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Journal

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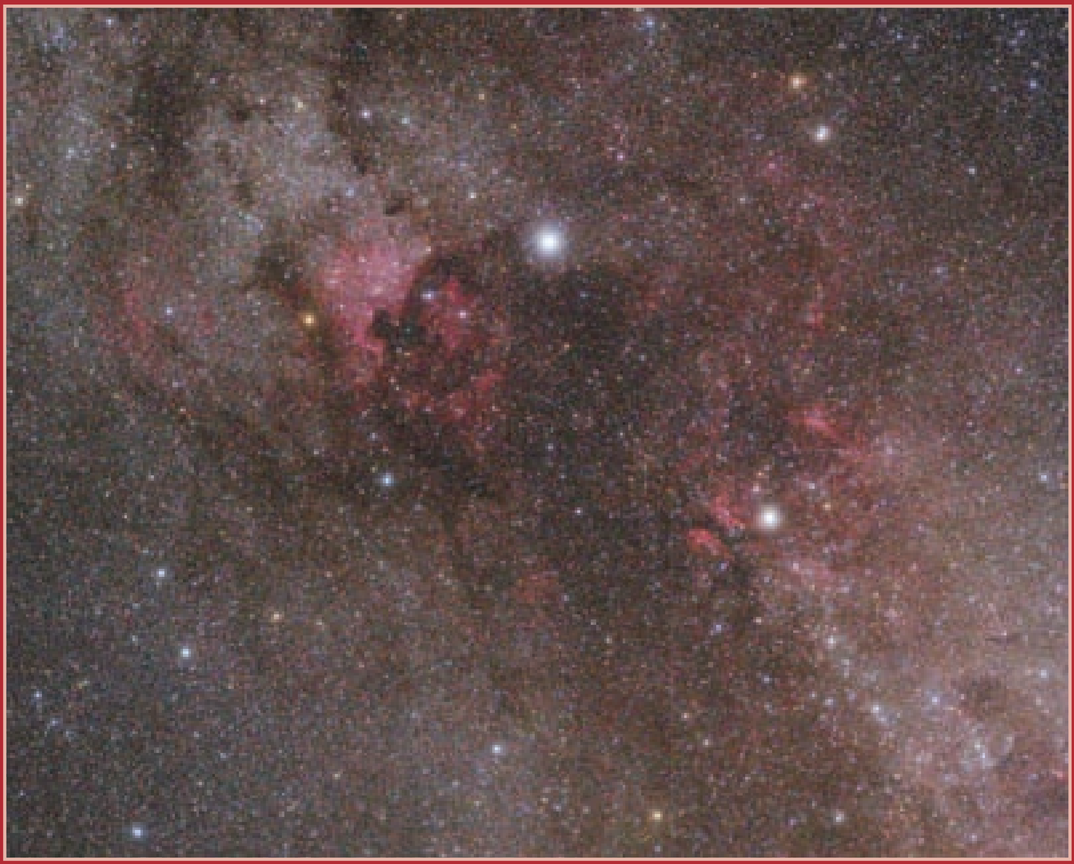

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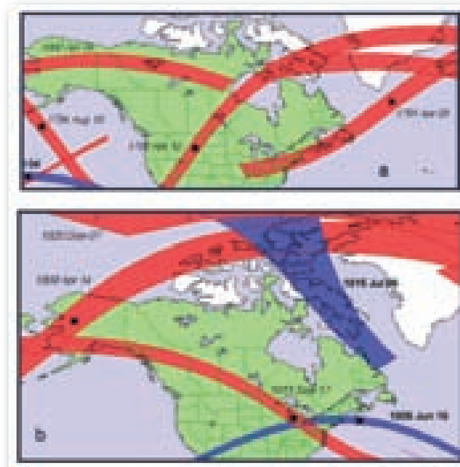

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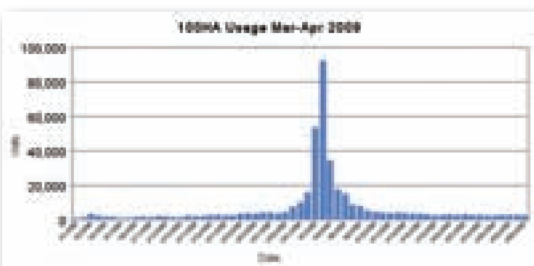

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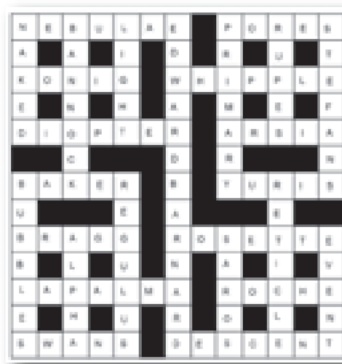

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SOCIÉTÉ ROYALE D'ASTRONOMIE DU CANADA

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

Best-selling Theoretical Physicist and Cosmologist Gives Prestigious Public Lecture

Dr. Lawrence Krauss

Lawrence Krauss of Arizona State University and author of seven popular books (including the international bestseller *The Physics of Star Trek* and the award-winning *Atom*) gave the 2009 *Helen Sawyer Hogg Public Lecture* to an audience of professional and amateur astronomers in Toronto on 2009 May 27. Foundation Professor in the School of Earth and Space Exploration and Physics Departments at Arizona State University, Krauss is a world leader in cosmology and astrophysics, and a winner of numerous international awards for his research.

The lecture, titled *Life, the Universe, and Nothing,* discussed the impact of new discoveries, including the key facts that the Universe is flat and the dominant form of energy in the Universe resides in empty space. Professor Krauss noted that the developments of the past decade have forced humanity to confront truly fundamental questions at the basis of science. In the far future, astronomers will not be able to detect evidence of the Big Bang in the form of what is known as background radiation. All evidence of the Big Bang will disappear, and scientists will think that humanity lives in a static, eternal Universe. Far into the future, the current night sky, twinkling with distant light, will appear as a dark, empty void.

Krauss stressed that humanity may be living at a very special time in the history of the Universe and that understanding why that appears to be the case is one of the biggest open questions in cosmology.

The *Helen Sawyer Hogg Public Lecture* is sponsored jointly by the Canadian Astronomical Society (CASCA) and the Royal Astronomical Society of Canada (RASC).

Saint Mary's University — First Ph.D. & *2009 Plaskett Medal*

The Department of Astronomy and Physics at Saint Mary's University in Halifax produced its first Ph.D. in August 2008

Journal

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

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when graduate student Catherine Lovekin successfully defended her thesis titled *Non-Radial Oscillations of Rotating Intermediate Mass Stars*. In her defence, Lovekin investigated "the influence of rotation on pulsation frequencies in upper main-sequence stars," using "... 2-D stellar-structure models and a 2-D linear adiabatic pulsation code to calculate pulsation frequencies for both uniformly and differentially rotating... ZAMS models."

For her scholarly efforts, Lovekin received the *2009 Plaskett Medal*, which is awarded annually to the Ph.D. graduate from a Canadian university who is judged to have submitted the most outstanding doctoral thesis in astronomy or astrophysics in the preceding two years. Established in 1988 in recognition of the pivotal role played by John Stanley Plaskett in the establishment of astrophysical research in Canada, the *Plaskett Medal* is jointly awarded annually by The Royal Astronomical Society of Canada and the Canadian Astronomical Society.

CASCA Presents First *Peter G. Martin Award*

Dr. René Doyon

The Canadian Astronomical Society (CASCA) presented its first *Peter G. Martin Award for Mid-Career Achievement* to astronomer René Doyon at its Annual General Meeting in May 2009 at the University of Toronto. In doing so, CASCA recognized Doyon's exceptional scientific contribution to adaptive optics and infrared imagery that led to the first images of extrasolar planets.

A full professor at the Université de Montréal, Doyon holds the university's industrial research chair in experimental astrophysics. The Director of the Observatoire du mont Mégantic as well, Doyon's main scientific interests are the search for exoplanets and the conception of cutting-edge astronomical instrumentation. In addition to his university activities, Doyon serves as the principal investigator of an international scientific team for the conception and construction of one of the four scientific instruments for *Hubble's* replacement, the upcoming *James Webb Space Telescope (JWST)*, scheduled for launch in 2013.

Celebration of Canadian Astronauts

Canadian astronauts Julie Payette and Robert Thirsk. CSA photo.

2009 will be a year of celebration for Canadian space exploration, which began almost 25 years ago. Canadian veteran astronauts Robert Thirsk began a six-month stay (May 2009) on the *International Space Station*, marking a space milestone where, for the first time, six astronauts will be living and working together in the world's largest orbiting microgravity scientific laboratory.

On the commercial side, 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 ONE DROP Foundation supports initiatives that promote "Water for all, all for water." Julie Payette has been scheduled to launch on an assembly mission to the *Space Station* as a crew member of the shuttle Endeavour. She will also take 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.

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

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

Correspondence

Hello:

Earlier this evening I rode my bike down to English Bay in Vancouver to watch the sunset. On my way home, I came across a group of members of the RASC who had set up their telescopes for people to look at the night sky. (As an aside, what would the collective noun for a group of astronomers be? A Magnification of Astronomers? A Vaulted Sky of Astronomers?). I had the absolute delight and pleasure of looking at the surface of the Moon, all pock-marked and dusty, and the glowing spectacle of Saturn and its moons, for the first time in my life. That was absolutely the COOLEST thing I have ever seen.

Please pass on a great big "Thank you!" to those folks who so kindly set up their telescopes, and who so patiently and enthusiastically explained everything. It was the perfect way to begin a weekend, and the perfect way to welcome summer to Vancouver. Thank you.

Cheers,

Scott Hughes
Vancouver, B.C.

Errata for *Herschel, Babbage, and Isaac Newton's Chair,* June JRASC

p. 117, column 1, line 4 from top	to take you] is expunctuated by Herschel
p. 117, column 1, line 9 from top	about change in Luc] is expunctuated by Herschel
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p. 118, column 1, line 8 from top	"res" of "pres" is underlined by Herschel
p. 118, column 1, line 9 from top	appareil q] is expunctuated by Herschel

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Astronomical Observations by Peter Fidler and Others in "Canada" 1790-1820

by Peter Broughton (pbroughton@3web.net)

Abstract. Peter Fidler (1769-1822) was a surveyor for the Hudson's Bay Company. He made more astronomical observations than anyone else in the Company's employ and used a greater variety of phenomena (occultations, eclipses, and Jupiter's satellites) to find his longitude. His telescopic observations and those of some of his contemporaries are discussed.

1. Introduction

King Charles II granted the London-based Hudson's Bay Company (HBC) its vast territory in 1670. Named Rupert's Land after the King's cousin, this huge land mass covered about a third of present-day Canada. During its first century, the Company stayed close to the coast of Hudson Bay. It was only after appointing its first surveyor, Philip Turnor, in 1778, that the HBC began to extensively explore and map the interior of the continent. Turnor was recommended to the HBC by William Wales, who had observed the transit of Venus at Churchill in 1769 and was now a teacher of mathematics and navigation in London. Two of Turnor's protégés, David Thompson and Peter Fidler, hired in England as teenagers, became outstanding explorers of the Canadian west.

In the vast archives of the HBC in Winnipeg, there are thousands of astronomical and meteorological observations. Auroral observations from this resource and for this time period were published earlier (Broughton 2002). As for astronomical records, few of Turnor's observations are extant, but a great many of Fidler's, and some made by others, are in the HBC records. Since Thompson left the HBC for the rival North West Company in 1797, many of his observations are not in the HBC archives but are found in his notebooks at the Ontario Archives.

Fidler and his contemporaries made these thousands of sightings with a sextant, to find latitude and longitude. Using an artificial horizon (basically a trough of mercury placed on the ground), they were able to measure double altitudes of the Sun and stars. This method halved the error in altitude and eliminated the correction for dip, which arose when the true horizon was used. In any case, observers could seldom see a true horizon from land-locked locations. They generally used a thermometer to record the temperature, in order to make accurate allowance for atmospheric refraction. The HBC men typically made observations for latitude by finding the (double) meridian altitude of the Sun at noon, and usually found longitude by measuring lunar distances, *i.e.* the angle between the Moon and the Sun, or between the Moon and a star. Besides the lunar distance, they also needed local apparent time in order to calculate their longitude, for which a corrected reading from a watch was needed. They found the watch correction by measuring the altitude of the Sun (or a star) at about the same time as the lunar distance was taken, and then used their latitude to calculate the time by means of spherical trigonometry. This then provided a correction to the watch. With the aid of tables and the *Nautical Almanac,* the HBC surveyors spent countless hours reducing their observations in order to fix their geographical locations — a task that was essential to mapmaking 200 years ago. Though it involved celestial observations, few modern-day astronomers, amateur or professional, are likely to consider it part of their domain today. Consequently, the sextants, watches, and methods have been discussed elsewhere (Broughton 2009). In that paper, the accuracy of the observations was assessed by comparing them with calculations from an online ephemeris generator (EG)[1]. The conclusions that are important to the present paper are that the HBC surveyors could measure angles using a sextant with an accuracy of about 20 arcseconds, and could determine local time correctly to within a few seconds of time.

In the present article, telescopic observations of eclipses of the Sun, Moon, Jupiter's satellites, and lunar occultations are discussed. These events were also used to find longitude, but *Journal* readers will probably relate more readily to them than to the more prosaic but plentiful solar altitudes and lunar distances. A few observations of comets will also be noted, though they served no geographical purpose.

Most of the observations described here were made by Peter Fidler, whose biography can be read online in the *Dictionary of Canadian Biography* or in a book by Macgregor (1966). He devoted a significant part of his life to his astronomical observing and calculating. Though his equipment and methods were similar to those of his contemporaries, Fidler was unique in the extent and variety of astronomical phenomena he observed and in his interest in exploring methods of predicting and reducing them. In order to appreciate his achievement in context, some other contemporary North American observations will be mentioned.

2. Telescopes Used by Fidler and His Contemporaries

At Cumberland House [Saskatchewan] in 1789, Fidler began his training in the art of astronomical surveying under Philip Turnor's guidance. He learned quickly and was soon working alongside his mentor. By 1792, Fidler ordered his own equipment, but the list of items did not include a telescope. Items charged to his accounts for 1798, however, include a "4 foot A[ch]-romatic Telescope Dolland £17.17" and a second smaller one (2 foot) at £4.4.[2] The former instrument was likely the one he described in his notebook as "Telescope with brass sliding tubes of 14 Inches when shut & 52 when in use, magnifying power 55 times."[3] While using his telescope to observe Jupiter's satellites at Nottingham House [Alberta] in 1803, he specifically referred to his Dollond achromat magnifying 80 times, four feet long, and at Île-à-la-Crosse [Saskatchewan] in 1811, as 3½ feet long. When he observed lunar eclipses at Brandon House [Manitoba] in 1808 and at Île-à-la-Crosse in 1811, he used 35 power on his achromatic telescope, and in the latter instance used a pocket telescope as well.[4] In his will, dated 1821, he left "a large achromatic telescope." It seems likely that the larger telescope in all these notes is the same Dollond extendable achromat equipped with three eyepieces having magnifying powers of 35, 55, and 80 times. Unfortunately, Fidler never mentioned the diameter of the telescope's objective lens, but it was probably no more than 6 cm. He did not refer to a stand either, but it would have been very desirable to have one for steadying the telescope.

Turnor must have had a telescope in 1780 since he observed Jupiter's satellites, as reported by Dalrymple (1789) and Arrowsmith (1794), but no details are known. By 1790, he apparently no longer had a telescope, since neither he nor his pupils, Thompson and Fidler, made any observations requiring one at that time. David Thompson, in about 1795, ordered a "4 foot Aromatick [*sic]* Telescope £12.12," two "Eye tubes" *i.e.* eye-pieces at £2.2, and a "Brass Stand" at £3.3.[5] In his *Narrative,* he says he had "an achromatic Telescope of high power for observing the Satellites of Jupiter and other phenomena, and one of the same construction for common use" (Glover 1962). Thompson seems to have observed with the former only a few times, at Red Deer's Lake [Lac La Biche, Alberta] in 1798-9, though he wrote of using a powerful achromatic telescope, perhaps the second one to which he referred, to view Mount Hood [Oregon] in 1811.[6] Other HBC men had telescopes too. A three-foot achromatic telescope was ordered for Isaac Batt on 1792 May 1, at a cost of £3.3.[7] John Hodgson, in 1796, requested a "Large Telescope A[chromatic] L[ens] £10.10,"[8] and Thomas Swain, in 1804, ordered a "2 ft. achromatic telescope with brass drawers [draw-tubes] £4.4, 3½ d[itt]o with Mahogany table, Brass stand, one eye [piece] to be for Day objects, three for Astronomy, Rackwork, Sliding Rods &c in a Mahogany box £31.10."[9]

When George Vancouver explored the west coast in the 1790s, he had a 42-inch achromatic telescope on a polar axis. The man who was intended to be his astronomer, William Gooch, had a similar telescope with "a divided Object-glass, Micrometer and stand by Dollond" as well as "A reflecting Telescope, by Burton" (David 1993). The former instruments may have been similar to the ones used on transit of Venus expeditions by Captain Cook and by William Wales in 1769, but there is no indication that Vancouver or Gooch used theirs for any astronomical purpose in the 1790s. Meriwether Lewis and William Clark, the famous American team who travelled overland to the Pacific in 1804-06, had a pocket telescope with them, but they did not attempt to use it to observe Jupiter's satellites. Thomas Jefferson advised them to stick with lunar distances since he considered that the eclipses of the Jovian satellites were too infrequent for explorers on the move (Bedini 1984).

3. Occultations and Solar Eclipses

Except for a few days around new Moon, lunar distances could be measured whenever the sky was clear. Consequently, the method of lunar distances was the favoured procedure in finding longitudes by astronomical observation. However, there were other methods involving occultations and eclipses that had the potential to give considerably more accurate longitudes. The drawback was that these events occurred only occasionally at any given location and so could be used only rarely in fixing geographic position. Since no angular separation was measured in these cases, only the time of the event was needed and that could be found with a margin of error of only a few seconds. A timing error of 4 seconds implies an uncertainty in longitude of only 1 arcminute, a margin of error about a 20th of typical errors in longitude found by lunar distances. Sometimes Fidler did time solar eclipses to this accuracy.

Occultations ought to be just as good as solar eclipses, but because they occur at night, the time of their occurrence was often corrected by using the altitude of stars. Though the HBC men did correct the catalogued mean stellar positions for precession, they did not take aberration and nutation into account, so nighttime occultations were generally less accurately timed than the phases of a solar eclipse. Moreover, when a star disappears or reappears behind the illuminated limb of the Moon, the glare of the bright Moon is likely to introduce further error. In addition, the tables in the *Nautical Almanac* were not perfect, and determining the longitude from these events was a complicated process, involving the usual corrections for parallax. Fidler showed the methods in his notebook, and in fact did deduce his longitude in some cases, but generally only within 8 arcminutes. (Often, the observations can be recomputed with modern data to find the longitude within a couple of arcminutes.) Fidler is known to have observed eight occultations. These are listed in Table 1, where the columns give the observed local apparent time (LAT), the name of the occulted star, the longitude of the place as derived by Fidler, the LAT of the occultation calculated using EG, the observed-minus-calculated (O-C) difference between the two times, and finally the reference to the HBC Archives source.

The two maps shown in Figure 1 show the central paths for solar eclipses between 1781 and 1820. There were no total eclipses visible in Rupert's Land during these years, and there is no record that anyone witnessed the spectacular sight of an annular eclipse during this period. The path for the annular eclipse of 1811 September 17 looks promising, but Fidler at this time was at York Factory waiting for a ship to take him to England for a year's leave.[10] He had to content himself with seeing the partial phases of this eclipse from outside the central path, as he had for a number of other solar eclipses; these are listed in Table 1. Fidler's observations of the solar eclipse of 1815 July 6 were unusual in that he not only timed the beginning and end but also used his sextant to measure the separation of the limbs of the Sun and Moon at eight times, which he recorded during the progress of the eclipse.

4. Lunar Eclipses

Lunar eclipses provide the simplest and most ancient astronomical method of finding longitude. Since the Earth's shadow falls on the Moon, there is no parallax to worry about. All observers on Earth see the phases—beginning, ingress, egress, and end — simultaneously. Of course two observers, say at Greenwich, England, and Cumberland House, perceive that any one of these phases occur at different local times. The difference between the local times of the two observers is their difference in longitude. The obvious problem with this method is that an observer might have to wait a year or more to see a lunar eclipse. Moreover, the exact instant at which the various phases occur is difficult to determine since the Earth's shadow has a rather fuzzy edge.

Fidler's lunar-eclipse observations are listed in Table 1. It is somewhat surprising that his earliest lunar-eclipse observation dates from 1801, since he would have had half-a-dozen earlier opportunities. It seems unlikely to have been cloudy on all these occasions. For instance, on 1790 October 22, Fidler measured the lunar distance to Aldebaran at about 9:15 p.m.[11] The time was less than two hours after the end of a total lunar eclipse about which he made no mention. He did try to see lunar eclipses on 1791 October 11 and 1797 December 3, but he was apparently thwarted by clouds.[12] Though the phases of a lunar eclipse can be seen with the naked eye and somewhat better through a sextant's small telescope, Fidler may have decided that such observations were too crude and waited until he had a proper telescope, which he did after 1799. The fact that the longitudes found by Fidler using lunar eclipses are often closer to the truth than the modern calculated values can be attributed to the current practice of publishing the times of contact only to the nearest minute, whereas the almanacs of Fidler's day published the times to fractions of a minute.

As an example of how Fidler used lunar eclipses, consider his observations at Chesterfield House on the night of 1801 March 29. Taking into account that his watch was 3 minutes fast, he noted the local apparent times shown in Table 1. Consulting the *Nautical Almanac* for 1801, he found the Greenwich apparent times, and from the difference between the local and Greenwich times, converted to degrees, he deduced his longitude as 110° 07½. In this case, the *Almanac*'s Greenwich times agree with modern values within a minute, so it is not possible to use this eclipse to improve on the longitude that Fidler found, a result that agrees as closely with modern calculations as the fuzziness of the lunar eclipse allows.

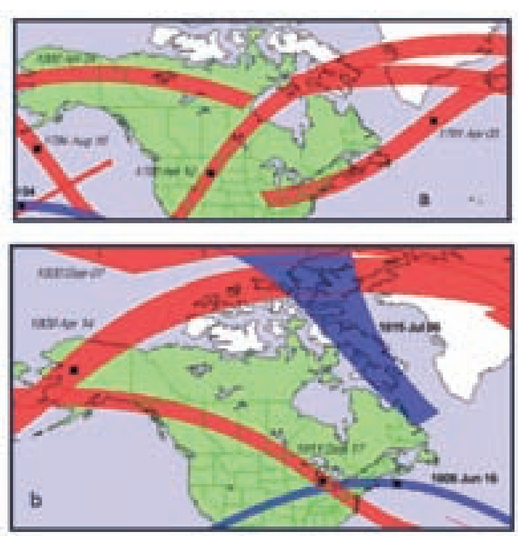

Figure 1 — Maps of paths of central solar eclipses 1781-1800 and 1801-1820. The only paths that cross the prairies are 1782 April 12 and 1811 September 17, and both of these are annular eclipses. (Courtesy of Fred Espenak, NASA/Goddard Space Flight Center. For more information on solar and lunar eclipses, see Fred Espenak's Eclipse Home Page: sunearth.gsfc.nasa.gov/eclipse/eclipse.html)

Another interesting example that clearly demonstrates Fidler's dedication comes from Nottingham House [Alberta]. There, with the temperature hovering around -35 °F, he watched the progress of the lunar eclipse for nearly three hours on the evening of 1806 January 4, noting the times at which the Earth's shadow passed over various lunar features (Figure 2), identified on a map of the Moon in Lalande's *Astronomie,* a book that Fidler had received in 1804.

Although Fidler was a prolific observer, other HBC men watched eclipses, too. George Sutherland, at Buckingham House, recorded the end of a lunar eclipse on 1797 December 3, writing enthusiastically (though without justification), "perhaps there is no Country in the World where heavenly Bodies can be viewed with the Naked Eye to more advantage then here in the Winter Season."[13] Thomas Swain, an assistant of Fidler's, posted near what is now Fort Resolution, NWT, timed the end of an eclipse of the Moon on 1805 January 11, with the thermometer standing at -38 °F. He also accurately timed the end of a solar eclipse at Lake Athabasca on 1805 June 26.[14] George Gladman, at Eastmain [Québec], saw the beginning and accurately timed the end of the solar eclipse of 1806 June 16.[15]

5. Jupiter's Satellites

Another celestial clock, which terrestrial observers can see with a small telescope, is provided by the four brightest satellites of Jupiter. As they orbit Jupiter, they slip into the shadow of their parent, only to reappear some time later, giving rise to several visible monthly eclipse phenomena, except for a couple of months each year when Jupiter is too close to the Sun. The phenomena were all predicted in the *Nautical Almanac* from 1795 on, a resource that Fidler always had with him. Longitudes can be found from eclipses of Jupiter's moons just as longitude can be found from lunar eclipses, with no complicated calculations. However, a telescope is required to see the eclipses of Jupiter's satellites and, since the satellites only subtend a very tiny angle of about 1 arcsecond, the beginning of an eclipse and the beginning of totality (ingress) cannot be detected separately — the only detectable phases of an eclipse of a satellite of Jupiter are disappearance and

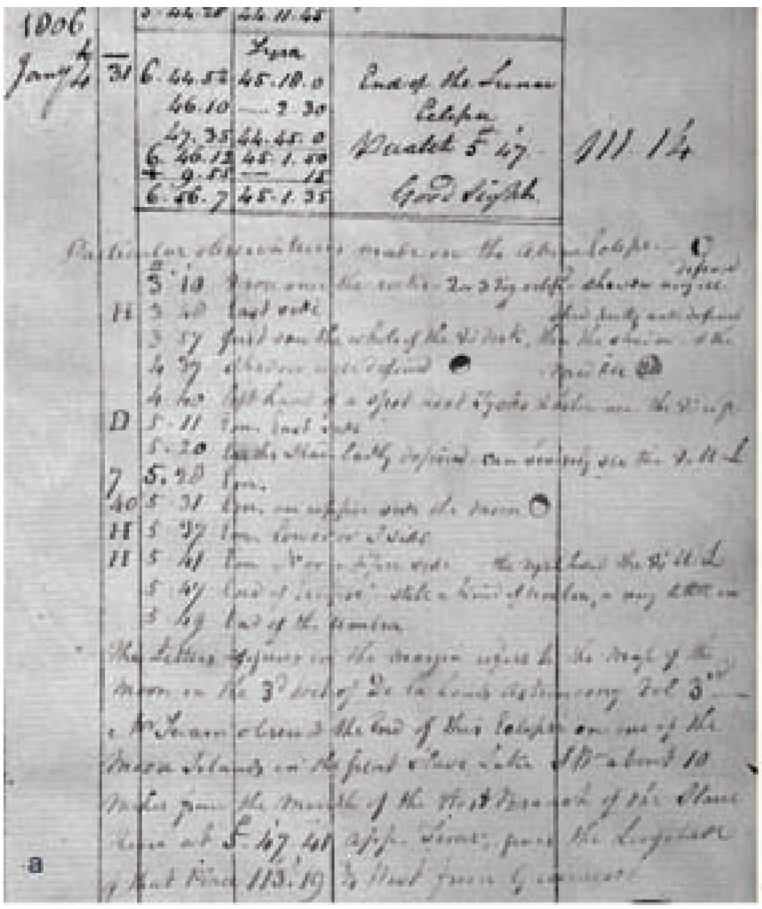

Figure 2a — Fidler's observations of the progress of the lunar eclipse of 1806 January 4, in which he noted the times at which the Earth's shadow passed over various lunar features, identified on a map of the Moon in Lalande's Astronomy. (HBC Archives, Archives of Manitoba, E.3/1 fo. 116)

Figure 2b — Map of Moon from J.J. de Lalande's *Astronomie* on which the features noted by Fidler are labeled. (The Thomas Fisher Rare Book Library, University of Toronto) reappearance. Some time is required for this process to take place, and so the moments of disappearance and reappearance are somewhat subjective, and could not be timed to an accuracy much better than a minute.

Nevertheless, the method was highly regarded for finding longitude on land. The Astronomer Royal wrote at the end of the 18th century:

> *The Eclipses of Jupiter's Satellites are well known to afford the readiest, and for general Practice, the best Method of settling the Longitudes of Places at Land; and it is by their Means principally that Geography has been so much reformed within a Century past, and the Position of the most distant Places determined with equal Accuracy to the nearest.*[16]

Christopher Middleton had used the method in Hudson Bay as early as 1742 though sometimes with difficulty in the winter. He wrote:

> *I endeavoured to make some observations on Celestial bodies particularly the emersions of Satellites of Jupiter with reflecting and refracting telescopes but the metals and glasses by that time fixed to the object was covered one quarter of an Inch thick with Ice and thereby rendered indistinct so that it is with difficulty that any observation can be taken.*[17]

As noted above, Philip Turnor observed Jupiter's satellites in 1780. Fidler began his Jupiter observations on 1799 October 29, at Greenwich House. The name that Fidler gave to his Greenwich House outpost is curious. It is true that there was at one time a royal residence at Greenwich, England, and there seems to have been a tradition of naming Hudson's Bay posts after English stately homes. Still, it may be that Fidler, with a touch of humour, named the new post where he began his telescopic observations for Greenwich Observatory. His observations of Jupiter's satellites are summarized in Table 2, and Thompson's observations, made a bit to the east of Greenwich House in 1798-9, are also shown for comparison.

Fidler's first observation of Jupiter is shown in Figure 3. In this case, he observed the immersion of the first satellite on October 29 at 14:54:30 by his watch, or as we would say, 30 October at 2:54:30 LAT in the morning. The watch had to be corrected and in order to find out by how much, he observed the Sun about six hours later. At three times, 8:46:52, 8:47:40, and 8:48:23 in the morning, he observed the double altitude of the Sun's lower limb, using an artificial horizon. He averaged the times and the altitudes and found that at 8:47:38 by his watch, the average double altitude was 20°05′25″. However, he calculated the apparent solar time when the Sun had this double altitude as 8:47:58. Therefore, he reasoned, 20 seconds must be added to the watch time. He then went through the same procedure with the Sun's lower limb and found the watch

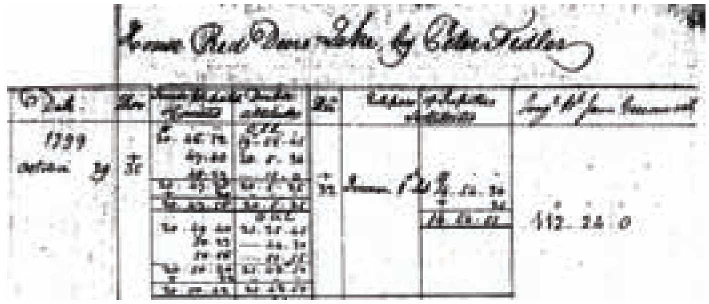

Figure 3 — Fidler's observations from Greenwich House [near Lac La Biche, Alberta] relating to an eclipse of Jupiter's first satellite on 1799 October 29. (HBC Archives, E.3/2, fo. 88 (portion))

correction was 22 seconds. He applied the average of these two corrections, 21 seconds, to the observed time of the immersion of Jupiter's 1st satellite arriving at a local apparent time of 2:54:51 in the morning of 1799 October 30.

Fidler would then have consulted the almanac and found that the immersion of Jupiter's first satellite occurred on 1799 October 30, at 10:24:27. Finding the difference between his observed time and the time tabulated for Greenwich, England, to be 7h 29m 36s and converting this to degree measure he arrived at a longitude of 112°24′00″. Using immersions and emersions of the first three Jovian satellites, Fidler made 17 determinations of longitude at Greenwich House between then and 1800 April 8. The mean and standard deviation of these 17 values is 112°07′ ± 11′. For the nine observations starting in 1800, Fidler calculated his longitude a second time using [Jean-Baptiste Joseph] DeLambre's tables. These predictions were also found in the *Nautical Almanac* and yielded 111°59′ ± 8′.

A fairly recent study of Delambre's ephemerides of Jupiter's satellites by Arlot *et al.* (1984) shows that differences between predicted times and contemporary observations have a dispersion of about 40 seconds. Of course, it is possible in some instances to avoid ephemeris errors entirely by comparing Fidler's observed times with those recorded at European observatories for the same phenomena. However, even when this is done, the standard deviation in derived longitude is still found to be ± 8′, which again suggests that the main source of error is the fact that the disappearance and reappearance of the satellites is not instantaneous.

During the same seasons that Fidler made his new Jupiter observations, he also continued with traditional methods, finding latitude by meridian observations of the Sun's lower limb, and longitude by lunars (*i.e.* lunar distances). The mean and standard deviation values he found for these coordinates of Greenwich House were 54°46′10″ ± 13″ from 8 values for latitude and 111°21′ ± 42′ from 21 values for longitude. The dispersion in the longitude values found by lunars is more than four times greater than the spread found by Jupiter satellites. It is surprising and unfortunate that the very straightforward latter method was not used more widely in the exploration of the West.[18]

6. Comparisons and Conclusions

Fidler found longitude by five different methods; typical errors in the overall results can be summarized as follows, from most reliable to least:

- Solar-eclipse times within ±12 seconds imply longitudes within ±3´
- Occultation times within ±32 seconds imply longitudes within ±8´
- Eclipses of Jupiter's satellites within ±48 seconds imply longitudes within ±12´
- Lunar-eclipse times within a minute imply longitudes within ±15´
- Lunar distances typically lead to errors in longitude in the ±15´ to ±30´ range.

These are all errors that could be expected from a single observation. By averaging several values, the errors were reduced and the reliability of the result was improved.

Some comparisons can be made with contemporary geographic positions found on the Pacific coast, particularly at Nootka on the west coast of Vancouver Island. The British expedition under Captain James Cook's command is best known. He and his compatriots spent April 1778 anchored in Ship Cove, King George's Sound (now Resolution Cove, Nootka Sound at 49°36´16˝ N, 126°31´46˝ W).[19] The longitudes that Cook deduced from 91 lunars have a mean and standard deviation of 126°42´ ±19´, which compares very favourably with the modern longitude of Resolution Cove 126°31´46˝ read from a topographic map (Cook found the mean to be 126°49´36˝). Two emersions of Jupiter's satellites were also timed, but not reduced to longitude. One of these was observed independently by both Cook and his lieutenant, James King, their times differing by 50 seconds.

Astronomical observations at Nootka also survive from the 1791 expedition of Alessandro Malaspina.[20] He and his men set up a temporary observatory on the shore of what is now known as Yuquot or Friendly Cove (at 49°35´25˝ N, 126°37´00˝ W, according to a topographic map). Using stars, they made seven meridian observations for latitude, obtaining a mean value of 49°35´15˝ with a standard deviation of ± 15˝. Using lunar distances on August 19, they found the mean longitude and standard deviation to be 119°34´ ± 13´west of Cadiz; on August 20, the results were 119°41´ ± 12´. Subtracting the longitude of the Cadiz observatory from the longitude found from the topographic map 126°37´- 6°17´ gives a modern longitude of 120°20´ west of Cadiz.

The following year, another Spanish expedition led by Dionisio Alcalá Galiano and Cayetano Valdés made astronomical observations at Nootka (Kendrick 1991). They made three longitude determinations using Jupiter's satellites: 120°26´, 120°30´30˝, 120°49´30˝ west of Cadiz, for a mean and standard deviation of 120°35´ ± 12´.

While it would be very desirable to study the statistics of Vancouver's astronomical positions found in 1792-94, it is not possible to do so since neither his log survey book nor his ship's log have survived.[21] Only mean values are published in his journals. He tells us, for instance, that the mean latitude of Nootka, found in October 1792 "by thirty meridional altitudes of the sun" was 49°34´20˝ N (Lamb 1984).[22] We are somewhat better off with the longitude observations, though, again, we do not have individual results. At Nootka, for example, Vancouver wrote that there were "forty-nine sets by myself and fifty-seven by Mr. Whidbey amounting in all to one hundred and six sets of lunar distances" giving the longitude 126°28´30˝ West of Greenwich.[23] He does present the mean results for each of them on each day separately so the 106 sets are divided into twelve groups with a mean and standard deviation of 126°37´ ± 9´, but, of course, the standard deviation would be larger than that if we had the individual values to work with, perhaps three times greater. All in all then, Fidler and the other HBC surveyors achieved results comparable in accuracy to the best-equipped expeditions sent out by the British and Spanish governments.

This comparison section would not be complete without at least a mention of Fidler's famous American contemporaries, Lewis and Clark. Their observations have always been problematic, and remain so even after a recent study by Preston (2000). The instructions the explorers followed were drawn up by Robert M. Patterson, and have been transcribed by Huxtable (2003). One of the methods (Problem 4th) advocated by Patterson and which Preston felt was unorthodox, was also the one used by Fidler and his HBC colleagues, so it was not that unusual. Huxtable, and others whom Huxtable cites, point out that Lewis and Clark erroneously halved the sextant reading before applying the index correction, rather than vice versa. He also suggests that Lewis and Clark may sometimes have incorrectly found the sextant's error. In addition, the explorers' artificial horizons were difficult to level, a problem that could have been a serious source of error. In any case, the values they found for latitude compared with modern values are off by several arcminutes, sometimes nearly half a degree. Fidler's accuracy, and that of his HBC colleagues, was dozens of times better than that. Could Lewis and Clark's longitudes have been less susceptible to error than their latitudes? It seems possible, since they used a sextant when they found longitudes by lunar distances, and it seemed much superior to the octant they used for latitude. But when Preston recently re-analyzed their longitudes, he found that the differences between the resulting longitudes and the modern values had a mean and standard deviation of −47´ ± 69´, a spread two or three times Fidler's. Probably there were many factors that reduced the accuracy of the Americans' work but incorrect altitudes could have been a serious flaw. Even though altitudes were not measured when lunar distances were taken, the time at which the lunars were taken ultimately depended on watch corrections found by measuring altitudes. If the time were wrong by a minute, the longitude would have been in error by 15 arcminutes. Whatever the reasons, the inescapable conclusion is that the quality of the astronomical work of the HBC men was better than — and usually much superior to — Lewis and Clark's. Of course, the quantity of the HBC surveyors' results was also much more extensive temporally, geographically, and in the range of phenomena used.

It would be a mistake, however, to think that the observations of the HBC men were unsurpassed in accuracy by North American contemporaries. Surveyors on the east coast, like Samuel Holland, Joseph DesBarres, and Thomas Wright, achieved better results on some occasions. For example, a highly accurate set of observations by Wright in 1797 shows a standard deviation of observations for longitude by Jupiter's satellites of about 3 arcminutes, and by lunar distances of about 10 arcminutes.[24] These are about a third of the spread in Fidler's results. In this case, Wright and his American counterpart, Samuel Webber, were attempting to settle a border dispute concerning the mouth of the St. Croix River. They set up a temporary observatory on a firm foundation, had more than one set of equipment with which to check their observations, and had a barometer as well as a thermometer to make their refraction corrections even more accurate.

7. Assessment of Fidler's Astronomical Work

There can be no doubt that Fidler had an enquiring mind. He amassed a library of 500 books by the time of his death at Dauphin, Manitoba, in 1822 (Lindsay 1986). Many of these volumes were quite technical in nature, such as Samuel Vince's *Practical Astronomy,* Pond's two-volume English translation of Laplace's *System of the world,* Benjamin Martin's *Venus in the Sun,* and Lalande's *Bibliographie Astronomique, avec l'Histoire de l'Astronomie depuis 1781 jusqu'à 1802.* Though there were a number of personal libraries as well as post libraries in Rupert's Land (Beattie 1993), there is other evidence of Fidler's intellectual nature in two notebooks he kept. One is referred to as Peter Fidler's "Notebook, 1794-1813" (though it contains entries as late as 1820) and the other as his "Notebook of Problems and Instruments of Practical Astronomy."[25] The former includes some elementary, though complicated, exercises in substituting numerical values in algebraic formulae, as well as tables relating to Mercator's projection. These would have been useful in mapmaking on a large scale, something that Fidler, unlike Turnor and Thompson, never seems to have done. In the other, larger notebook, he wrote out many complicated calculations of eclipses and occultations. While he may have simply copied these examples from a book as an intellectual exercise, he clearly was striving to understand the steps involved. A beautiful example is shown in Figure 4 where he found, by geometrical construction, the circumstances of the solar eclipse of 1804 February 11, apparently for a location in northern Europe. The eclipse was over before sunrise in North America. In another instance, he listed all the steps needed to compute the circumstances of a lunar eclipse, and then carried out these calculations for the lunar eclipse of 1807 November 14-15. There is no record that he observed this eclipse (perhaps he was prevented by clouds), but even if he had planned to see it, there was no need to compute the circumstances. He could have easily looked up the information in the almanac, but he evidently felt a strong need to find out for himself.

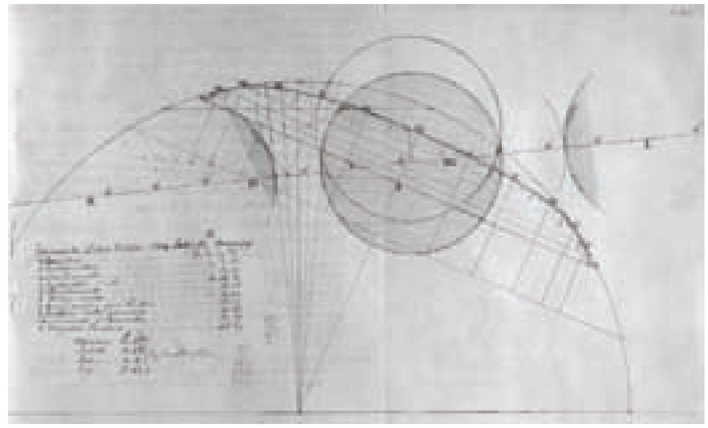

Figure 4 — Drawing by Fidler illustrating the circumstances of the solar eclipse of 1804 February 11 for some location in northern Europe. Since this eclipse was completely invisible in North America, the process was purely an intellectual exercise for him. (HBC Archives, Archives of Manitoba, FTL PF 17, p.218a)

Had Fidler lived in England, he might well have followed William Wales and Philip Turnor, who were employed as computers for the *Nautical Almanac.* He had exactly the requirements for such an occupation:

> *...considerable literacy and numeracy, the ability to use a range of mathematical and astronomical tables, attention to detail, and neatness. Knowledge of astronomy and the theory behind the data presented in the Nautical Almanac was also desirable. (Croarken 2003).*

Not only did Fidler apparently enjoy the computational side of astronomy, he occasionally engaged in observing purely for personal satisfaction. The details of his eclipse observations of the Moon in 1806 and 1811 and of the Sun in 1815 were already mentioned. In another instance, on 1803 April 22, at Nottingham House, Fidler studied Jupiter and Saturn and their satellites, noting the immersion of Jupiter's fourth satellite (which he recognized occurred too gradually to be suitable for finding longitude), and a few minutes later the start of the first satellite's transit across the planet's disc. He then watched three of Saturn's satellites and saw the rings of the planet nearly edge-on.[26]

Fidler would surely have taken great interest in the comet of 1811 — probably the most spectacular of his lifetime. It was recorded on 38 nights in the Churchill meteorological register, but its appearance coincided with Fidler's departure for England and there are none of his journals extant for that period.[27] His sextant observations at Fort Dauphin of a comet (Comet Trailles) on 1819 July 2 and July 8 are the only example of his observing a comet.[28] It was a very bright object and not hard to see, but taking a series of positions was unusual and of no practical importance to anyone but an astronomer. The six distances he measured between the comet and certain stars never differed from positions calculated using a modern ephemeris by more than 4 arcminutes, which is remarkably good for a diffuse object like a comet. Fidler's observations can be contrasted with the mistakes of the American surveyor, Stephen Long, who also saw the comet on July 7 and 8 while he was on an exploring expedition in Missouri (Thwaites 1905). Long was a graduate of Dartmouth College, a teacher at West Point Military Academy and a major in the U.S. Corps of Topographical Engineers. He was equipped with instruments at least as good as Fidler's, but the two polar distances that he recorded for the comet were several degrees in error.

Though it was shown elsewhere (Broughton 2009) that Fidler may not have been quite as accurate with his sextant as David Thompson, he observed a much wider range of phenomena. No one else in Rupert's Land timed occultations and eclipses of the Sun, Moon, and Jupiter's satellites to the extent that Fidler did. Because these methods gave much better results for longitude than lunar distances, it can be said that in these cases he made more accurate longitude determinations than anyone else. In an era before permanent astronomical observatories were established on this continent, it is no exaggeration to claim that no North American contemporary undertook more astronomical work than Fidler. It is a conclusion that complements perfectly the assertion of Canadian geographer, Richard Ruggles (1991), that "Fidler drew more maps than any other company cartographer. ... [He] is remarkable not only for the volume of his output, but for its quality. The careful measurements ... provided an expanding network of more precise locations for the map of British America."

Endnotes

1 EG = Ephemeris Generator, http://ssd.jpl.nasa.gov/horizons.cgi

2 HBCA A.16/111 fo.51d, also cited in Johnson (1967), 46. Telescopes were described by their focal length rather than aperture. English units are retained here, but one may convert to metric by using 1 inch = 2.54 cm and 1 foot = 12 inches = 30.5 cm.

3 Manitoba Archives MG 1 D3 is a 46-page notebook.

4 HBCA B.39/a/2 fo.43d.

5 HBCA A.16/111 fo.35.

6 The coincidence of dates makes it conceivable that Thompson had to give up one of his telescopes to Fidler. Thompson left the employ of the HBC in 1797, and by 1799 word of his defection would have traveled back and forth to London. The reference to Mount Hood is in Glover, 353.

7 HBCA A.16/110 fo.14. This seems strange since Batt died in the summer of 1791.

8 HBCA A.16/111 fo.37d.

9 HBCA A.16/112 fo.20.

10 MacGregor (1966), 183. An interesting sidelight is that Fidler noted (HBCA B.89/a/2 fo. 44d) that the end of the solar eclipse was timed at the north end of Mansfield Island by John Bell, Chief Mate of the ship *Eddystone*. This suggests that Fidler sailed to England aboard that ship in 1811.

11 HBCA E.3/1 fo. 103d.

12 Tyrrell (1968), 493-555; E.3/1 fos. 24d-68.

13 HBCA B.24/a/5 quoted in Johnson (1967), 104.

14 HBCA B.41/a/3 fo. 15d-16.

15 HBCA B.59/a/83.

16 [Maskelyne, N.], *Nautical Almanac* for 1801, 151.

17 HBCA E.2/4 fo. 14. Middleton's observations were used by the renowned mapmaker Thomas Jefferys to regulate the chart of North and South America in his 1776 atlas.

18 An exception seems to be Alexander Mackenzie (1801), 144, 150, 178, 195, 221, 277, 351, who mentions only observations of Jupiter as a means of finding longitude.

19 The identification of Cook's anchorage is found in the *Dictionary of Canadian Biography* article on Cook. The modern coordinates were read from the promontory on the northeast corner of Resolution Cove on Canadian topographic map 92E/10.

20 Tello (1809), 61-63, 105-108.

21 David (1993), 60

22 Lamb (1984), 687

23 Lamb (1984), 685

24 LAC, MG40, I6, Thomas Wright, "Report of the Astronomical Observations"

25 The smaller notebook was referred to in Note 3. The larger one is also in the Manitoba Archives, RB FTL PF17, 245

26 HBCA B.39/a/2 fo. 80d

27 Two versions of the Churchill meteorological register for 1811-13, by an unknown author (perhaps Thomas Swain), are HBCA B.42/a/139a and B.42/a/139b

28 HBCA B.51/a/2

Table 1 — A compilation of the occultations recorded by Fidler. Columns give the name of the occulted star, a description of the site, the longitude of the place as derived by Fidler, the observed Local Apparent Time (LAT), the LAT of the occultation calculated using EG, the observed-minus-calculated (O-C) difference between the two times, and finally the reference to the HBC Archives source.

Table 1

Event	Site with modern coordinates	Fidler's longitude	Date	Obs LAT (corrected)	Calc LAT (EG)	O-C from EG (sec)	Longitude calculated	Reference	Note
Occultations									
Immersion α Tau	Hill SSE of old Fort Chipewyan 110°35′ 29″ W, 58°38′37″ N	110°29′15″	1792 April 23	21:05:55	21:06:05	-10	110°37′28″	E.3/1 f.109 MG1D3 p.21	1
Immersion ε Gem	Nottingham House 111°11′51″ W, 58°41′51″ N	110°54′45″	1804 March 18	23:32:16	23:32:33	-17	111°15′24″	E.3/1 f.116	2
Immersion HIP 31696	"	n/a	1805 May 2	22:29:21	22:30:32	-71	111°29′11″	B.39a/5b f.94d	3
Emersion ε Gem	"	n/a	"	23:55?				E.3/1 f.116	2
Immersion ζ Gem	"	n/a	1806 April 23	22:39:09	22:38:27	42	111°00′29″	E.3/2 f.110	4
Immersion δ Ari	Cumberland House 102°15′45″ W, 53°57′27″ N	101°42′30″	1807 February 14	20:10:22	20:09:59	23	102°09′38″	B.49/a/32b f.25	
Immersion δ Psc	Clapham House (103°19′12″ W, 56°19′50″ N)	103°14′30″	1808 November 27	20:23:49	20:23:26	23	103°11′23″	E.3/3 p.40 MG1D3 p.25	5
Immersion α Vir	"	103°18′30″	1809 April 1	1:08:54	1:09:55	-61	103°31′26″	"	Full Moon
Immersion HIP 21257	Îsle-à-la-Crosse (107°54′08″ W, 55°26′15″ N)	n/a	1811 March 28	20:26:08	20:26:23	-15	107°57′21″	B.89/a/2 f.43	6
Immersion α Tau	"	107°46′52″	"	21:40:47	21:40:45	2	107°52′21″	"	
Emersion α Tau	"	107°46′52″	"	22:20:39	22:20:12	27	107°48′28″	"	Bright limb
Immersion Jupiter	Fort Dauphin	100°40′45″	1820	17:13:03			99°45′30″	B.51/a/3 f.37d	7
Emersion	(99°37′ W, 51°18′ N)	"	November 14	18:09:01			99°54′15″	"	"
Solar Eclipses									
End	Nottingham House 111°11:51 W, 58°41:51 N	110°07′15″	1805 January 30	11:57:00				E.3/1/ f.116	8
End	"	111°00′15″ 111°01′15″	1805 June 26	17:31:31		3	111°11′54″	E.3/1 f.116 B.41/a/3 f.15d B.39/a/5a f.22	9
Start	Clapham House (103:19:12 W, 56°19:50 N)	103°20′45″	1809 April 14	12:48:57	12:48:58	-1	103°19′14″	E.3/3 p.40	5
End	"	103°25′30″	"	15:24:42	15:25:02	-20	103°20′42″	"	"
Start	York Fort 92°18:34 W, 57°00:12 N		1811 September 17	10:43:08	10:43:13	-5	92°19′17″	B.89/a/2 f.44d	10
End	"		"	13:40:53	13:41:09	-16	92°21′29″	"	"
Start	Norway House (97:50 W, 53.°:42:30 N)		1815 July 6	17:16:20	17:16:26	-6	97°51′42″	B.235/a/3 f.36	11
End	"			18:59:39	19:07:16	-37	98°00′03″	"	"
End	Vicinity of Fort Dauphin R. (~99:48 W, 51°44N)	99:43:30	1820 September 7	6:16:53	6:16:56	-3	99°35′33″	B.51/a/3 f.10	12
Lunar Eclipses									
					Calculated (Espenak)				
2nd contact	Chesterfield House (110°01′ W, 50°55′15″ N)	110°07′30″	1801 March 29	21:06:40	21:08:09	-89	110°32′30″	E.3/2 f.89d	Using Fidler's coordinates
4th	"	"	"	23:50:30	23:50:12	18	109°56′30″	"	"
Start	"	(109°41′15″)	1802 March 19	2:30:30	2:30:46	-16	110°05′00″	B.39/a/2 f.91	13
End	"	(110°15′00″)	"	5:01:30	5:02:48	-78	110°20′15″	& B.34/a/3 f.31	14
Start	Nottingham House 111°11′51″ W, 58°41′51″ N	111°22′15″	1805 January 14	23:16:31	23:19:11	-160	111°51′45″	E.3/1 f.116 B.39/a/5b f.82d	15
Start of totality	"	111°07′15″	1805 January 15	0:15:31	00:16:46	-115	111°30′30″	"	"
End	"	111°52′15″	"	2:53:31	2:53:01	30	111°04′15″	"	"
End	"	111°01′15″	1806 January 4	17:56:55	17:57:18	-23	111°17′30″	E.3/1 f.116	16
Start	Brandon House (99°37′40″ W, 49°40′27″ N)	99°41′15″	1808 May 9	23:16:55	23:18:19	-84	99°58′45″	E.3/3 f.56	17
Start of totality	"	99°35′30″	1808 May 10	00:15:41	0:16:19	-38	99°47′15″	"	"
End of totality	"	99°29′00″	"	01:49:37	1:50:20	-43	99°48′15″	"	"
End	"	99°14′00″	"	02:48:53	2:48:20	33	99°29′15″	"	"
Start of totality	Clapham House (103°19′12″ W, 56°19′50″ N)	103°13′30″	1808 November 3	0:46:24	0:48:58	86	102°57′45″	E.3/3 p.40	5
End "	"	103°16′00″	"	2:24:54	2:24:58	-4	103°20′15″	"	"
Start	Îsle-à-la-Crosse (107°54′08″ W, 55°26′15″ N)	107°41′45″	1811 March 9	21:58:58	21:58:36	22	107°48′45″	B.89/a/2 43d	18
End	"	107°49′15″	March 10	0:32:58	0:30:37	141	107°49′00″	"	
End	Brandon House (99°37′40″ W, 49°40′ 27″ N)	99°28′00″	1814 December 26	17:39:39	17:39:29	10	99°34′45″	B.235/a/3 f.33d	19

Notes for Table 1:

1. Fidler wrote "The observations for Latitude & Longitude are taken 600 or 700 yards SSE from Fort Chepawyan on the East or South side, the Athapescow Lake." The modern coordinates of a small hill at the supposed site have been found from a topographic map.
2. The modern coordinates are given by Karkis Karklins, *Nottingham House: The Hudson's Bay Company in Athabasca, 1802-1806* (Parks Canada, 1983). The watch correction of +6:14, which Fidler applied, is the average of +6:04 found from the double altitude of α Lyr and +6:24 found from the double altitude of Capella. When these are recalculated, the watch correction should be +6:18. Fidler noted the emersion at nearly 23:55 but queried it. In fact the emersion occurred at 23:59:29.
3. Fidler described this event as "Im of a small star of the 5th or 6th magn near the [Moon's] UL at 10:27 per watch." The watch correction and index error have been inferred from other observations.
4. The watch correction appears to be uncertain. It should be -14:43 rather than -14:33, which would reduce the O-C by 10 seconds.
5. The modern co-ordinates are of the mouth of the Little Deer River, Saskatchewan, taken from NTS Map 64D6. It is not known if this is the site of Clapham House, but the longitudes certainly agree very closely.
6. Coordinates estimated from NTS Map 73O. Fidler said "Imm a small star" which was surely HIP 21257, of magnitude 6.6 (just below naked-eye visibility).
7. The occultation of Jupiter would have been a striking sight, since Jupiter is one of the brightest objects in the night sky. Since Jupiter was 44″ in diameter, the immersion and emersion would each have taken nearly 2 minutes, and therefore the times of these events are not perfectly known. The modern calculations are based on the time of immersion and emersion of Jupiter's centre.
8. The watch correction is unknown Fidler noted in his meterorological register (E.3/7 p.114) "Observ^{d} the Solar Eclipse 2´ eclips^{d} UL."
9. The modern coordinates are those given by Karklins. The first two sources attribute the observations to Thomas Swain, but the derived longitudes differ slightly. The heading in Swain's journal (B.41/a/3 f.15d) is "at Athapescow Lake." Perhaps Swain and Fidler carried out the calculations separately. The last reference is in Fidler's meteorological register (B.39/a/5a f. 22) where he wrote "End of solar eclipse $5^{h}31^{m}31^{s}$ app time."
10. The end of this eclipse was also noted at Mansfield Island (B.89/a/2 f.44d) and at Churchill (B.42/a/139b f.6)
11. The modern longitude is approximately that of the town of Norway House. How close this is to Fidler's site is unknown but he described his location as "the Norwegan House at the Discharge of lake Winnipeg" and said his latitude was "about 53°42½´ N." This latitude was adopted for the calculations. Fidler did not work out the watch correction, but it was inferred from three double altitudes he took of the Sun.
12. The location is not certain. Fidler stopped while travelling to observe the solar eclipse and gave his latitude as 51°44´. The next day he sailed for the Fort Dauphin River and at its mouth he found the latitude to be 51°38´41″ and wrote "The course from where the Eclipse was observed to this spot about NEbN 14 miles per Compass variation about 1 Point East."
13. Fidler did not show his deduced longitude, but it would have been 109:41:15 using the Greenwich time from the *Nautical Almanac*.
14. Fidler did not show his deduced longitude, but it would have been 110:15 using the Greenwich time from the *Nautical Almanac*.
15. Fidler mistakenly copied the time ten minutes too early in E.3/1. Lewis and Clark observed this eclipse at Fort Mandan, but the longitude deduced was about two degrees (eight minutes) off. (Moulton, ed., *The Journals of the Lewis & Clark Expedition,* vol. 3, 273-5.)
16. The end was also timed by Thomas Swain on "one of the Moose Islands" in Great Slave Lake at 17:47:41 or 17:48:41 (B.41a/2 and B.41/a/3 f.15d). This may have been Moose Deer Island at 113:45W, 61:12N, near Fort Resolution. Swain deduced longitude as 113°4¾´.
17. This the eclipse where Fidler recorded times as the Earth's shadow swept over various lunar features. He also noted that the Moon was red but still visible during the eclipse. He did not specifically say what the watch corrections were, but they have been inferred by interpolating between observations of the Sun's lower limb at 4 p.m. of the afternoon before, and at 9 a.m. after the eclipse. The modern coordinates given here are of the site marked "Fort Assiniboine" on NTS map 62G12.
18. Fidler described the progress of the eclipse in detail, including the times when the shadow covered and uncovered various parts of the feature identified on Lalande's map as No. 35 Proclus Mons Corax.
19. Fidler wrote "Observed the End of the Lunar Eclipse" opposite 1814 December 4. There was no eclipse on that date. The time of his observation is consistent with the lunar eclipse of December 26. Modern coordinates as explained in note 17.

"A Galileo Moment"

Table 2. OBSERVATIONS OF JUPITER'S SATELLITES				
Date	Location	Deduced longitude	No.of obs.	Reference
By Fidler:				
1800 May 18	Buckingham House	110°43'	1	MG1 D3 p.15
1799 - 1800	Greenwich House	112°07' ± 10'	17	E.3/2 f.88-88d
1800 – 01	Chesterfield House	110°05' ± 14'	6	E.3/2 f.89d
1803	Nottingham House	111°02' ± 19'	8	E.3/1 f.115d & B.39/a/1/33
1810 – 1811	Îsle-à-la-Crosse	107°51' ± 6'	28	B.89/a/2 f.42d-43
1815 – 1816	Brandon House	99°38' ± 11'	6	B.235/a/3 f.33d & B.22/a/19
By Thompson:				
1798-99	Red Deer's Lake	111°54' ± 8'	4	Ont. Arch. Series 1, Vol. 5, Book 10

Table 2 — A summary of Fidler's and Thompson's observations of Jupiter's moons.

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Peter Broughton is a distinguished Society Member, having served for many years in various positions: National Secretary, 1st Vice-President, President, and Historian. His book, Looking Up, *now out of print, is a comprehensive history of the RASC from its early beginning to 1994. We place great value on his historical ruminations.*

Buzzard Coulee - An Amateur Search Effort

by Murray D. Paulson, Edmonton Centre (murrpaul@telus.net)

The 2008 November 20 fireball put a record number of meteorites onto the ground in the Buzzard Coulee region, 35 kilometres southeast of Lloydminster, Saskatchewan. The University of Calgary's Alan Hildebrandt had invested a team to recover specimens on the properties owned by the Mitchell families, and had excluded recovery efforts by other teams by way of legal contracts with the land owners. However, there still were many "treasure" hunters on site doing undocumented removal of meteorite specimens. Through occasional visits to the area, I managed to convince some of these hunters to donate their position and mass data for the stones that they had collected, so that the data could be preserved for a future scientific study of the strewnfield. In the course of this work, I chanced on a parcel of land that Hildebrand had not contracted for, and assembled a team to recover stones from the property of Justin Lamb, located just north of the discovery pond in Buzzard Coulee. The land is bounded on the south and east sides by Buzzard Coulee and railroad tracks, and by roads on the west and north sides of the property.

Figure 1 — One of the search teams in action.

Our search started with the spring melt of the snow, on the weekend of April 10-11. Three of us recovered 1.55 kilograms of specimens. Our success here urged us to commit to a continued search of this field. Over the next month and a half, we fielded teams of five to ten individuals to systematically search the field in "police-search-style" scans, with a row of searchers spaced 1.5 metres apart. Our search efforts went from early mornings (~ 8:00 a.m.) to late afternoons when the fading light made it difficult to continue. On a typical day, we walked 20 to 25 kilometres scanning for meteorites. During our searches, we discovered that you typically see a meteorite just when you are about to step on it, though larger stones become visible somewhat sooner. We used wooden dowels with 31.75-mm rare-earth magnets affixed to their end to identify and recover stones on the ground. (H4 chondrites stick well to these magnets.) This saved the searchers' backs, reducing the need to stoop to inspect every black stone they passed over, and quickly eliminated stones that were not meteorites. Upon finding a candidate, our recovery procedure was to first verify that it was a meteorite, then create a waypoint on our GPS receiver, and finally label the recovered stone with the waypoint number and the finder's initials. All stones were immediately bagged in Ziploc® bags. Over the seven weekends that we were able to search the field, we managed to recover 742 stones with an accumulated mass of 17.5 kilograms. This single 218-hectare field allowed our search team to single-handedly beat the 1960 Canadian recovery record of the Bruderheim fall of approximately 700 stones. Our statistics show that the average recovery rate was seven stones per person per day with an average mass of 24 grams per stone, and that each person walked an average of three kilometres to find one stone. Our most prolific searcher recovered 175 stones over the 7 weekends, and a second person recovered 115 stones with a total mass of 3583 grams for the greatest accumulated mass. With so many stones to examine, we have so far managed to identify three pairings of broken stones that were recovered from widely separated points: the longest baseline was 1.14 kilometres for two halves of a 123-gram stone, and another broken pair was separated by 170 metres.

I thank the Lamb family for permission to search their land, and the many people who made up my search team.

Figure 2 — Eureka! A large meteorite *in situ*.

Prominent among them was Brad Newman, who worked diligently to take the GPS data in the field, and later reduced the data to the format I used in my meteorite database. This database will be published and will include detailed data and photos for every stone recovered by this expedition. The database will also include the volunteered data from other hunters. I also thank my team members, who were:

Brad Newman, Jen Newman, Joanne, Connor, Daniel, and Sean Paulson, Luc and Joan Guillemette (St. Albert, Alberta);

Bruce McCurdy, Frank Florian, Doug Hube, Dale Nosco, Alister and Elizabeth Ling, Brian and Bea Moore, (Edmonton, Alberta);

Richard Huziak, Kathleen Houston, Darrell Chatfield, Collin Chatfield, Gordon Sarty, Tenho Tuomi, and Bob Johnson (Saskatoon, Saskatchewan).

Murray Paulson is a long-time member of the Edmonton Centre of the RASC and an ardent planetary observer.

Running Large-Scale Astronomy Events on the Web

by G. Tulloch[1], P. Trudel[2], and M. Simmons[3]

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Abstract: The 100 Hours of Astronomy IYA2009 Cornerstone Project was a four-day event designed to bring astronomy to the public around the world. In this paper, we review 100 Hours of Astronomy (100HA) with particular reference to how a large-scale event of this nature is tied to the Web presence, evolution of the Web site, and issues that were experienced in the time preceding, during, and following the event. Of particular relevance was evolution of the technology environment required to support the event, software employed, and how the technical environment responded to the anticipated and unanticipated volume of participants. Finally, the paper examines how lessons learned during the 100HA event can be used to plan for future events during the International Year of Astronomy and beyond.

The 100 Hours of Astronomy Experience

The 100 Hours of Astronomy IYA2009 Cornerstone Project was a four-day event designed to bring astronomy to the public around the world. Groups planned events ranging from a few hours on one day to a 100-hour marathon, with plans that fit the resources and enthusiasm available to them. All activities and events during 100HA were aimed at bringing astronomy to a new audience and providing a million people with a "Galileo Moment." In addition to worldwide groups publishing their own events via the `100hoursofastronomy.org` Web site, 100 Hours of Astronomy also conducted several global events promoted through a centralized Web server. Science facilities and enthusiasts were encouraged to make whatever plans were appropriate to their resources, and to be creative and innovative in attracting the public to the events in their areas. There were several component projects within the 100HA central program, including:

- Around The World In 80 Telescopes Webcast — a 24-hour Webcast from within 76 observatories and space-telescope control rooms. Each observatory's segment included a brief pre-recorded introduction to their facility and the work they do, followed by live presentations from astronomers on-site and questions from the public. The Webcast was organized by and anchored from the headquarters of the European Southern Observatory (ESO) in Garching, Germany.
- 24-Hour Global Star Party — a series of telescope observing events open to the public, held by amateur astronomers throughout the world.
- 100 Hours of Remote Astronomy — several remotely operated telescopes offered free time to allow the public to sample the capabilities of this emerging technology.
- Sun Day — a day organized by the IYA2009 Solar Physics Task Group that supported worldwide activities for the public focusing on the Sun, particularly through public observing events.

In the following sections we review the progress of the Web site during the ramp-up to the event, how the event itself transpired, and post-event activities.

Before the Event

In January 2009, the `100hoursofastronomy.org` Web site transitioned from a simple hosted HMTL-based site to a *LAMP*-based (*Linux/Apache/MySQL/PHP*) site implemented on the *Joomla* 1.5x content-management system to enable content editing via Web browser by the 14-member 100HA Task Group. This group was responsible for organizing the worldwide effort on behalf of the International Astronomical Union.

Two volunteer Web masters were engaged through a general request for assistance, one (GT) predominately responsible for hosting and configuration of servers and network, and one (PT) responsible for content and *Joomla* configuration and customization. Part of the core 100HA Web site was an event-registration function, *EventList,* deployed as a module to *Joomla*. When modifications were required, a vendor was engaged to modify the code to include *Google Maps* functionality and generally enhance the application for use in registration and display of 100HA events worldwide. The initial hosting for the site was via an inexpensive, mass-market Web-hosting company located in the United States.

As site traffic increased, a preplanned move to a dedicated hosting environment was made, initially to a single server located at a data centre in Chicago, USA. Configuration of this server began in early March 2009, and the site was transitioned to the new server on March 17. There was some concern that the change of the Domain Name record for the site — changing the IP address from the old to the new server — would take some time to propagate through the Internet due to caching of the old address. Both sites remained active during the changeover, and the databases were compared after a few days to catch any data that were entered on the old site before the new site address propagated. However, only three events were registered during the interim period and they were manually transferred to the new site, so propagation delays were very minimal, likely because most users were new to the site and had not cached the old IP address.

During the 100HA Event

The new server operated at very light loading until the commencement of the 100HA event. The technical team hypothesized that load on the server would likely increase to approximately 25,000 visits per day during the event, but most of the load would come from reading information rather than entering new events. The number of visits would increase, but the actual load per visit on the server would be low, as read activity (viewing Web pages produced from the database) was expected to be much more efficient than write activity (*e.g.* adding new events to the database). Because of minimal loading of the server at approximately 5000-6000 visits per day, it was judged that the site could remain on a single dual-core server with 4GB of RAM and still be able to handle the load. Plans were made to add a second server to host the database if required, and inquiries were made about the method by which multiple servers could be set up on a load-balanced network to handle large loads, but none of these plans were put into effect, in order to minimize costs.

On April 2 and 3, on commencement of the Around The World in 80 Telescopes Webcast, utilization of the site skyrocketed, with 32,000 visits on the 2nd, growing to 98,000 on the 3rd, mostly attributable to visitors accessing the site to view the Webcast. Since the actual Webcast content was hosted on a partner Web-streaming provider, the Webcast was not expected to introduce a heavy load on the 100HA server. Once the user had linked to the streaming provider Web site, the user would have no further interaction with the 100HA Web site. This assumption proved to be in error, since, as constructed, all users accessing the Webcast needed to load the 100HA front *Joomla* page every time they accessed the site. The content editors embedded a viewer for the video directly on the 100HA Web-site main page, which ensured that traffic on the 100HA main page was inadvertently maximized. To exacerbate matters, issues with the streaming video provided caused users to often "reload" the page to unfreeze the video.

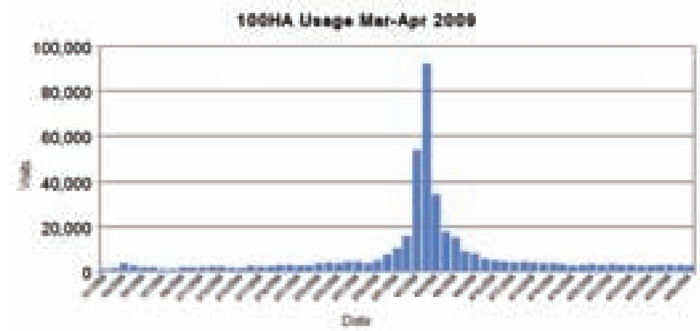

Figure 1 — Chart comparing site visits 209 March 1 - April 30

The Webcast therefore created an additional huge volume of traffic on the 100HA site as many hundreds (possibly thousands) of people, pressed the refresh buttons near-simultaneously on their browsers, forcing the Web server to re-transmit the 200+ kilobyte *Joomla* main page. Most of this retransmission would have been pulled from *Joomla's* built-in cache; however substantial parts of the site were built dynamically on the fly, forcing *Joomla* to go back to the database for a significant amount of content. While the Webcast was hosted on *Ustream* (a sponsor who provides Webcasting) and thus the majority of the data being transmitted was obtained from another site, repeated transmission of the embedded viewer on the main page of the 100HA Web-site front page introduced an extreme and unanticipated load on the server, causing performance to plummet. Once server CPU and memory utilization became very large, the *MySQL* database task on the server was unable to keep up with requests and began returning database errors to users, directly affecting the visitors' experience. In the end, this resulted in the site becoming unusable.

The first remediation tactic employed, in the early morning hours of April 3, was to redirect the `100hoursofastronomy.org` domain to an ESO Web server that served up a simple Web page with a link to the Webcast, a solution that proved to be effective. This page was migrated to the main 100HA server, and, during the Webcast, was the only content displayed by the site. Since the priority was to provide the link to the Webcast, the simple Web page remained in place throughout the Webcast on April 3. Several times through the day, the main site was re-enabled after attempts were made to resolve performance issues, but each attempt was rolled back to the simple *HTML* page due to the number of visitors, who rapidly saturated the server. This saturation turned out to be worse than the original loads on the server, since *Joomla's* built-in caches had expired, effectively resulting in every access to the site hitting the database server, and, in turn, causing server loads to reach extreme levels.

Interestingly, the Open Source software on which the entire 100HA site ran performed extremely well under enormous loads. For example, a measure of utilization of a *LINUX* server is the Load Average, representing the number of CPUs required to handle the load being imposed on the server. Normally, this measure is less than one (in other words there are no server tasks waiting to be processed at any given time) but during the Webcast event, the load average climbed to 125. The Web masters expected that the entire system would crash long before this point was reached. Amazingly, the *LINUX* server continued operating, the *MySQL* server continued serving database requests (albeit occasionally causing errors), and the *Apache* Web-server software continued to process requests for Web pages. At no point, even during the most intense pressure on the server, did any component fail. The technical team was extremely impressed by the robustness and efficiency of the *LINUX* Operating System *(CentOS 5),* the *MySQL* database, *Apache* Web server software, and *PHP Hypertext Preprocessor*. Of particular interest was the ease with which the *Apache* Web server handled the Webcast traffic after the main site was disabled — server load averages remained under 1 while the simple page was replacing the *Joomla* site. This implies that use of content management applications like *Joomla* require significantly more resources under high load than a simple *HTML* page.

A database server was ordered from the hosting provider and was in place by the following day, which proved to be effective in reducing the server load and eliminating database errors, although by that time the Webcast had concluded and extreme loads had dissipated. In addition to the database server, an additional "mirror" server was put in place, expanding the server infrastructure to two content servers accessing a separate database server. Unfortunately, load balancing would not be available until the last day of the event, which was judged to be too late to prove useful, so a link was placed on the main page of the 100HA site to invite users experiencing performance issues to access the mirror server. This proved effective, but, because the load had diminished by that time, the second server saw little activity. As the 100 Hours of Astronomy ended, volumes on the server diminished to the previous levels.

After the Event

The Web site remained active, with 5000 visitors per day during the weeks immediately following the event, as users accessed recordings of the Webcast, entered event reports, and posted photos of their local events. By the end of April 2009 through mid-May (the time of this writing), visitors had stabilized at approximately 2000 per day, as users added reports of their 100HA activities and perused the reports and photos uploaded by others.

Issues and Lessons Learned

The following sections enumerate issues that were experienced during the 100HA program that required action and generated some interesting learning experiences for the Task Group and technical team.

Site Content/Joomla

As the 100HA site got larger, a number of issues arose regarding how many data packets were being sent to clients logged onto the site with Web browsers, particularly through slow dial-up and satellite connections. For example, the front page of the Web site grew to approximately 600kb at one point, through extensive use of graphics and a dynamic map on the main page that contained stickpins in a *Google* map. Each stickpin data point was sent to the site as an independent record in an XML table and, as the number of events around the world grew to thousands, the data being sent to clients became quite voluminous.

For content-related issues, the lessons learned included:

- Limit front-page content size as much as possible — this is the first page users see and if it takes prohibitively long to download, users may choose to visit another site. In the 100HA case, hindsight shows that a simple *HTML*-page front ending the *Joomla* Web site would have reduced or eliminated subsequent problems.
- Use small graphics and limit the number of graphics — balance the desire to make a very attractive front page against the experience of the user with the slowest connection speed, particularly if use is worldwide and developing countries with a lower prevalence of broadband connections are a target audience.
- Optimize *HTML* content (such as defining explicit sizes for graphics and tables) so that the *HTML* content can be rendered and displayed according to the intended design as supporting files (JavaScript, CSS, images) are loading in subsequent steps.
- Test and validate the rendering of the site using as many browser combinations as possible. This can be facilitated by Web sites such as *BrowserShots* that can confirm the rendering on a wide variety of Web browsers on any of the widely used client operating systems.

Continued on page 158…

Figure 1 — With long summer nights, noctilucent clouds replace stars as photographic subjects in the semi-twilight of June skies. Because of its latitude, Edmonton Centre photographers are prolific cloud collectors. This flowing image from David Roles was taken at the very hour of the summer solstice in 2006. The bright star is Capella.

Figure 2 — Stef Cancelli and Paul Mortfield of the Toronto Centre continue to amaze with their astrophotography. They captured the western part of the Veil Nebula on August 8 last year. Taken from SRO (Sierra Remote Observatories, California), on a RCOS 16-inch f/8.9 using an Apogee U9000 Paramount ME Hα and OIII - Astrodon Filters, 3.5hrs of Hα, and 1.5hrs of OIII. Processed with CCAP, CCD Stack, MaxIm DL, Photoshop CS3.

Figure 3 — Pierre Tremblay paid a visit to the celestial zoo when he capured this image of the Elephant Trunk Nebula and VDB 142 in Cepheus on 2006 July 29. VDB 142 is the strange red-and-orange-coloured object in the middle of the dark area to the right of the Elephant Trunk. Pierre used a Takahashi Sky 90 on a Losmandy G11 mount. His camera was a Starlight Express SXV-H9 taking exposures in Hα (10x500 s) and RGB (R: 6x390 s, GB: 12x300 s) that totalled more than 3.5 hours.

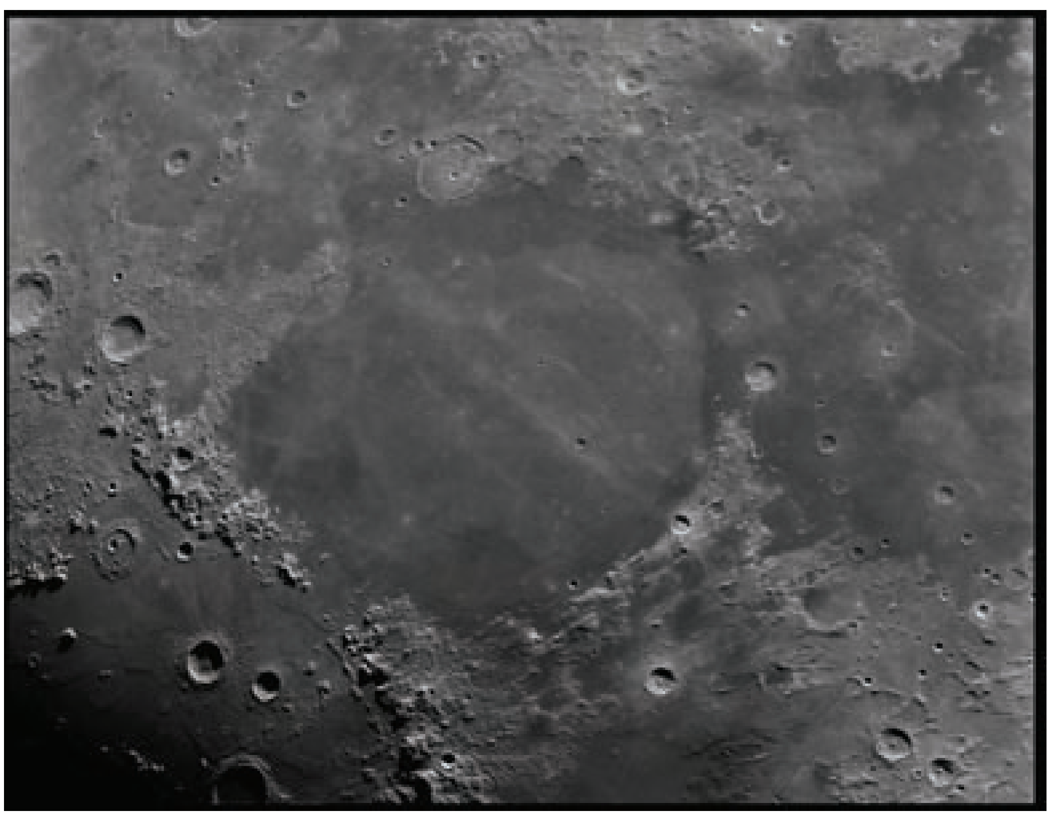

Figure 4 — Afraid to go out in the bright moonlight? Mike Wirths isn't, and one of the results is this first-class image of Mare Serenitatis. Mike used an 18-inch Starmaster telescope, a Lumenera camera, and the latest version of Registax to put it all together.

…continued from page 155

- Ensure that the software providing the dynamic content (in our case, *Joomla*) is producing the minimum amount of data to be sent to the browser. For example, *Joomla,* by default, loads a large (200+K) *JavaScript* library on every page it serves, in turn requiring that the client browser download this each time the site is accessed. It is important to note that much of this framework is a one-time load each time that the site is accessed. As the user navigates the site, these one-time load items are left in the browser's cache. However, when the page is refreshed, the 200+K is retransmitted.
- Minimization of client bandwidth utilization through the use of on-the-fly compression techniques. While not enabled by default in *Apache* Web servers, the mod_deflate plugin takes advantage of the fact that textual content (such as *HTML* Webpages) can be heavily compressed. While requiring a small CPU overhead to compress textual content, the benefits to network consumption are impressive. Using the 200+K *Joomla* framework as an example, the plugin compresses the data to roughly 80K before they are transmitted to the client for subsequent decompression when the client visually renders the content.

Planning for extremely high volumes

The huge volume of visits to the site on April 3 is instructive from a number of points of view, and a primary lesson learned is to fund and create a much more resilient technology environment than was created for the 100HA event.

Lessons learned:

- Expect the unexpected for volumes (four times expected might be a good estimate) and configure the site to accommodate those loads. Provision servers ahead of time — by the time new servers can be brought online, it is too late, at least for short events like 100HA. Costs are fairly minimal (in our case about $400 per month per server) compared to the cost of not providing the service when demand is highest.
- Consider using the simplest, fastest-loading (*i.e.* simple *HTML* with few graphics) front page to the site, especially if there is content (such as Webcasts) for which the main site is simply a "gateway." The *Apache* Web server proved to be extremely robust and able to serve up pages to almost 100,000 visitors during the period when the main page was offline. If the front page of the site had been simple *HTML,* it is likely that the single server (with a separate database server) could have handled the load.
- Create an "edit enabled" server, where content managers can work at maximum performance even during peak loads.
- Similarly, structure the site (which does not change and is normally implemented as simple *HTML* pages) in such a way that users need only access dynamic content when there is a need for it. In the 100HA example, most content was relatively static and only implemented in *Joomla* to facilitate online content editing by the Task Team. The only content that needed to be dynamic was the Event add/edit/change/display code.

Technology Configuration

On the technology side, there were a number of areas where the 100 Hours of Astronomy experience offered lessons learned:

- Always configure Web sites with separate Web application and database servers (in the 100HA case, *Joomla/Apache* and *MySQL,* respectively) prior to expected peak loads to ensure that high user loads on the Web application servers do not impact the database server.
- Consider load balancing the Web site, particularly when the site is predominately static. Load balancing distributes users across multiple servers for the same domain. This is generally implemented as a hardware appliance that sits in front of the Web servers and distributes the load between those servers.
- Optimization of database configuration — although *MySQL* works "out-of-the-box," it is not adequately configured for a full-scale production server. Tools such as *sqltuner.pl* should be used to optimize the *MySQL* database for the available hardware and system resources.

Conclusions

The 100 Hours of Astronomy event was a tremendous success — *Sky & Telescope* Editor-in-Chief Robert Naeye blogged on the 100HA site that "...the actual event exceeded the most optimistic expectations. Reports from around the world indicate that more than a million people looked through a telescope for the first time. Moreover, these people were spread over more than 100 nations. This was truly a global event!" (Naeye). While days have been set aside for special events to bring astronomy awareness to the public, including Astronomy Day and International Sidewalk Astronomy Night, 100HA was the first united effort with centralized planning and resource management combined with grassroots planning worldwide. Participation in 100HA by astronomy enthusiasts and the public show the value of programs that use the Internet to create truly global programs that are carried out by local planners.

The 100 Hours of Astronomy project showed what a few determined amateur astronomers could do to enlist the legions of amateur astronomers worldwide in a project that had a global effect. While not without a few technical hiccups, overall the 100 Hours of Astronomy event's Web presence was a crucial underpinning of the whole initiative. Future large-scale outreach initiatives (including a potential follow-up event in the fall) should consider the 100 Hours of Astronomy initiative as a largely successful prototype, and build upon its success during this International Year of Astronomy, and beyond.

Works Cited

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Web Links

100 Hours of Astronomy Web Site: www.100hoursofastronomy.org
Joomla Content Management: `www.joomla.org`
MySQL Database: `www.mysql.org`
The Apache Software Foundation: `www.apache.org`
PHP: Hypertext Preprocessor: `www.php.net`
MySQL Tuner : `wiki.mysqltuner.com/MySQLTuner`
BrowserShots: `browsershots.org`
Apache mod_deflate: `http://httpd.apache.org/docs/2.0/mod/mod_deflate.html`

On Another Wavelength

M27 - A Bipolar Planetary Nebula

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

Almost every amateur astronomer knows the Dumbbell Nebula. It is one of the most observed objects in the night sky, simply because it is easy to find and beautiful to look at. M27, also known as NGC 6853, is a planetary nebula (PN) in the constellation Vulpecula. With a visual magnitude of 7.5 and a diameter of about 8 arcminutes, it is easily visible with small telescopes and even binoculars. Discovered by Charles Messier in July 1764 (the first planetary nebula discovered), it is possibly the finest planetary nebula in the sky.

The accompanying image of M27 in Figure 1 gives one good reason to spend time at the eyepiece and with a camera. Here is where and what to look for:

- Right Ascension $19^h\ 59^m\ 36.340^s$
- Declination +22° 43′ 16.09″
- Distance 1360 ly (one of the closest)
- Description Bipolar elliptical planetary with inner structure and multiple shells

Sir William Herschel invented the name "Planetary Nebula" around 1785 to describe these deep-sky objects. He was unsure of what these nebulous objects were, but found they resembled large gaseous planets such as Uranus, which he had recently discovered. By 1790, he was convinced that these nebulae were made up of gas or dust and associated with a central star. Even though Sir William's ideas and accomplishments were quite

Figure 1 — This image of M27 comes from Steve Holmes of the Kitchener-Waterloo Centre. The image was captured with a 120-mm f/7.5 Sky-Watcher telescope on an EQ6 PRO mount. The camera was a QHY8 with IR filter. Steve compiled the image from 14 10-minute exposures.

impressive for his time, an understanding of the physics and significance of planetary nebula like M27 was beyond 18th-century science.

Today, we describe M27, like other planetary nebulae, as the outer layers of a progenitor red-giant star that were expelled by pulsations and strong stellar winds (there is a simulation of this at `www.youtube.com/watch?v=az5X5jSVlnc&NR=1`). Note the thermal pulsing in the simulation. Each time the pulsation occurs, it causes an outer layer of gas to be puffed into space. Successive puffs build up shells of gas that then glow from the radiation of the hot central star.

The gaseous nebula of M27 is much brighter than its central star, which is typical of planetary nebula. The hot central star emits highly energetic radiation, which excites the surrounding gas, which then re-emits the radiation as visible light. For almost all planetary nebulae, approximately 90 percent of the visible light emitted by the gas is in one spectral line, the green line at 500.7 nanometres. When first discovered, this spectral line could not be assigned to any known element, and so was called "nebulium." Eventually the "nebulium" spectrum was found to be caused by ionized oxygen. There are also other less abundant elements present in the expanding nebula including hydrogen, helium, nitrogen, and neon.

Bipolar planetary nebulae such as M27 often have surprisingly intricate structures that include concentric gas shells, jets of high-speed gas, and knots of gas that form at the interface between the hot and cool areas of the nebula. Many other planetary nebulae are similarly bipolar, having symmetry with respect to the rotation axis of the central star.

The standard model for the formation of a bipolar nebular structure can be described in terms of the complex interacting winds from the different components of the nebula. Observations have shown that M27 has three shells. Although $H\alpha$ (656.3 nm) appears to originate throughout a large fraction of the nebular volume, the outer shell of [NII] spans 15′ across and is expanding at 35 km s^{-1}. This speed gives an expansion rate of 6.8 arcseconds per century, which leads to an estimated age of 4000 years for the nebula. Just inside this outer shell are an [OIII] shell expanding at 31 km s^{-1} and another inner shell expanding at approximately 12 km $^{s-1}$ surrounding an HeII-emitting volume (Meaburn *et al.* 2005). Interestingly, the emission lines of $H\alpha$ (656.3 nm), found throughout the volume, and [NII] (658.3 nm), in the outer shell, are very close. Both have a red colour and are usually not separated in commercial narrowband filters.

The very small but hot core of the star that remains at the centre of M27 is causing the ejected layers of gas to glow. The central star of M27 is a blue dwarf with a magnitude of 13.5. It is an unusual star (spectral type O7) with emissions in the ultraviolet and x-ray wavelengths, and a surface temperature of about 85,000 K. Eventually the central star will cool to become a white dwarf. The radius of the central star is about 1/20th the radius of our Sun, and is estimated to have just over half of a solar mass. Planetary nebulae are typically formed by mass loss from stars with initial masses less than eight solar masses, so we should expect our Sun to become a white dwarf in perhaps another five to eight billion years.

M27, as with other planetary nebula, is expected to have a very short life compared to the time scale of several billion years for its stellar evolution. It will be visible for only a few tens of thousands of years, and then fade as its nebular matter is spread throughout the surrounding space and its central star cools down. This cooling process goes on until all heat energy has radiated. After many billions of years, the star will assume its final state as a "black dwarf."

Just as an aside, there is an interesting variable star near the Dumbbell that is called Goldilocks' Variable. Take a look at `http://tocobs.org/m27.htm` and compare it to Figure 1 to determine the brightness of the variable star. The next time you are observing the Dumbbell Nebula, take a moment to look also at Goldilocks' Variable.

References

Meaburn, J., Boumis, P., Christopoulou, P.E., Goudis, C.D., Bryce, M., and Lopez, J.A. 2005, Mexicana de Astronomia y Astrofisica, Vol. 49, 109-119

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.

Titan's Shadow

by Geoff Gaherty
Toronto Centre (geoff@foxmead.ca)

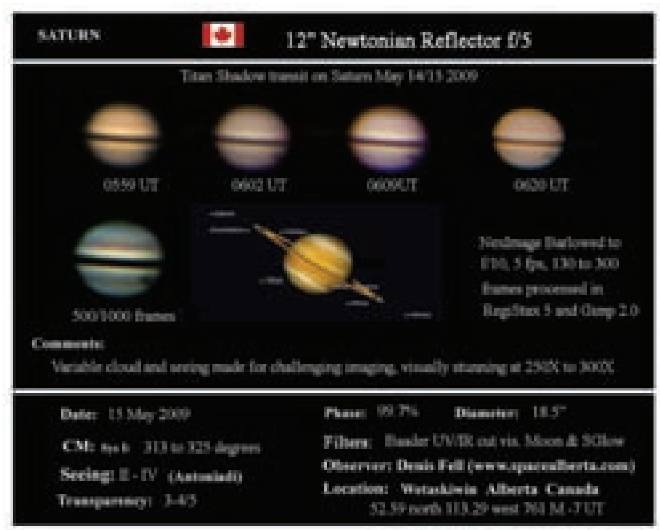
As I said in my last column, I've always managed to keep astronomy fresh by finding new challenges. Here is a recent example.

On Friday morning, 2009 May 15, I observed what was for me a lifetime first: the shadow of Saturn's biggest moon, Titan, in transit across the face of Saturn. Because Saturn's equatorial plane is currently almost perfectly aligned with the Sun, there are now satellite "phenomena" occurring, similar to those that occur all the time with Jupiter's moons. Because of Saturn's much greater distance from the Earth and the small size of most of Saturn's moons, only the transits of Titan's shadow are visible. These occur every two weeks plus two days, as Titan's orbital period is 15.945 days. Details can be found at `www.skyandtelescope.com/observing/highlights/42917562.html`

This transit was predicted to begin at 5:26 UT (1:26 a.m. EDT). Having observed many shadow transits on Jupiter, I knew that I wouldn't be able to detect the shadow until sometime after first contact. To be safe, I started observing at 01:00, using an Orion 180-mm f/15 Maksutov-Cassegrain, which I'm currently testing. I used a Tele Vue Nagler 11-mm eyepiece yielding 245×. Saturn had its familiar 2009 appearance of a cocktail onion impaled on a toothpick. Titan's disk was visible very close to the junction between the rings and the disk, hard to pick out in the glare from the planet. At this point, Saturn's altitude was only 26°, and it was sinking rapidly toward the western horizon. The seeing, which was poor to start with, deteriorated as Saturn got lower in the sky.

I first detected the shadow of Titan as a notch in the limb of the planet at 1:45 a.m. (05:45 UT). I continued to follow it for the next 15 minutes, until the seeing reached the point where the shadow blended in with the planet's blur. Saturn's altitude was now only 15°, and the chromatic aberration caused by the Earth's atmosphere was strongly evident. Still, I felt lucky to have caught this rare appearance of the three-dimensional pattern of Saturn, Titan, and Titan's shadow.

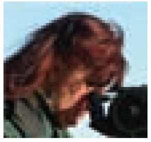
I posted my observing report on the RASCals email list, and soon heard from Bill Weir in Victoria and Denis Fell in Wetaskiwin, Alberta, who both had also succeeded in observing the shadow transit. The observers out west had the advantage of Saturn being higher in the sky, but seeing was poor for both of them as well. Despite the poor seeing, Denis succeeded in imaging the transit with his 12-inch Newtonian.



As a strictly visual observer, I'm always delighted to have a photographic record of something I have observed, so I thank Denis for allowing me to use his beautiful images here.

Geoff Gaherty recently received the Toronto Centre's Ostrander-Ramsay Award for excellence in writing, specifically for his JRASC *column,* Through My Eyepiece. *Despite cold in the winter and mosquitoes in the summer, he still manages to pursue a variety of observations, particularly of Jupiter and variable stars. Besides this column, he writes regularly for the* Starry Night Times *and the* Orion Sky Times. *He recently started writing a weekly column on the* Space.com *Web site.*

Quick Picks for Observing



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

August 2009	Event
Monday,, August 3 1:00 UT	Moon at apogee* (406,026 km)
Wednesday, August 5	Penumbral Lunar Eclipse - NE America
Thursday, August 6 0:55 UT	Full Moon
Thursday, August 6 22:00 UT	Jupiter 3° S of Moon
Tuesday, August 12	Perseid Meteor Shower peak
Thursday, August 13 18:55 UT	Last-quarter Moon
Thursday, August 13 - Sunday, August 16 Monday, August 17 21:00 UT	Saskatchewan Summer Star Party and the RASC General Assembly visit `www.rasc.ca/ga2009/index.shtml` Venus 1.7° S of Moon
Tuesday, August 18 21:00 UT Wednesday, August 19 5:00 UT Thursday, August 20 10:02 UT	Mercury 3° S of Saturn Moon at perigee* (359,639 km) New Moon
Saturday, August 22 4:00 UT 6:00 UT	Venus 7° S of Pollux Saturn 7° N of Moon
Monday, August 24 16:00 UT	Mercury at latest elongation E 27°
Thursday, August 27 11:42 UT	First-quarter Moon
Monday, August 31 11:00 UT	Moon at apogee* (405,269 km)

Plan your summer and fall vacations around a summer/fall star party. See page 356 of the 2009 *Observer's Handbook* for selected star parties, and on pages 12-14 for the latitude and longitude of each star party

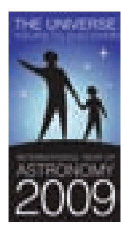
September 2009	Event
Tuesday, September 1 - early morning twilight - also viewable until Sept 3 a.m.	Venus is 1.5° S of Beehive (M44)
Wednesday, September 2 21:00 UT	Jupiter is 3° S of Moon Observe the moons of Jupiter disappear starting at 11:58 p.m.
Friday, September 11 22:16 UT	Last-quarter Moon
Sunday, September 13 16:00 UT	Mars is 1.1° S of Moon
Thursday, September 17	Zodiacal Light visible in the East for the next two weeks.
Friday, September 18 18:44 UT	New Moon (lunation 1073)
Sunday, September 20 10:00 UT	Venus is 0.5° N of Regulus
Tuesday, September 22 21:19 UT	Fall Equinox
Thursday, September 24 6:00 UT	Antares 0.8° S of Moon.
Saturday, September 26 0:50 UT	First-quarter Moon
Wednesday, September 30 0:00 UT	Jupiter 3° S of Moon

September is the month to watch **Jupiter** for the disappearance of its satellites. Get comfortable and enjoy the view! See page 236 in the *Observer's Handbook* on Galilean Satellites

October 2009	Event

October features 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 event.

Sunday, October 4 6:10 UT	Full Moon "Harvest Moon" — the period of fullness that is 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 6th -10th)
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 2nd to November 7th)
Saturday, October 24	Fall Astronomy Day — Fall Astronomy Week runs from October 19th to the 25th.
Monday, October 26 0:42 UT	First-quarter Moon



2009 International Year of Astronomy

As we celebrate the global celebration of Astronomy, make sure to visit `www.astronomy2009.ca` for more information on Canadian and local events.

Come be part of the excitement in 2009!

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

The 2010 copies will be available online at the RASC eStore in Sept/October 2009. Go to `www.rasc.ca` and click on eStore.

Meteor Showers for August to October are available from `www.imo.net/calendar/2009` This includes several minor and major meteor showers: see page 258 of the 2009 *Observer's Handbook.*

For more more information on the Harvest Moon or Hunter's Moon, visit `http://en.wikipedia.org/wiki/Harvest_moon`

A Moment With…

Dr. Peter Martin

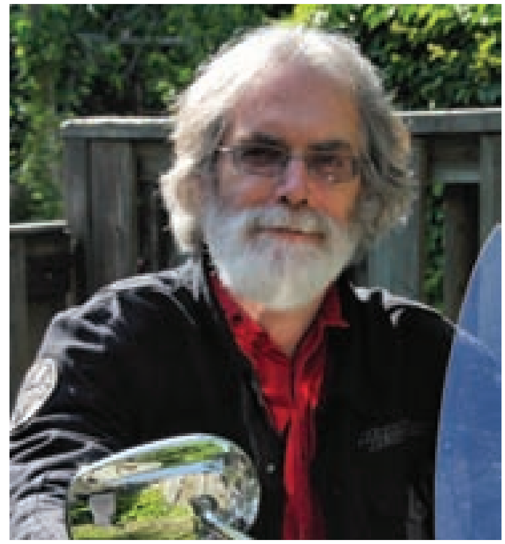
by Phil Mozel
Toronto and Mississauga Centres
(phil.mozel@sympatico.com)

Imagine this: you have set up your large, new telescope at your favourite observing site, when suddenly a gust of wind blows it over. Worse, as the wind picks up speed, it carries your instrument down the street, shedding accessories as it goes, leaving gouges in the pavement. A nightmare to be sure. But it has happened — to a large professional telescope. Just ask Dr. Peter Martin.

While Dr. Martin at one time dabbled in amateur astronomy, it was only as a 4th-year undergraduate, inspired by a few earlier astronomy courses and two summers working at NRC in Ottawa and at the Algonquin Radio Observatory, that he chose to focus on this discipline rather than simply theoretical physics within the math and physics program at the University of Toronto. Now here was an interesting area in which to apply his love of physics! And he was clearly good at it, too, receiving the RASC's gold medal (awarded to the top undergraduate student graduating with first-class honours from the Astronomy and Physics Department at the University of Toronto) along the way.

After completing his M.Sc., and obtaining a Commonwealth Scholarship, he left for Cambridge University, a magnet for theoretical astrophysicists (Fred Hoyle was then director and Steven Hawking a young researcher), to complete his Ph.D. under Dennis Sciama and Martin Rees. Here he found topnotch professors, post-doctoral students, and visiting scientists from around the world (and simultaneously helped satisfy his wanderlust). Returning to Toronto in 1972 at age 24, he joined the faculty of the Department of Astronomy and Astrophysics, where he is currently the chair. He is also the interim director of the Dunlap Institute for Astronomy & Astrophysics and a professor in the Canadian Institute for Theoretical Astrophysics (CITA), of which he was the first faculty member in 1984.

Dr. Martin may be considered a "galactic ecologist" and, as such, studies the interstellar medium and its relationship to stellar evolution. He looks at the astrophysics of nebulae and works in computational astrophysics and observational astronomy, particularly at longer wavelengths. He studies how stars form, change, die, and return material to the interstellar medium in cyclic processes analogous to ecosystems on Earth. He is particularly interested in stellar birth, an area in which we have much less knowledge than for the rest of the stellar evolutionary process. And while there is much optical and radio data available on what stars are up to for much of their existence, information on the raw material of star construction, *i.e.* cold dust and gas, is somewhat lacking, and so he looks at that too.



Dr. Peter Martin

Dr. Martin explained that the key to learning about star formation is to observe what is going on before the embryonic star becomes too energetic, warming and altering the gas and dust from which it formed. To determine where this material is and what it is doing, observations at wavelengths longer than visible light are needed. Infrared light, for example, is particularly useful for tracing the whereabouts of dust.

However, in the densest clouds that form stars, the shielding dust is too cold even for infrared — at 10 K, it emits predominantly at sub-millimetre wavelengths. Dense clouds literally light up in the sub-millimetre but are dark in the infrared. The Earth's atmosphere screens out all these wavelengths, necessitating the placement of instruments at high altitudes or in space. One solution is a *BLAST*.

The *Balloon-borne Large-Aperture Sub-millimeter Telescope (BLAST)* is a 2-tonne, 2-metre-aperture telescope suspended beneath a 33-storey-tall balloon that carries it to altitudes approaching 40 kilometres. Here, there is plenty of long-wavelength light. Two science missions have been flown, one from the Arctic and one from the Antarctic. Dr. Martin helped select the galactic targets and, with other astronomers, is deeply involved in analyzing the data.

Involvement in this project has been hair-raising. During the northern flight, something went wrong with the primary mirror, resulting in hexagonal images being returned. This is reminiscent of the problem with the *Hubble Space Telescope's* mirror, and Dr. Martin and one of his graduate students developed a similar deconvolution program to rectify the problem.

The southern flight, lasting eleven days, targeted the cold molecular clouds of the Vela region. While quiet now, Dr. Martin expects that within a million years or so the area could become a hotbed of star formation. We almost didn't find this out. At the end of its mission, the telescope and its associated instruments were lowered to the ground by parachute, which then failed to release after landing. The telescope was blown for over 100 kilometres across the ice before becoming lodged in a crevasse, where it remains. Before coming to rest, the primary mirror fell off and was recovered, along with the pressure vessel containing the data-recording computers. This was most fortunate because no scientific data was transmitted to the ground during flight; it was all stored onboard. A close call!

A wealth of data has come from that recorder. In addition to studies of star-forming regions in the Milky Way, the "cosmic far-infrared background" was found to contain as much energy as there is in all the visible light seen from the stars and galaxies in the distant Universe. *BLAST* actually resolves this "background" into individual galaxies, within which dust enshrouds active regions of star formation, capturing much of the visible starlight, and reradiating it in the infrared. This solves a longstanding puzzle as to the source of the infrared background.

Just as the Universe that our eyeballs can actually see is but a small fraction of what is out there (*i.e.* most of it is dark matter and dark energy), so too is this visible energy a fraction of what is being produced. What we see is not what we get!

At the time of our interview, Dr. Martin was looking forward to the imminent (and ultimately successful!) launch of the European Space Agency's *Herschel Space Observatory.* Best known for his discovery of Uranus, Sir William Herschel also determined that invisible, infrared light was part of the electromagnetic spectrum. His namesake observatory will probe unexplored far-infrared and sub-millimetre wavelengths using a 3.5-metre mirror, the largest single mirror ever sent into space. From its vantage point, *Herschel* will provide data to answer questions relating to how galaxies formed and evolved in the early Universe, how stars form and evolve and their relationship with the interstellar medium, the chemistry of the Milky Way and of planetary, cometary, and satellite atmospheres in the Solar System.

It doesn't get any better than that for an astronomer — or does it? Launched on the same rocket was *Planck,* named for physicist Max Planck. Following in the footsteps of the *Cosmic Background Explorer (COBE)* and *Wilkinson Microwave Anisotropy Probe (WMAP)* satellites, *Planck* will map the cosmic microwave background (CMB) with far greater sensitivity and resolution than any previous spacecraft. Using its data, astronomers will attempt to determine a more accurate value for the Hubble constant, whether the Universe actually did go through an inflationary phase, and what all that dark matter is actually. For Dr. Martin though, the payoff from the all-sky survey is unprecedented multi-wavelength maps of the entire Milky Way galaxy, which lies as a "foreground" to the CMB. No wonder he is excited!

Dr. Martin is a permanent member of the scientific management of the Canadian Galactic Plane Survey, and its offshoot, the *Dominion Radio Astrophysical Observatory Planck Deep Fields (DPDF)* project, studying the region around the Milky Way at high galactic latitude using the synthesis telescope at the DRAO near Penticton. The aforementioned foreground emission from the gas and dust can mask the CMB, so characterizing this material, a worthy study in and of itself, will also help clarify data from the *Planck* mission.

And as if that's not enough, Dr. Martin is also a science team member for the *James Webb Space Telescope (JWST).* This telescope, with an enormous folding, segmented 6.5-metre mirror, will work mostly in the near infrared and study such things as the first galaxies to form after the Big Bang, newly developing planetary systems, the locations of the building blocks of life in those systems, and dark matter. Dr. Martin will be helping to define just exactly what galactic objects are worthy of observation. Furthermore, Canadians will be providing the Tunable Filter Imager, which allows any near-infrared wavelength to be dialed up, and the Fine Guidance Sensor, which keeps the entire *JWST* correctly pointed with one one-hundredth of a degree precision.

Over his long career, Dr. Martin has seen the development of many new technologies. I asked in particular about the differences in observing remotely compared to traveling to a distant site. He allowed that, while there is a degree of romance to standing in the cold and dark, one does have to adapt to whatever techniques are current. He minds not at all being able to observe right from home!

Beyond his research, he finds time, somehow, for teaching, not just grad students and post-docs, but younger students and the "over-55 group" at Elderhostel. It is truly a remarkable career for a world-renowned scientist who has been justifiably honoured with election to the prestigious Royal Society of Canada. He just wishes he had more of those grad students and post-docs to help with the avalanche of data soon to come!

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.

Alfred Russel Wallace and the RASC

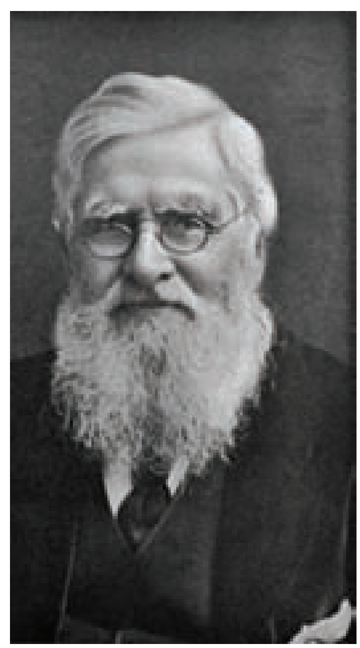
by R.A. Rosenfeld, RASC Archivist
(randall.rosenfeld@utoronto.ca)

No year passes without some milestones of that particularly significant part of human culture we call "science" being celebrated in a big way. Big ideas get big parties. Astronomy is decently endowed with such occasions. The 1986 apparition of Halley's Comet included a celebration of Edmund Halley's work, and, from the cometary proof of Newtonian celestial mechanics, led to a year-long party hosted by his successors for themselves and for the shades of Halley, his friend Newton, and their admirers Delisle, Messier, and others (gains for the history of astronomy are well presented in Thrower *et al.* 1990). The 2004 transit of Venus commemorated historical efforts through parallactic methods to determine and refine what we now know as the astronomical unit (AU), and honoured those who made the predictions, undertook the measurements, and travelled to make them: Horrox and Crabtree; Mason and Dixon; Lord Lindsay; and David Gill (IAU 2004; Sheehan and Westfall 2004). We are currently in the midst of one such celebration, the 400th anniversary of the inauguration of telescopic astronomy, with Galileo the principal symbolical recipient of the IYA cake and champagne (there is a desire in some quarters to give a portion of Galileo's cake to Thomas Harriot [Chapman 2009], yet from his letters it seems that Galileo's English contemporary would not have disputed the Tuscan philosopher's claim to his fame). For all of their epochal importance, Galileo's telescopic lunar and Jovian observations and the current celebration they've sparked may not be remembered as the chief scientific commemoration of the year. That distinction is undoubtedly reserved for the 200th anniversary of the birth of Charles Darwin, and the sesquicentennary of the publication of *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (`www.darwin2009.cam.ac.uk`).

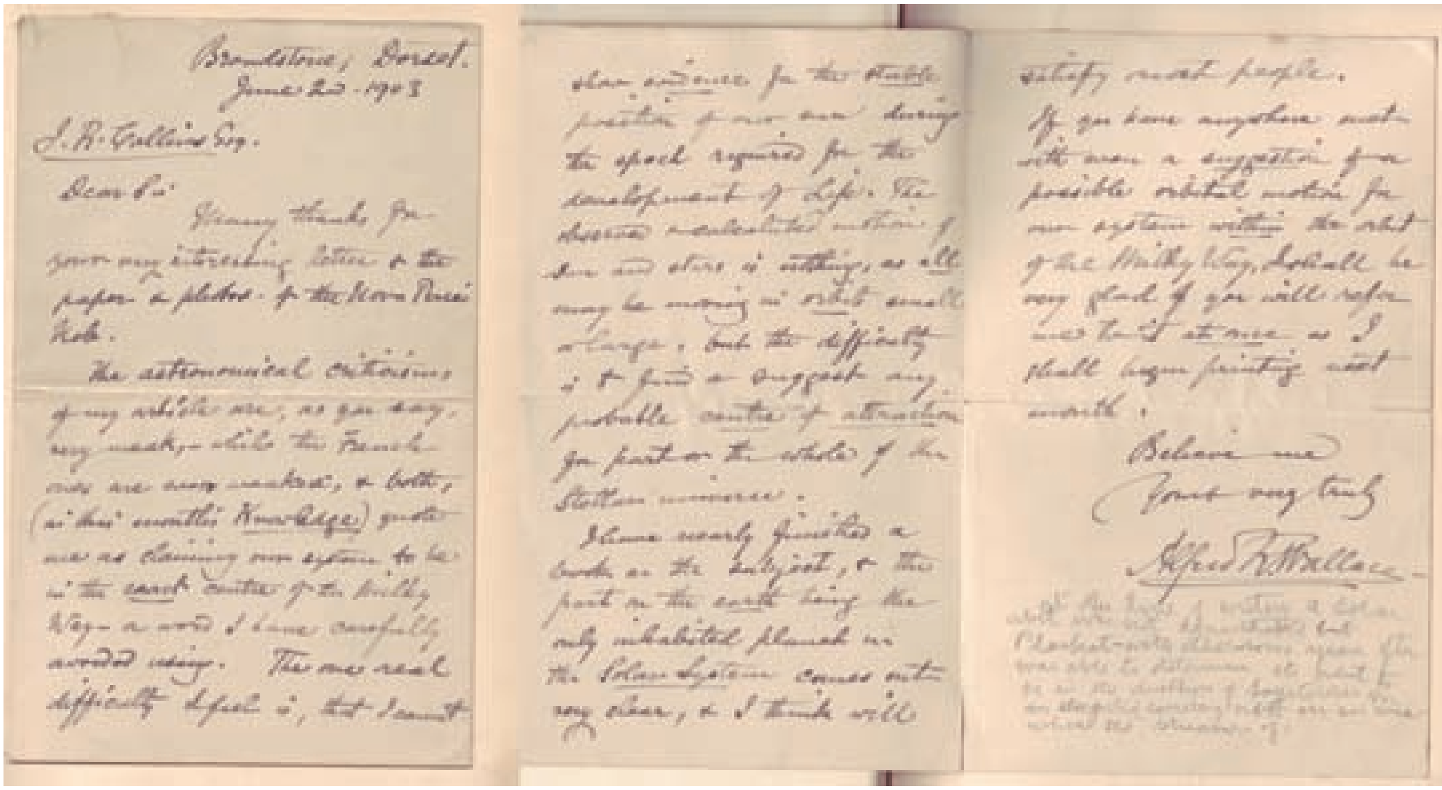
That there are connections between Darwin, his work, and astronomy is not news. Probably no part of astrophysics, planetary astronomy, astrobiology, or even instrumentation has remained unaffected by the idea of evolution. It's so common as an explanatory template to order data that we hardly notice its use (we're more likely to notice its absence). What readers may not know is how quickly evolution made its mark in astronomy, at least in some quarters. It had proceeded so far that, by 1892, a decade after Darwin's death, the great popularizer Sir Robert Ball could even state that "Astronomers were thus the first evolutionists, they have sketched out a majestic scheme of evolution for the whole solar system and now they are rejoiced to find that the great doctrine of Evolution has received an extension to the whole domain of organic life by the splendid genius of Darwin [Lightman 2007, 413]." Ball's words carried weight. Formerly the Astronomer Royal of Ireland, that same year he was appointed to succeed John Couch Adams in the Lowndean Chair of Astronomy and Geometry at Cambridge University. At Cambridge he was a colleague of the other professor of astronomy, Sir George Darwin, Plumian Professor of Astronomy and Experimental Philosophy, and second son of Charles. Sir George was a distinguished celestial mechanician, and an honorary member of the RASC.

Charles Darwin himself wished to study rudimentary positional astronomy in preparation for his trip aboard the *Beagle* (Darwin Letter 122, 1831 September 9). The RASC Archives, unfortunately, does not contain any original correspondence or documents of Charles Darwin, but it does own an unpublished letter of his good friend, and co-discoverer of the theory of evolution by natural selection, Alfred Russel Wallace (1823-1913; McKinney 1976; Garwood 2004; Smith 2007; Smith 2008).

Now considered one of the great natural philosophers of all time, some scientists and historians of science would rate Wallace as "the single most outstanding field biologist and tropical regions naturalist in history" (Smith 2008), which is, as it were, astronomical praise, given the constellation of highly gifted and persevering naturalists at work in and beyond Victoria's



Alfred Russel Wallace



Broadstone, Dorset.
June 2nd 1903

J.R. Collins Esq.

Dear Sir

Many thanks for your very interesting letter & the paper & photos. of the [illegible] [illegible]

The astronomical criticisms of my article are, as you say, very weak,—while the French ones are very wicked, & both, (in this month's Knowledge) quote me as claiming our system to be in the exact centre of the Milky Way—a word I have carefully avoided using. The one real difficulty I feel is, that I cannot show evidence for the stable position of our sun during the epoch required for the development of Life. The observed motions of Sun and stars is nothing, as all may be moving in orbits small or large, but the difficulty is to find or suggest any probable centre of attraction for part or the whole of the stellar universe.

I have nearly finished a book on the subject, & the part on the earth being the only inhabited planet in the Solar System comes out very clear, & I think will satisfy most people.

If you have anywhere met with even a suggestion of a possible orbital motion for our system within the orbit of the Milky Way, I shall be very glad if you will refer me to it at once as I shall begin printing next month.

Believe me
Yours very truly
Alfred R. Wallace

empire. The golden age of visual observational astronomers was also the golden age of daring field naturalists. Their like and numbers have not been seen since. Among Wallace's many achievements, in addition to the co-discovery of the theory of natural selection, are the Wallace Line, a major demarcation between the zoogeographical regions of Asia and the transitional zone bordering Australia, the early development of the field of biogeography, and the formulation of the concepts of warning colouration, and the Wallace Effect, which states that natural selection can lead to reproductive isolation.

Wallace's competence in astronomy, and commitment and contributions to the discipline far outstripped those of Charles Darwin. He received solid training in practical astronomy when he was educated by his brother in the craft of surveying (Fichman 2004, 13-14). Some of his work from the 1880s dealt with astronomical matters, but it wasn't until the increased activity of the pluralists — those arguing for an abundance of life throughout the Universe — that Wallace made his main contributions. He was also a noted opponent of Percival Lowell's Martian theories and "discoveries" (Crowe 1986, 530-531). Wallace showed himself fully conversant with the professional astronomical literature, and fully able to use it professionally. His work on the atmosphere and surface features of Mars was much more cogent and scientific than Lowell's. He has been claimed as a founding figure of modern astrobiology, and an early developer of a form of the Anthropic Principle (Smith 2008).

Wallace's relations with the RASC (and the Toronto Astronomical Society, when it was so styled) were entirely conducted through the Society's Secretary, J.R. Collins (1865-1957; Broughton 1994, 71). That this was not the only letter exchanged between the two men is clear from a statement in a review (Collins 1905) of one of Wallace's major works on astrobiology (the field would then be known as the "life on other worlds" question), *Man's place in the Universe* (1903). In light of the nature of Wallace's reply to Collins *(supra),* it's not unexpected that Collins' review of Wallace's forthcoming book was favourable. While there is nothing particularly novel revealed in the letter published here, what is perhaps surprising to a modern reader is the apparent freedom with which a relatively undistinguished office holder in a provincial society can initiate an epistolary exchange with a figure of world standing. There's something almost disarming about the apparent lack of reflection in the act. The good will evident in Wallace's response to Collins says much for the character for the man. This lion at any rate is not going to devour the oblivious lamb. Equally surprising is Wallace's request for Collins' assistance. It's as if Stephen Hawking placed a call in the *RASC Bulletin* for assistance on a particular aspect of Hawking radiation, after having received a letter from the Archivist!

The tenor of the times was such that this was not a particularly infrequent occurrence. And it may hold a lesson in public relations for those concerned with improving public perceptions of the "image" of the professional scientist during either of the landmark 2009 celebrations. Perhaps we should all try to be more like Wallace, professionals or amateurs.

Edition

Letter pasted into front end-papers of Wallace 1903b, RASC Archives Rare Book Collection, s.n.

/p. 1 Broadstone,[1] Dorset.
June 2nd - 1903
J.R. Collins Esq.

Dear Sir[,]

Many Thanks for your very interesting letter[2] & the paper & photos. of the Nova Persei neb[ula].[3]

The astronomical criticisms of my article are, as you say, very weak, — while the French ones[4] are even weaker, & both, (in this month's Knowledge[5]) quote us as claiming our system to be in the exact centre of the Milky Way — a word I have carefully avoided using. The one real difficulty I feel is, that I cannot /p. 2 show evidence for the stable position of our sun during the epoch required for the development of Life. The observed & calculated motion of sun and stars is nothing, as all may be moving in orbits small or large, but the difficulty is to find or suggest any probable centre of attraction for part or the whole of the Stellar universe.

Struve[6] nearly finished a book on the subject, & the part on the earth being the only inhabited planet in the Solar System comes out very clear, & I think will /p. 3 satisfy most people.

If you have anywhere met with even a suggestion of a possible orbital motion for our system within the orbit of the Milky Way, I shall be very glad if you will refer to it at once as I shall begin printing next month.[7]

Believe me
Yours very truly
Alfred R. Wallace -

Endnotes

1 The house was built the year before this letter was written, and is pictured in the frontispiece of the second volume of Wallace's autobiography (1905).

2 I have been unsuccessful in tracing this letter, should it still be extant.

3 Probably the photographs given to the Toronto Astronomical Society (*i.e.* RASC) by George Ellery Hale (TAS/RASC honorary fellow), taken by George Willis Ritchey with the Yerkes 24-inch Newtonian, and published with commentary by Society member W. Balfour Musson (1902). Collins may also have sent Wallace his own paper on Nova Persei (Collins 1902). The nebula in the photographs is not the Fireworks Nebula (LEDA 13065 [GN 03.27.8] – a bright nebula mistakenly lurking in a galaxy catalogue!), which had not then become visible, but was rather the nova's light echo moving through cosmic dust. For some idea of the contemporary impart of Nova Persei, see Clerke 1902, 400-401; Burnham 1978, 1427-1432. For the modern context, see Bode and Evans 2008.

4 Such as Flammarion 1903a and 1903b, and Moye 1903.

5 *E.g.* Maunder 1903, and Flammarion 1903a.

6 Wallace's wording is ambiguous. If he is referring to *his* inference from a Struve treatment of the galactic location of the Solar System and the Earth, then he could be citing something similar to Struve 1847, but if he means a Struve manuscript that emphasizes the unique qualities of the Earth for life, I can find no reference to it in either Crowe 1986, or Batten 1988. It is also unclear to which of the Struve clan of astronomers Wallace is referring. The wording may imply that Wallace thought such a work was to appear shortly, but that need not mean the author was alive in 1903. Wallace 1903b does not clarify matters.

7 Presumably the printing of Wallace 1903b.

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R.A. Rosenfeld was appointed RASC Archivist after being surrounded by antique celestial atlases that wouldn't take "no" for an answer. Before that, he was headmaster of a borstal for errant footnotes. He is currently seeking a robotic telescope that can respond to commands in Latin.

Second Light

Intermediate-Mass Black Holes

by Leslie J. Sage
(l.sage@naturedc.com)

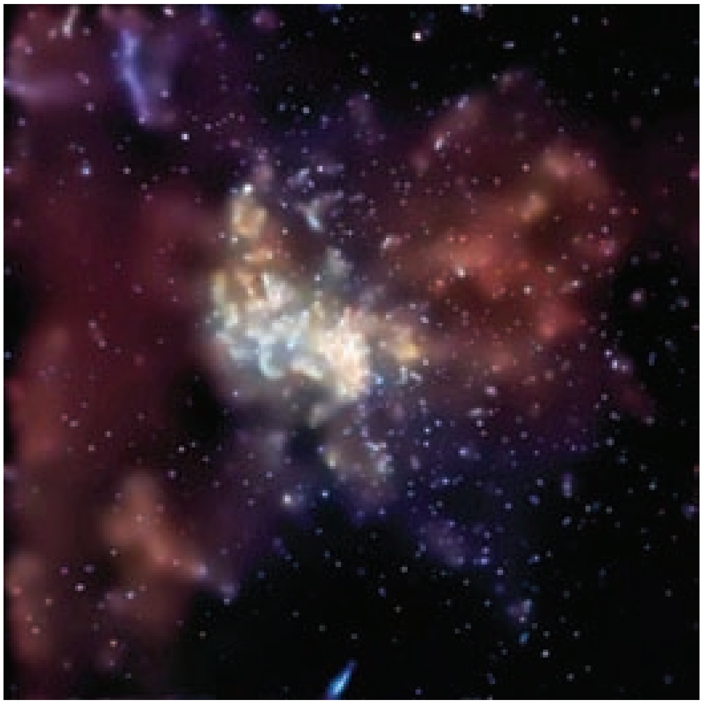
Essentially all astronomers now accept as a matter of course that black holes of 20 solar masses exist in our Galaxy, and that supermassive black holes of 10^6–10^{10} solar masses lie at the centres of large galaxies (such as our own). Whether "intermediate-mass black holes" (10^2–10^4 solar masses) exist, however, has been a lot more controversial. Sean Farrell (now at the University of Leicester, in the UK) and his colleagues believe they have identified the current best candidate (see the July 2 issue of *Nature*).

Stellar-mass black holes are believed to form mainly as a result of supernova explosions of particularly massive stars. Once nuclear fusion in the core of the star starts producing iron, there is no longer energy available to support the surrounding star and it begins to collapse. Although the details remain hazy because simulations still have not realistically produced a supernova, it is believed that a supernova results from this inward collapse. In most cases, a neutron star is left behind after the star explodes, but when the progenitor star is very massive, the result is a black hole. There are some who believe that gamma-ray bursts, which appear to be associated with very massive stars, often come with the formation of such black holes. The newly created black holes suppress the visible light normally arising from the supernova.

There is considerable scientific discussion about the formation of supermassive black holes, but several methods appear to be viable. They might get started as stellar-mass black holes in the early Universe and grow along with a young galaxy, either through accreting gas, absorbing other black holes, or both. Although the formation and growth mechanisms remain uncertain, there is no real doubt about the existence of supermassive black holes. Radio observations of the centre of the Milky Way have come within a few black-hole radii, and general relativistic effects on spectral lines from other galaxies (among other evidence) seem to demonstrate definitively the presence of such objects.

Curiously, many physicists have not yet fully accepted the presence of black holes in the Universe — they are waiting to see the "event horizon," through which objects disappear. This is yet another example of the rather striking differences in cultures between physics and astronomy.

Intermediate-mass black holes are more controversial for several reasons. The conditions needed to create them, and



This Chandra image of the supermassive black hole at our galaxy's centre, a.k.a. Sagittarius A* or Sgr A*, was made from the longest X-ray exposure of that region to date. In addition to Sgr A*, more than 2000 other X-ray sources were detected in the region, making this one of the richest fields ever observed.

then prevent them from growing to the supermassive stage, seem rather contrived. One could imagine several black holes orbiting each other that eventually merge together (the orbits decay because energy is lost to gravitational waves), but it seems difficult to imagine such a system growing to over 100 solar masses. Alternatively, they might result from runaway collisions at the centres of dense globular clusters. That could produce black holes in the right size range, but, as we see lots of globular clusters around our galaxy and other galaxies, the process cannot be particularly efficient.

Intermediate-mass black holes are also controversial because the techniques used to discern their presence are indirect and the results open to alternative interpretations. People look for X-ray emission above a critical luminosity, and then argue that the only way to produce such luminosity is for a black hole to be at the centre of the emission. This is a weak hypothesis, because often the distance to the source is uncertain by a factor of two or more, there might be multiple sources within a sufficiently small region of space that we cannot distinguish between the sources, or there might be a chance superposition between a distant quasar and a closer galaxy that fools us into thinking that the quasar is really an intermediate-mass black hole in the nearby galaxy. As a result, no claim has previously been accepted as anything more than suggestive.

Using a catalogue of data, Farrell and his colleagues found an X-ray source about 8 arcseconds away from the nucleus of the galaxy ESO 243-49, but still within the optical limits of the galaxy. They have gone to considerable lengths to rule out the usual alternatives to an intermediate-mass black hole, such as foreground objects in the Milky Way, background quasars, and groups of less luminous sources. The arguments against foreground and background objects are quite good, leaving the possibility of a group of X-ray-emitting compact (white dwarf, neutron star, or black hole) stars. In order to rule those out, they re-measured the X-ray flux and found that it was variable. Between the time of the original catalogue observation (2004) and late last year, the flux decreased by about a factor of two and the overall spectrum changed. It would be inconceivable for a population of several thousand X-ray-emitting compact stars to change their aggregate luminosity and spectrum by so much over so short a time, meaning that it must be a single source. Assuming that the accretion of gas onto an intermediate-mass black hole scales like it does with stellar-mass ones, they conservatively estimate the lower limit on the mass to be 500 solar masses.

Taken all together, this appears to be the best case yet for the existence of an intermediate-mass black hole. Whether it will be accepted as such by most astronomers remains to be seen.

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

Orbital Oddities

Delight(s) of Day, Part 2

by Bruce McCurdy
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Summertime and the viewin' is ea-sy.

Besides the Sun, which we talked about last time, there are many other observing attractions in the daytime sky. At the Telus World of Science, Edmonton's Observatory, we have the ideal tools to view them: permanently mounted polar-aligned telescopes with GoTo and PushTo capabilities, as well as others with old-fashioned mechanical setting circles.

The daylight hours are, in many ways, the best time to view the entire inner Solar System. Mercury and Venus can be found high in the sky only when the binding Sun is also above the horizon. Venus in particular is bright and easy to see, a pleasant surprise to many visitors who cross the threshold of the observatory asking, "What can you possibly see in the daytime?" When it has a pronounced phase, kids often mistake Venus for the Moon.

On a clear day, especially when the planet is near its elongation, people are challenged to spot Venus in the sky with their unaided eye, using the telescope tube as a guide. An alternate method is to find a location fully shaded from the Sun where the target area of sky is still accessible and much more comfortable to scan. It is also safer; this method is particularly recommended to folks using binoculars or unguided telescopes such as Dobsonians.

Venus is particularly interesting around the time of its inferior conjunction, which is as interesting in its way as the opposition of an outer planet. In the summers of 1999 and 2007, inferior conjunction occurred in mid-August, so I was able to follow the apparition on a regular basis as the planet approached, growing in angular size even as the sunlit portion slimmed to a razor-thin crescent. Right on the day of conjunction/closest approach, it was possible to view Venus as slender as a fingernail clipping, cusps pointing straight down as it passed some 8 degrees below the Sun. I did these observations one better in March 2009, when I observed Venus in the very hour of its inferior conjunction, which occurred right around local noon in western Canada, this time passing about 8 degrees north of the Sun with the cusps pointing straight up.

Of course, the ultimate conjunction occurred on 2004 June 8, when I joined a number of other Edmonton Centre RASCals in Fort McMurray to observe the silhouette of Venus in transit across the rising Sun. Seen through a white-light filter, I was astonished by the colours of this event, as atmospheric distortion along the horizon produced a squashed Sun and undulating seeing that bordered on the surreal.

Four days before the transit, I had another unforgettable observation of our sister planet. Venus had closed to within 5.5 degrees of the Sun, closer than it gets during most inferior conjunctions. In moments of perfect seeing, our superb 7-inch Astrophysics Starfire refractor revealed the cusps of the crescent extending faintly all the way around the planet! It is possible to see this annulus under ideal conditions because of scattered light in Venus' atmosphere. The pains I had taken to maximize the observation, from the makeshift baffle extending far beyond the objective lens that minimized internal reflections, to the dark cloth enveloping my head at the eyepiece end, were amply rewarded by this exquisite view of the Other Ringed Planet.

In 2007, I took my conjunction obsession to a ridiculous extreme by successfully observing a superior conjunction of Mercury just 2 degrees from the solar limb. Paradoxically, due to phase effects, Mercury is at its brightest when it is furthest from the Earth. Using a finely tuned GoTo telescope, its tiny full disc was glimpsed in a very bright sky, practically *through* the solar corona. I proved that it is possible, but such an observation is not recommended. The after-image that persisted in my desensitized right eye for the next hour or so convinced me that having "succeeded" once, there was absolutely no need to ever try that again!

I have enjoyed many conjunctions of other sorts over the years. Conjunctions between planets frequently occur in the vicinity of the Sun; those involving Mercury and/or Venus demand it, and meetings of outer planets are much more likely to occur toward the Sun than away from it. If the pair passes within a telescopic field of view, I'll go after it in broad daylight, no problem. Volunteering has its privileges, and one of mine comes in the form of a key to the observatory.

I find Saturn and Mars virtually impossible to see in a blue sky within about 15 degrees of the Sun, but further out than that they're fair game. Beggars can't be choosers, but ideally the target is at a higher altitude than the Sun, where those tolerances are maximized. If the observing window is sufficiently wide, I will try to plan the observation when the target is near the meridian, in mid-morning, or later in the afternoon.

Daytime observations of the Moon are often challenged by low contrast, especially when the Moon is lower in the sky. The best opportunities occur when it is around first or third quarter and, by definition, passing through the polarization bands that lie 90 degrees from the Sun. This is also the best place to attempt daytime observations of Jupiter with the naked eye, ideally around the time the relevant quarter Moon is just passing through. There is typically one such opportunity per year on each of the morning and evening sides.

Conjunctions between planets and bright stars, such as Regulus, can be fun too. It's much easier to get a fix on the motion of the planet when anchored to a "fixed" object than against another moving planet.

Planetary occultations are another pursuit to which daytime occurrence is more nuisance than impediment. I was never more fortunate than in late July 2000, when I observed three lunar occultations of inner Solar System bodies on consecutive days, all from the observatory. First, the very old Moon occulted Mercury in a luckily timed late-morning timeslot under near-perfect conditions. The next evening, the new Moon partially passed in front of the Sun in a memorable sunset eclipse that drew a thousand visitors to the observing deck. In the late afternoon of the third day, the very young Moon occulted Venus through broken cloud that opened up at just the right moment. The wind was nasty, and just a single visitor was there to share my observation. He had shown up serendipitously at a moment that had been highlighted on my observing calendar for months, and he was presented with a free view of this spectacle through a 14-inch telescope!

Other opportunities are less predictable. A personal favourite was making a naked-eye observation of the brilliant Comet McNaught, when it lay just 6 degrees from the Sun in early January 2007. The Sun was technically above the southwestern horizon, but blanketed in a very low bank of clouds, above which hung the brightest comet in many decades.

Many of these are "once in a lifetime" events, of course; the key is to be alert and aware to the opportunities that arise.

Stars are another worthwhile target. At the observatory, we find Sirius, 40 degrees below the Sun, every clear July afternoon. Around the time it sets into the local horizon, Arcturus has soared above the large poplar tree just to our east. My co-worker, Sherrilyn Jahrig, a top-notch observer with whom it has been my pleasure to job-share over a number of summers, has a popular program in which she sweeps up all seven Big Dipper stars, which are cruising high overhead in summer afternoons. Engaged visitors will spend a quarter of an hour or more at the eyepiece of the 16-inch GoTo, assiduously picking out one after another of these faint points of light, pausing near the end of the tour to exclaim at Mizar. Once that double is resolved, the next challenge is to spot 4th-magnitude Alcor on the other side of the field of view.

Multiple stars are another popular target. Paired bright stars such as Castor (α Gem) or Algenib (γ Leo) are best seen against a deepening blue, pre-sunset background that reduces star glare. This is particularly true of colourful pairs such as Izar (γ Boo) or Almach (γ And); as it gets darker they flare to white.

Solar eclipses by definition are daytime observations, but are worthy of their own column(s). I could write further about some of the beautiful atmospheric effects of a daytime sky, but I fear I have already sufficiently taxed your time, and my space!

Ever the contrarian, Bruce McCurdy's personal observing program is never more active than in the summer months, when perpetual twilight at his latitude near 54 degrees north encourages many of his deep-sky brethren into hiatus. Besides the daytime astronomy described here, Bruce is an enthusiastic observer of the noctilucent clouds of June and July, as well as the August Perseids.

Gizmos

Springwater Observatory — The Floor

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

When we built Springwater Observatory, it was important to us that there was as little impact as possible on the land around it — no excavators, no cement trucks. We built the pier as described in the last article but were determined that it should be the only thing that was built for the ages. The rest of the building would be more benign, so we decided on a wood pier foundation. This is probably one of the oldest building techniques known to man, and has been used for everything from Viking longhouses to pole barns on the prairies. At its most basic, you dig holes and put in posts. The earth holds up the posts and the posts hold up the building.

We didn't get much more sophisticated than that. We dug holes about 18″ square and 24″ deep and cleaned all the loose soil out of them. We put a rock the size of a grapefruit in the bottom of each and set a 6×6 pressure-treated post on top. We aligned the posts with braces, carefully filled concrete around each one, and worked it with the shovel so that it flowed completely under and around. We gave each hole about an 18″ depth of concrete, waited a day to let the concrete set, and topped them up with earth.

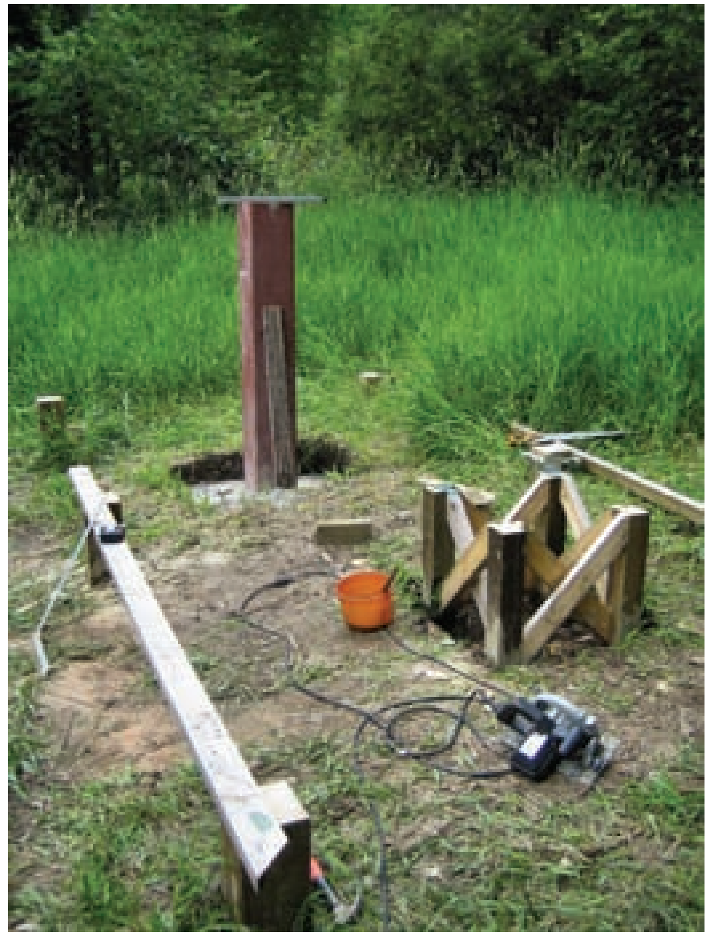
The Dobsonian platform was built much the same way, using 4×4 posts this time, with firm bracing between, and sized to be topped by a standard 2′×2′ concrete paver. We prebuilt this as a unit, set it into one large hole and filled concrete around it. We cut these posts level very carefully, laid on the paver, and having thus determined our floor elevation, marked all the other posts accordingly, and cut them too.

We framed the floor with 2×10s staying about 1½″ away from the pier and the Dob base.

A few thoughts on all this in case you decide to build one.

Use pressure-treated lumber for the posts. As I said, we are not building for the ages here but three or four decades would be nice. Put only the factory-treated ends of the posts into the ground and leave the cut ends up. If you are using ACQ-treated lumber (ask at the building supply) you must use galvanized or stainless steel nails or screws. The copper-based preservative will corrode anything else.

When you put down the floor plywood, leave at least ¾″ gap around the pier and the Dob platform. That way, no



vibration will transfer from the floor to your telescopes. It's also a great place to run wires.

What advantages does this design have over a concrete slab?

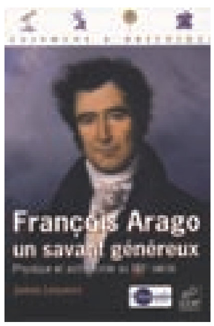
One advantage will be obvious the first time you drop an eyepiece. Another is that air can circulate under the floor, so cool-down times of the structure are much shorter. But the greatest advantages are that this structure can be built on almost any terrain without the need to level the area and that everything you need can be carried on a pickup truck into a remote place.

The pictures should tell you almost everything you need to know about how we built this, but if you have questions email me at *dvanakker@gmail.com*.

The walls and roof can be built in a variety of ways, and we will examine some of them in a future article. Next issue however, a great idea from Bill Weir on how to protect your secondary mirror if you don't drink whiskey.

Don Van Akker and his wife Elizabeth are members of the Victoria chapter. They observe from Salt Spring Island. They are feeling pretty good right now because Salt Spring had two clear nights, a new Moon, and a weekend that all happened at once.

Reviews/Critiques



François Arago, un savant généreux. Physique et astronomie au XiX siècle, James Lequeux, pages 5233 + vii, 16 cm × 24 cm, EDP Sciences/ L'Observatoire de Paris, 2008. Price €35.00 softcover (ISBN 978-2-86883-999-2).

Nineteenth-century astronomer and physicist François Arago is a relatively little-known but important figure in the non-French-speaking scientific world. James Lequeux has produced a welcome and impressive book of this leading figure of French science. This monumental biography of Arago is also a vivid and richly detailed history of European astronomy, geophysics, and physics in the 19th century.

Although Arago receives the greatest attention, this biography gives scores of lively portraits of the many individuals who dominated not only French science, but also French politics, in the aftermath of the French Revolution and during the upheavals in a string of successive political regimes. The biography also describes the close connection and interactions of Arago and leading French scientists with numerous other scientists in the British Isles, Germany, and The Netherlands.

To better appreciate Arago's contributions, one can imagine a group portrait of the leading scientists in European physical sciences of 19th-century science: on the front row are Laplace, Fresnel, de Lalande, Ampère, Young, Faraday, Oersted, William and John Herschel, Fourier, and Carnot. On the second row we would have Arago, Berthollet, Le Verrier, Daguerre, Fizeau, Foucault, and Dulong. If one may consider Arago among secondary contributors, his role was nevertheless very important in the remarkable way he enabled others to emerge more prominently. When he was collaborating with other scientists, like Fresnel or Ampère, he deployed all his efforts to promote them ahead of himself. Arago was particularly efficient at highlighting new science results or new discoveries (by others) at regular meetings of the Académie des Sciences, Mathematical Sciences Division.

Arago spent his scientific career at the Paris Observatory from 1805 until his death in 1853; he was its Director from 1834 until 1852. His contributions were numerous: he advanced our understanding of the nature of the polarization of light, worked with Fizeau to derive a more precise value for the velocity of light, and demonstrated the gaseous nature of the Sun and of stars. He also worked in many areas of applied science. With Dulong, he determined the elastic force of water vapour. He was an extraordinarily versatile scientist, apparently interested in just about every field of the physical sciences of the 19th century. He acted as a strong political and institutional leader and enabled many science initiatives.

James Lequeux has written a wonderful book. Its numerous details and explanatory notes, as informative side-text insets, reflect the fine art of a good pedagogue. The author often comments on results obtained in the 1800s in the perspective of today's value or the current status of knowledge. The book is almost encyclopedic in the coverage it provides on a number of fundamental physical, astronomical, and geophysical phenomena. Most informative is the discussion of Arago's contribution to many areas of applied physics (electromagnetism, meteorology, geomagnetism, geophysics, and oceanography), as well as several areas of technology (steam engines, photography, railroads, *etc.*). Some of the best chapters are those devoted to the nature of light and the use of light to understand the nature of stars, or to measure their properties (photometry).

Arago played an active role in French politics at a time of the many upheavals that shook the country in the aftermath of the Revolution. He was elected deputy of Perpignan in 1831, and was re-elected several times thereafter. He sat in French

Parliament, where he played a very active role as a consistent republican, ferociously opposing Napoleon and Louis-Napoleon Bonaparte as Napoleon III. With others, he led the promulgation of a law that abolished colonial slavery in 1848. He was the 25th Prime Minister of France, holding the office for a very short period in 1848. The fact that so many boulevards and places in France are named after Arago is probably more a recognition of his political role as a staunch republican than of his scientific contributions. However, there is no doubt that the man had an enormous range of talents and appeal. His political engagement was not unique for his time, but his dual career in French politics and in 19th-century science was remarkable and quite successful. He was indeed a "generous" man.

François Arago is remarkable by the number and wealth of illustrations (drawings, documents, paintings, and photographs). They illustrate vividly the stunning range of apparatus built during the 19th century to measure new phenomena or to test the reality or predictions of new theories.

The book also presents a frank assessment of the sometime chauvinistic, protectionist, and isolationist currents of some French scientists of that era. The weaknesses of French science of the period are attributed to political and sociological issues, such as the inability of French astronomers to enroll the best opticians to build the telescopes they needed. Instead, the great discoveries of the 20th century were made in Germany, Great Britain, and the United States.

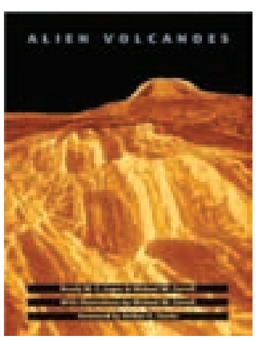
For readers interested in the origins of so many fundamental concepts and tools of modern science, *François Arago* is a gold mine.

James Lequeux is a world-known French astrophysicist whose field of research is the interstellar medium. He was the Chief Editor of the European journal *Astronomy & Astrophysics* for several years. This recent work is part of the EDP Sciences collections *Sciences & Histoire* that offers several titles on the history of French science.

— Jean-René Roy

Jean-René Roy is Deputy Director and Head of Science for the Gemini Observatory, and works and lives in La Serena, Chile.

Alien Volcanoes, by Rosaly M.C. Lopes and Michael W. Carroll (with an Introduction by Arthur C. Clarke), pages 152, 22 cm × 28 cm, Johns Hopkins University Press, 2008. Price $29.95 US hardcover (ISBN-13 978-0801886737).



Alien Volcanoes is a captivating text. It is aimed at the non-expert and assumes little knowledge of geology, planetary science, or volcanology. Nevertheless, there is enough information to enchant the specialist, not the least because of its coverage of cryovolcanism on extraterrestrial planetary bodies, a subject with which most geologists are unfamiliar.

There are eight chapters, the first two dealing with Earth's volcanoes and their historic significance (Chapter 1), followed by an informative introduction to the main volcano types (Chapter 2). After this relatively conventional opening, the book departs from being what could have been another coffee-table adornment by venturing beyond Earth in a journey across our Solar System. The voyage has been facilitated by technology and the prowess of orbiters and their ability to explore beyond our planet. The facilitators include *Magellan, Venera, Mariner, Voyager 1 and 2,* and *Cassini*, to name but a few, all successful space and planetary probes that yielded amazing data. They have revealed volcanoes on the active, or recently active, terrestrial planets, Venus and Mars (covered in Chapter 3), and volcanoes on the so-called "dead" terrestrial planets, the Moon and Mercury (Chapter 4). The next two chapters consider the numerous moons of the giant gas planets, namely Jupiter's Galilean satellites, Io (Chapter 5) and Europa (Chapter 6), the latter with its exotic cryomagmatism and potential links to submarine volcanic activity on Earth, Uranus's Miranda and evidence of past cryovolcanism, and Saturn's largest moon, Titan (which is larger than Mercury) and its putative ice magmatism. Chapter 7 describes Neptune's moon, Triton, with its nitrogen-based sublimation, melting, and freezing processes, and Saturn's tiny (500-km diameter) moon, Enceladus, which exhibits geyserlike plumes of icy water and ammonia blasting hundreds of kilometres into space.

Much of the text reveals the truly dynamic nature of our Solar System, exhibiting volcanic activity based on materials unfamiliar to most geologists, such as light-element ices and their liquids. Chapter 8 concludes with a short appraisal of space, volcanoes, and culture, with reference to the mythology of societies that live side-by-side with active volcanoes (*e.g.* Hawaii, Nicaragua, Java, Japan) and the associated advantages (bathing in hot springs) and risks of living in volcanic neighbourhoods.

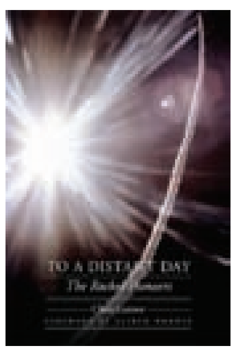
The book not only introduces the layperson to volcanism in our Solar System by its writing, but also illustrates volcanoes through a plethora of images — some photographic and others created by artists. Co-author Michael Carroll has drawn numerous scenes of planetary surfaces and perspectives unfamiliar to Earth-bound readers. The colour artwork is inspiring; it makes us think about being human observers on other planets. One image illustrates a future astronaut standing on the surface of Titan based on Arthur C. Clarke's book *Imperial Earth*. The notion of humans exploring an alien planet is an important one — the prospect of occupying and functioning in an unknown place is part of how we understand, familiarize, and interact with the material world — how we become "one" with it. Until humans go to other planetary bodies again, we must rely on robots to be our proxies. In the meanwhile, *Alien Volcanoes* allows us to imagine what it might be like to visit such exotic places, many of which appear both hostile and strangely beautiful. It also makes us appreciate that volcanoes need not be made from magma that is hotter than 1000 °C (typical for liquid rocks on Earth), but also from phase changes in nitrogen, methane, and water. As the authors state on page 125, "Nothing is more exciting to a planetary volcanologist than the discovery of active volcanism on another world."

Alien Volcanoes will appeal to people interested in the natural realm, in volcanoes and planetary exploration. Astronomers will get a close-up view of the planetary surfaces that they glimpse afar through their telescopes. It will also be attractive to those who are curious about places beyond our own and how such worlds may appear to the human visitor. At $29.95 US, the book is very good value, especially with its glossy paper and fine artwork. I recommend it!

— John Spray

John Spray is Director of the Planetary and Space Science Centre at the University of New Brunswick, where he holds a Tier 1 Canada Research Chair in Planetary Materials. He manages a research team of 14 staff and students focusing on high-strain-rate processes, including frictional melting, shock processes, and impact-cratering mechanics.

To a Distant Day: The Rocket Pioneers, by Chris Gainor (Foreword by Alfred Worden), pages 264, 15 cm × 23 cm, University of Nebraska Press, 2008. Price $29.95 US hardcover (ISBN-13: 978-0-8032-2209-0).



Chris Gainor, a historian and science writer, presents a captivating history of the pioneers of rocketry in his book *To a Distant Day*. The overall scope of the book is quite broad, as it begins with the early Greeks and ends with the launch of *Apollo 11*'s mission to the Moon. However, the main focus of the book is the time period between the 1920s and the first manned orbit by the Soviet cosmonaut Gagarin in 1961. In the preface, Gainor invites the reader to consider how human curiosity, historical events, and social forces shaped developments in space exploration.

The book does not disappoint. *To a Distant Day* is not simply about scientific and technical developments. It provides insight into the social and political context of the early rocket pioneers and how progress emerged amidst competing egos, political pressures, and technical challenges.

The first chapter is a quick introduction to the history of rocketry. It begins with the musings of the early Greek astronomers who, despite being bound to the Earth, set out to make sense of our place in the Cosmos. Gainor emphasizes that it was this intellectual curiosity that in many ways set the course for humanity's journey into space. The text goes on to describe how that curiosity was captured by the science-fiction writers of the 19th and 20th centuries, and used to inspire the imaginations of the public; that inspiration in turn garnered public support for rocket research. But human history is not all glorious, and a recurring theme is introduced here — that it was the need for better weaponry that spurred the research and development of rockets. The first chapter ends with a brief description of the rôle that rockets played in conflicts from the 13th to the 19th centuries.

Chapters 2 through 5 discuss the work of Russian, American, and German rocketeers in the early 20th century. Chapter 2 is a look at the birth of Soviet astronautics, and covers in detail the lives of four predominant rocketeers: Tsiolkovsky, Kondratyuk, Tsander, and Korolev. Gainor commands a scholarly understanding of this part of Soviet history. The book does an excellent job portraying the complexities of life in early Soviet Russia, and demonstrates in a very captivating way, how political intrigue influenced and shaped the lives of the four rocketeers and the course of the Soviet space program. Chapter 3 is about American-born rocketeer Robert Goddard. Chapters 4 and 5 are about the work of German rocketeers Hermann Oberth, Wernher Von Braun, and Walter Dornberger. Chapter 5 covers the era around World War II and its impact on the lives of German rocketeers. The presentation does an excellent job of demonstrating how the defeat of Germany and the post-war manoeuvring of the Soviets and Americans altered the path of their respective astronautics programs.

Chapters 6 through 11 take us from the end of World War II to the launch of the first manned space flight in 1961. World War II clearly marked a decisive shift in the way rocket research was done. Despite the fact that they shared a common goal — human space flight — many of the early rocket pioneers worked in isolation, driven by personal aspirations. Situations changed, though, with the advent of the Cold War, when research and development became much more collective and institutionalized efforts. Political forces and institutional structures had a strong influence on both Soviet and American attempts to send humans to space.

A broad view is taken in these six chapters. As emphasized here, human space flight is not just about rockets; rockets are obviously important, but they are not the whole story. A lot of work had to be done to understand the effects of acceleration forces and the impact of high altitudes on living creatures. Quite a bit of time is spent discussing the first jet test flights, high-altitude balloon flights, and high-altitude parachute jumps.

Chapter 11 ends with the successful launch of Gagarin into space, a day where humankind's dream to reach space was finally realized. The book itself ends with a brief epilogue on the launch of *Apollo 11* on 1969 July 16. It is a fitting end to the book, and succinctly summarizes and ties together the lives of the many pioneers who made the journey to the Moon possible.

To a Distant Day is insightful, instructive, and definitely worth the read. Although it is sufficiently detailed in both history and science, the book does not get bogged down in details, and manages to keep thoughts moving sufficiently enough to maintain readers' interests. It is easily accessible to the general reader.

— Greg Andres

Greg Andres is a part-time philosophy professor at the University of Western Ontario. He has been a member of the RASC since 2008.

Society News

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

With all the action at and around National Office at the end of last year and the beginning of 2009, these past few weeks have had a truly calm feeling about them — no startling news at all! How nice! Executive Secretary Jo Taylor and Randall Rosenfeld, our Archivist, have busily unpacked boxes, putting our archives into a permanent spot at the new digs on Dundas Street West. Thanks to them both for all the hard work!

Our Membership and Publications Clerk, Francis Knowles, found a better offer — in his chosen field of aerospace engineering. So we bade him farewell, knowing that he is going on to bigger and better things.

We're almost halfway through IYA2009 as I write this, and we are approaching halfway to our goal of one million people putting their eyes to an eyepiece. The on-line counter at the IYA Web site displays over 458,000 such Galileo Moments! Congratulations to all who are helping make this our year to shine — in more ways than one. Make sure you get out under the skies this summer, and be sure to take a newcomer with you to show them their own Galileo Moment — celebrate IYA2009!

Astrocryptic

by Curt Nason

The Solution to last issue's puzzle

N	E	B	U	L	A	E		P	O	R	E	S
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K	O	N	I	G		W	H	I	P	P	L	E
E		N		H		A		M		E		F
D	I	O	P	T	E	R		A	R	S	I	A
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U				E		A				E		
B	R	A	G	G		R	O	S	E	T	T	E
B		L		U		N		A		I		V
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E		H		U		R		O		L		N
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Great Images

The August JRASC is the right issue to show off a picture of summer's M17, and Stuart Heggie's contribution is a fitting way to do it. Stuart used an STL11000 camera with a Takahashi FSQ F/5 Astrograph from Flesherton, Ontario, under excellent conditions on August 1 last year. The photo is composed from 3x20 minutes of Hα and 5x5 minutes per channel in RGB. Messier 17 (M17, NGC 6618), goes by a variety of names: the Omega Nebula, the Swan Nebula, the Horseshoe Nebula, or (especially in the southern hemisphere) the Lobster Nebula. It is a region of star formation that shines by excited emission, energized by the ultraviolet radiation of young nearby stars.