldrin salutes the U.S. flag on the Moon. The rod holding the flag horizontally would not extend fully, giving the flag a slight waviness and the appearance of being windblown. Image: NASA.

A-6: Among other things, a confidence that we humans were/are capable of getting outside of just one living location (maybe vital someday!). Among other things, it also enhanced my sense of the adventure side of science. And made the night sky feel all that more human and personal — still carry that feeling as a RASC member and at public events.

A-7: Politicians and politicos who saw and see science just as a space race to be abandoned when the other side flags, or see science as very secondary for them to understand and support. Also, if we humans had continued to go to the Moon back then, we well might have developed — years ago — much technology to already go to Mars.

7. Deane McIntyre

[Deane noted when listing his current location "...where I enjoyed a nice view of the crescent Moon with earthshine last night (2009 April 28)".]

A-1: Television tuned to CKVR Barrie, which at that time carried the CBC network.

A-2: Grandmother's cottage at Alcona Beach on Lake Simcoe, Ontario, near Barrie, where we usually spent our summer holidays. In addition to my grandmother, my parents, sister, aunt, uncle, cousin, and the neighbours, who did not have television at their cottage, were there.

A-3: I had been interested in astronomy for a few yours at that point, and had closely followed the *Gemini* and *Apollo* programs — was a bit too young to remember much of the *Mercury* program.

I had been looking forward to the first human landing on the Moon for years. After getting interested in astronomy, of course I had longed for a telescope; and for Christmas 1966 had got a 50-mm Tasco refractor (in those days Tasco used real glass in their lenses). I remember looking at the Moon and wondering where man would first land. So, the first landing had a major impact on me.

A-4: 11 years old, in between grades 6 and 7

A-5: I remember that we had gone swimming in the lake that afternoon, and had got back to the cottage in time for the landing of the *Eagle*. During the Moon walk that evening, I remember my grandmother sitting in her chair appearing somewhat dumbfounded — after all, she was old enough to remember the first flights of the Wright brothers.

A-6: I got to stay up the latest I had ever been allowed to stay up.

A-7: After reaching the Moon, it seemed that colonies on the Moon and a landing on Mars were just years away — yet we are still nowhere close to either 40 years later. Who would have thought at that time that 40 years later we would be limited to low-Earth orbit as far as manned missions were concerned? It seems that everyone old enough to remember recalls where they were at the time of the *Apollo 11* Moon walk and the oxygen-tank explosion, but few seem to recall *Apollo 12*. At that time, I was in our house at Bowmanville, Ontario, and got up early in the morning to watch the second Moon walk. This time I was by myself in front of our DuMont television — the rest of the family was in bed. I seem to recall that the camera was damaged by being accidentally pointed at the Sun at the beginning of the Moon walk with the result that it could not be viewed; only the audio feed was left. I was rather disappointed, to say the least.

Figure 4 — The Lunar Excursion Module (LEM) returns from the Moon. Image: NASA.

8. Bruce McCurdy

A-1: TV

A-2: At my family's home in St. John's, Newfoundland. Had several family members on hand for the whole approach and landing. Very confusing as the animated television sequence showed the *Eagle* safely on the ground while the audio feed indicated the drama was still unfolding. Later watched the moonwalk at a very late hour (the small step occurred at 0:26 NET on the 21st). Again, family members around for the start, but I was the only one who hung in for the whole thing, including a boring hour or so when the astronauts deployed the ALSEP science package far from the camera. The fact that we were able to watch this historic event on live TV was amazing in its own right.

A-3: Very much. Possibly *Apollo 8* had more impact, but the whole *Apollo* series opened my eyes to the skies. I watched every mission from launch to splashdown.

A-4: 13 years old that summer, going into Grade 9

A-5: The drama of the Space Race carried right into that eventful day, not just with the success of *Apollo 11* but the crash that same afternoon of the unmanned *Luna 15,* which was the Soviets' last ditch effort to, uh, "scoop" the Americans with a sample-return mission.

A-6: My interest in space and astronomy was awakened during that period.

A-7: Certainly no disappointment at the time — it was a triumphant, transcendent moment. Disappointments now include humankind being locked in low-Earth orbit, with the prospects of a lunar base or a Martian outpost being at least as far in the future today as they seemed to be that day. I'm also disappointed that international cooperation has seemingly achieved less than international competition once did.

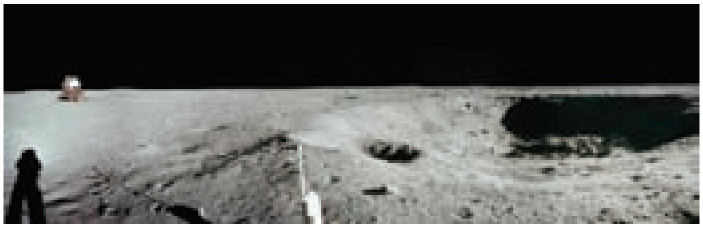

Figure 5 — East Crater panorama from the *Apollo 11* landing site. Image: NASA.

9. Victor Gaizauskas

[Victor wrote as a preamble: "The summer of 1969 was very hectic for me. Construction of a "solar spar" telescope was well advanced at Canadian Westinghouse in Hamilton; a contract had been awarded to an Ottawa firm to put up a building to house the telescope at what came to be the Ottawa River Solar Observatory on Shirley's Bay (*JRASC,* v.70, 1, 1976); my wife and son were holidaying at her family's old cottage at a place called Oliphant on the Bruce Peninsula; I was racing around Ottawa-Hamilton-Oliphant-Ottawa, with brief stops in Toronto to visit my parents, from June to August.]

A-1: I recall watching the Moon landing, by myself, on our old black-and-white Zenith TV.

A-2: At home in Ottawa.

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Pen & Pixel

Figure 1 — Ottawa Centre's Doug George used a new Ceravolo 300 Astrograph at f/4.9 on a Paramount mounting to collect this image of the Veil Nebula in three wavelengths. Total exposure was approximately 5 hours: 100 minutes in SII (red), 105 minutes in $H\alpha$ (green), and 90 minutes in OIII (blue). Doug used an Apogee Alta U9 camera and Astrodon filters. *MaximDL* was used for image processing.

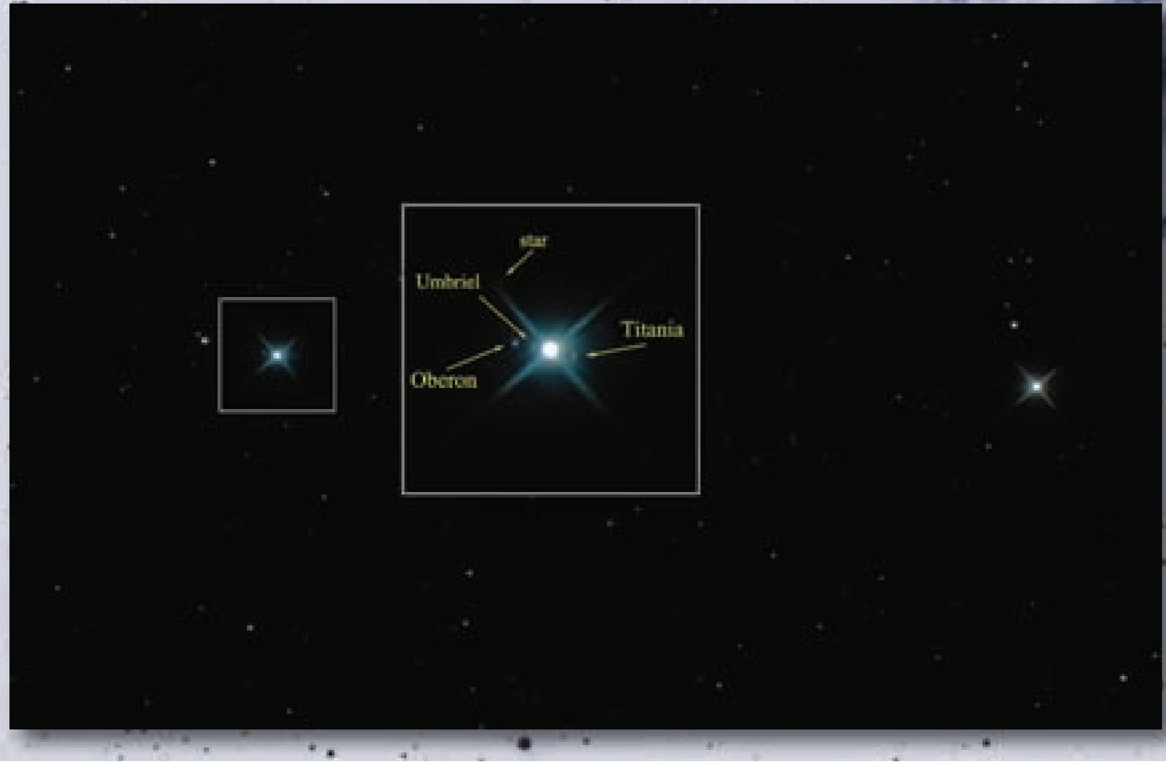

Figure 2 — Massimo Torri extended his high-resolution double-star photography (see article in this issue) to the moons of Uranus, capturing this charming image from his home in Edmonton. The image consists of 90 20-second individual exposures (30 minutes total) using a Canon XSi camera set at 1600 ISO on a 10-inch f/4.7 reflector at prime focus. A Baader Coma Corrector was used to contain coma.

Figure 3 — Jim Chung from the Toronto Centre convinced Jupiter and Europa to pose for this image on July 8 from his backyard. Jim used a Celeston 8-inch telescope at f/20 and a PGR Flea firewire ccd running at 15 fps. The image is constructed from 250 of 1000 frames for each RGB colour channel. Europa with its shadow is seen on the left; Ganymede is on the right.

Figure 4 — Joe Carr is particularly pleased with this image of the Crux-Carina area acquired from La Ensenada Lodge, Gulf of Nicoya, Costa Rica, last February. Joe used a Hutech-modified Canon XTi DSLR, a 70-200-mm zoom lens set at 70 mm, f/5, and ISO 1600. The image consists of 31 raw exposures at 2 minutes each. From left to right, we see the Southern Cross and Coalsack Dark Nebula, IC 2944/8 nebula, Stock 13 cluster, the Eta Carina Nebula, and the Southern Pleiades cluster (IC 2602).

Continued from page 197

A-3: I was amazed at the success of this highly complex mission when so many things had to go right to avoid a calamitous loss of life and a catastrophic public-relations disaster. I was awed by the supreme confidence displayed by the Americans to put this show on LIVE for the entire world to watch — unlike other nations who might record the event in secret and then release it only if it succeeded. The Americans rightly deserve to be extremely proud of this magnificent achievement, their pinnacle of technical prowess.

A-**4:** Two months shy of being 39 years old

A-5: It was frustrating not being able to communicate with my wife and son (he was then 14) while this fantastic event was unfolding. There was no telephone or TV at the old family cottage where they were, so they followed the event on the radio.

A-6: None related to the Moon landing itself.

A-7: Insofar as space exploration goes, I am disappointed by the overemphasis on manned space flights. Canada got sucked into the wasteful *Shuttle* program — wasteful in getting so little real science for such high expenditures — and abandoned building an independent space program. Our communications satellites and *Radarsat* are terrific, but much of it is American-built and all of it is American-launched.

10. Joseph O'Neil

A-1: TV

A-2: At home. Mom and Dad got me up in the middle of the night and told me there was something very special about to happen. We had one TV, an old black-and-white, maybe a 16-inch, cannot remember. 12 channels, but the tuner didn't work very well, so we had a pair of vice grips to hold the tuner in place.

A-3: Yes, I started reading and paying attention to the small astronomy section of the *Reader's Digest World Atlas* Mom and Dad had, and started looking at any and all astronomy and space articles in the *National Geographic,* to which Mom and Dad had a subscription.

A-4: 8 years old

A-5: I was as a child [sick] a lot back then — had everything you could get, both red and German measles, chicken pox, bronchial pneumonia, and a whole slew of other things. About the only reason I was ever woken up in the middle of the night before this time by my parents was to be rushed off to the hospital to be placed on an O_2 tent or something similar. It was kind of neat to wake up in the middle of the night and NOT have to go to the hospital.

A-6: Yeah, a house full of optics — cameras, telescopes, microscopes, binoculars, *etc, etc...*

A-7: Yeah, we haven't gone back yet. That, and no flying cars yet either. :)

11. Andrew Oakes

A-1: TV

A-2: I was at summer youth camp in the Quebec Laurentian Mountains near a small town called St. Theodore de Chertsey, about 90 kilometres northeast of Montreal. The camp organizers brought in a black-and-white TV for the special event, which they hoisted above our heads into the corner of a roofed kiosk [a wooden structure that housed the confectionary and had three sides open to the elements]. It was a comfortable evening, late enough for the mosquitoes to be somewhat at bay. Those who responded to the invitation to watch did so. There were about 50 of us youngsters, in addition to camp counsellors and a few adults from nearby cottages.

A-3: It made me determined to learn more about astronomy, to seek out the RASC Montreal Centre and attend its monthly Saturday evening meetings at its observatory on Mount Royal, and to become a frequent visitor of the then-named Dow Planetarium (a 1967 Centennial project) in Montreal.

A-4: 14.5 years old

A-5: Sitting on a wooden bench in the kiosk watching the TV screen, which was receiving a fuzzy broadcast signal from one of the local-area stations; we were in complete darkness as all the lights were turned off to show the TV screen better and keep the moths away; one could glance around three sides of the kiosk — the roof was held up by logs cut locally — and see the darkened trees surrounding the three sides, while a small man-made lake extended 100 metres beyond one of the open sides.

The above memory was closely linked to the previous November when my dad had bought me a Tasco refractor telescope that I still have. It cost $56, which was a lot of money for my dad to spend, given what the wages were in the late 1960s, if you were a working-class labourer. I shall never forget his generosity, for I had not asked for a telescope given the cost, but he surprised me, as he knew how much I was infatuated with the Solar System, the stars, and the Universe. The Moon landing only enhanced my wonder of the celestial heavens, space travel, and Solar System exploration. I realized how the human will, backed by engineering, determination, funding, and creativity could conquer what might seem an unattainable dream.

A-6: I have kept astronomy as a serious hobby over the decades since the Moon landing — basically as an armchair amateur astronomer — and have continued to read widely on the subject.

A-7: My disappointment is that western governments and their voting publics in past years have not always understood the importance of space exploration; and that the United States allowed its lead in landing humans on an extraterrestrial body to grind to a halt. Now with China, India, and other non-western nations showing exploratory interest and developing the capability to act, it is hoped that countries like the United State, Canada, and those of the European Union and Russia will seriously move forward with determined, effective space efforts and truly expand their recent collaborative efforts.

12. Denis Fell

A-1: TV

A-2: I watched the Moon landing from the lounge in our barracks.

A-3: I was already an amateur [astronomer] albeit with a 60-mm refractor but enthusiastic none the less.

A-4: 19 years old

A-5: A soldier getting ready to ship out to the Middle East on a peacekeeping assignment.

A-6: N/A

A-7: N/A

Figure 6 — The *Apollo* 40th-anniversary logo. Image: NASA.

Over three decades earlier, when the *Apollo 11* mission celebrated its 7th anniversary, a distinguished RASC member recorded her thoughts about the landing in her book titled *The Stars Belong to Everyone — How to Enjoy Astronomy*.[5] Helen Sawyer Hogg wrote in 1976, "... the incredible day dawned: July 20, 1969. For the first time in the 4 billion years of the earth's existence a being from earth set foot on another celestial body."[6]

The former RASC National President noted that those who had studied science for the previous half century, "the first step was so fantastic as to seem unreal." Hogg wrote:

> *I watched on my TV set beside a western window. My gaze was such that I could see the quarter moon through the window at the same time that I saw the LEM and the astronaut on the TV screen.*
>
> *On one side of my view was the moon as it had been since human life began on earth. On the other side was the impossible attained. Which is the greater miracle — that man has reached the moon or that from the earth, a quarter of a million miles away, we could see and hear the landing?*[7]

As we near the end of the first decade of the 21st century, much promise of adventure in space awaits humanity — in the near-to mid-term. Let's hope it's not too optimistic to anticipate that some of us who have recalled *Apollo 11* in the 2009 anniversary year may one day also witness the first human landing on Mars. Now won't that be one nice way to round out one's brief life-journey on this planet Earth!

Andrew I. Oakes is a long-time Unattached Member of RASC who lives in Courtice, Ontario.

Endnotes

1 © Copyright Guinness World Records 2009
2 *Von Braun — Dreamer of Space, Engineer of War,* Michael J. Neufeld; Alfred A. Knopf, New York, 587 pages; 2007; page 431
3 *Leap of Faith — An Astronaut's Journey into the Unknown,* Gordon Cooper with Bruce Henderson; HarperCollins Publishers Inc., New York, 279 pages; 2000; page 265.
4 *Analog Science Fiction and Fact* is an American science-fiction magazine. As of 2009, it is the longest-running continually published magazine of that genre.
5 *The Stars Belong to Everyone — How to Enjoy Astronomy,* Helen Sawyer Hogg; Doubleday Canada Limited, Toronto; 274 pages; 1976.
6 Ibid, page 66.
7 Ibid.

Meteorite
by Joanne Osborne-Paulson
2009 February 24

Hold this in your hand
This small black rock is an astronaut
An alien traveler from another
Place in our solar system

It came to Earth like a dragon:
Breathing fire

For hundreds of miles around
Our hearts skipped a beat
We put aside our tools and our thoughts
We looked at the sky with wonder

You saw it too
It roared and it broke apart
Like a fireworks celebration
Then scattered across the wintering
Fields of Buzzard Coulee

Hold this in your heart
It is a jewel from heaven
Rich with the dust of creation
It remembers the Earth being born

It is a messenger
From silence
It speaks the language
Of mystery

Hold this in your mind
It is your heritage

The Colours of the Stars

by Massimo Torri, Edmonton Centre (mi97ki@yahoo.com)

One of my favourite summer projects is imaging double stars using a digital SLR camera.

According to Alan Dyer (2007), "...digital single-lens reflex (DSLR) cameras have several key features that make them particularly desirable for nighttime photography. First and most important, their large sensors offer much lower noise and cleaner images than do compact point-and-shoot digital cameras, especially at ISO 400 and higher." Dyer's investigation is targeted at long-exposure astrophotography, but the previous sentence made me believe that DSLRs might do a better job at imaging double stars than conventional Webcams, particularly in reproducing colours. There is one problem, though. A large sensor implies a large field of view (FOV), which is the linear dimension of the portion of the sky captured by the camera, but the most popular double stars are usually less than 1 arcminute wide, with more than half separated by less than 15 arcseconds (″) (see `www.astroleague.org/al/obsclubs/dblstar/dblstar2.html`)

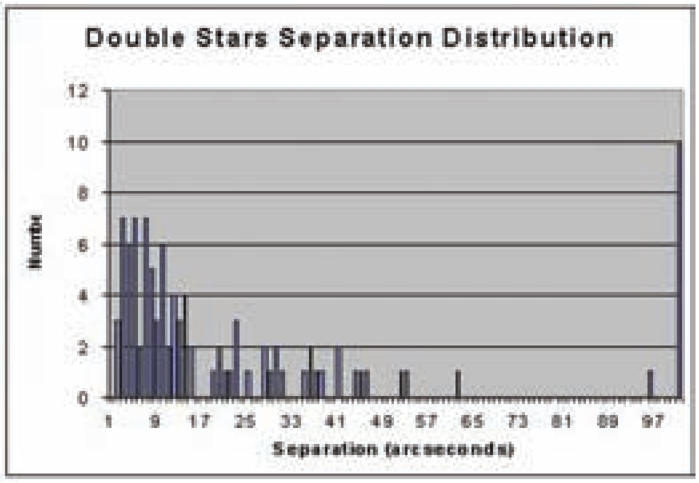

Figure 1 — Angular-separation distribution of the 100 brightest double stars.

The FOV of a DSLR camera at prime focus is determined by the following formulae:

$$\text{FOV (horizontal)} = 206265 \times \text{sensor size in horizontal direction (mm)} / \text{focal length (mm)} \tag{1}$$

$$\text{FOV (vertical)} = 206265 \times \text{sensor size in vertical direction (mm)} / \text{focal length (mm)} \tag{2}$$

For example, the sensor size of my Canon XSi (a very popular DSLR) is 22.2 mm × 14.8 mm. The focal length of my 10-inch Newtonian is 1200 mm. If I used my DSLR at prime focus, the camera sensor would be able to image a portion of the sky 3815″ × 2544″, more than 100 times wider than the typical separation of the components of a double star. The large sensor size of DSLRs makes double stars appear very small, especially when the camera is used at the prime focus of telescopes of relatively short focal length.

One way of boosting the effective focal length of an optical system is to use eyepiece projection, where the camera lens is removed, but the eyepiece is left in place. A special adapter is required to connect the camera to the focuser and to hold an eyepiece at the same time, as shown in this image:

Figure 2 — Eyepiece projection

My adapter is a 1.25-inch Variable Universal Camera Adapter sold by Orion Telescopes and Binoculars. In eyepiece projection, the effective focal length is given by:

$$\text{Effective FL} = \text{Telescope FL} \times \text{Amplification Factor} \tag{3}$$

where the amplification factor of the telescope-eyepiece-camera system is given by:

$$\text{Amplification Factor} = S / \text{Eyepiece FL} - 1 \tag{4}$$

S is the distance from the eyepiece to the CCD chip and Eyepiece FL is the focal length of the eyepiece.

For example, if I use my Orion adapter with a 10-mm eyepiece, then S = 95 mm and the amplification factor will be 8.5×. That means that the effective focal length of my setup when I use my 10-inch f/4.7 Newtonian will be 10,200 mm. The FOV will be reduced in both directions by the amplification factor. Therefore, the prime focus FOV is reduced (in this case) by 8.5 times, and for my Canon that turns out to be: 449″ × 299″. Still a little too big, but a 2× or 3× Barlow should solve the problem.

Figure 3 is an image of Albireo obtained using eyepiece projection with a Canon XSi, a 10-mm Plössl eyepiece, a 2× Barlow, and an 8-inch f/4.9 Newtonian:

Notice that the design of the Orion adapter is such that the eyepiece does not slide inside the focuser, but it sort of "hovers" on top of the focuser. That increases the amplification provided by my 2× Barlow lens, boosting it to 3.2×. The effective focal length of the

Figure 3 — Beta Cygni - Albireo

optical system is then 1200 mm × 3.2 x 8.5 = 32,640 mm and the focal ratio f = 32,640 mm/254 mm = 128!! The image above (obtained with my 8-inch Newtonian f/4.9) is not cropped and the field of view is about 168″ × 112″ (Albireo's separation is 34″).

Figure 4 — Epsilon Lyrae — "the Double-Double"

Here is a list of double stars that I imaged over the last two years using the technique outlined above with images:

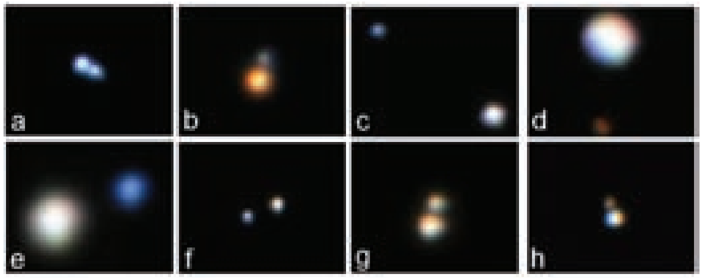

Figure 5 — A sample of double stars: a) Alpha Geminorum – Castor; b) Alpha Herculis – Rasalgethi; c) Delta Cephei – Alrediph; d) Eta Cassiopeiae – Achird; e) Gamma Andromedae – Almach; f) Gamma Delphini; g) Gamma Leonis - Algieba; h) Xi Bootis

In some cases (Almach and Achird), I experimented with higher magnifications, in others, (the Double-Double) I had to stitch together two frames. I usually collect a number of frames and then align and stack them in *Registax*. The number of frames varies between 20 and 60 typically. The exposure time is between 0.5 and 3 seconds, depending on the brightness of the target, the angular separation, and the magnitude difference of the two components. ISO is usually set at 800, although I experimented at 400 and 1600 on a couple of occasions. During processing, I saturate the colours a bit, but that's pretty much it. The main enemy is seeing, as always, when imaging at high magnifications. Resolving angular separations smaller than 2″ is very challenging, as that's what the seeing allows most of the time from my backyard in Edmonton.

The same technique can be employed on small objects like the outer planets. Here's an image of Uranus, for example:

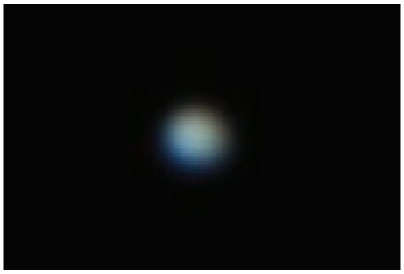

Figure 6: Uranus

The goal this year is to get better at processing stacked images, particularly by reducing "flaring" caused by mediocre seeing. At the moment I have reached the point where I can use eyepiece projection with a DSLR consistently, a starting point from which to improve.

The new season has started. More gems to come!

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On Another Wavelength

The North America and Pelican Nebulae

by David Garner, Kitchener-Waterloo Centre (jusloe1@wightman.ca)

The North America (NGC 7000) and Pelican (IC 5070 and IC 5067) nebulae are H II regions in close proximity but separated by the dark nebula, LDN 935 (LDN: Lynd's Catalog of Dark Nebulae). You can find them, on a clear and dark night, by first locating Deneb in Cygnus. The North America Nebula is just a few degrees east of Deneb, and the Pelican can be found in between the two. They can be seen with a small telescope; the North America has an apparent magnitude of approximately 4 and the Pelican, 8, though these values are at considerable odds with their actual detectability, as they are found embedded in a very rich star field that camouflages the presence of the nebulae. Very dark skies are a definite benefit. The North America Nebula has a maximum extension of 3 degrees; the Pelican is somewhat smaller. Both are actually part of the same interstellar cloud of gas and dust, lying at a distance of around 1600 to1800 ly.

Figure 1 — NGC 7000, courtesy of Stephen Holmes, Kitchener-Waterloo Centre. Stephen's camera was a QHY8 using a Tele Vue NP-101 on an EQ6 mount. The image was produced from 180 minutes of exposure with a Baader UV/IR filter.

Most observers find the area around the "Gulf of Mexico" to be the first feature that strikes the eye, with more-diffuse parts following as a part of a celestial geography lesson. Perhaps a map of North America would be of more use than a star chart!

The accompanying image of the North America and Pelican nebulae in Figure 1 shows you what to look for. Here is where to look:

- North America (NGC 7000): RA: 20^h 59^m 17^s / Dec: +44° 31´ 44″
- Pelican (IC 5067-5070): RA: 20h 50^m 48^s / Dec: +44° 21´ 00″
- LDN 935 (the dark nebula): RA: 20^h 56^m 54^s / Dec: +43° 52´ 00″

NGC 7000 may have first been discovered by Sir William Herschel in 1786, when he described a "faint, extremely large, diffuse nebulosity" near this location, but credit is also given to Max Wolf who first photographed it in Heidelberg on 1890 December 12.

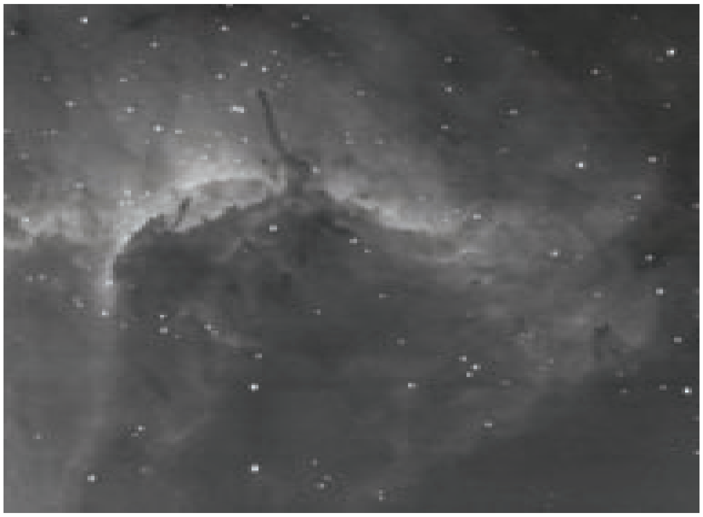

Figure 2 — Pelican Nebula, courtesy of Stephen Holmes, Kitchener-Waterloo Centre. Stephen used an 8-inch, 1600-mm-focal-length GSO Ritchey Chretien telescope at f/8 on an EQ6 mount guided with *KWIQGuide*. Exposure was 110 minutes (11x10 minutes) with a QHY9 camera through a Baader Hα filter.

The North America and Pelican complex is an interesting emission nebula because it has a very active mix of star formation and evolving gas clouds. It is not precisely known which star (or stars) is responsible for ionizing the hydrogen gas, causing it to emit Hα light. Some sources have suggested that it might be Deneb, which is a blue-white supergiant about 60,000 times more luminous than our Sun. There have been other suggestions that an ionizing star is located behind the dark dusty cloud LDN 935.

Recent studies (Straizys & Laugalys 2008; Guieu *et al.* 2009) have found several hot O- and B-type stars throughout the nebula that are more likely responsible for the ionization of the gas clouds. They have identified young energetic stars in the nebula that are heating the cold gas, forming an ionization front that is gradually advancing outward at around 5 km/s. These hot stars have produced a number of interesting bright-rimmed clouds and other structural details that are easily seen in photographs. The bright rims are typically located at the edge of dark clouds where they meet the ionized region.

There is also an interesting Herbig-Haro object, known as HH555, located in the Pelican Nebula. In the image of the Pelican Nebula in Figure 2, you can just make out a bipolar jet emerging from the tip of an elephant trunk, entering the neck of the Pelican Nebula from the adjacent molecular cloud (the neck is the bright arch in the middle of the photo). Herbig-Haro objects are small shock regions associated with star formation that exhibit bright patches of nebulosity on the surface of a dark cloud of gas and dust. The bright patches result from light scattered and reflected by a protostar embedded in the cloud. The bipolar jets of high-speed gas observed in this image are emerging from the protostar.

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Dave Garner teaches astronomy at Conestoga College in Kitchener, Ontario, and is a Past President of the Kitchener-Waterloo Centre of the RASC. He enjoys observing both deep-sky and Solar System objects and especially trying to understand their inner workings.

A Moment With…

Dr. Wayne Barkhouse

by Phil Mozel, Toronto and Mississauga Centres (phil.mozel@sympatico.ca)

This is another tale of a cat, the Cheshire cat, and the search for whatever lies behind the smile. For it seems to me that this is what astronomers such as Dr. Wayne Barkhouse are up to.

There appears never to have been a time when Dr. Barkhouse was not interested in what lies beyond Earth. As documented so many times in this column, this was, at least in part, the result of the dark skies under which he grew up in Nova Scotia and the space program that captured his interest. He remained under those dark skies while working on an undergraduate and Masters Degree at Saint Mary's University and then moved to the somewhat less pristine skies of the University of Toronto to earn his Ph.D.

After arriving in Toronto, Dr. Barkhouse found that, unlike the situation at Saint Mary's, there was no public-outreach program at the downtown U of T campus. He corrected this oversight by engaging graduate students to present popular-level talks to the public, followed by an observing session using the telescopes topping the physics building. His interest and experience in outreach convinced him to accept the position of *Journal* Editor when it became available. By expanding this *Journal*'s volunteer staff, he made the production work less onerous for any one individual; he also encouraged amateurs to make contributions. It was, in fact, under Dr. Barkhouse's auspices that this column saw first light. After five years as Editor, he "retired" and went on to a couple of post-doctoral positions before assuming his current post in the Department of Physics and Astrophysics at the University of North Dakota. There, he is in the fortunate position of being able to conduct research that combines aspects of his many interests: galaxy clusters, multiwavelength surveys, and dark energy.

As a post-doc at the Harvard/Smithsonian Center for Astrophysics, he was (and still is) involved with ChaMP (the Chandra Multi-wavelength Project). ChaMP, a data-miner's dream, is an example of a serendipitous survey — the data acquired by the Chandra X-ray telescope is being scoured for information not directly sought by the original investigators. Estimates are that some 3000 new X-ray sources in about 8 square degrees of sky will be found during the current mining operations. The ChaMP team will find and study quasars, galaxies, galaxy clusters, active galactic nuclei (AGN), quiescent X-ray binaries, and stars. With so much data available, the rare (*e.g.* BL Lac objects, a type of AGN) and the bizarre should make themselves obvious and appear in statistically significant numbers. Post-detection spectroscopy of these objects, using, for example, the Blanco 4-m telescope of the Cerro Tololo Inter-American Observatory in Chile, is helping to determine their properties.

During his second post-doc, at the University of Illinois, Dr. Barkhouse was part of the Blanco Cosmology Survey team that was interested in studying the acceleration of the Universe. One facet of this program allowed Dr. Barkhouse to use the Blanco scope to observe distant galaxy clusters with a view to sorting out such things as how active galactic nuclei work, how galaxies evolve, and just how far away the distant ones really are. He also worked on data management, an area of increasing importance, considering the deluge of information from current and future instruments. This project was coordinated with the survey being conducted with the South Pole Telescope (SPT) that was used to discover galaxy clusters using millimetre wavelengths.

Following on from the proving ground of the Blanco Cosmology Survey, Dr. Barkhouse is currently involved with the Dark Energy Survey (DES), a program designed to study the nature of dark energy, *i.e.* whether it has changed over time, its relationship to the expansion of the Universe, and the growth of structure in the

Universe on cosmic scales. The heart of DES, on the Blanco scope, is DECam, an extremely red-sensitive, 500-megapixel camera (one of the largest ever to be deployed on a telescope) and its associated data-acquisition system. Each image, covering 3-square degrees of sky and involving an exposure of about 100 seconds, will contain an estimated 20 galaxy clusters totalling some 200,000 individual galaxies. Only 17 seconds will be required to read out each image. Over 300 GB of data will be generated each night and, with the sky being scanned several times, 1 PB (petabyte) during the 5 years of the project.

Since no current technique is up to the task of fully characterizing dark energy, even though it makes up three-quarters of the Universe, DES will use four, each better than any single method now in use. For example, thousands of galaxies will be detected at millimetre wavelengths by the SPT, imaged with the Blanco scope, and their redness measured. Because of the expansion of the Universe, the faster-moving galaxies will be redder and therefore more distant. A map of the remote Universe can be constructed and expansion rates determined. In combination, DES and SPT will provide the most powerful probe of our unseen Universe developed so far. Coming at the problem from another angle, or more correctly, another wavelength, Dr. Barkhouse is working on an *optical* cluster-finding tool to ferret out galaxies from the recesses of the deep images provided by DECam. DES is scheduled to be underway in 2011.

The work done by the DES team, in turn, will form the basis of future programs, including NASA's Supernova Acceleration Probe (SNAP, part of the Joint Dark Energy Mission) and the Large Synoptic Survey Telescope (LSST) Science Collaboration, of which Dr. Barkhouse is a member. LSST is a program of superlatives. It involves mounting a car-size digital camera (the world's largest), with a three-billion-pixel detector, on an 8.4-metre telescope, surveying the entire sky every 3 days and providing 20 terabytes of data nightly (eventually storing more than 50 petabytes). In its first month of operation, LSST is expected to see more of the Universe than all previous telescopes combined. A single exposure will detect objects as dim as 24th magnitude. Here, the most common objects are not stars but galaxies — 60,000 of them per square degree of sky. In one pass through the heavens (requiring three nights of observation), LSST will detect and classify 840 million objects, and eventually generate a database of over 3 billion objects. Its all-sky map will ultimately reach magnitude 27. Tens of thousands of anticipated alerts per night will allow suitably equipped amateurs to follow up on many of LSST's discoveries. The data-mining possibilities are mind boggling!

Using images from the LSST over a period of ten years, what is being billed as the greatest movie ever made will show the Universe in action, from asteroids zooming past Earth to supernovae exploding in distant galaxies. Information generated by LSST will allow the construction of three-dimensional maps of the Universe, the plotting of dark-matter maps, and the plumbing details of dark energy. In fact, anyone with a computer will be able to download the maps, and fly through the Universe in the comfort of their own home!

Dr. Barkhouse is a member of the Large-scale Structure/Baryon Oscillation Science Collaboration, one of ten groups within the LSST program. He will continue development of optical-galaxy-cluster-detection tools for use with LSST data, an extension of his work on the DES.

The Universe is not the only thing accelerating. Clearly, so is the pace with which the tools of science are brought to bear on problems both new and old. The idea of dark matter, for example, dates back to the 1930s, but little supporting evidence was found until many years later. Dark energy dates back just over a decade, and it represented a major paradigm shift for many astronomers, and was founded upon a single line of evidence: the change in brightness of Type Ia supernovae with distance. However, as scientists such as Dr. Barkhouse are demonstrating with programs like DES and LSST, a battery of observational tests are now rapidly being marshalled to shed light on the observations.

A mere two years before the announcement of the Universe's acceleration, a book was published suggesting that all the interesting discoveries in science may have already been made. Now, that's bad timing, given that three-quarters of the Universe had been overlooked! Dr. Barkhouse points out that relativity and quantum mechanics were other ideas that also seemed to come out of nowhere, and they certainly haven't been completely figured out either! It would seem that he and his colleagues will be busy with the Cheshire cat for quite some time to come!

I will give the last word to Frank Herbert, author of the science fiction series *Dune,* who could easily have been speaking of dark energy when he wrote: "The universe as we see it is never quite the exact physical universe. There's something beyond subtlety. We must have a place in our awareness to perceive what we can't preconceive."

Phil Mozel is a past librarian of the Society and was the Producer/Educator at the former McLaughlin Planetarium. He is currently an educator at the Ontario Science Centre.

Quick Picks for Observing

by Kim Hay, Kingston Centre (cdnspooky@persona.ca)

October 2009	Event
October brings the Dance of the Planets in the early morning twilight. From Monday, October 5 to Friday, October 16, Saturn, Venus, Mercury, and the Moon will create an eastern morning observing and photography spectacular.	
Sunday, October 4 6:10 UT	Full Moon: "Harvest Moon" - the full Moon nearest to the autumnal equinox.
Monday, October 5 22:00 UT	Mars is 6° S of Pollux
Thursday, October 8 7:00 UT	Draconid meteor-shower peak (Active October 6 to 10)
Sunday, October 11, 8:56 UT	Last-quarter Moon
Monday, October 12 1:00 UT	Mars 1.2° N of Moon
Saturday, October 17	Zodiacal light visible in the east before morning twilight for the next two weeks
Sunday, October 18, 5:33 UT	New Moon (lunation 1074)
Wednesday, October 21 10:00 UT	Orionid Meteor Peak (active from October 2 to November 7)
Saturday, October 24	Fall Astronomy Day; Fall Astronomy Week runs from October 19 to 25.
Monday, October 26 0:42 UT	First-quarter Moon

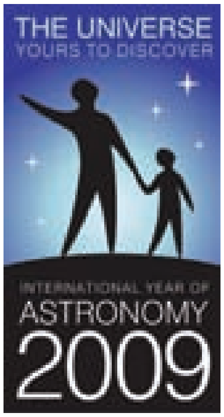
November 2009	Event
Sunday, November 1 7:00 UT (2:00 a.m.)	**Daylight Saving Time Ends!**
Sunday, November 1 8:00 UT	Mars 0.05° S of Beehive Cluster (M45)
Monday, November 2 2:00 UT	Venus 4° N of Spica
Monday, November 2 19:14 UT	Full Moon: "Hunter's Moon"*
Tuesday, November 3	Nearly full Moon occults the Pleiades (evening)
Thursday, November 5 Peak at 10:00 UT (5:00 a.m.)	S. Taurid meteor-shower peak
Friday, November 6 11:00 UT	Moon 0.9° N of open cluster M35
Monday, November 9 6:00 UT	Mars 3° N of Moon
Monday, November 9 15:56 UT	Last-quarter Moon
Thursday, November 12 10:00 UT	N. Taurid meteor-shower peak
Monday, November 16 19:14 UT	New Moon
Tuesday, November 17 16:00 UT (daytime peak)	Leonid meteor-shower peak
Monday, November 23 22:00 UT	Jupiter 4° S of Moon
Tuesday, November 24 21:39 UT	First-quarter Moon

* November Hunter's Moon: Moon Lore states that this is the closest moon to the autumn equinox and the first full Moon after the Harvest Moon. It also states that the light of the Moon was used for hunting migrating birds and animals for winter food. For more information, visit `http://en.wikipedia.org/wiki/Hunter's_moon`

* December Cold Moon: The month in which the nights are long and dark, and cold temperatures are settling in. For more on all the names of the Lore Moons, see `www.farmersalmanac.com/full-moon-names`

December 2009	Event
Wednesday, December 2 7:30 UT	Full Moon: "Cold Moon"*
Monday, December 7 3:00 UT	Mars 5° N of Moon
Wednesday, December 9 0:13 UT	Last-quarter Moon
Monday, December 14 5:00 UT	Geminid meteor-shower peak
Wednesday, December 16 12:02 UT	New Moon
Friday, December 18 8:00 UT	Mercury 1.4° S of Moon
Sunday, December 20 5:00 UT	Jupiter 4° S of Neptune
Monday, December 21 17:47 UT	Winter Solstice
Tuesday, December 22 22:14 UT	Ursid meteor-shower peak
Thursday, December 24 17:36 UT	First-quarter Moon
Tuesday, December 29 1:00 UT	Moon 0.03° N of the Pleiades (M45)
Thursday, December 31 6:00 UT	Moon 0.8° N of open cluster M35
Thursday, December 31 19:13 UT	Full Moon: "Blue Moon" - second full Moon of the month of December
Thursday, 2009 December 31 - Friday, 2010 January 1.	Partial lunar eclipse - see pages 130 and 147 of the 2009 *Observer's Handbook* for more information.

Meteor Showers for October to December are available from `www.imo.net/calendar/2009`, including several minor and major showers. See page 258 of the 2009 *Observer's Handbook*. Visit the North American Meteor Network at `www.namnmeteors.org/`



2009 International Year of Astronomy

Throughout the global celebration of astronomy, make sure you visit `www.astronomy2009.ca` for more information on Canadian and local events.

Come be part of the excitement in 2009 and enjoy astronomy for a lifetime!
Take some time to visit the International IYA Web page at `www.astronomy2009.org`

See the wonderful events that have happened, are happening, and will be happening in the future. See the IYA experience leave its legacy for years to come — be part of it!

Items for this article are from the 2009 *Observer's Calendar* and *Observer's Handbook*

The 2010 editions will be available online at the RASC eStore in September/October 2009. Go to `www.rasc.ca and Click on E-store.`

Astronomical Art & Artifact

An RASC Catalogue of Meteorites

by R.A. Rosenfeld, RASC National Office (randall.rosenfeld@utoronto.ca)

Abstract: This article briefly outlines the historical interest in meteoritics within the RASC, the vagaries of the vestigial collection associated with the RASC National Archives, and presents a catalogue of the current holdings.

Introduction

In the early evening of the second-last day of January 1868, a bolide dramatically detonated in the vicinity of Pultusk, Poland, raining down a shower of more than 100,000 meteorites (H5 ordinary chondrites) in an extensive strewn field (*JRASC* 85 [1991], 263-280; 91 [1997], 68-73). This was one of the largest such events recorded, and the news doubtless struck the ears, sparked the interest, and fired the imagination of at least several of the fathers of the RASC, or rather the Toronto Astronomical Club, founded towards the end of that year.[1] It is striking that the extraterrestrial origin of meteorites had been a broadly accepted and respectable scientific doctrine for only half a century, and that Ernst Chladni's (1756-1827) *On the Origin of the Object found by Pallas and Other Masses of Iron Similar to It, and on Some Natural Phenomena Occurring in Connection to It (Über der Ursprung der von Pallas Gefundenen und anderer ihr ähnlicher Eisenmassen, und Über Einige Damit in Verbindung stehende Naturerscheinungen),* one of the starting points for modern meteoritics, had appeared just seven decades earlier (Marvin 2007). A convincing demonstration of the cometary origin of meteor streams was then very recent, the brilliant work of Giovanni Virginio Schiaparelli (1835-1910) (Schiaparelli 1867; DSB 12, 159-162; Buffoni *et al.;* Littmann 1998).

From the inception of the Society's publication programme, meteoritics was well represented. Between 1890 and 1931, there appeared in *JRASC* and its predecessors 133 notices of meteorite observations, reports of falls and finds, lectures, historical treatments, presentations of theory, and reviews. C.A. Chant, who played such a formative role in the RASC in the half-century beginning around 1900, was responsible for 10 of those contributions, and the well-known English meteoriticist, W.F. Denning (1848-1931; *JRASC* 84 [1990], 383-396; Meadows 2004; BEA, 1, 290-292),[2] a corresponding member of the RASC, was the author of 16 (Harper 1931, 64-66). The first annual ephemeris of the RASC, *The Canadian Astronomical Handbook for 1907 (1906),* edited by Chant, contained a table of 81 "Meteoric Showers" by Denning (1906, 74-75), 65 more than in the 2009 *Observer's Handbook*, its lineal descendant (2008, 258)![3]

In addition to Denning, the names of other eminent late 19th- and early 20th-century Commonwealth and American meteoriticists were inscribed on the roll of honorary RASC membership: Daniel Kirkwood (1814-1895), Sir George Darwin (1845-1912), W.H.S. Monck (1839-1915; like Denning, a corresponding member), and Simon Newcomb (1835-1909). The distinguished Soviet meteoriticist, I.S. Astapowitsch, published several articles in *JRASC* during the 1930s, as did the American meteoriticist, Lincoln Lapaz, in the 1950s, and Dorrit Hoffleit in the same period.

Canadian meteoritics can be said to have come of age in the 1940s-1960s with the rise of internationally recognized professionals such as Peter M. Millman (1906-1990; *JRASC* 85 [1991], 67-78), D.W.R. McKinley (1912-), C.S. Beals (1899-1979; *JRASC* 73 [1979], 325-332), and Ian Halliday (Schmadel 2003, 350). For 40 years (1933-1973), Peter Millman's *JRASC* column "Meteor News" brought reports of matters meteoritic worldwide to RASC members, eventually running to 132 issues. To the average Society member, two research programmes probably seemed especially promising: one, the Dominion Observatory's programme for the identification and investigation of Canadian impact craters,[4] and the other, the Meteorite Observation and Recovery Project, or MORP (1970-1985), the prairie network of semi-automated meteor-camera field observatories (*JRASC* 52 [1958], 18-19; *JRASC* 72 [1978], 15-39; Bowden 2006, 382-383). Most members would have known of Millman and McKinley's cooperation with amateurs of the Society in the observing groups of the NRC Springhill Meteor Observatory (1957-1987) and the organized meteorite recovery teams out west. More amateurs had their own copies of McKinley's influential text *Meteor Science and Engineering* (1961) than could comfortably understand it, but through its pages they would have been introduced to the importance of Millman and Halliday's meteor spectrography and McKinley's radar observations. The Springhill veterans could boast of temporary interment in the relative luxury of the heated observing "coffins" designed by Millman!

A retrospective of meteoritic contributions to *JRASC* over the last three decades demonstrates that it still serves some of the needs of the community, with the names Beech, Brown, Connors, Dale, Herd, Hildebrand, Hube, Huziak, McCausland, McCurdy, Majden, Plotkin, Sarty, Spratt, and Tatum, among the contributors. While it cannot hope to compete with *ICARUS* or *Meteoritics and Planetary Science,* it does remain the sole serious Canadian *astronomical* journal that can accommodate meteoritics.[5] And the RASC continues as a place where professional meteoriticists can call on their amateur colleagues for help in scientific endeavours, such as staffing meteorite field-recovery teams.

RASC Meteorite Collection

By any standards, the Society's collection is, and always has been, extremely modest. Compared to the major Canadian research collections, such as the University of Alberta's Meteorite Collection, the largest in Canada (`www.museums.ualberta.ca/dig/search/meteors`), or the Canadian National Meteorites Collection (*JRASC* 82 [1988], 24-30; Herd 2002), it is as an interplanetary dust particle to the impactor that created the Sudbury basin (N 46° 36´, W 81° 11´).

The history of the RASC collection is extraordinarily poorly documented for a meteorite collection. The evidence, such as it is, points to a consistently inconsistent plan of collection development, and a disquietingly inchoate approach to curation. Given the problems of continuity, it is probably to the good that nothing more ambitious was pursued. That the RASC owned and owns any meteorites at all can probably be attributed to the venerable idea that astronomical institutions of any kind with non-meteorite collections of any sort are incomplete without a few bits of space rock. The idea can ultimately be traced to natural-philosophy cabinets of the 17th century, part of the learned matrix from which associations like the RASC arose. Some associated material survives, such as lantern slides of meteoritical interest (first mentioned in *JRASC* 4 [1910], A35), and a few stray publications, such as *A Chapter in the History of Meteorites* (Flight 1887), *Meteorites, Their Structure, Composition and Terrestrial Relations* (Farrington 1915), and *The Nininger Collection of Meteorites: A Catalog and a History* (Nininger 1950). Curiously enough, McKinley 1961 is not in the Archive's Rare Book Collection.

It is likely that specimens were acquired through mechanisms similar to the following:

> Mr. A.F. Miller, on behalf of Mr. Joseph Townsend, of Dixie, presented to the Society a very beautiful specimen of meteoritic iron. Several years ago Mr. Townsend gave the Society a fragment broken off the same specimen. Mr. Miller has learned that the meteorite was kept for years in a collection of curios owned by the late Mr. Edward Terry, of Toronto [*JRASC* 1 (1907), 197].

Neither specimen forms part of the collection today, nor is there any record of how and when they may have been removed for "unofficial" study purposes. One suspects that over the years the RASC has unknowingly granted several similar "loans" to more than one budding amateur collector. Such has been the success of that "programme" that the earliest acquired specimen remaining in the collection is from the Bruderheim fall of 1960 (RASC M1.19600304).

Inattention has its price. Two years ago the collection had been so decimated that the Bruderheim stone was in poor company; the rest of the collection consisted of two low-class meteorwrongs (RASC Mwr1.19XX00XX, and RASC MWr2.196100XX).

The collection is in better shape today, thanks mainly to a generous and anonymous donation by a RASC member, who said that at the very least the Society "should have a collection of which a beginning amateur wouldn't be ashamed." As it stands, the donor's words are an apt characterization of the collection at present. It is fortuitous that the gift coincided with the Society's move to its new premises, for the Archives can now provide a much-improved measure of climate control, and stable heat and humidity conditions, to help check the processes of meteorite terrestrialization.

Catalogue

The catalogue fields consist of:
1. inventory number;
2. type and origin;
3. provenance;
4. dimensions;
5. weight;
6. form;
7. appearance;
8. state of preservation;
9. bibliography.

Given the limited size of the collection, a little more detail can be supplied in the fields than is usually the case in catalogues. This is not to be taken as a sign of the relative importance of the specimens in the RASC collection; rather it attests to the opposite. It should also be noted that characterizations of the meteorites are referred to descriptions of the type specimens, or other properly analyzed specimens in the literature, for samples from none of the RASC specimens have been subject to extensive laboratory analysis. This catalogue has been prepared with the needs of the amateur uppermost, rather than the professional.

Meteorites

1\. 1. RASC M1.19600304; 2. Bruderheim, L6 Chondrite, Bruderheim, Alberta (N 53° 54′, W 112° 53′), witnessed fall 1969 March 4 *ca.* 08h 06m UT, *ca.* 303 kg; 3. Given to the RASC by the recovery team? (Documentation missing). Paper label: "STONY METEORITE FROM/ BRUDERHEIM, ALTA." Inventory number in black ink on white ink: "B-151"; 12.4×7.05×6.45 cm; 5. 750 g; 6. Irregular, with prominent ridge on one side, regmaglypts tend to be elongated (indicating flight orientation?); 7. Fusion crust > 99% intact; 8. Excellent state of preservation; 9. Not previously published(?); Grady, p. 118; IMCAEM `www.encyclopedia-of-meteorites.com/meteorite.aspx?id=5156`; MB 18 (1960), 1; MBDB `http://tin.er.usgs.gov/meteor/metbull.php?code=5156`

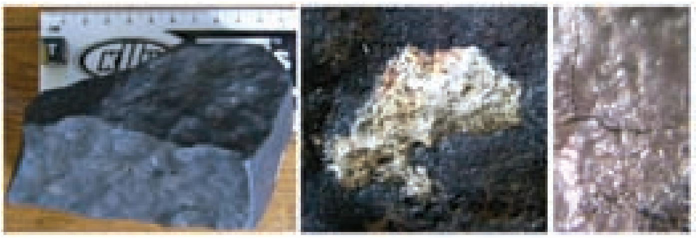


Figure 1 — Bulk appearance, exposed surface, and fusion crust on the RASC M1 meteorite.

2\. 1. RASC M2.20090712; 2. Canyon Diablo, IAB coarse octahedrite, Meteor Crater, Arizona, (N 35° 3′, W 111° 2′), found 1891, *ca.* 30 mt; 3. Anonymous gift 2009 July 12; 4. 3.52×2.39×1.22 cm; 5. 13.8 g; 6. Shrapnel, oriented; 8. Good state of preservation; some small rust spots common to these specimens; 9. Not previously published; Grady, pp. 128-129; IMCAEM `www.encyclopedia-of-meteorites.com/meteorite.aspx?id=5257;` MB 33 (1965), 1-2 (Fair Oaks, paired; Bloody Basin, paired); MB 37 (1966), 2 (Oildale, paired?); MB 54 (1976), 82-83 (Panamint Range, paired); MBDB `http://tin.er.usgs.gov/meteor/metbull.php?code=5257`

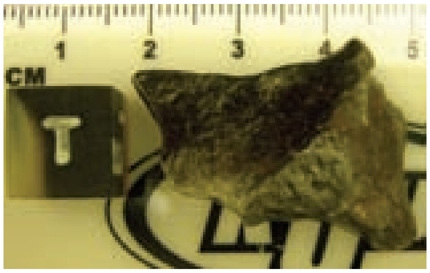


Figure 2 — The RASC M2 meteorite.

3. 1. RASC M3.20090712; 2. Sikhote-Alin, IIAB coarsest octahedrite, Sikhote-Alin, Russian Federation, (N 46° 9′ 36″, E 134° 39′ 12″), witnessed fall 1947 February 12 *ca.* 00h 30m UT, ca. 23 mt; 3. Anonymous gift 2009 July 12; 4. 3.03×1.40×0.67 cm; 5. 7.7 g; 6. Shrapnel, oriented; 7. Lacquered?; 8. Excellent state of preservation; 9. Not previously published; Grady, pp. 462-463; IMCAEM `www.encyclopedia-of-meteorites.com/meteorite.aspx?id=23593`; MB n.a.; MBDB `http://tin.er.usgs.gov/meteor/metbull.php?code=23593`

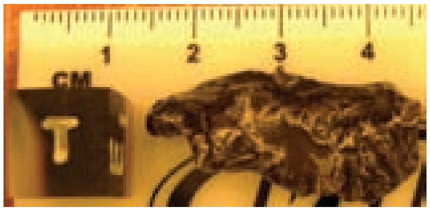


Figure 3 — The RASC M3 meteorite.

4. 1. RASC M4.20090712; 2. Gibeon, IVA fine octahedrite, Namibia (S 25° 30′, E 18° 0′), found 1836, *ca.* 26 mt; 3. Anonymous gift 2009 July 12; 4. 2.28×0.62×0.94 cm; 5. 6.5 g; 6. Etched slice; 7. Fusion crust on longest side; 8. Fair state of preservation; some rust spots; 9. Not previously published; Grady, p. 214; IMCAEM `www.encyclopedia-of-meteorites.com/meteorite.aspx?id=10912`; MB 36 (1966), 2 (Nico, paired); MBDB `http://tin.er.usgs.gov/meteor/metbull.php?code=10912`

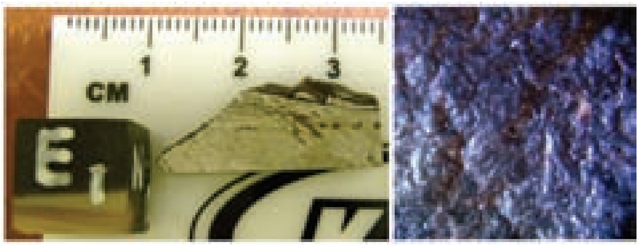


Figure 4 — The RASC M4 meteorite (left) and an enlargement (x30) of its fusion crust (right).

5. 1. RASC M5.20090712; 2. Gibeon; 3. Anonymous gift 2009 July 12; 4. 1.41×0.94×1.19 cm; 5. 4.8 g; 6. Etched slice; 8. Fair state of preservation; some rust spots; 9. Not previously published

6. 1. RASC M6.20090712; 2. Gibeon; 3. Anonymous gift 2009 July 12; 4. 1.05×0.72×0.33 cm; 5. 4.2 g; 6. Etched slice; 7. Traces of fusion crust(?); 8. Fair state of preservation; some rust spots; 9. Not previously published

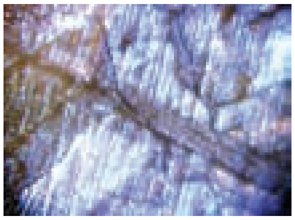


Figure 5 — The RASC M6 meteorite x30.

7. 1. RASC M7.20090712; 2. Gibeon; 3. Anonymous gift 2009 July 12; 5. 0.09 gr; 6. fragment; 9. Not previously published

8. 1. RASC M8.20090712; 2. Gold Basin, L4 Chondrite, Gold Basin, Arizona (N 35° 52′ 30″, W 114° 14′ 0″), found 1995, *ca.* 61 kg; 3. Anonymous gift 2009 July 12; 4. 2.06×1.95×0.47 cm; 5. 2.6 g; 6. End cut, polished face; 7. Weathering rind (?); 8. Good state of preservation; 9. Not previously published; Grady, pp. 218-219; IMCAEM `www.encyclopedia-of-meteorites.com/meteorite.aspx?id=10940`; MB 82 (1998), 223; MBDB `http://tin.er.usgs.gov/meteor/metbull.php?code=10940`

9. 1. RASC M9.20090712; 2. Gold Basin; 3. Anonymous gift 2009 July 12; 4. 2×1.95×2.39 cm; 5. 2.4 g; 8. Good state of preservation; 9. Not previously published

Impactites

10. 1. RASC I1.20080920; 2. Tektite, Australasian Strewn Field; 3. Anonymous gift 2009 July 12; 4. 3.63×1.59 cm; 5. 17.2 g; 6. Elongated tear-drop splashform; orientated; 8. Excellent state of preservation; 9. Previously unpublished; McCall 51-54

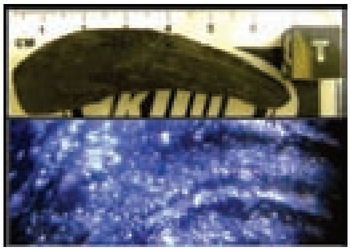


Figure 6 — The RASC I1 meteorite (above) and an enlargement (x30) (below).

11. 1. RASC I2.20080920; 2. Tektite, Australasian Strewn Field; 3. Anonymous gift 2009 July 12; 4. 1.22×2.39×1.68 cm; 5. 15.3 g; 6. Pear-shaped splashform; orientated; 8. Excellent state of preservation; 9. Previously unpublished; McCall 51-54

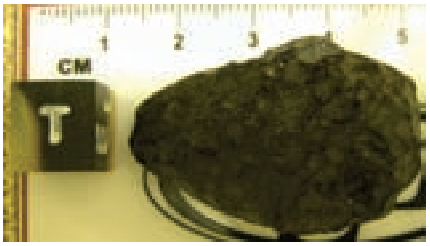


Figure 7 — the RASC I2 meteorite.

Meteorwrongs

12. 1. RASC MWr1.19XX00XX; 2. Ilmenite ($FeTiO^3$), possibly an Ontario find; 3. Unknown. Whoever added it to the collection was undoubtedly misled by its mild magnetism and "dark" colour; 4. 3.65×2.85×1.26cm; 5. 34.2 g; 9. Previously unpublished

Figure 8 — The RASC MWr1 meteorite.

13. 1. RASC MWr2.196100XX; 2. Partially melted crystalline silica; 3. Unknown. Paper label (on collection bag): "Bought from U. of Alberta for/$28. in 1961. Identified Dec. 18th/ 1974 by J.A. Mandarino, Curator/ Dept. of Mineralogy R.O.M." Note that Mandarino's identification is not directly reported, nor does it survive in written form elsewhere in the RASC Archives. The implication is that Mandarino identified the specimen as a "meteorite," but that may reflect the interpretation of his words by the writer of the label; 4. 6.5×5.3×2.87cm; 5. 83.2 g; 6. Loosely bound amorphous mass of fine grains in various stages of melt, ≈60% glass; probably post-industrial waste product; 8. The glass has a mildly green-coloured cast, covered with a glaze-like crazed skin; the less-fused portions of the mass are very friable; 9. Previously unpublished

Figure 9 — The RASC MWr2 meteorite.

Acknowledgements

The author wishes to thank the donor of the anonymous gift of meteorites for reading over this paper and catalogue, and the Specula astronomica minima for the generous loan of lab equipment. This research has made use of NASA's Astrophysics Data System.

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Abbreviations

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DSB=Dictionary of Scientific Biography, ed. C.C. Gillispie *et al.,* 18 vols., 1970-1990, Scribner, New York

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IMCAEM=IMCA Encyclopedia of Meteorites `www.encyclopedia-of-meteorites.com/`

MB=Meteoritical Bulletin

MBDB=Meteoritical Bulletin Database

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End Notes

[1] The Pułtusk meteor was famous, or rather infamous, as the best contender for the title "meteor in a hyperbolic (interstellar) orbit." It, and the problems it posed, was well known to prominent RASC meteoricists like D.W.R. McKinley, who wisely expressed caution on the nature of its orbit, and the interstellar origin or not of its constituent parts (McKinley 1961, 163). Subsequent work has not favoured the reliability of Pułtusk's reputed hyperbolic orbit (*JRASC* 91 [1997], 68-73).

[2] Denning's omission from the recent DNCBS is inexplicable. Martin Beech has written a life of Denning (`http://uregina.ca/~astro/DEN/Denning.html`).

[3] Chant wisely chose Denning to compile the radiant tables, for he was the acknowledged expert in their discovery at that time (Denning 1899). Unfortunately, many of his showers are now considered illusory corollaries of his fixed radiant theory (Littmann 1998, 148-151; Jenniskens 2006).

[4] For an updated list see `www.unb.ca/passc/ImpactDatabase/NorthAmerica.html`, maintained by the Planetary and Space Science Centre at the University of New Brunswick.

[5] There are, of course, more consistently professional Canadian journals for geology and geochemistry that publish meteoritics.

Carpe Umbram

Spectacular Occultation in China!

by Guy Nason, Toronto Centre (asteroids@toronto.rasc.ca)

"I'm goin' where the Sun keeps shinin'
Through the pourin' rain...
Bankin' off a northeast wind,
Sailin' on a summer breeze..."

From: *"Everybody's Talkin'"*
Written by Fred Neil, performed by Harry Nilsson
(c) BMG Music

In July 2009, a number of us from the RASC Toronto Centre, plus a few extra folks, travelled to China to attempt observations of a spectacular lunar occultation of the Sun. This is by far the closest and brightest star that the Moon can occult, so we were all very anxious to witness this, one of the most awe-inspiring events in Nature.

Our group of 20, led by Toronto Centre President Dr. B. Ralph Chou, was successful in finding a gap in the clouds just in time to set up and record the Disappearance and Reappearance times (D and R, respectively, in occultation-speak). Our original plan was to observe the event on the morning of July 22 from a lakeside park in Wuhan. Alas, the weather prospects were poor there, so after a vigorous discussion with our tour guides and bus driver, we convinced them that it was in their financial interest to do as we asked, and off we trundled into horrid rush-hour traffic to where we hoped the Sun kept shinin'. Eventually, we broke out of the automotive free-for-all, found a southbound highway, and picked up speed. We were in a race against time to get to a clear patch of sky before the occultation began. The clouds in the vicinity of the Sun slowly thinned, but too slowly for our liking. The occultation began while we were still on the highway. Unlike occultations with other stars, lunar occultations of the Sun allow detection of the First and Fourth Contacts — the initial and final apparent "touches" of the Moon on the star's limbs. So it was not such a bad thing that we were still on the move for First Contact. At least we did see and time it through a small hole in the clouds. The partial phase had begun. At this point, expedition member Jim Low (Toronto Centre) commented that even if we were clouded out of the total phase, we could still claim a "partial success."

But we weren't going to give up so easily. "Bankin' on a northeast wind," we continued south-westward. Sixty-eight km outside Wuhan, and about halfway between the centreline and the south limit, we outran the clouds and found a suitable place in a tiny hamlet. We had about ten minutes to set up our gear before the Sun would disappear. Of course, the local population came out to see what all the excitement was about. We distributed solar-filter "glasses" so they could enjoy the show along with us. The residents were exceptionally polite and respectful — although this could have been mostly shyness and an uncertainty of how to interact with us. It might very well have been the first time any of them had seen Westerners up close.

D-time in Wuhan was 09:24 CST (Chinese Standard Time) and would be similar, but not exactly the same, where we were. Where we were, it turned out, was in Tian Pu Cun at latitude N30° 09′ 16″ and longitude E114° 12′ 55″. Expedition leader Ralph Chou and American John Lowe were the only ones who brought telescopes. I came equipped with a video camcorder and binoculars with the intention of letting the video run its course while I kicked back and enjoyed the show. Jim Low, as is his habit, brought a thermometer with which to measure changes in ambient temperature during and after the occultation. Wuhan and environs is known as one of three Chinese "furnaces" in July and Jim confirmed that. The temperature rose as the Sun climbed the sky, only slowing the rate of increase during our time in the shadow. By Fourth Contact, the temperature was 40.7 °C and rising. In the shade! I don't think anyone cared to measure the relative humidity, but I'd estimate it was greater than 80 percent. Whew!

Ralph and I recorded the following times during the occultation: First Contact: 08:16:46; Second Contact: 09:24:14; Third Contact: 09:28:42; Fourth Contact: 10:46:03. (All times are Chinese Standard Time; for UTC, subtract 8 hours.)

We made the duration of totality at our station to be 4m 28s. The predicted duration of totality at Wuhan was 5m 36s. We sacrificed 68 seconds of shadow time, which was definitely worth it to witness the whole event. We learned later that people who had stayed in Wuhan were not so fortunate.

Figure 1 — This image of the July 22 eclipse was taken by Toronto Centre's Ralph Chou using a Nikon 200 mounted on an Oracle refractor. The exposure encompasses a range of seven stops, aligned and tone mapped in Photoshop.

A few ancillary phenomena were noted. For instance, the so-called "360° sunset" was extremely vivid, but covered only about 220° of the horizon, presumably because of our off-centre location in the path. The hamlet's resident roosters were outrageously vocal during the ingress period, but were absolutely silent during totality. Even after Third Contact, they were slow to resume their "serenade." Water buffalo seemed to be oblivious to the darkening sky. No doubt they had more pressing matters in mind, such as keeping comparatively cool in a nearby pond. During totality, Venus blazed away near the zenith, and Mercury, much more modestly, danced in and out of the clouds below and slightly west of the Sun and Moon. Although I made a point of looking for Mars, Sirius, and the brighter stars in Orion, I detected none of them, perhaps because of cirrus clouds in those parts of the sky. We stretched out a white T-shirt on the ground in hopes of detecting shadow bands, but in the excitement leading up to the diamond ring, we all forgot about it. Both diamond rings, by the way, were spectacular.

All in all, this was a "total" success! In the days before and after the occultation, we visited many of the famous tourist sites in and near Beijing, including the Great Wall, Tiananmen Square, the Forbidden City, the Summer Palace, the Temple of Heaven, the Old Imperial Observatory, and the Beijing Astronomical Observatory. In Wuhan, our sightseeing took us to the Yellow Crane Tower and Hubei Museum. At Xi'an, our visits were to the Terracotta Warriors archaeological site, and in Shanghai, the National Observatory and the Jade Buddha Temple. We also enjoyed more Asian cuisine than I've eaten in the last five years! Yummy!

On behalf of my expedition mates, I thank Ralph Chou for organizing the 12-day tour and Alan Whitman (Okanagan Centre) for correctly reading the weather situation. Without his input, we would have missed some, if not all, of the occultation. We also thank our tour guides and bus driver for agreeing to run to better skies on "occultation day."

* * * * * * * * * *

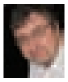
Obviously, throughout this article, I have deliberately avoided the word "eclipse." That is because the phenomenon under discussion is not an eclipse at all, although it is nearly always called that. In all other astronomical contexts, an eclipse occurs when one celestial object casts its shadow onto another. When an object passes directly in front of another, the event is an "occultation." When we discuss the mutual events involving Jupiter and its Galilean satellites, we always use "eclipse" and "occult" correctly to avoid confusion. When the Moon hides any other star, we correctly call that an occultation. For instance, I and several other IOTA members recently observed and timed the Moon passing directly in front of Antares (α Scorpii). Everyone called it a lunar occultation of Antares. No one called it an Antarean eclipse.

I acknowledge that striving for correct nomenclature in this case is a lost cause. The term "solar eclipse" is just too strongly entrenched. I confess I even use it myself on occasion. But I'll continue to tilt at this windmill when it suits me — which is quite often, actually.

* * * * * * * * * *

With this column, I am discontinuing my list of upcoming asteroidal occultations. Instead, I urge everyone to go to `www.asteroidoccultation.com` for summaries of upcoming events and consider observing those in their vicinity.

Guy Nason currently lives in Toronto. He joined The Royal Astronomical Society of Canada in 1985 and has served on Toronto Centre Council continuously since 1986 (currently Coordinator of Observational Activities). He joined the International Occultation Timing Association (IOTA) in 1990, and successfully observed several lunar grazing occultations, total lunar occultations, and — so far — ten asteroidal occultations. He owns and operates Gneiss Hill Observatory at his cottage, 80 km northwest of Kingston, Ontario.



Gizmos

Skippy Does Astronomy

by Don Van Akker, Victoria Centre (don@knappett.com)

We are all very careful about covering the primary when we put away the Dob, but often the secondary gets forgotten. It's not as impressive as the primary of course. It's not figured like the primary and it's only about 1/20th the area of the primary, but think about that — with 1/20th the area, it reflects the same amount of light. That means that the same smudge or particle of dust is 20 times as deleterious to what you see in your eyepiece. Worth doing something about then.

The traditional solution involves a Crown Royal bag. This is likely to put dust on the mirror instead of keeping it off but has the advantage that it needs to be emptied before use.

But what if you don't drink whiskey? Are you condemned forever to having a dirty secondary?

Bill Weir to the rescue. Bill is a member of the Victoria Centre

and an observer in the purest sense of the word. He knows that late nights and whiskey will do nothing for your Messier list.

His solution? Peanut butter.

A peanut butter jar, that is. A plastic one — or any other kind of plastic jar that fits easily over the secondary. Cut slots to fit over the spider vanes, slide the jar up from beneath, and screw the lid on to hold it in place.

The plastic jar is too tough to cut with a knife. Your fingers are not — so cut the slots with a hacksaw or something with similarly small teeth. Make sure the slots are wide enough; this should be a loose fit when you slide it on but get the depth just right and the lid will hold the jar gently in place without slop.

And emptying the jar? Get a loaf of fresh bread and a couple of youngsters to help out. Just as much fun and better for you.

Don Van Akker eats peanut butter only occasionally. Contact him with your good idea at dvanakker@gmail.com.

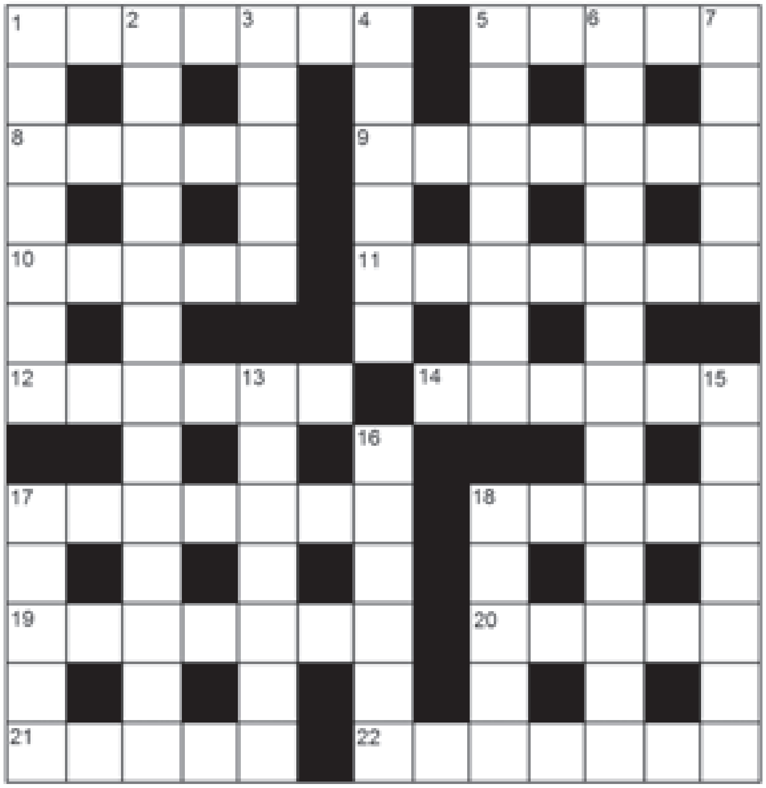
Astrocryptic

ACROSS

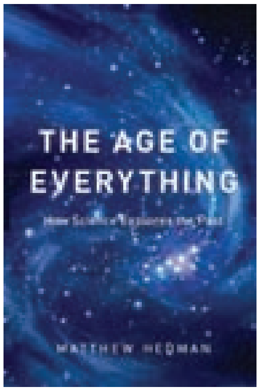
1. Herb also known as a belt star (7)
5. Our LPA head heads east where he pondered G with Brans (5)
8. M82 gets smoked (5)
9. Tire out in a surrounding state of inactivity (7)
10. Rubber axle breaks around start of telescope use (5)
11. See star explode in a planetary trough (7)
12. Eagle's first claw used in solar filters (6)
14. Asteroid discovered by Tempel and by C. Lee, unfortunately (6)
17. Young pitcher sings badly about a dwarf nova (1,1,5)
18. Sixth asteroid follows time closely around Jupiter (5)
19. Nagler guy heads a first chapter of the *Observer's Handbook*, essentially (7)
20. I hear you enter code to achieve focus along the polar axis (5)
21. Bolide boom spills coins (5)
22. Oort was first named in retro sort of leading asteroids (7)

DOWN

1. A male dances around copper dark features on a planet (7)
2. He works until dawn a la Dickinson (13)
3. Brightest star from across the southern hemisphere (5)
4. Toil back in Alan Hills to start a big handle (6)
5. Reverse speed to Kentucky for some faint fuzzy observing (4,3)
6. Somehow Lee's beauty can rival that of a famous planetary (4,3,6)
7. The Spanish altar travels about Jupiter (5)
13. Open cluster contains wild grain made of carbon (7)
15. Willy rockets back in poetic evenings for an ocular (3,4)
16. Game hunter's description of Leo (3,3)
17. W-O eyepieces for observing Cygnus and M17 (5)
18. Rayed crater formed in Sea of Tranquility chondrites (5)



Reviews
Critiques



The Age of Everything: How Science Explores the Past, by Matthew Hedman, pages 249, 16 cm × 24 cm, University of Chicago Press, 2007. Price $31.95 hardcover (ISBN-10: 0-226-32292-0).

"This book explores how researchers in a wide variety of fields determine the age of things.... [It] is not intended to provide an exhaustive catalog of every single dating technique. Nor does it present some sort of comprehensive survey of the history of humanity, the Earth, and the Universe. Instead, it will focus on a few specific points in time and a sample of methods of measuring age." So writes the author on the second page of the introductory chapter. In the subsequent 11 chapters, he presents an account of various dating techniques and some of the ages arising therefrom, arranged according to increasing time into the past.

Matthew Hedman is an astronomer at Cornell University. The book grew out of a series of public lectures he gave in 2004 at the University of Chicago as a participant in the Compton Lecture program.

The main story begins with Chapter 2, which, unfortunately for me, I found to be the least interesting chapter. It starts off well with Mayan calendars and an explanation of the Mayan "Long Count." However, the last half of the chapter goes off on a tangent, describing "The Life and Times of Yuknoom Ch'een," a Mayan king — a topic that has no particular relevance to the theme of the book.

Early in the book, the letters CE and BCE appear after numerical years without explanation. My Webster's dictionary gives several meanings, such as "Church of England" and "Bachelor of Civil Engineering," respectively, but nothing relating to a date. Eventually, on page 74, Hedman implies (but does not clearly state) that CE/BCE is the same as the familiar AD/BC notation. Another slight annoyance is an occasional American bias, including reference to "the Declaration of Independence" and the use of the American spelling for metre rather than the international spelling. The latter point goes beyond mere convention, for the American spelling can cause confusion with the term for rhythm in verse and music, or for an instrument for measuring an electrical quantity, flow of a liquid, or whatever.

"Precession, Polaris, and the Age of the Pyramids," the topic of the third chapter, renewed my enthusiasm. The high point is an account of the apparent discovery by Kate Spence, an Egyptologist, of the method used to align several pyramids with the cardinal points of the compass. Not only is the method plausible (it involves a vertical alignment of the bright stars Kochab and Mizar), but also because precession slowly shifts the position of the north celestial pole relative to the stars, the orientation of each pyramid reveals the date its construction began, with a precision of a few years. Six explanatory star charts appear, but unfortunately, they are very difficult to read because the star symbols are all the same size, irrespective of the different magnitudes of the stars. Either Hedman is unfamiliar with the night sky, or he was careless in selecting star charts. In addition, he should have mentioned that 4500 years ago, the north celestial pole was near the star Thuban. Thuban appears on the charts, but is not labelled.

Chapter 4 is the first of three chapters concerned with dating organic materials using the radioactive isotope carbon-14, with its 5700-year half-life. Carbon-14 occurs in the environment because it is in dynamic equilibrium, being continually produced by cosmic ray bombardment of Earth's atmosphere, and continually being removed by radioactive decay. Living plants and animals exchange carbon with the environment and thus have the same fraction of carbon-14 as found in the environment. After they die, their carbon-14 content decreases gradually, decaying into the stable isotope nitrogen-14.

Hedman's understanding of nuclear physics is not the best. For example, he presents the mass-energy relation as if it plays a special role in nuclear reactions (more on this later). In addition, he describes alpha, beta, and gamma decay, but says that "other sorts of transformations have never been observed." Other transformations that have been observed include spontaneous fission, proton emission, and neutron emission (the latter transformation makes possible the control of nuclear reactors). In describing the nature of the decay of carbon-14, Hedman's choice of words will likely confuse most readers. For example: "The rate of change of the probability [that the decay of a nucleus has not yet happened] must be proportional to the probability that the decay has not yet happened." It would be simpler to say that the probability of decay of a radioactive nucleus is constant (unlike human lifetimes!). At this point, a numerate reader cries out for a line or two of calculus, but Hedman's book is not intended for such readers.

Chapter 5 is concerned with calibration of the carbon-14 chronology against dendrochronology (tree-ring data) and the link between carbon-14 production by cosmic rays and the strength both of Earth's magnetic field and of solar activity. Ice cores from glaciers yield data on concentrations of the radioactive isotope beryllium-10 and of the isotope ratio oxygen-18/oxygen-16, going back tens of thousands of years. The correlation of beryllium-10 with carbon-14 confirms that variations in cosmic ray intensity are responsible for much of the variation in carbon-14 concentrations, and variations in the oxygen isotope ratio indicate that ocean temperatures also influence the amount of carbon-14 in the environment.

Among the time spans revealed by carbon-14 is the arrival of people in the Americas some 13,000 years ago [an age in considerable dispute – ed.] at the end of the last ice age, the main topic of Chapter 6. However, as in Chapter 2, Hedman goes off on what to this reviewer is another tangent, one that is anthropology, not dating methods.

Not only are our bodies radioactive because of carbon-14, but the unstable isotope potassium-40 is within us too. The relatively short 5700-year half-life of carbon-14 limits its use for dating to time spans considerably less than 100,000 years. Potassium-40, with its 1.25 Ga (*i.e.* 1.25 billion year) half-life, can be used to date much longer intervals. It exists in our environment as the still-warm embers of one or more supernovae that preceded the formation of the Solar System. One of the decay modes of potassium-40 produces argon-40, a stable isotope of this noble gas. Potassium-argon dating is applicable to igneous rocks, because argon begins to accumulate once the rock solidifies.

Chapter 7 leaps back in time a few million years to the ancestors of *Homo sapiens* and the other great apes. The relative ages in that era and branching points in the heredity tree (dendrogram) are estimated from similarities of DNA base-pair sequences, under the assumption that mutations accumulate steadily with time. Where possible, the time scale is quantified by potassium-argon measurements of adjacent rocks. Among interesting discoveries is that walking upright on two legs (bipedalism) likely occurred about 5 or 6 Ma ago, and that our closest living relative is the chimpanzee.

Chapter 8 goes back about 100 Ma, to the earliest mammals and the rapid diversification of mammals after the dinosaurs vanished 65 Ma ago. DNA sequences provide the most reliable guide to organizing the diversity of mammals in a dendrogram. Once again, I began to lose patience with the author as he detailed some of the many possible branches in the mammalian tree. Among the more interesting topics he covers is the correlation of DNA similarities with plate tectonic displacement of the continents.

Another large step backward in time occurs in determining the age of the Solar System, the topic of Chapter 9. As mentioned, potassium-argon dating depends upon argon accumulating after a molten rock solidifies. Given the non-igneous origins of most meteorites and the collisions they have experienced, argon content is not a reliable indicator of age. However, rubidium-87 has a long half-life (48 Ga) and a decay product that is not a gas, strontium-87. Hedman provides a clear description of the use of isochrone plots to deduce the age of a meteorite from the rubidium-87, strontium-87, and strontium-86 content of the various minerals it contains (strontium-86 provides a reference, because it is both stable and not produced by radioactive decay). Meteorite ages tend to cluster around 4.5 Ga, making them the oldest known objects in the Solar System.

The half-life of rubidium-87 is too long to resolve the small age differences among various types of meteorites. For this, measurements of magnesium-26 are used, the decay product of aluminum-26 that has a 0.73 Ma half-life. Isochrone plots using abundance data of the stable isotopes aluminum-27, magnesium-26, and magnesium-24 reveal which types of meteorite are older. That relatively short-lived isotopes like aluminum-26 and manganese-53 (half-life 3.7 Ma) were present in the earliest stages of the Solar System suggests the fascinating possibility that a nearby supernova explosion may have triggered the formation of the Sun and its planets. In other words, had a certain supernova not occurred about 4.6 Ga ago, you would not be reading this book review!

Besides potassium-argon and rubidium-strontium, another standard method of establishing absolute ages of millions of years or longer involves the decay of uranium-235 (half-life 0.70 Ga) and uranium-238 (half-life 4.5 Ga). The end products of the decay chains are lead-207 and lead-206, respectively. Because the half-lives are much shorter than that of rubidium-87, the results are more precise for age determinations in the ballpark of a billion years. Also, because there are two decay chains, only the lead isotopes 204, 206, and 207 need be measured, which can be done with very small uncertainties because they have essentially identical chemistry. As a result, ages based upon uranium-lead can be surprisingly accurate, to 4 or 5 significant figures!

Having dealt with ages in the Solar System, Hedman devotes Chapter 10 to the stars. Here, as an astronomer, he is in his element and does a good job of introducing readers to the properties of stars. Only when he addresses the energy source of stars does he err by focusing on $E = mc^2$, the relation for the equivalence of mass and energy. Such a focus is all-too-common in popular accounts of nuclear reactions, and is typical of authors who do not have a solid background in physics. The universal relation $E = mc^2$ applies equally well to skiing and to stellar energy; it does not "explain" the origin of the energy released in either situation. To attribute an energy change to a mass change merely passes the buck. The reason for an energy change, and the concomitant mass change, lies in the strength of the binding interaction at play. Skiers speed down hills not because of $E = mc^2$, but because of the gravitational interaction between the skier and planet Earth. Stars shine for a long time not because of $E = mc^2$, but because of the strong nuclear interaction between protons and neutrons.

In the final two chapters, Hedman addresses the age of the Universe, and does it well. His text ranges from redshifts and the use of Cepheids to establish the distances of closer galaxies, to dark matter, dark energy, and the subtle angular brightness variations in the cosmic microwave background.

It is obvious that the book is aimed at a general audience. There is almost no mathematics. The only equation presented is the ubiquitous $E = mc^2$, which, like a mantra, appears on at least seven pages. The exponential equation of radioactive decay would have been more appropriate, given the theme of the book.

Among the attractive features of Hedman's book are the annotated "Further Reading" sections at the ends of the chapters, and a 12-page glossary. An entry in the glossary, consistent with the message of Chapter 7, reminded me of my place in the scheme of things: "Great Apes: A group of animals consisting of humans, chimpanzees, gorillas, and orangutans."

Among the unattractive features of the book is the author's tendency to go off on tangents when dealing with fields far from his own background in astronomy (as in Chapters 2, 5, and 8, mentioned earlier). Possibly, he had difficulty finding enough suitable material for those chapters. The text reads well, and I spotted only about a dozen typos or minor errors; however, the text is rather dry, lacking humour and items of human interest. The book would appeal to a wider audience if it contained more historical material. The names of seminal figures in the history of age determinations (such as: Hutton, Kelvin, Rutherford, Boltwood, and Holmes) are not mentioned.

Nevertheless, I recommend the book for the overview it presents of how science explores the past. Hedman does a credible job for a topic involving several disciplines, and covering ages spanning eight orders of magnitude, from organic material dating back a century or two to the 13.7 Ga age of the Universe.

— Roy Bishop

Roy Bishop is retired from Nova Scotia's Acadia University where he was a professor and Head of the Physics Department. He is a Past-President of the RASC and is Honorary President of the Society's Halifax Centre. For his contributions to the Observer's Handbook, *he received the Chant Medal of the Society. The asteroid 6901 is named Roybishop in his honour.*

Bang! The Complete History of the Universe, by Brian May, Patrick Moore, and Chris Lintott, pages 192, 23.5 cm × 28 cm, The Johns Hopkins University Press, 2006. Price $29.95 US hardcover (ISBN-13: 978-0-8018-8985-1).

If you have ever wanted to hang out with the monocled, xylophone-playing grandfather of BBC astronomy and the man who played guitar on "Bohemian Rhapsody" and hear the history of the whole Universe, this is your chance. Of the three authors, May is no doubt best known for playing guitar in the legendary rock band Queen, but his name is not just here for celebrity status. He was most of the way through his astronomy Ph.D. when he started playing with Queen, but shelved the degree when Queen took off in the early '70s. Recently, however, he has again taken up astronomy and completed his doctorate. Sir Patrick Moore has been hosting the BBC television show "The Sky at Night" for over 40 years, making it the longest-running science show ever. Chris Lintott is now Patrick's co-host on "The Sky at Night," and is an active postdoctoral researcher at Oxford University.

The book is an enjoyable overview of, pretty much as the title says, the complete history of the Universe. The first thing one might notice is the cover, which has an eye-catching lenticular print of an explosion suggesting the Big Bang. The authors do note that the illustration is "for fun only." Since we are living inside the Big Bang, there is no place to view it in the fashion seen on the cover. However, it sets the tone for the plentiful and gorgeous illustrations and photographs that illuminate the rest of the book. It is well laid out, and in addition to the main text, there are numerous "grey boxes" giving more detail or asides on various topics. There is a glossary and a generous number of appendices, including one giving pointers on how to get started as an amateur astronomer and another giving short capsule biographies of famous astronomers. I did have the occasional minor quibble. For example, the authors seem to doubt the existence of any planets around pulsars, whereas I believe that at least the original pulsar planets (orbiting the millisecond pulsar PSR 1257+12) are generally well accepted by the astronomical community. They also identify the Red Spider Nebula as "NGC 6532" when it is in fact NGC 6537, and the Rotten Egg Nebula as "OH231" when it should be OH231.8+4.2, but I imagine most readers will prefer the evocative names to the catalogue designations. These are minor quibbles, and overall the material presented is solid.

Brian May has been quoted as saying that "This is not a book for scientists, it's a book for everybody." *Bang!* will not make you a string theorist, but it does do an admirable job of giving an introduction to the history of the Universe. It is arranged in chronological order, an effective narrative device that proceeds from 10^{-43} seconds after the Big Bang, through the evolution of structure in the Universe, including our own marvellously complex little blue planet, to a somewhat gloomy heat death in the very distant future. It might seem difficult to start with something as exotic as a Planck time after the Big Bang, but it is not. The Universe shortly after the Big Bang, although much different from the one we live in, was quite simple and had almost no structure. The sweep of the book is grand, and it is in its nature and to its benefit, that it does not cover things in any exhaustive depth.

If you find it difficult to think about whether the Universe is infinite, this is likely not the book that will give you satisfaction (I suspect that such a book does not exist). As the authors of *Bang!* put it, "We cannot explain infinity in everyday language, and neither could Albert Einstein (we know because Patrick asked him!)." Notwithstanding, the text is in fact easy to read and leavened with the occasional personal tidbit like the above question to Einstein.

In summary, *Bang!* does an admirable job of living up to its subtitle: giving an overview of astronomy, a capsule-biography, so to speak, of our entire Universe. To that end, it weaves together the well known with the more speculative, in grand chronological order, and without becoming bogged down with some of the harder-to-grasp ideas of cosmology. It is a welcome addition to the coffee tables of those interested in astronomy!

—Michael Bietenholz

Michael Bietenholz, who was born in Basel, Switzerland, holds dual appointments as a research associate at York University and a staff scientist at Hartebeesthoek Radio Observatory in South Africa. He specializes in the study of supernovae and supernova remnants at radio wavelengths, and recently chaired the IYA2009 Image Team that assembled Canadian astronomy images for display. In his youth, 28 years ago, he was privileged to see Brian May and Queen perform live at a concert in Zurich.

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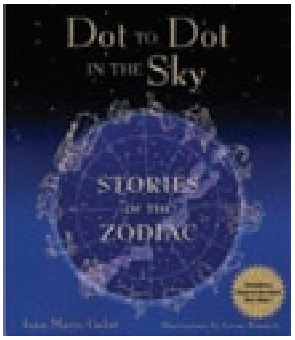


Dot to Dot in the Sky: Stories of the Zodiac, by Joan Marie Galat, pages 68, 20.5 cm × 23 cm, Whitecap Books, 2007. Price $16.95 paperback (ISBN: 1-55285-805-7).

Dot to Dot in the Sky is the fourth book in a series by Joan Marie Galat. It has a little something for every child, no matter what their background level in astronomy. Since the book focuses on the zodiacal constellations, the author does introduce astrology, though it is never stated that astrology is a science. The author explains the origins and meanings of each constellation, the significance of the Sun's path through the constellations, and the fact that there is no scientific value to astrology. In spite of this, astrology is discussed for about one-third of the book, which I found somewhat excessive. However, I liked the fact that the author stuck to science, for the most part. She even explains precession, which over the last few millennia has pushed the Sun's location at different times of the year over by nearly one constellation, and which makes every "star sign" out by almost one constellation. I was also impressed with the mention of Ophiuchus as the 13th zodiac constellation in the story of Scorpius, though it should have had its own story.

Most of the book deals with how to find the constellations and interesting objects in them, such as individual stars, Messier objects, and meteor showers, but also included are newly discovered planets around dim stars, which will be much more difficult to locate. It does contain two glow-in-the-dark star charts that will allow children to practice looking for each constellation indoors before going out in the cold.

The stories about the zodiac are short and not particularly violent, although all are based on Greek and Roman mythology. As one who has read a number of the constellation myths, I know that there are different versions for each, but I had not heard some of those in *Dot to Dot,* which just made it more of a surprise. Nevertheless, the stories should make it easy (and fun) for children to get interested in astronomy, in spite of some difficult-to-read names. I would have preferred if the pronunciation was included along with some of the more difficult names like Zubenelgenubi.

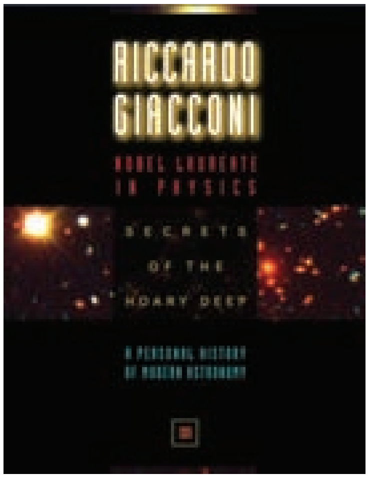
The colour drawings for the stories are beautiful. In addition, besides the glow-in-the-dark charts, there are numerous others, which are used for finding the constellations. These charts are illustrated by drawings with arrows on them, making it easy to locate objects. The book also indicates the seasons when one can locate the constellations in the evening sky, for both hemispheres, although all of the charts are not shown in the same fashion in the sky. It would have been preferable to have all of the charts printed in the same fashion and to include a statement to turn the book upside down for southern-hemisphere observing.

If you like a combination of science and mythology, *Dot to Dot* is the book for you. I would recommend it for children ages 8 to 12. There is a good glossary at the back for defining words, but parents should be prepared for questions about the pronunciation of some of the more complex names.

— Leslie Harvey

Leslie Harvey has been a member of the RASC Toronto Centre since 1997. She is the Centre's Public Education Committee Chair.

Secrets of the Hoary Deep: A Personal History of Modern Astronomy, by Riccardo Giacconi, pages 432 + xvii, 18 cm × 23 cm, The John Hopkins University Press, 2008. Price $16.95 paperback (ISBN-13: 978-0-8018-8809-0).



We currently live in the golden age of X-ray astronomy. Three of the most powerful X-ray observatories are currently operating in orbits around Earth. The European Space Agency-led *XMM-Newton* offers a telescope with the largest collecting area; NASA's *Chandra* telescope has the highest spatial resolution to date; and JAXA's *Suzaku* observatory can produce spectra over a very broad range of energies. In addition to these facilities, there are several smaller missions well suited for specific science goals (*e.g. SWIFT* and *RXTE*). It is difficult to imagine a time when X-rays were considered negligible in the study of astronomy. In many areas of research, X-rays are a dominant form of emission. Indeed, our understanding of clusters of galaxies, active galaxies, and compact objects would be trivial if we knew nothing of their X-ray emission. I "grew up" in the present golden age of X-ray astronomy, beginning my Ph.D. studies in 2002, two and three years respectively after the launch of *XMM-Newton* and *Chandra*. That was also the same year that Professor Riccardo Giacconi was awarded the Nobel Prize in Physics for discovering X-ray emission from Sco X-1 in 1962.

Secrets of the Hoary Deep is not only the story of X-ray astronomy, but it is also that of modern observational astronomy, told from the perspective of Riccardo Giacconi. Giacconi describes in great detail the managerial and scientific skills he acquired from experience and honed while developing the first X-ray satellite, directing the Space Telescope Science Institute (STScI) when the *Hubble Space Telescope* was preparing to launch, and restructuring the European Southern Observatory (ESO) to its present glory. Scattered throughout, the reader is bestowed with the author's personal anecdotes. As Giacconi recounts several ardent encounters with fellow scientists, administrators, and even grade-school teachers, it becomes abundantly clear that he put the "Uhuru spirit" into action throughout his career and personal life. Giacconi describes this spirit as the passionate criticism and support of ideas without regard to their originator, all done in the quest for truth. He does not spare criticism or praise as he describes the roles he saw people play in the development of modern astronomy.

The book has several pedagogical aspects and at times reads as a textbook. As expected for anyone familiar with Giaconni's work, he is meticulous and gives a full account of instrumentation, projects, and scientific results. There are many detailed schematics and figures included in the book that help to elucidate the text and references for those interested in further discovery. Indeed, I would certainly recommend the book to young students just entering the field. However, for the same reasons, the book may not appeal to everyone. It should be noted that the book does not constitute Giacconi's personal memoirs. Although Giacconi does reflect on personal events and encounters with key figures, that is not the emphasis of the book. A casual reader may become overwhelmed with details about the science, technology, or management.

The book is well written, enlightening, and inspirational. Those with an interest in the history and maturation of observational astronomy will find *Secrets of the Hoary Deep* fulfilling. Even those with no interest in X-ray astronomy will be inspired by the dedication the author and his colleagues demonstrated as they built an instrument to detect cosmic X-rays that they did not know existed for certain, and then the sense of awe they must have experienced on their discovery. *Secrets of the Hoary Deep* still holds many secrets. We will not know what is up there until we look.

—Luigi Gallo

Luigi Gallo is an assistant professor of astronomy and physics at Saint Mary's University in Halifax. His research focuses on X-rays emitted from the innermost region of black-hole environments.

Designer's Corner

Heaven Helped Us; Surveying by Starlight

By Brian G Segal, CFT, MGDC

Thirty-two years ago, after graduating at the top of my class from forestry school, I found myself employed by a land surveying firm in Fredericton, New Brunswick. Back then land surveying was just emerging from the world of slide rules, transits, and 100-foot tapes, and heading into what was then the high-tech world of pocket calculators, theodolites, and Electronic Distance Measuring (EDM) devices. We thought we were at the leading edge of technology — indeed, having the ability to navigate through an HP calculator with Reverse Polish Notation (RPN), reasonable programming capacity, and an EDM, which reduced errors dramatically, put us into the land surveying space age (to mix a metaphor).

Back then, New Brunswick had just started placing survey monuments around the province as part of the Land registration and Information Services (LRIS) program to tie the entire province into a standard grid system that would replace magnetic north with "Grid North." Each monument was at a known longitude and latitude, and had been surveyed and corrected to within a very high degree of accuracy. The monuments were even corrected for the curvature of the earth. All you needed to do was to set up on one monument, take a back sight on another, swing your angle and measure your distance to a new point and, SHAZAAM, you knew exactly where in the grid system you were.

Unless, of course, there were no monuments within sighting distance of your job; then things were not quite as straightforward. There was no GPS — just a heap of historical evidence and records, some of it rather unreliable, and whatever physical evidence you could find on the ground. Every surveyor has a sack full of hilarious, tragic, and simply baffling stories about weird property lines, missing evidence, and, in some cases, completely misplaced properties.

Our firm seemed to specialize in boundary-line retracement — likely by default or by accident — or maybe because no one else wanted to do it. At any rate we often found ourselves deep in the woods trying to imagine the logic of some long-forgotten surveyor. Property lines were often defined by meandering rail fences with dozens of strands of barbed wire woven into them. In some cases, each neighbour maintained the line every second year, and we would come across a 25-foot-wide swath of barbed wire, reminiscent of the killing fields of the First World War, as each neighbour tried to gain a few feet of property on his turn, and his neighbour would reclaim that and grab more on his.

All of this made our lives difficult. Nothing grabs a landowner's attention more than having a surveyor show up next door to define the adjacent property lines.

So with this in mind you can imagine the potential for all sorts of problems when sent to a difficult site. One day my boss told me that we were going to a property north of Minto, New Brunswick. Now Minto was famous in the survey business; it was loaded with challenging surveys. Not only were many of the "plans of survey" highly imaginative — when you could find one — a lot of physical evidence was simply not to be found. Our mission was to survey a squarish shaped 40-acre lot of land and then divide it up into four equally sized strips, each with equal road frontage, as a settlement imposed on four siblings who couldn't agree on how to share their late parents' property.

Needless to say the scene was classic Minto. On one side a split-rail fence with 20 strands of barbed wire woven in around and through it, on the other side an old page-wire fence through the woods with many strands of barbed wire on either side. Keep in mind we were required to produce linear accuracy equal to within 2/10ths of an inch per mile (for you young folks, that's 0.51 cm per 1.61 km), and equally demanding angular precision.

As the Province of New Brunswick had decreed that all surveys now had to tie into the provincial grid system you understand that everything depended upon the accurate location of the property on the grid. Failing that, nothing else mattered, and that's where astronomy came in. Since there were no known LRIS monuments within miles of the site, we decided to do a "star shot" to find our location on the planet. Short of surveying our way up from some monument near Fredericton, there was no other way.

Star shots for land surveying were already an arcane art in the 1970s, although air and sea navigators were still required to know the trade. Since we didn't have one on the team, we relied on one of our crew who happened to be an instructor at the forestry school. He was keen to make the effort (no doubt to incorporate in his next term's lectures), so we saddled up for the mission. Essential to the project were a reliable watch, a precise theodolite, rock-solid tripods, flashlights, bug repellent, a bunch of celestial tables, and a bottle of rum. The rum, of course, was for the post-observation celebration.

Off we went into the clear, cool August night. We arrived at our site and set up the instrument in a predetermined spot in a field on the property. A stake was driven into the ground with a piece of red ribbon nailed to its head. The nail was our reference point on the ground. A similar stake-nail-ribbon combo was situated within sighting distance. We set up a tripod over that point with a target indicating exact centre of that reference point. Then we had a pre-celebratory pull on the rum and waited for the sky to go dark. It was a moonless night — we wanted to make the sighting as easy as possible.

Without getting into a long discourse on the methodology (that would be an article in and of itself) suffice it to say that we had to take a series of shots at Polaris and then tie them into our two station points. This included swinging angles from the horizon (in this case the levelled instrument) to the star to determine latitude. Using the theodolite for angles, and the watch for precise GMT, we could swing the horizontal angles from Polaris to another star (accompanied by precise time measurements) to determine longitude. We measured the angles and distance to the second point, and we were done.

Of course, all we had at the end of the day was the raw data. Converting this information into an exact spot on the New Brunswick grid required some extensive and rather tedious calculations.

Fortunately, we had cultivated a relationship with a keen computer genius at the Department of Natural Resources, so we met him there later that night and handed him our field notes. You have to understand that this was three decades ago. The computer he used was the size of a tractor-trailer and was very good at basic math, and some trig and calculus. Fortunately, that was all we needed. Armed with the required tables and ephemera, we fed the information into the computer and, after some thought, it spat out a set of coordinates that placed our two nails on the planet and integrated them to the grid system. Now we had a real reason to celebrate, and we polished off the rum.

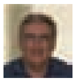
The next day we dragged ourselves out to the site and began the real work — surveying the ground — confident that we could establish grid coordinates for each survey marker.

Although I can be easily accused of boasting, I have to tell you that after doing a least-squares (best fit) analysis of the rail fence and traversing the distance cited on the old meets-and-bounds deed (about a quarter mile), we hit the exact centre of a huge old tree with four big blazes on opposite sides. We swung a 90-degree angle and hacked our way a quarter mile to another equally huge and blazed tree and then, swinging our final 90-degree angle, hacked, hewed, and sniped our way back to the road through a 50-foot-wide nest of barbed wire inconveniently woven through alders and a spruce thicket.

When we hit the road we looked to our right and there it was, a house exactly where it shouldn't have been; smack on our client's property. At least we knew its exact grid coordinates!

"Minto!" we exclaimed in unison, and went home for the day.

Brian G Segal is, among other things, an honours graduate of the Maritime College of Forest Technology *(or as it was previously, and more humbly known, the* Maritime Forest Ranger School*). He is currently President of* Redgull Incorporated, *a communications design firm, and is responsible for the graphic design and pre-press production of the* Journal *and the* Observer's Calendar. *An amateur astronomer, he lives under clear skies near Antigonish, Nova Scotia.*



Society News

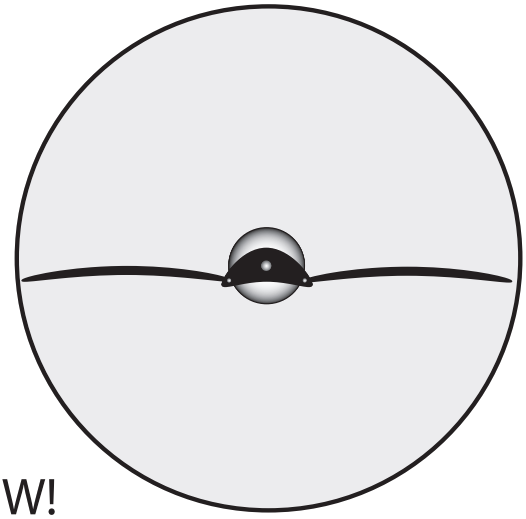
by James Edgar, Regina Centre (jamesedgar@sasktel.net)

Late-breaking news from the Star-Party realm — I call the 2009 GA/SSSP a "Theoretical Star Party," since it really wasn't one. After Wednesday night's grand showing of numerous bright Perseid meteors, the clouds rolled in and stayed pretty much that way the rest of the weekend. On Saturday morning, fellow Regina Centre member, Paul Meyer, set up his Coronado SolarMax 90, but only for about 20 minutes! That was it! So, in theory, we had a star party, but not really! And much the same can be said for Starfest and Nova East, both of which were greyed out with clouds, rain, and high winds.

On a brighter note, I'm pleased to announce here that our newest Honorary President is Dr. James Hesser. Many of our readers and members may already know of Jim through his activities during IYA2009, and, for those who don't, we have this small but revealing quote from the NRC Web page:

Dr. Hesser is one of Canada's leading astronomers. He has contributed significantly to a number of research areas, such as stellar populations and chemical evolution in nearby galaxies with emphasis on the cosmologically interesting oldest stars and star clusters. He is renowned for promoting interest in astronomy among B.C. schoolchildren and received the Michael Smith Award for Science Promotion in 1997. Dr. Hesser is...Director General of the NRC Herzberg Institute of Astrophysics (NRC-HIA).

Asteroid 38791 is named "Jameshesser" in his honour (see `www.rasc.ca/education/asteroids.shtml`).



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2831 Alexandra Ave, Windsor ON N9E 2J8

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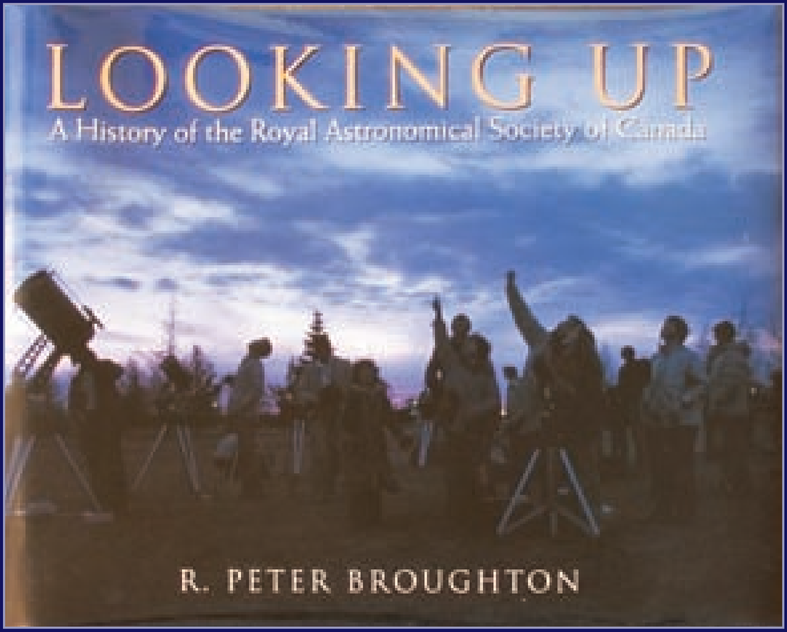
Great Reading



Looking Up Digitized

R. Peter Broughton's important and thorough *Looking Up: A History of the Royal Astronomical Society of Canada* (1994) has been digitized! Peter, a Past National President of the RASC and veteran of many positions on National Council (winner of the Service Award 1987), is a recognized historian of astronomy in Canada and the English-speaking world, with many publications to his credit. Thanks to the work of Walter MacDonald (Kingston Centre, Service Award 2009), *Looking Up,* long out of print and virtually unobtainable, is now available at `www.rasc.ca/publications/lookingup/index.shtml`

Don Fernie, in *Cassiopeia,* gave the work high praise: "If you count yourself a Canadian astronomer, this book is part of your heritage; you will be pleased to have it on your bookshelf." Now it can grace the shelves of virtual libraries around the world.

The passage of time has made the jacket image of *Looking Up* itself an intriguing artifact of Canadian astronomical history from the age of film emulsions. It was taken by Alan Dyer (Calgary Centre, winner of the Simon Newcomb Award in 2007), a renowned Canadian astrophotogapher and astronomy writer, a contributing editor of *Sky & Telescope, SkyNews,* and a collaborator with Terence Dickinson on acclaimed projects. Alan writes that the photograph was "taken at one of the 1970s Starnights we held annually in Coronation Park, Edmonton, outside the old Queen Elizabeth Planetarium. The Edmonton RASC and Planetarium organized Starnights each year, carrying on a tradition begun the 1960s. The Starnights started as space exhibits at the Jubilee Auditorium, then in the 1970s when travelling NASA exhibits were no longer available, evolved into observing sessions in the Park, using portable telescopes supplied by the Planetarium and RASC members.

"The current Observing Deck at the TELUS World of Science-Edmonton, now 25-years-old this year, is a direct result of those events, giving the city a permanent home for public telescopes, to carry on the tradition of those early Starnights. Indeed, the Celestron 14 telescope depicted at left in the cover photo is still in use at the TWS Observing Deck. Hundreds of thousands of people must have looked through it by now (it has superb optics)."