FEATURING A FULL COLOUR SECTION!

April / avril 2008 Volume/volume 102 Number/numéro 2 [729]

Journal

The Journal of the Royal Astronomical Society of Canada

Le Journal de la Société royale d'astronomie du Canada

INSIDE THIS ISSUE

Abstracts from the Planetary Science Research Symposium

Aboriginal Canadian Sky Lore of the Big Dipper

Building for the International Year of Astronomy (IYA2009)

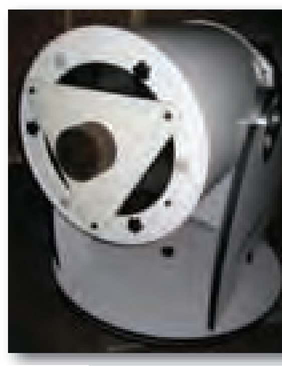
April / avril 2008
Journal
Vol. 102, No. 2 Whole Number 729

contents
table des matières

RESEARCH PAPERS/ ARTICLES DE RECHERCHE

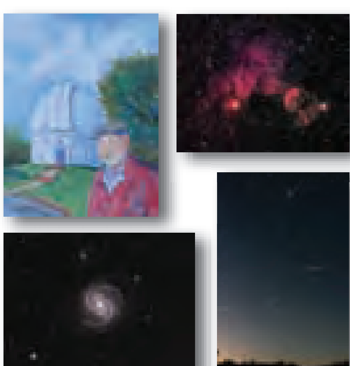
FEATURE ARTICLES / ARTICLES DE FOND

Aboriginal Canadian Sky Lore
p. 59

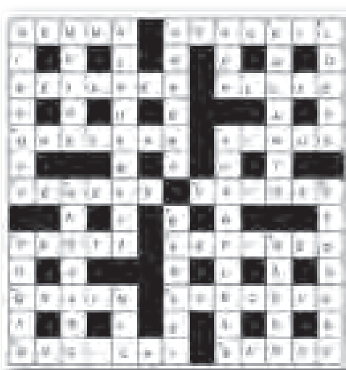


Gizmos
p. 71

A Moment With...
Dr. James Hesser
p. 61



Pen & Pixel
p. 66



Astrocryptic Answers
p. 84

Attend the 2008 GA
p. 86

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

DEPARTMENTS

Cover photo:
Pierre Tremblay's photo of M81 graces our cover this month. The photo was taken using a Takahashi TOA150 at 1000 mm on a Paramount mounting. Exposure is 6 x 180 seconds for each of R, G, and B filters and 14 x 300 seconds in L using an SBIG STL-11k camera. M81, in Ursa Major, is well known to RASC members, along with its nearby companion, M82.

COLUMNS

News Notes

Compiled by Martin Beech (beechm@uregina.ca) and Orla Aaquist (AaquistO@macewan.ca)

Arecibo, Alive and Kicking?

Last September, the Washington Post informed us that the largest and most sensitive radio telescope on Earth would have to close if it could not find outside funding for half of its already reduced $8 million budget in the next three years. When I first encountered this bit of news, my first thought was that perhaps the Royal Astronomical Society of Canada could get a proposal together to save the Arecibo Observatory. Then I remembered that none of the RASC Centres, except Edmonton, has any money, so I put the thought aside. Two months later, we were told that U of T was thinking of closing the David Dunlap Observatory. Apparently, the RASC loves the DDO, because a call went out to Canadian amateur astronomers to help save this historic observatory. The possible demolition of the DDO has been in the RASC news circles ever since and probably by the time that this publication of *JRASC* gets downloaded on your computer we will have learned of its fate. But what about the fate of Arecibo and the National Astronomy and Ionosphere Center, NAIC?

Until I visited Dr. Russ Taylor at the University of Calgary last December, I had completely forgotten about the possible closure of this outpost of radio astronomy. Russ told me about a project, in which he was involved, to use the Arecibo telescope in conjunction with something called ALFA to carry out a survey of the sky visible from Puerto Rico. I gathered from Russ that ALFA refers to a new Arecibo L-band Feed Array, which is a cluster of seven cooled dual-polarization feeds that will allow large-scale full-stokes spectro-polarimetric studies of the sky with unprecedented sensitivity. I know that some of you would have preferred ALFA to have been a new healthy type of Swedish dog food, but a few of our hard-core readers will have just received a significant adrenalin rush and will want to read the above sentence a few times before continuing.

In the past, use of the Arecibo telescope as a survey instrument has been limited by the relatively small field of view in a single observation, but ALFA, with its seven feeds, has a much larger field of view. This new system will have a broad appeal within the astronomical community and it is hoped that it will drive research at Arecibo for the next 10 to 15 years. So, under the threat of reduced funding, scientists convened in Washington on 2007 September 12 and 13, to identify key science that is possible with the new system and hopefully to get the National Science Foundation to reconsider their extreme budget cuts. A summary of this meeting is posted in the *NAIC Newsletter #42*. According to this newsletter "much

Journal

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

The *Journal of The Royal Astronomical Society of Canada* is published at an annual subscription rate of $80.00 by The Royal Astronomical Society of Canada. Membership, which includes the publications (for personal use), is open to anyone interested in astronomy. Applications for subscriptions to the *Journal* or membership in the RASC, and information on how to acquire back issues of the *Journal* can be obtained from:

The Royal Astronomical Society of Canada
136 Dupont St
Toronto ON M5R 1V2, Canada
Internet: nationaloffice@rasc.ca
Web site: www.rasc.ca
Telephone: (416) 924-7973
Fax: (416) 924-2911

Canadian Publications Mail Registration No. 09818
Canada Post: Send address changes to 136 Dupont St, Toronto ON M5R 1V2
Canada Post Publication Agreement No. 40069313

We acknowledge the financial support of the Government of Canada, through the Publications Assistance Program (PAP), toward our mailing costs.

U.S. POSTMASTER: Send address changes to IMS of NY, PO Box 1518, Champlain NY 12919. U.S. Periodicals Registration Number 010-751.
Periodicals postage paid at Champlain NY and additional mailing offices.
The *Journal* is printed on recycled stock.

of the identified science builds on the large-scale surveys currently being done with the Arecibo L-band Feed Array (ALFA). These include (1) a pulsar survey that is sensitive to compact relativistic binary pulsars and millisecond pulsars; (2) surveys for extragalactic hydrogen that are determining the HI mass function in the local Universe among many other results; (3) galactic surveys of hydrogen to probe turbulence in the interstellar medium; (4) Faraday tomography of galactic and extragalactic magnetic fields; and (5) SETI." Taylor, at the U of C, is involved with a survey of galactic magnetic fields dubbed the GALFA Continuum Transit Survey (GALFACTS). This is a five-year project, which "promises a transformational advance in our understanding of the magnetic field of the Milky Way and to serve as a 'pathfinder' to the Square Kilometre Array (SKA) in the area of cosmic magnetism."

NAIC still has lots of hurdles to overcome, but progress is being made. The outcome of the US National Science Foundation's ten-year review process in 2010 will be central to the future of Arecibo, but for now it looks like the professionals do not need the help of the RASC, so we can focus our efforts on saving the DDO.

References

1. `www.naic.edu/alfa/`
2. `www.naic.edu/~ehowell/newslet/dec2007/Newsletter42-shortened.pdf`
3. `www.ucalgary.ca/ras/GALFACTS/`

Figure 1 — The newly painted Arecibo telescope receiver platform housing ALFA. Image from *NAIC Newsletter # 42*.

Stars with Pure Carbon Atmospheres

Astronomers have discovered white dwarf stars with pure carbon atmospheres. The stars are possibly part of a previously unknown sequence of stellar evolution. They may have evolved from stars that are not quite massive enough to explode as supernovae but are just on the borderline. All but the most massive two or three percent of stars eventually die as white dwarfs rather than explode as supernovae.

When a star burns helium, it leaves "ashes" of carbon and oxygen. When its nuclear fuel is exhausted, the star then dies to become a white dwarf. Astronomers believe that most white dwarf stars have a core made of carbon and oxygen, which is hidden from view by a surrounding atmosphere of hydrogen or helium. They didn't expect, therefore, to find stars with carbon atmospheres. "We've found stars with no detectable traces of helium and hydrogen in their atmospheres," said University of Arizona Steward Observatory astronomer Patrick Dufour. "We might actually be observing directly a bare stellar core. We possibly have a window on what used to be the star's nuclear furnace and are seeing the ashes of the nuclear reaction that once took place."

Dufour, along with James Liebert (Université de Montréal) and colleagues at the Paris Observatory, published the results in the November 22 issue of *Nature*. The stars were discovered among 10,000 new white-dwarf stars found in the Sloan Digital Sky Survey. The survey, known as the SDSS, found about four times as many white-dwarf stars as previously known. Liebert identified a few dozen of the newfound stars as DQ white dwarfs in 2003. When observed in optical light, DQ stars appear to be mostly helium and carbon. Astronomers believe that convection in the helium zone dredges up carbon from the star's carbon-oxygen core.

Dufour developed a model to analyze the atmospheres of DQ stars as part of his doctoral research at the Université de Montréal. His model simulated cool DQ stars — stars at temperatures between 5000 and 12,000 K. For reference, our Sun's surface temperature is around 5780 K. When Dufour joined Steward Observatory in January, he updated his code to analyze hotter stars, stars as hot as 24,000 K. "When I first started modeling the atmospheres of these hotter DQ stars, my first thought was that these are helium-rich stars with traces of carbon, just like the cooler ones," Dufour said. "But as I started analyzing the stars with the higher temperature model, I realized that even if I increased the carbon abundance, the model still didn't agree with the SDSS data." In May 2007, "out of pure desperation, I decided to try modeling a pure-carbon atmosphere. It worked," Dufour added. "I found that if I calculated a pure carbon atmosphere model, it reproduces the

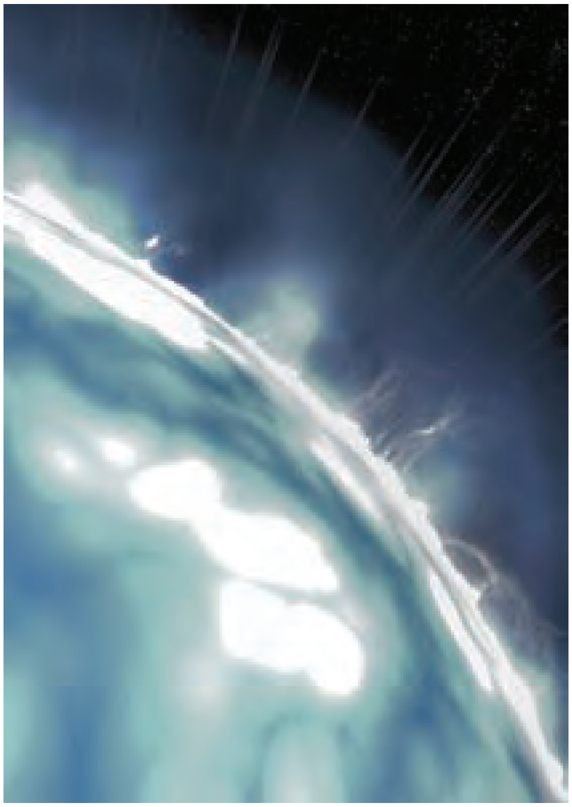


Figure 2 — A high-resolution, artistic representation of the surface of H1504+64.

spectra exactly as observed."

The great mystery is why these carbon-atmosphere stars are found only between about 18,000 and 23,000 K. "These stars are too hot to be explained by the standard convective dredge-up scenario, so there must be another explanation," Dufour noted. The stars might have evolved from a star like the unique, much hotter star called H1504+65 that Pennsylvania State University astronomer John A. Nousek, Liebert, and others reported in 1986. If so, carbon-atmosphere stars represent a previously unknown sequence of stellar evolution. H1504+65 is a very massive star at 200,000 K. Astronomers currently suggest this star somehow violently expelled all its hydrogen and all but a very small trace of its helium, leaving an essentially bare stellar nucleus with a surface of 50 percent carbon and 50 percent oxygen. "We think that when a star like H1504+65 cools, it eventually becomes like the pure-carbon stars," comments Dufour. As the massive star cools, gravity separates carbon, oxygen, and trace helium. Above 25,000 K, the trace helium rises to the top, forming a thin layer above the much more massive carbon envelope, effectively disguising the star as a helium-atmosphere white dwarf. This being said, between 18,000 and 23,000 K, convection in the carbon zone probably dilutes the thin helium layer. At these temperatures, oxygen, which is heavier than carbon, has probably sunk too deep to be dredged to the surface.

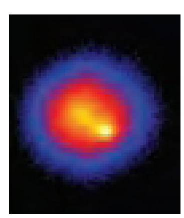
Dufour and his colleagues say that models of stars 9 to 11 solar masses might explain their peculiar carbon stars. Indeed, the numerical models predict that stars 9 to 10 times as massive as our Sun will become white dwarfs with oxygen-magnesium-neon cores and mostly carbon-oxygen atmospheres. More massive stars explode as supernovae. But scientists aren't sure where the dividing line is, whether stars 8, 9, 10, or 11 times as massive as our Sun are required to create supernovae. "We don't know if these carbon atmosphere stars are the result of 9 or 10 solar-mass star evolution, which is a key question," Liebert said.

The UA astronomers plan making new observations of the carbon-atmosphere stars at the 6.5-metre MMT Observatory on Mount Hopkins, Arizona in December to better pinpoint the stellar masses. The observations could help define the mass limit for stars dying as white dwarfs or dying as supernovae.

A Short Tail for 17p/Holmes

The recent brightening of Comet Holmes has spurred a frenzy of observations both by amateur and professional astronomers alike. All these observations reveal a tailless, round, yellowish fuzzball in the constellation Perseus. Near-infrared images of Comet 17/P Holmes, obtained with the 1.6-m Ritchey-Chrétien telescope at Mont Mégantic Observatory, indicate a small tail-like feature next to the comet's head (figures 3 and 4). The images were obtained by graduate student Sandie Bouchard and night assistant Bernard Malenfant on the morning of 2007 October 26, using SIMON, a Near Infrared Polarimetric Imager.

A preliminary analysis performed by astronomers Pierre Bastien and René Doyon from Université de Montréal and the Centre de recherche en astrophysique du Québec clearly shows a bright elongated feature surrounding the more luminous comet's coma. This elongated feature, probably a cloud of dust and gas, which resembles a small tail, is going out at a position angle of 215 degrees (+/- 5 deg), measured from north and going east. This direction makes an angle of about 33 degrees relative to the Sun-comet direction. Although the images display tantalizing evidence of a tail, the direction of the feature does not point directly in the direction opposite to the Sun, as expected.



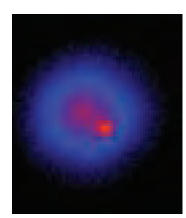


Figure 3 (left) — Comet 17P/Holmes image taken with an I filter on 2007 October 26 at 04:37 edt (08:37 UTC)

Figure 4 (right) — Comet 17P/Holmes image taken with a J filter taken on 2007 October 26 at 04:10 EDT (08:10 UTC).

Research papers
Articles de researche

Abstracts from the Planetary Science Research Symposium 2007

University of Western Ontario, 2007 November 9

Convened by Phil J. A. McCausland and Peter G. Brown, Department of Physics and Astronomy, University of Western Ontario

The L5 Shelburne Meteorite, Revisited. Howard Plotkin[1] and Phil J.A. McCausland[2] [1]Dept. of Philosophy, U. of Western Ontario, London ON N6A 3K7 (*hplotkin@rogers.com*); [2]Dept. of Earth Sciences, U. of Western Ontario, London ON N6A 5B7 (*pmccausl@uwo.ca*).

Rationale: The century-old Shelburne L5 chondrite fall [1,2] is being reinvestigated as part of a program to revisit Canadian meteorite falls to further understand fall circumstances and the recovery and distribution of fragments, and to refine and expand the meteorite description where warranted [*e.g.* 3,4]. An added benefit is the opportunity to engage public interest in community history and in the study of meteorites.

Shelburne Fall: The Shelburne meteorite fell on the night of 1904 August 13. Its fireball was widely seen and reported by nineteen observers from well-distributed locations up to 140 km from Shelburne [1]. Two fragments were soon recovered just north of Shelburne — a 5.6-kg fragment that fell less than a metre from John Shields' farmhouse and a 12.6-kg fragment that fell in Thomas Johnston's oat field. Local observers of the fireball reported it to have had several explosions, so there was widespread belief that other fragments probably existed. None, however, were known to have been found [1,2].

Present Investigation: Our reinvestigation of the Shelburne meteorite involved a reassessment of contemporary accounts of the fall event, public outreach, visits to potential Shelburne fragment owners, and limited ground searching of the fall area. Following an archival study at the Dufferin County Museum and Archives, we prompted newspapers in Shelburne and Orangeville to publish stories of the fall and recovery of the meteorite, noting its recognizable appearance and the possibility of additional fragments having fallen on nearby farms. An invitation to readers to contact us drew more than a dozen responses. We went to Shelburne and met with 18 persons to examine their specimens. We met some at their farms, but most in a public event organized at the Dufferin County Museum and Archives. Our efforts resulted in the identification of one 29-g Shelburne sliced fragment belonging to the grand-niece of John Shields; she also possessed a Field Museum cast of the entire original 5.6-kg Shields specimen studied by Farrington [2]. On a subsequent visit to the Shelburne fall area, we unsuccessfully searched several farmers' rock piles, rock walls, gardens, and ~3 hectares of a cedar bog where a fragment was anecdotally said to have fallen.

Discussion: Most notably, our experience in this study contrasts with our reinvestigation of the 1939 Dresden meteorite fall [3,4] in that the Shelburne fall no longer exists in living memory and entire groups of families (such as the Johnstons) are no longer resident in the area so that the local history has been lost. In addition, the possibility of recovering new fragments from the Shelburne fall area is remote after a century of exposure. We are currently attempting to identify the fate of the Johnston 12.6-kg fragment, which was studied by Borgstrom [1] but is not now substantially present in the Queen's University collection.

Acknowledgements: Our Shelburne study was initiated at the suggestion of Ian Nicklin (Royal Ontario Museum), who also participated in our field searching. We also thank Roberta Flemming for field assistance and Wayne Townsend, the Director of the Dufferin County Museum and Archives, for archival assistance and for kindly hosting our public meteorite event.

References:

[1] Borgstrom, L.H. 1904, JRASC **2,** 69
[2] Farrington, O.C. 1906, Field Columbian Mus. Publ. **109,** 7
[3] Plotkin, H. 2006, JRASC **100,** 64-73
[4] McCausland *et al.* 2006, JRASC **100,** 104-113

A Very Bright Yet Non-Productive Fireball. M. Connors[1], C. Herd[2] [1]AUGO, Athabasca University, Athabasca AB T9S 3A3 (*martinc@athabascau.ca*); [2]Dept. of Earth and Atmospheric Sciences, U. of Alberta, Edmonton, Alta.

Figure 1 — Image captured near the time of the terminal burst of the 2007 May 25 Alberta fireball. This image was taken by a Sandia mirror camera about 75 km (horizontally) from the fireball and shows the shadow of the mirror at the top. The sky is completely saturated. To the left the horizon is visible as a curved line partly inside a box drawn by the motion-detection software. Dirt on the mirror is near the centre of this box. This fireball resulted in near-daylight illumination in some regions north of Edmonton.

Introduction: An extremely bright fireball event took place on 2007 May 25 at 01:07 MDT (07:07 UT), with numerous witnesses throughout Alberta. A camera monitoring for fireballs at Athabasca University triggered during the event; one in Edmonton did not. Trigonometric results were nonetheless obtained through novel use of fireball shadows on proximal security cameras. Despite the brilliance of the fireball, the relatively small search area indicated by the optical solutions, and numerous visits to the inferred fall region near Legal, Alta, no proximal witnesses were located, nor proximal phenomena reliably reported, and no meteorites have been found.

Methods: Athabasca University, at the time of the event, was running a tested Sandia mirror camera with automated detection [1], an upward looking all-sky lens system under test, both in Athabasca, Alta, and a tested mirror camera in Edmonton. Of these, the tested system at Athabasca responded to this very bright event by capturing 7 images over 3 seconds. Some of these were almost completely saturated and showed the shadow of the mirror on the surroundings. The apparent track of the meteor was burned temporarily into the cathode. The system under test captured only one frame near the end of the event. The Edmonton system appeared to have been rendered inoperative due to a power failure. A continuous recording system about 600 km east, in

Saskatoon, also captured the event. Since these data were not suitable for trigonometric reduction, the region was visited to search for other video evidence. Although a number of recording systems were found to have recorded the flash, only one in Redwater, Alta, nearly below the brightest point in the trajectory, had extremely clear shadows, apparently through a break in patchy cloud in the region at the time. A fall region NE of the town of Legal, Alta. was determined. Despite extensive canvassing and distribution of information, no reports indicating an actual fall were obtained (although some were suggestive of fragments remaining after the terminal burst). No systematic search was carried out, and no meteorites were subsequently found.

Discussion: In practical terms, this event showed that automated meteor cameras can detect bright events [2], although with the minimal funding available, the Athabasca network has deteriorated to the point of having only one reliable camera. The use of security cameras to quantitatively analyze shadow phenomena is likely to be more important in the future as these systems become more widespread. It is difficult to assess from current data whether meteorites were actually produced from this anomalously bright event, or if the terminal burst resulted in total destruction of the incoming object.

Acknowledgements: We thank local volunteers and store/gas station owners, and A.R. Hildebrand for invaluable field work and data reduction. MC's research on this topic is supported by Athabasca University and the CRC program.

References:

[1] Connors, M. *et al.* 2003, JRASC **97,** 271-276
[2] Connors, M. *et al.* 2005, JRASC **99,** 14-22

Using the Atlantic All-Sky Cameras System to Enhance Space Science Delivery in New Brunswick Schools.

J. Whitehead[1] and P. Pheeney[2] [1]Sci. and Tech. Studies, St Thomas Univ., Fredericton NB E3B 5G3[2] Dept. Education, St Thomas Univ., Fredericton NB E3B 5G3

Introduction: Unusual celestial events, like fireballs, often generate interest from the public when observed. Children are similarly inspired to take a greater interest in the night sky when they realize it is not merely a static frame of stars with no dynamic events. We are capitalizing on the New Brunswick all-sky camera system's (Table 1) ability to capture and archive some of these dynamic events to generate an interest in space studies. This is inspired by a Denver Museum of Science and Nature program in Colorado, where state schools operate and process data from a network of cameras [1].

Camera	Latitude/Longitude	Status	Operator
Fredericton	45.949N 66.646W	Online	J. Whitehead
Saint John	45.266N 66.050W	Online	P. Backmann
Miramichi	47.016N 65.553W	CoL Nov 2007	J. Whitehead
Halifax	44.631N 63.581W	Online	M. Hiland

Table 1. All sky cameras in New Brunswick. CoL = coming online

Curriculum: The science content that must be delivered by schools in New Brunswick is defined in the Atlantic Canada Science Curriculum document [2]. The curriculum is based on clearly defined science "outcomes," which are basic skills and knowledge that the student must achieve. Elements of Space Science appear in both Grades 6 and 9. In many cases at these grade levels, teachers do not have the basic science backgrounds to confidently deliver inspiring and well-founded exercises that meet these outcomes. We are addressing this need by 1) tasking future teachers in the B. Ed. programme at St. Thomas to produce exercise worksheets that can be used by teachers in the classroom, and 2) creating links between specific schools and fireball monitoring using the all-sky cameras.

Worksheets: The primary goal of the teacher worksheets is to provide teachers with exercises that can fulfil specific outcome needs. Where appropriate, the B. Ed. students were challenged to include reference to meteorites, fireballs, or related aspects that can be used to create a framework in which students can understand fireball tracking (*e.g.* constellation recognition). The worksheets comprise a student question sheet and a teacher's guide with solutions. We aim to make final versions of these worksheets available to schools via the Web site of Science East, the provincial science outreach organization (`www.scienceeast.ca`).

All-Sky Cameras and Schools: Pilot schools will take on primary responsibility for accessing the nightly camera records via remote desktop access. They will delete non-meteor/non-fireball events and post those remaining to a Web site that other schools in the province can monitor. Events caught by several cameras will then be clearly identifiable. The camera software (UFO Capture) produces a thumbnail, a video, a light-intensity map (defining bright visible stars), and a data file. The star maps are used to define trajectories for individual events. Building upon the framework of knowledge established by the worksheets, 3-D sky tracks and potential meteorite fall sites for fireballs can be identified for events caught by several cameras (Access date: 2007 October 21).

Acknowledgements: Funding for the camera was provided by the Association of Professional Engineers and Geoscientists of NB.

References:

[1] Caldwell, A. 2005, The Science Teacher, **72,** 47-49
[2] Atlantic Canada Science Curriculum 2002, `www.gnb.ca/0000/anglophone-e.asp#cd` (Access date: 2007 October 21)

The Carancas Peru Meteorite Crater. P. Brown[1], E.A. Sukara[1], D.W. Eaton[2], W.N. Edwards[3] D.O. ReVelle[4] P.J.A. McCausland[3] [1]Dept. of Physics and Astronomy, U. of Western Ontario, London ON N6A 3K7 (*pbrown@uwo.ca*); [2]Dept of Geoscience, U. of Calgary, 2500 University Drive NW, Calgary AB T2N 1N4; [3]Dept. of Earth Sciences, U. of Western Ontario, London ON N6A 5B7; [4]Atmospheric, Climate and Environmental Dynamics Group, EES-2, Los Alamos National Laboratory, PO Box 1663 MS D401, Los Alamos NM 87545, USA.

Figure 2: A 7-g fragment of the Carancas meteorite (with 1.2-cm scale cube). Carancas is an H4-5 ordinary chondrite, but with spectacularly developed dark shock-melt veins.

Introduction: A widely observed fireball was seen from south-eastern Peru and western Bolivia on 2007 September 15 near 16:45 UTC. Immediately following this fireball, a 13.5-m penetration crater was witnessed to have formed near Carancas, Peru at 16.665° S, 69.045° W [1]. Subsequent reports noted steam rising from the crater for some minutes after the impact, debris having been ejected more than 100m from the crater, windows shattered 1 km from the crater site and a sulphurous smell reported by local residents [1]. Media reports indicated many villagers became sick shortly after the impact event [2], but the cause and true scope of sickness remain unclear. Meteorite fragments provisionally typed as an H4-5 chondrite [3] were found surrounding the crater [4].

Fireball Kinematics and Energetics Analysis: Airwaves from this event were detected at infrasound stations in Bolivia and Paraguay and at least two seismic stations in Peru and Bolivia. Preliminary analysis of these data tentatively suggests that the fireball producing the impact crater emanated from a radiant with azimuth ~ 60°, altitude ~ 50°. Interpretation of the airwave information combined with numerical modeling of the entry/impact suggests the initial meteoroid had an entry velocity below 17 km/s and was initially ~10^4 kg in mass, corresponding to an object 1m in radius. The initial energy is estimated to be 0.15 – 0.4 kilotons TNT, with ~1% of this energy remaining to form the impact crater. Modeling also suggests that the impact velocity at the crater was hypersonic with a probable range from 1.5 – 3 km/s and that the very high altitude of the impact location (3.8 km) contributed to the substantial size of the crater by ensuring the meteoroid had not slowed substantially before impact.

Discussion: Recent examples of meteorite falls producing penetration craters include the Sikhote-Alin iron meteorite shower of 1947 [5], the Jilin chondrite fall of 1976 [6], the Sterlitamak iron of 1990 [7], and most recently the Kunya-Urgench chondrite in 1998 [8]. The Carancas crater, however, is the largest documented crater produced by an observed chondrite fall and is comparable to the largest penetration craters produced by the Sikhote-Alin fall. Based on impact scaling relations and comparisons to other events, we estimate that the impacting meteorite was 2-5 tonnes and a portion of this mass is likely buried at a depth > 5m in the SW corner beneath the existing flooded crater floor, most likely as a series of fragments rather than a single consolidated body.

References:

[1] Macedo, L. and Machare, J. 2007, The Carancas Meteorite Fall, 15 Sept. 2007 Official INGEMMET initial report.

[2] Carroll, R. 2007, *The Guardian UK,* September 18 "Peru meteorite crash causes mystery illness"

[3] Farmer, M., personal communication, 2007 October 15

[4] Blanco Cazas, M. 2007, "Informe Laboratorio de Rayos X — FRX-DRX"

[5] Krinov, E.L. 1966, *Giant Meteorites,* Pergamon Press, 395 pp

[6] Joint Investigation Group, Kirin meteorite shower 1977, Scientia Sinica, **20**: 502-512

[7] Petaev, M.I., Kisarev, Y.L., and four others 1991, LPI Conference Abstracts **22,** 1059

[8] Mukhamednazarov, S. 1999, *Astronomy Letters,* **25,** 117-118

Embedded Star Clusters and the Formation of the Oort Cloud III: Evolution of the Inner Cloud During the Galactic Phase. R. Brasser[1], M.J. Duncan[2], and H.F. Levison[3] [1]Dept. of Phys. Sciences, U. of Toronto at Scarborough, Toronto ON M1C 1A4 (*brasser_astro@yahoo.com*); [2]Dept. of Phys. & Astron., Queen's U., Kingston, Ont.; [3] Southwest Research Institute, Boulder, Col., USA.

Simulations have been performed where some of the inner Oort clouds of Brasser *et al.* (2006), generated while the Sun was in its embedded birth cluster, were resumed in the current galactic environment to determine whether or not the inner cloud (defined as comets having semi-major axis a<20,000 AU) can be heated sufficiently rapidly by passing galactic field stars to replenish the outer cloud.

Since visible Oort-cloud comets come directly from the outer cloud, a mass estimate exists only for the latter, with a lower limit of one Earth mass (Francis, 2005). Knowing the heating rate could therefore yield a mass estimate of the inner (unseen) cloud.

Results from numerical simulations performed show that the heating rate of comets starting in the inner cloud and ending up in the outer cloud is no more than about 10%. If one assumes that all or the majority of the mass of the outer cloud has come from the inner cloud, then a lowest estimate of the mass of the inner cloud is about 10 Earth masses, implying an unrealistic 100 Earth masses of the mass in solids scattered by Jupiter and Saturn from the primordial solar nebula.

This result implies that either Giant Molecular Cloud complexes play a much more important role in the evolution of the inner cloud than previously thought, or that the current Oort cloud is a result of a two-stage process.

Acknowledgements: RB and MJD acknowledge support from NSERC, while HFL is supported by NASA's Origins Programme.

References:

Brasser, R., Duncan, M.J., and Levison, H.F. 2006, Icarus **184,** 59-82

Francis, P.J. 2005, ApJ **635,** 1348-1361

Stellar Occultation as a Probe of the Kuiper Belt Size Distribution: Results from the Plaskett 1.8-m and Plans for a Micro-sat. J.J. Kavelaars[1], S.J. Bickerton[2], A. Scott[3] and D.L. Welch[4] [1]Herzberg Institute of Astrophysics, National Research Council of Canada, Victoria, B.C. (*jjk@hia.nrc.ca*); [2]Department of Astrophysical Sciences, Princeton University, Princeton, N.J., USA.; [3]COM-DEV, Cambridge, Ont.;[4] Department of Physics and Astronomy, McMaster University, Hamilton, Ont.

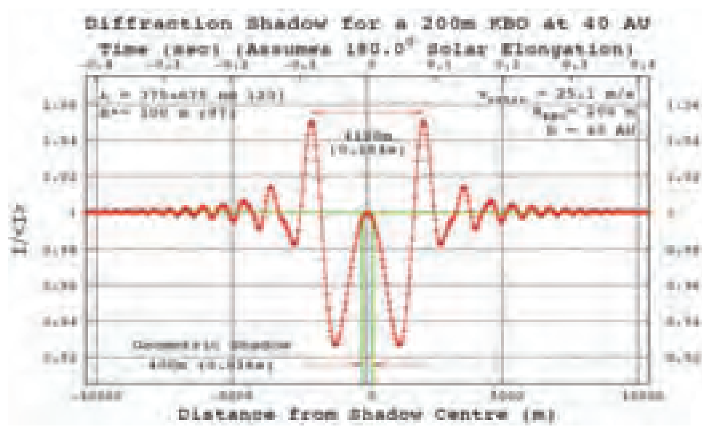


Figure 3 — Ideal observable diffraction pattern produced during a stellar occultation by a 400-m Kuiper Belt Object. Spacecraft-based monitoring of compact bright stars offers a unique opportunity to ascertain the population of sub-kilometre objects in the Kuiper Belt.

Introduction: Collision processes in the early Solar System produce small-body populations with size distributions that are functions of the strength of the member objects and formation/evolution environment [1]. For objects in the Kuiper belt, probing to the size range (~1km) where strength and collision processes are significant is not achievable using current facilities; the solar radiation reflected off a ~1-km object in the Kuiper belt is too faint to be detected using current ground-based facilities. We are exploring the use of serendipitous stellar occultation as a probe of the Kuiper belt small-body population.

Methods: The shadow created when a Kuiper belt object (KBO) at ~40AU passes across the line of sight to a star crosses the Earth at ~30 km/s. For objects of a few kms diameter, these shadow-crossing events will last ~1/20 of a second. Due to the geometry of the events, one does not observe a geometric occultation but instead a Fresnel diffraction event [2]. As the diffraction pattern sweeps across the telescope, one observes a time-series variation in the flux from the star. The structure of this time-series variation is determined by the circumstances of the occultation [angular size of the occulting KBO and the occulted star, distance to the KBO, wavelength of observations, *etc.*]

Discussion: Using the 1.8-m Plaskett telescope at DAO and a CCD imager specifically designed to operate at ~40Hz over a moderate field of view, we have monitored two stars for ~10 hours in an attempt to observe such occultation events. Our conclusion from this effort is, that due to scintillation effects (caused by Earth's atmosphere) and the inability to monitor a large group of stars (lack of FOV) for a long period of time (lack of a dedicated facility on clear a site), further ground-based occultation searches are unlikely to be successful [3].

We are now exploring the requirements for a space-based occultation facility in order to determine if a "micro-sat" platform is sufficient to provide a high likelihood for successful detection of occultation events. Such a facility would be a ~15-cm diameter mirror feeding a 2048 × 2048 hybridized-CMOS array focal plane with a 2 × 2 degree FOV. Such a facility could be used to monitor hundreds of compact bright stars at +40Hz sampling for extended periods of time, enabling the era of serendipitous stellar occultations as a probe of the structure of the Kuiper belt.

Acknowledgements: This research supported by fund from the Theodore Dunham Fund for Astrophysical Research, the National Research Council of Canada, and the Natural Science and Engineering Research Council of Canada.

References:

[1] Kenyon, S., Bromley, B.C., O'Brien, D.P., and Davis, D. 2007, in "The solar system beyond Neptune," 2007arXiv0704.0259K

[2] Roques, F. and Moncuquet, M. 2000, Icarus, **147,** 530

[3] Bickerton, S.J., Kavelaars, J.J., and Welch, D. 2007, AJ, *submitted*

CFEPS : The Canada-France Ecliptic Plane Survey of the Kuiper Belt's Orbital Structure. B. Gladman[1], J. Kavelaars[2], C. VanLaerhoven[1]. [1]Dept. of Physics and Astronomy, University of British Columbia, Vancouver, B.C.; [2]CADC, Hertzberg Institute, Victoria, B.C.

Introduction: The orbital distribution of trans-Neptunian objects (TNOs) in the Solar System's Kuiper Belt was sculpted by dynamic gravitational interactions with the growing giant planets as the latter formed. These small bodies thus preserve a dynamical signature to the violent dynamical processes that we now realize must have perturbed the outer Solar System.

The CFEPS survey: After a pre-survey study [1] that confirmed feasibility and tuned observational cadence, the "discovery portion" of the CFEPS survey ran on CFHT from early 2003 to mid-2005. During this period about 240 new TNOs were discovered. Orbital determination requires 3-5 years of additional observation to precisely measure the heliocentric orbital parameters. Except for the faintest 15% of the sample, we have tracked (up to fall 2007) essentially all of these discoveries. Although 200 TNOs is small compared to the roughly 1000 already in the Minor Planet Center database, only the CFEPS TNOs are coupled to a survey with an absolute photometric calibration, known pointing history and detection efficiency, along with a high tracking fraction.

Discussion: As of the time of writing, the 55 objects discovered in calendar year 2003 (the "L3" sample) have now been tracked long enough to provide quality orbits. Surprisingly, based on only this small sample, we already can present several new results [2] on the orbital structure of the Kuiper Belt: (1) The so-called "cold" (low inclination) component of the classical Kuiper belt is restricted to a small semimajor axis range (roughly 43-46 AU), (2) the Plutino population (in the 3:2 resonance) has no cold component, and thus its population is much larger than previously estimated, (3) it appears that all the resonant populations may share this lack of a low-inclination sub-population. The L4 release will roughly triple the statistics of the L3 release and should allow measurement of the total population of the classical belt's hot component, a better characterization on the internal distribution of the 3:2 resonance, and estimates of the relative populations of some of the resonances.

References:

[1] Jones, R.L., and 14 co-authors 2006, Icarus, **185,** 508-522.

[2] Kavelaars, J., and 18 co-authors 2007, Icarus, submitted.

Co-Orbital Motion in the Solar System. P.A. Wiegert[1], R, DeBoer[1], R. Brasser[2], M. Connors[3], [1]Dept. of Physics and Astronomy, U. of Western Ontario, London, Ont. (*pwiegert@uwo.ca*); [2]Dept. of Astronomy, U. Toronto, Toronto, Ont.; [3]Centre for Science, Athabasca U., Athabasca, Alta.

Introduction: An asteroid moving around the Sun having the same mean motion as a planet is in 1:1 mean-motion resonance, or in a "co-orbital" state because (in some loose sense) it shares the planet's orbit. The Trojan asteroids of Jupiter are perhaps the best-known examples of such motion. There are four known distinct types of co-orbital motion [1][2]. The conditions under which these can occur will be discussed and examples of recently discovered co-orbital objects in our own Solar System will be examined.

Methods: Asteroids were determined to be in a co-orbital state (or not) on the basis of simulations run with a Wisdom-Holman [3] style symplectic code that handles close encounters by the Chambers method [4]. The orbital elements were obtained from the AstDys (`http://hamilton.dm.unipi.it/cgi-bin/astdys/astibo`) and NeoDys (`http://newton.dm.unipi.it/cgi-bin/neodys/neoibo`) Web sites. The simulations included all the planets, Mercury through Neptune, as well as the three most massive asteroids, 1 Ceres, 2 Pallas, and 4 Vesta. All bodies were subject to their mutual gravitational perturbations, with the exception of the asteroids themselves. Owing to their small masses, they were treated as test particles, that is, they felt the gravitational influence of the massive bodies but did not influence them in return.

Discussion: We report that the recently discovered asteroid 2006 FV_{35} is a quasi-satellite of the Earth. As well, the newly christened "dwarf planet" Ceres has at least 16 co-orbital asteroids, four of which were previously reported [5]. The discovery of numerous co-orbitals of Ceres may influence models of near-Earth asteroid delivery since asteroids drifting into the co-orbital region of massive asteroids under Yarkovsky forces may have their evolution in semimajor axis overridden by the co-orbital resonance. Ceres and other large asteroids may thus present "co-orbital barriers" that (perhaps only temporarily) block the passage of other asteroids otherwise destined to escape. Determining whether this is the case will require very careful simulations of the Yarkovsky effect on asteroids in the vicinity of the larger members of the main belt.

Acknowledgements: This work was supported in part by the Natural Sciences and Engineering Research Council of Canada.

References:

[1] Wiegert, P., Innanen, K., and Mikkola, S. 1998, Astron. J, **115,** 2604

[2] Namouni, F., Christou, A., and Murray, C. 1999, Phys. Rev. Lett., **83,** 2506

[3] Wisdom, J. & Holman, M. 1991, Astron. J., **102,** 1528

[4] Chambers, J.E. 1999, MNRAS **304,** 793

[5] Christou, A. 2000, Astron. Astrophys., **356,** L71

Archean Ichnofossils in Volcanic Rocks from the Abitibi Greenstone Belt. Nathan Bridge[1], Neil R. Banerjee1, Wulf Mueller[2]

[1]Department of Earth Sciences, University of Western Ontario, London ON N6A 5B7 (*nbridge@uwo.ca*), (*neil.banerjee@uwo.ca*) [2]Centre d'étude sur les Ressources minérales, Université du Québec à Chicoutimi, 555 Boulevard Université, Chicoutimi QC G7H 2B1 (*Wulf_Mueller@uqac.ca*)

Research from the past decade has shown that volcanic rocks are hospitable environments for microbial life. Studies of volcanic glass preserved in submarine basalts have demonstrated the importance of endolithic microbes in glass alteration. Volcanic rocks from the Abitibi Greenstone Belt (AGB), Pilbara Craton, and Barberton Greenstone Belt all preserve microfossils indicative of ancient microbial activity. The ichnofossils are tubular mineralized structures formed during the etching of glass by microbes along fractures in ancient glassy rocks. The tubules have been mineralized by micrometre-scale titanite grains, which has allowed for the delicate textures to be preserved through greenschist facies metamorphism.

The study area in the AGB is located on the Hurd Property, Harker Township, eastern Ontario and has been dated at 2701 Ma as part of the Blake River Group. The outcrop is an ancient hyaloclastite deposit, with massive to brecciated basalt flows as well as variolitic basalt lobes, overlain by a large sequence of hyaloclastite containing numerous glass shards ranging from 1-3 mm in size. The hyaloclastite layer is overlain by a further massive basalt layer indicating subaqueous eruption in an ancient Archean Sea.

Subaqueous volcanic rocks provide a new setting in the search for early life on Earth. Recent missions to Mars have shown the presence of liquid water on the surface in the past. Basalts are common rocks on the surface of Mars making up a large percentage of the regolith and country rock. This abundant basalt, along with impact breccias, could have interacted with liquid water on the surface. Since basalts are likely to be returned by any extra-terrestrial sample-return mission, detailed studies of microbial alteration signatures preserved in aqueously altered basalts provide a useful Earth analogue for studies of possible extraterrestrial microbial habitats.

Micro-XRD Studies of Meteorites: Rapid *in situ* Mineral Identification and Textural Information. R.L. Flemming[1], P.J.A. McCausland[1], M.R.M. Izawa[1], and N. Jacques[1]. [1]Earth Sciences, University of Western Ontario, London, Ont. (*rflemmin@uwo.ca*).

Micro X-ray Diffraction (μXRD) is a versatile technique in geoscience[1]. In meteoritics, it is particularly useful for non-destructive *in situ* study of individual mineral grains in whole-rock specimens, cut surfaces, or polished sections, while preserving their context. Our data were collected with a Bruker D8 Discover (λ(CuKα) = 1.5418 Å; 40 kV, 40 mA; spot size 500-50 μm). General Area Detector Diffraction System (GADDS) images enabled mineral identification and detection of textural features: crystallite size, alignment, and strain-related mosaicity. This has been observed previously in meteorites using Debye Scherrer X-ray cameras[2,3], and has been related experimentally to shock state[3,4]. Horz *et al.*[4] observed XRD patterns of experimentally shocked minerals to proceed from spots in unstrained single crystals, to streaks after applying moderate shock pressure, to virtually continuous polycrystalline rings with increasing shock pressure.

Mineral ID and textural information - DaG 400: DaG 400 is a lunar melt breccia[5] consisting of white relict anorthite grains in a fine-grained matrix of microcrystalline anorthite with minor pyroxene. GADDS images from the relict grains exhibit streaks, indicating a high mosaicity of the anorthite lattice.

Shock-related mosaicity Martian NWA 3171: The μXRD of NWA 3171 confirmed the major crystalline components to be augite and pigeonite. Mineralogy of shergottites is typified by the amorphization of plagioclase to maskelynite, due to its low tensile strength. Pyroxene has high tensile strength[3] and has retained its crystal structure but with high mosaicity. Pyroxene from glassy areas showed polycrystalline rings of augite only, likely due to crystallization from a shock-related partial melt associated with the ejection event.

Comparison of relative strain in Diogenites: Diogenites Dhofar 700 and NWA 2038 are both enstatite cumulates; XRD confirmed ferroan enstatite to be the dominant mineral present. Dhofar 700 exhibited relatively minor mosaicity, likely reflecting a low shock state, whereas NWA 2038 showed streaks suggestive of greater shock.

Acknowledgements: We thank D. Gregory and P. Brown for kindly providing these meteorites. RLF acknowledges support from CFI/OIT-2001, PREA-2002, ADF-2005 and NSERC RTI-2003 and Discovery. NJ and MRMI were supported by NSERC USRAs (2004 and 2006, resp.).

References:

[1] Flemming, R.L. 2007, Can. J. Earth Sci. **44,** 1333-1346
[2] Lipschutz, M.E. and Jaeger, R.R. 1966, Science **152,** 1055-1057
[3] Hörz, F., Hanss, R., and Serna, C. 1986, Geochim. et Cosmochim. Acta **50,** 905-908
[4] Hörz, F. and Quaide, W.L. 1973, The Moon **6,** 45-82
[5] Zipfel, J. *et al.* 1998, Meteor. Planet. Sci. **33,** A171

Diffuse Reflectance FTIR of Halophilic Bacteria from the British Columbia MG-Sulfate Lakes: Implications for Remote Sensing on Mars. I. Foster [1], G. Southam [1], P. King [2] [1]Dept. of Earth Sciences, U. of Western Ontario, London, Ont; [2]Institute of Meteoritics, University of New Mexico, Albuquerque, N.M., USA.

Introduction: IR spectroscopy detects bonding in molecules making it a valuable tool for remote sensing and detection of both organic and inorganic materials [1]. Terrestrial hypersaline environments commonly occur in areas of high evaporation/low precipitation, and are inhabited by a variety of halophilic organisms from all domains of life. Halophilic organisms cope with hypersaline conditions by balancing high, extracellular ionic concentrations with intracellular K^+, or by producing an osmotic solute such as glycerol ($C_3H_8O_3$) to balance water activity across the cellular membrane [2]. Due to these differences in adaptive mechanism, species that employ an osmotic solute will be easier to detect using remote-sensing techniques than those that tolerate high-intracellular-ionic conditions.

Methods: Biological material used for enrichment of halophilic species was obtained from the Mg-Sulfate lakes of British Columbia, Canada. ICP and IC data from brine water was combined with SHAND lab SMR2A media and culturing procedures [3] to create a brine-based growth medium (BBGM.) For analysis, biomass samples were centrifuged and washed with synthetic brine four times to remove excess organic molecules from the media. The biomass pellet produced was dried, powdered, and impregnated into a Na- or Mg-sulfate matrix at differing organic matter/sulfate concentrations for IR analysis with a Nicolet Nexus 670 FT-IR with a Pike Technologies Automated Diffuse Reflectance (DRIFTS) attachment.

Results: Spectra obtained for 0.5 mg $_{\text{Red-halophilic-Archaea}}$ in 9.5 mg $_{\text{matrix}}$ and 1 mg $_{\text{Red-halophilic-Archaea}}$ in 9 mg $_{\text{matrix}}$ show CH_2 and CH_3 stretching features at 2920-2930 cm^{-1}, Amide II C-N and N-H absorptions at 1553 cm^{-1} and organic signatures at 1443 cm^{-1}. In samples containing less than 0.5 mg $_{\text{Red-halophilic-Archaea}}$ biomarker absorption features became weak and ambiguous.

Discussion: Spectra collected separately for pure Mg-sulfate and Red-halophilic Archaea both show molecular H_2O and SO_4^{2-} vibrational features due to similar structural components. Halophile samples contained additional features at 1443 cm^{-1}, which correspond to a number of organic molecules, and 1553 cm^{-1}, which can be attributed to Amide II C-N and N-H stretching [4], as well as weak CH_2 and CH_3 absorptions at 2920-2930 cm^{-1}, corresponding to C-H stretching. These features were selected for use as biomarkers.

Conclusions: Our results show that, although it is not possible to detect extremely low populations of halophiles due to the relatively weak absorption features produced compared to the matrix material, detection of halophilic organisms within a sulfate matrix is possible with remote-sensing methods using established biomarkers and halophile populations similar to those found in natural, ephemeral, oligotrophic environments.

Acknowledgements: Thanks to B. Hyde, K. Moser, and H.W. Nesbitt for helpful discussions. This project was funded by a Canadian Space Agency (CARN-02) grant.

References:

[1] Riedaar, R. *et al.* 2004, Science, **306,** 1746-1749
[2] Oren, A. 1999, Microbiol Mol. Biol. Rev., **63,** 334-348
[3] Shand Lab 2006, `http://jan.ucc.nau.edu/~shand/protocol.htm`
[4] Marshal, C.P. *et al.* 2006, Vibrational Spectroscopy, **41,** 182-189

Meridianiite ($MgSO_4$-$11H_2O$): A New Mineral on Earth. Where on Mars Would You Expect to Find This Mineral? R.C. Peterson[1], W. Nelson[2], B.Madu[3], and H.F.Shurvell[4] [1] Department of Geological Sciences and Geological Engineering, Queen's University, Kingston ON K7L 3N6 (*peterson@geol.queensu.ca*), [2] Artisan Minerals, Ashcroft BC V0K 1A0 [3], Mining and Minerals Division, Ministry of Energy Mines and Petroleum Resources, Kamloops BC V2C 4N7, [4] Department of Chemistry, Queen's University, Kingston ON K7L 3N6

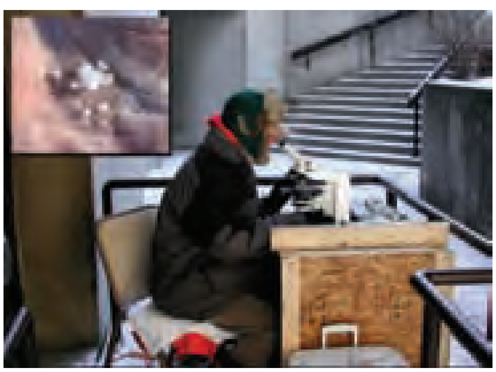


Figure 4 — Ron Peterson studies the natural occurrence of the newly discovered magnesium sulphate mineral, meridianiite (inset), in an outdoor setting at Queen's, keeping it stable below 2 °C.

Meridianiite, a new mineral with formula $MgSO_4 \cdot 11H_2O$, was recently discovered on the surface of a frozen pond in central British Columbia, Canada. The pond is located where $MgSO_4$ has been mined in the past and the locality serves as a terrestrial analogue of Martian conditions.

$MgSO_4 \cdot 11H_2O$ is stable below 2 °C. Above 2 °C it melts incongruently to a slurry of epsomite ($MgSO_4 \cdot 7H_2O$) and water. Magnesium sulfate minerals are thought to exist in the soils at Gusev crater and elsewhere on the Martian surface. These minerals may have formed through evaporation of a brine solution at or below the surface. Meridianiite, instead of epsomite, is the expected magnesium-sulfate phase in equilibrium with saturated brines below 2 °C. $MgSO_4 \cdot 11H_2O$, under the current low-humidity conditions on most of Mars, would ultimately dehydrate to a fine dust of kieserite ($MgSO_4 \cdot H_2O$) that could be dispersed by wind across the Martian surface. The name of the new mineral was chosen to reflect the locality of Meridiani Planum on Mars where the MER rover *Opportunity* observed crystal molds in sedimentary rock that are thought to be caused by minerals that have since dehydrated or dissolved.

Meridianiite is also observed on Earth as small crystals in brine inclusions found in sea ice. On Mars, meridianiite would be stable where ice and a magnesium-sulfate-containing solution are in equilibrium. It is possible that meridianiite persists on Mars near the polar icecap in the subsurface.

Current plans are to return to the pond in British Columbia with a portable X-ray diffractometer and study the other sulfate minerals associated with meridianiite on and below the surface of the pond.

New Interpretation of Landscape Assemblages and Ages in Gorgonum and Atlantis Basins, Mars. Radu Dan Capitan, Dept. of Geography, U. of Western Ontario, London ON N6A 5C2 (*rcapitan@uwo.ca*).

Introduction: A previous study [1] emphasized the role of five mechanisms and factors of control in defining the landform evolution: (1) impact cratering, (2) volcanism, (3) tectonism and base-level variability, (4) the response of substrata to the action of landforming processes and topographic control, and (5) climate. Gorgonum and Atlantis basins present evident signs of fluvial and periglacial resurfacing processes, which contradict the initial hypothesis referring to their evolution [2]. This study proposes an approach of landscape hierarchy and mapping procedures, leading to a new dating system of landforms, which is correlated to Martian meteorite constraints [3].

Methods: I propose three stages of study in defining genetic linkages among different landforms and setting the phases of evolution: landform assessment and hierarchical correlation, which lead to a preliminary evolution pattern; relief mapping and watershed delineation reflect the reality of landform distribution and set the boundaries following the topographic limits among them; within delineated patterns, dating landforms involves taking into consideration the relationship between crater diameter and crater height, which varies due to crater evolution.

Discussion: The three stages of landform identification, morphologic mapping, and age determination using morphometric data of impact craters superposed on different landforms reflect a reality of landscape evolution, which is sustained by recent studies [1,4]. The inability of current studies to discern the ages among highly evolved vs. recent exhumed morphologies raises a fundamental aspect of Martian studies — is the evolution of the Martian surface correctly evaluated? The presence of hydrated carbonates crystallized ~670 Ma ago [5] suggests the manifestation of aqueous processes related to episodic volcanic/magmatic stages. In Gorgonum and Atlantis basins, areas strongly affected by evolution of Tharsis volcanism (*e.g.* Sirenum Fossae emplacement), the ages derived using the present paper's method give time of formation

Surface	Volume -V	Age-Ga	Meteorite[3]	Cur.Geol.time
Hellas imp	61001.5	4.09	Predate volc.	Npl_1 4-4.5 Ga
High cr.ter	54326.3	3.2609	Predate volc.	Npl_1 4-4.5 Ga
Gorgonum	13258.39	1.050575	Predate volc.	Npl_2 3.7-4 Ga
Atlantis	12108.17	0.907122	Predate volc.	Hpl_3~ 3.2-3.7 Ga
Intrcr.dep.W	20459.15	1.365077	>1.3 Ga	Npl_2 3.7-4 Ga
tectonicEAtl	10652.8	0.64261	~Volc. Phase	$Npl_1$3.7-4.5 Ga
Fluv. outflow	7327.09	0.679866	~670-Ma carbonates	$Npl_1$3.7-4.5 Ga
Lake Vy.crat	9306.169	0.683500	~670-Ma carbonates	$Npl_1$3.7-4.5 Ga
Intrcr.fl.depr	7543.21	0.676421	~670-Ma carbonates	$Npl_1$3.7-4.5 Ga

Table 1: Planetary landscape ages of Martian landforms inside Atlantis and Gorgonum correlate with meteorite constraints [3,5]

for fluvial and lacustrine paleo-processes exactly in the range of ages determined for precipitated carbonates in Martian meteorites (Table 1).

References:

[1] Capitan R.D. 2007, LPSC XXXVIII, 1318.pdf.

[2] Irwin, R.P. III *et al.* 2004, JGR, **109,** No. E12009, doi:10/2004JE002287,2004.

[3] Nyquist, L.E. *et al.* 2004, Second Conference on early Mars, pdf. 8041.

[4] Malin, M.C. *et al.* 2006, Science, **314.** no. 5805, 1573-1577

[5] Wentworth, S. and Gooding, J. 1994, Meteoritics **29,** 860-863

Mars Sample Return via Phobos Cache and Human Retrieval.

P.J. Stooke[1], [1]Dept. of Geography, U. of Western Ontario, London ON N6A 5C2 (*pjstooke@uwo.ca*)

Introduction: *Apollo 8* and *Apollo 10* were rehearsal flights that tested hardware and procedures prior to the first *Apollo* landing mission. A similar rehearsal flight may precede the first *Orion* landing. The first human Mars landing will be the most difficult and dangerous human operation ever conducted in space. Prudence suggests a rehearsal flight would be desirable, but inadequate science return would make the cost and risk hard to justify. Samples of Mars and other possible targets, cached on Phobos for retrieval by the first human crew, provides ample science return for a challenging rehearsal mission. The sample-collection procedure can include international cooperation without being compromised by any failed mission.

Scenario: The scenario proposed here involves a decade-long program of sample collection from multiple sites on Mars, and possibly other targets. The samples would be delivered to Mars orbit and the carrier would rendezvous with Phobos. The simplest possible landing procedure (probably propulsive braking plus airbags) would deposit the samples on Phobos. Tracking or descent imaging would locate the samples. When a suitable set of samples was available, the first human crew would undertake a Mars orbital mission, including one or more Phobos landings to retrieve the samples. During these landings, other activities would include Phobos sampling, drilling, and instrument emplacement. Phobos equipment would replace the mass and volume of Mars surface equipment (*e.g.* pressurized rover) in a full Mars-lander mission.

Scenario: Over ten years, the US deposits five Mars samples on Phobos (possibly preceded by small direct-to-Earth sample missions). ESA deposits two Mars samples on Phobos. Russia collects one Mars sample and one Deimos sample and lands them on Phobos. Japan flies a *Hayabusa*-like mission to a Mars Trojan asteroid and delivers the sample to Phobos. A Mars-crossing asteroid might also be a candidate, with orbit achieved via a Lagrange Point. Other possible partners (Canada, India, China) might map Phobos at high spatial and spectral resolution to locate the samples and search for Mars ejecta blocks on Phobos. A rover to gather sample containers in one location might also be flown. The human crew collects the samples, returns them to Earth and distributes them to the partners, with mutual sharing agreements in place.

Advantages: The cost of sample return is shared with the *Constellation Program.* The risk of the return journey (additional flight time, re-entry failure) is reduced. International cooperation is practical, but no one mission is critical to the success of the rehearsal mission. Sample study during the return flight can help reduce planetary protection fears (samples containing microbes can be sterilized). The timetable is flexible — if the human flight date recedes, more samples can be collected. Science return is adequate to justify the costly human rehearsal mission, compared with (for instance) orbital remote sensing or a simple Phobos landing.

Habitability of Enceladus: Planetary Conditions for Life.

C.D. Parkinson[1], Mao-Chang Liang[2,3], Yuk L. Yung[3] [1]Department of Atmospheric, Oceanic and Space Sciences, University of Michigan, 2455 Hayward St, Ann Arbor MI 48109, USA (*theshire@umich.edu*), [2]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA, USA, [3]Research Center for Environmental Changes, Academia Sinica, Taiwan.

The prolific activity and presence of a plume on Saturn's tiny moon Enceladus offers us a unique opportunity to sample the interior composition of an icy satellite, and to look for interesting chemistry and possible signs of life. Based on studies of the potential habitability of Jupiter's moon Europa, icy satellite oceans can be habitable if they are chemically mixed with the overlying ice shell on Ma time scales. We hypothesize that Enceladus' plume, tectonic processes, and possible liquid-water ocean may create a complete and sustainable biogeochemical cycle that may allow it to support life. We discuss evidence for surface/ocean material exchange on Enceladus based on the amounts of silicate dust material present in Enceladus' plume particles. Microphysical cloud modeling of Enceladus' plume shows that the plume particles originate from a region of Enceladus' surface where the temperature exceeds 190 K. This could be consistent with a shear-heating origin of Enceladus' tiger stripes, which would indicate extremely high temperatures (~273 K) in the subsurface, leading to the generation of subsurface liquid water, chemical equilibration between surface and subsurface ices, and crustal recycling on a time scale of 1 to 5 Ma. Alternatively, if the tiger stripes form in a mid-ocean-ridge-type mechanism, a half-spreading rate of 1 m/a is consistent with the observed regional heat flux of 250 mW m-2 and recycling of south-polar terrain crust on a 1 to 5 Ma time scale as well.

Empirical Transfer Functions: Application to Determination of Outermost Core Velocity Structure Using *SmKS* Phases.

C. Alexandrakis[1], and D.W. Eaton[1] [1]Dept. of Earth Sciences, U. of Western Ontario, London ON N6A 5B7 (*calexan3@uwo.ca*)

Introduction: The outermost 200 km of Earth's liquid core is a poorly defined region [1]. Previous studies used *SmKS* wave observations to resolve the velocity structure in this region, yielding differential travel-time measurements with 1.29s of scatter [2]. Here, we calculate transfer functions based on Wiener filtering to accurately identify *S3KS-SKKS* differential travel-time measurements. This empirical transfer function (ETF) method yields much less scatter (0.43s) by implicitly removing common source and path effects. We have tested several core-velocity models against our observations and find that the best fitting model is formed when using IASP91 [3] with a PREM-like velocity [4] at the top of the core.

Methods: The ETF technique transforms a reference pulse *(SmKS)* into a target waveform *(SKKS)* by 1) time-windowing the respective pulses, 2) applying Wiener deconvolution, and 3) convolving the output with a Gaussian waveform. ETFs for 446 earthquake observations were used to produce a global stack. The first major zero-crossing on the ETF correlates to the *S3KS-SKKS* differential time. These differential-time measurements are used to calculate a moveout curve for distances between 115° and 140°. The RMS difference between the moveout curve and the observed differential times is 0.43s. *S3KS-SKKS* differential times for several standard Earth models (PREM [4], IASP91 [3], and AK135 [5]) and a series of models created by perturbing the standard models, are calculated by applying the same ETF technique to synthetic waveforms. When the RMS misfit between the modeled times and the moveout curve exceeded the observed scatter, we deemed a trial Earth model to be unacceptable.

Discussion: Using the above criterion, we found that PREM, IASP91 and AK135 (RMS misfit of 0.48s, 0.52s, and 0.49s, respectively) are all marginally unacceptable. Slight perturbations to IASP91 yielded models that fit our acceptance criterion. Of all models tested, the one with the lowest RMS misfit (0.27s) used IASP91 as a base model, with a PREM-like velocity of 8.040 km/s at the top of the core. We also tested models containing a thin (10-km thick), high-velocity layer (8.23 and 8.36 km/s) beneath the CMB. These velocity values correspond with possible values for a light *S*-rich, immiscible fluid layer for core temperatures of 3500 and 4300 K [6]. Although the addition of such a layer increases the misfit from the best-fitting model, these two models still meet our acceptance criteria since the misfit (0.28s and 0.30s) is still below the scatter in the observed data. The global stacked section will improve as more data becomes available, resulting in less scatter. This will allow for stronger constraints on the velocity structure of the outermost core.

Acknowledgements: Data used for this study were obtained from the waveform archives of IRIS and POLARIS. This work was funded by NSERC (DWE) and OGSST (CA).

References:

[1] Eaton, D.W. and Kendall, J.M. 2006, Phys. Earth Planet. Int. **155,** 104-119

[2] Souriau, A. *et al.* 2003, Geophys. Res. Lett. **30,** doi: 10.1029/2003GL017008

[3] Kennett, B.L.N. and Engdahl, E.R. 1991, Geophys. J. Int. **122,** 429-465

[4] Dziewonski, A.M. and Anderson, D.L. 1981, Phys. Earth Planet. Int. **25,** 297-356

[5] Kennett, B.L.N. *et al.* 1995, Geophys. J. Int. **122,** 108-124

[6] Helffrich, G. and S. Kaneshima 2004, Science **306,** 2239-2242.

Zircon Dating of Post-Impact Deep Lithosphere Flow. D.E. Moser[1], W.J. Davis[2], S.R. Reddy[3], R. Flemming[1], R.J. Hart[4] [1]Dept. of Earth Sciences, U. of Western Ontario, London ON N6A 5B7 (*desmond.moser@uwo.ca*); [2] Geological Survey of Canada, 601 Booth St, Ottawa ON K1A 0E8; [3]Dept. of Applied Geology, Curtin University of Technology, GPO Box U1987, Perth WA 6845, Australia, [4]iThemba labs, Johannesburg, South Africa.

Introduction: Although primarily known as an invaluable tool for U-Pb geochronology, the refractory nature of zircon ($ZrSiO_4$) allows it to survive the intense pressures and temperatures of impact environments while developing a range of unique microstructures and material changes related to the degree of shock metamorphism and post-shock heating [1]. Zircon shock morphotypes form over a large pressure range (20 GPa to >80 GPa) and temperatures as high as the zircon melting temperature (1676 °C). Microstructures include the pressure-induced development of multiple sets of parallel, micron-scale planar features, local transformation of zircon to its high-pressure polymorph Reidite, domainal conversion to diaplectic zircon glass, partial to complete recrystallization into granular zircon aggregate, and finally total breakdown to Baddeleyite (ZrO_2) and silica at extreme temperatures. Comparatively little is known regarding impact-related effects on zircon deep beneath impact craters. Here we report that indirect effects include crystal-plastic deformation and trace-element alteration of zircon at the crust-mantle boundary, as discovered in xenoliths from kimberlite cross-cutting the ancestral Vredefort impact structure, South Africa.

Methods: We have combined *in situ* and single-zircon U-Pb isotopic dating (ID-TIMS and SHRIMP) with colour SEM cathodoluminescence analysis of zircon in grain mounts and petrographic thin sections. Strain analysis of single zircons was carried out by micro-XRD and Electron Backscatter Diffraction (EBSD) techniques.

Discussion: Our results allow us to directly date a crystal-plastic deformation fabric in Archean xenolith samples of the African Moho at 2023 ±15 Ma, indicating deep-level flow coeval with rebound of the 2020 ±3-Ma giant Vredefort impact crater. The deformed zircons are restricted to the main mylonitic fabric, whereas undeformed zircons in the same sample occur in the cores of garnet porphyroclasts. LREE enrichment of the deformed and isotopically disturbed ductile-zircon zones suggests participation of fluid in the up to 100 percent evacuation of radiogenic Pb from the zircon lattice. Our study demonstrates a new method for strain chronometry of planetary materials while offering a first view into post-impact processes at the crust/mantle transition of continental lithosphere.

Acknowledgements: De Beers is gratefully acknowledged for access to the kimberlite property for sample collection, and Dr. Daniel Schulze, University of Toronto, is thanked for guidance in xenolith research.

References:

[1] Wittman, A., Kenkmann, T., Schmitt, R.T., and Stöffler, D. 2006, Meteoritics and Planetary Science **41,** 433-454

Lovina, A New Ataxite from Bali, Indonesia. S.A. Kissin[1], R.L. Flemming[2], P. Corcoran[2], P.J.A. McCausland[2], and M. Biesinger[3] [1]Dept. of Geology, Lakehead U., Thunder Bay ON P7B 5E1 (*sakissin@lakeheadu.ca*); [2]Dept. of Earth Sciences, U. Western Ontario, London ON N6A 5B7 (*rflemmin@uwo.ca*). [3]Surface Science Western, U. Western Ontario, London ON N6A 5B7

Figure 5 — The 8.2-kg Lovina ataxite main mass (cm scale). The iron shows deep vugs in its bottom and lower surfaces and odd, ziggaraut-like pyramids on its upper surface.

Introduction: A new ataxite, Lovina, has been discovered and its description submitted to the nomenclature committee of the Meteoritical Society. Lovina was found by Dan Richer in January 1981 on a beach in Bali, Indonesia. Richer brought it to UWO where it was investigated by *in situ* micro-XRD [1] and discovered to contain abundant taenite with awaruite, but no kamacite. A polished thin section was prepared for petrographic and SEM observations, which confirmed its meteoritic origin.

Description of Specimen: Lovina is an elongate football-sized 8.2-kg iron with a strongly weathered exterior featuring cm-sized pyramidal projections on its upper surface (as oriented on beach). The pyramids have basal ribs spaced at ~mm intervals, which are more resistant to weathering. In polished section, the ribs are not the expression of a Widmanstätten structure but rather a microstructure in taenite, indicating that the specimen is an ataxite. SEM, micro-XRD, and petrographic observations indicate the taenite to be massive, lacking exsolved kamacite spindles, daubreelite, and Neumann bands, which are commonly present in ataxites. The taenite has an approximate composition of 36% Ni, 2% Co. Abundant globular troilite nodules up to 0.8 mm in diameter are present, containing minute (c. 10 μm) chromium oxide grains. Many of the nodules are partially or totally oxidized to Fe oxides and display Ni-enriched rims of awaruite adjacent to the metal matrix.

Geochemical Methods: Polished blocks (3.2-mm thickness; 0.4 to 0.7g) of "Lovina" and reference standards Odessa and Standard steel NBS 809B were prepared for INAA analysis at Activation Laboratories Ltd., Ancaster, Ontario using the protocol of Wasson *et al.* [2]. The steel provided the standard for As, Au, Co, Cr, Co, Ga, Ni, Pt, Sb, and W whereas the Odessa meteorite was the standard for Ge, Ir, and Re. Except for the previous three elements, the well-known composition of Odessa served as an internal standard for the ten other elements [3].

Results: Lovina has the following composition: Ni 345 and Co 8.73 mg/g; As 5.6, Au 0.07, Cr 321, Cu 395, Ga 22, Ge 150, Ir 0.252, Pt <0.5, Re <0.01, Sb 390, and W <10 (all in μg/g). The composition clearly lies outside the range of most grouped ataxites in group IVB, thus Lovina is an ungrouped ataxite.

Discussion: Grady [4] lists 54 ataxites, of which 12 belong to group IVB, 9 belong to other groups and 33 are ungrouped or unclassified. Lovina resembles other ungrouped ataxites, *e.g.* N'Goureyma, in its abundance of troilite nodules with a very low abundance of kamacite spindles and daubreelite, but differs in composition [5]. Although the high Ni-content and low Ir-content is similar to that of some other ungrouped ataxites, *e.g.* Santa Catharina and Twin City, Lovina differs in its relatively high Ge and Ga contents [5]. The unusual exterior of Lovina provides an opportunity to study terrestrial weathering of irons.

Acknowledgements: We thank owner D. Richer for providing a fragment of the meteorite for analysis, G. Wood for thin section preparation, and A.L. Hammond for preparation of NAA samples.

References:

[1] Flemming, R.L. 2007, Can. Jour. Earth. Sci. **44,** 1333-1346
[2] Wasson J.T. *et al.* 1998, Geochim. Cosmochim. Acta **62,** 715-724
[3] Choi B.-G. *et al.* 1995, Geochim. Cosmochim. Acta **59,** 593-612
[4] Grady, M. 2000, *Catalogue of Meteorites,* Cambridge University Press
[5] Buchwald V.F. 1975, *Handbook of Iron Meteorites,* Univ. Calif. Press.

Investigation of Matrix Mineralogy in the Tagish Lake and Gao-Guenie B Carbonaceous Chondrites by Micro X-Ray Diffraction. M.R.M. Izawa[1], R.L. Flemming[1], and P.J.A. McCausland[1], [1]Dept. of Earth Sciences, U. of Western Ontario, London ON N6A 5B7 (*mrizawa@uwo.ca*).

Introduction: Zolensky *et al.* (2002) noted a similarity between the matrix mineralogy of Tagish Lake (C2 ungrouped) with that of CR chondrites (*1*). Both are characterized by very-fine-grained phyllosilicates, Fe, Ni sulfides, magnetite, and carbonates (*2-5*). The matrices of Tagish Lake and the CR chondrite Gao-Guenie B (CR2) have been investigated using micro X-ray diffraction (μXRD) to see if these similar materials might be distinguished.

Methods: Micro X-ray diffraction (μXRD) extends XRD analysis to the micron scale, allowing rapid, non-invasive and *in situ* mineral characterization that is of great value in meteoritics (*6*). μXRD allows point-by-point correlation of crystal structure with other microanalytical data. μXRD also provides texture and crystallinity information via examination of the 2-D diffraction patterns. Intact fragments of Tagish Lake and Gao-Guenie B were investigated.

Results and Discussion: The Tagish Lake and Gao-Guenie B chondrite matrices are comprised of anhydrous and hydrous silicates, Fe-Ni sulfides, magnetite, and carbonates. The anhydrous component of Gao-Guenie B consists of forsteritic olivine, clinopyroxene (clinoenstatite ± minor fassite and diopside), and minor anorthite. Forsteritic olivine is the only anhydrous silicate detected in the Tagish Lake matrix. Hydrous silicate phases in both consist primarily of very-fine-grained, poorly crystalline saponite ± serpentine. Siderite and calcite are abundant in Tagish Lake. A trace amount of calcite was detected in Gao-Guenie B, but it lacks the distinct white carbonate nodules evident in Tagish Lake. Pyrrhotite is the dominant sulfide detected in both meteorites. Sulfide, oxide, and carbonate phases are finely disseminated throughout the matrix of both meteorites. A weathered surface on Gao-Guenie B shows evidence of magnetite oxidation to maghemite and the breakdown of matrix sulfides to sulfates, notably jarosite. A surface interpreted as fusion crust shows a broad signal consistent with glass.

μXRD has allowed the identification of the major phases present in two whole-rock carbonaceous chondrite samples and has successfully distinguished them. This offers the possibility of quickly identifying the general type of unknown carbonaceous chondrites in a non-destructive manner, and to rapidly survey the mineralogy of whole-rock carbonaceous chondrite samples deemed too rare or valuable for other investigative techniques. μXRD is also ideal for identifying grains or areas of interest for further study using other techniques.

Acknowledgements: P.G. Brown provided the Gao-Guenie B sample for this study. Thanks also to A.R. Hildebrand, P.G. Brown, and all those connected with the recovery of the Tagish Lake meteorite. A.R. Hildebrand is also thanked for his efforts in the curation of the Tagish Lake meteorite. Support from the Natural Sciences and Engineering Research Council of Canada (NSERC) is gratefully acknowledged.

References:

[1] Zolensky, M.E. *et al.* 2002, Met. & Pl. Sci. **37,** 737
[2] Brown, P.G. *et al.* 2000, Science **290,** 320
[3] Hildebrand, A.R. *et al.* 2006, Met. & Pl. Sci. **41,** 407
[4] Brearley A.J. and Jones, R.H. 1998, in *Planetary Materials,* J.J. Papike, Ed., Min. Soc. of America, v. 36, pp. 398
[5] Krot, A.N. *et al.* 2002, Met. & Pl. Sci. **37,** 1451
[6] Flemming, R.L. 2008, Can. J. Earth Sci. **44,** 1333

Soluble Organic Compounds in the Tagish Lake Meteorite: Preliminary Results. C.D.K. Herd[1] and R. Hilts[2] [1]Dept. of Earth and Atmospheric Sciences, University of Alberta, Edmonton AB T6G 2E3 (*herd@ualberta.ca*); [2]Grant MacEwan College, Edmonton AB T5J 4S2

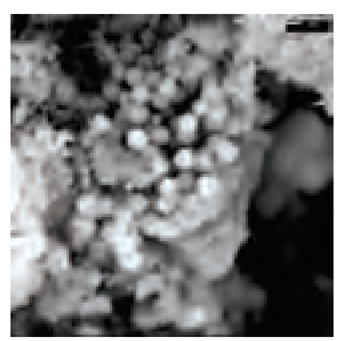


Figure 6 — Magnetite framboids in the pristine Tagish Lake meteorite.

Introduction: The Tagish Lake meteorite is an ungrouped carbonaceous chondrite preserving primitive Solar System material. It contains a high amount of organic carbon (~2.6 wt%) of which only 2% is soluble in polar solvents [1]. This study takes advantage of the pristine nature of the Tagish Lake meteorites collected a few days after their fall [2] and that are available at the University of Alberta to 1) develop a method for organic molecule analysis that can be readily applied in the context of other (esp. mineralogical and petrological) studies, and 2) identify sources of terrestrial contamination as part of efforts to establish curation and handling protocols.

Methods: A 1.685-g subsample of pristine Tagish Lake sample 11v (5.65 g of dust/disaggregated material in a Ziploc bag) forms the source of the material used in this study. The subsample was stored in an Ar-containing Schlenk vessel in a freezer at -30 °C. The extraction process involved adding ~0.40 mL of either neat dichloromethane (DCM) or a 50:50 (v/v) toluene-methanol mixture to ~0.30 g of the dust at -78 °C under an Ar blanket. The resulting black slurry was allowed to warm to room temperature and lightly tapped, causing the insoluble material to settle out. The slightly cloudy brown supernatant (~0.2 mL) was extracted and split into two 0.1 mL portions, one of which was analyzed by GC-MS and the other by FTIR. GC-MS data were acquired with an Agilent Technologies 5975-C instrument equipped with an HP-5MS column packed with (5% phenyl)methyl polysiloxane. FTIR spectra were recorded as DCM casts on a Thermo-Nicolet Nic Plan FTIR microscope attached to a Magna 760 spectrometer. Omnic software (7.1) was used to collect and process the spectra, which included 256 scans for both background and sample over the range 4000-650 cm^{-1}.

Results and Discussion: Through comparison of GC-MS results with known molecule retention times and peaks, we have identified 67 organic molecules in the DCM extract, of which 10 are likely terrestrial. The organic molecules are linear and branched alkanes, aromatics, aldehydes, linear alkenes, carboxylic acids, and polyene, consistent with [3]. Results of FTIR analysis show peaks from alkane C-H bonds between 2800 and 3000 cm^{-1} and aromatic C-H bonds at 3090 cm^{-1}, consistent with results from GC-MS and [4]. The most prevalent terrestrial contaminant found is oleamide, a plasticizer used in the manufacture of Ziploc bags. Although it does not interfere significantly in organic analysis of other molecules, Ziploc, and other plastic bags, are not optimal collection media.

Conclusions: The soluble fraction of Tagish Lake organic carbon contains very few oxygenated groups. This is in contrast to the mineralogy of Tagish Lake [5] and the insoluble organic matter, both of which indicate low-temperature chemical oxidation on the parent body [6]. Determining the relationship between the petrology of Tagish Lake and the distribution of organics is of primary importance in determining the origin and history of organic matter in the early Solar System.

References:

[1] Grady, M.M. *et al.* 2002, Meteor. Planet. Sci., **37,** 713-735.
[2] Hildebrand, A.R. *et al.* 2006, Meteor. Planet. Sci., **41,** 407-431.
[3] Pizzarello, S. *et al.* 2001, Science, **293,** 2236-2239.
[4] Matrajt, G. *et al.* 2004, Astronomy & Astrophysics, **416,** 983-990.
[5] Zolensky, M.E. *et al.* 2002, Meteor. Planet. Sci., **37,** 737-761.
[6] Cody, G.D. and Alexander, C.M.O.D. 2005, GCA, **69,** 1085-1097.

Astromaterials and Small Bodies Research at the University of Winnipeg Planetary Spectrophotometer Facility. E.A. Cloutis, Department of Geography, University of Winnipeg, 515 Portage Ave, Winnipeg MB R3B 2E9 (*e.cloutis@uwinnipeg.ca*).

Introduction: We have established a state-of-the-art spectrophotometer facility at the University of Winnipeg tailored to supporting spectroscopy-based studies of planetary surfaces. The facility includes a variety of spectrophotometers spanning the range from the UV (200 nm) to the far IR (200 μm). The equipment suite includes benchtop spectrometers (Jasco Model 570 180-2500 nm; Buck M500: 2-16 μm; and Hyperion/Bruker micro/macro FTIR: 0.3-200 μm). We also have field-portable instruments for studies of terrestrial analogues (Ocean Optics S2000: 200-1150 nm; ASD FieldSpec HR: 350-2500 nm; D&P Model 102 FTIR: 2-14 μm). Our lab currently supports a wide range of projects, including a number related to astromaterials and small bodies, and we are constantly upgrading our facilities and capabilities to better support astromaterials research.

Astromaterials Research: Our work on astromaterials to date generally falls into two broad categories: analysis of geological materials in quarantine and direct analysis of astromaterials. We have developed environment chambers [1] that allow us to expose materials to various planetary surface conditions and monitor their spectral properties, as well as to measure spectra of materials in quarantine. This capability is currently being used to determine mineral stabilities on the Martian surface [2]. We are currently studying the spectral properties of iron meteorites as a guide to analysis of M-asteroid spectra. We have also measured reflectance spectra of thermally processed ordinary chondrites to support analysis of S-asteroid reflectance spectra. We are also developing a capability to spectrally characterize single-mineral grains.

Small-bodies research: Our research on small bodies is currently focused on asteroids, comets, and terrestrial analogues. We are in the midst of an extensive study of the spectral reflectance properties of possible S-class asteroid surface assemblages: iron-meteorite-silicate mixtures, olivine-pyroxene, and two pyroxene-mixtures. These data are being used by colleagues at the University of North Dakota in the interpretation of M- and S-class asteroid spectra [3].

Other asteroid-related projects currently under way include analysis of a small absorption band in pyroxenes at 506 nm that has been detected in telescopic spectra of Vesta, and that shows rotational variations in wavelength position and depth, which may be a sensitive indicator of pyroxene composition [4]. We are also examining spectral properties of shocked materials from the Mistastin and St. Martin craters to determine how shock processes may affect spectral properties of planetary surfaces.

The U of W is also engaged in a feasibility study with colleagues from Europe on a proposed ESA comet sample-return mission; our role is to assess the applicability of reflectance spectroscopy for surface characterization.

References:

[1] Cloutis, E., Craig, M., Kaletzke, L., McCormack, K., and Stewart, L. 2006, Lunar Planet. Sci., **37,** abstr. #2121.
[2] Cloutis, E.A., Craig, M.A., Mustard, J.F., Kruzelecky, R.V., Jamroz, W.R., Scott, A., Bish, D.L., Poulet, F., Bibring, J., and King, P.L. 2007, Geophys. Res. Lett., **34,** L20202, doi:10.1029/2007GL031267.
[3] Hardersen, P.S., Gaffey, M.J., Cloutis, E.A., Abell, P.A., and Reddy, V. 2006, Icarus, **181,** 94-106.
[4] Kaletzke, L., Cloutis, E., Craig, M., McCormack, K., and Stewart, L. 2006, Lunar Planet. Sci., **37,** abstr. #2174.

Sponsored by: Canadian Space Agency, UWO Planetary Science Research Group, and Geophysics Division of the Geological Association of Canada

Aboriginal Canadian Sky Lore of the Big Dipper

by Frank Dempsey, Toronto Centre (frank.dempsey@sympatico.ca)

The Big Dipper stars were associated with a Great Bear in many Canadian First Nations legends. This painting "Ursa Major" is by Yukon, artist Mary Dolman, and is used with permission.

Introduction

Spring constellations in Canadian skies include the familiar Big Dipper group of bright stars in the constellation known as Ursa Major. This star group was well known in various cultures and peoples around the northern hemisphere. Aboriginal North Americans also recognized the star group, and several interesting interpretations and legends related to the Big Dipper stars were known to the early inhabitants of Canada.

Mythologies of indigenous peoples served various purposes including explaining and educating about the natural cycles of life and death, the cosmos, and other natural phenomena, as well as instructing tribal standards and customs by which to act and live. The mythologies associated with constellations were important because they emphasized participation with nature for the mutual benefit of all living things, and the mythologies provided a cultural and social context for the timekeeping and calendar functions of constellation knowledge, which were of agricultural and ritual importance.

An examination of Canadian aboriginal interpretations of the Big Dipper star group reveals some similarities that coincide with regional geography and climate features, as well as with language similarities.

Language Groups of First Nations in Canada

Several main language groups defined similar cultures. In eastern Canada, the geographic region that could be generally referred to as the eastern woodlands was mostly dominated by the Algonquian language group, and this language group included native groups across the subarctic and westward across the northern Great Plains to the Rocky Mountains. Another language group was the Iroquoian group, which included groups in locations in southwestern Ontario but mainly in the region south of Lake Ontario. The Siouan language group included the Assiniboin peoples of the northern Prairies. Other language groups that influenced native mythology of constellations in Canada included the Eskimo-Aleut language group of northern regions, the Salish language group of the central regions of British Columbia, and the Athabaskan group of languages found in First Nations of various regions of western Canada.

Some Legends of the Big Dipper Stars

The most common legend explaining the origin of the stars of the Big Dipper is the celestial bear hunt. A legend of the Mi'kmaq, a group indigenous to the Atlantic Provinces, was common to many regions of Canada as well as North America. In the Mi'kmaq legend, birds are the main characters that hunt the bear, while humans feature in most other legends. (Various regional interpretations can be found in Clark 1960; Miller 1997; Rockwell 1991; Monroe and Williamson 1987; and Bastion and Mitchell 2004.) This legend begins with the bear waking in late spring after a long hibernation and emerging from her den to look for food. The bear is spotted by Chickadee, who decides to hunt the bear but is too small to hunt the bear alone. Chickadee calls other hunters to help with the chase. Six other hunters join in the chase, including Robin, Moosebird (or Gray Jay), Pigeon, Blue Jay, Barred Owl, and smaller Saw-whet Owl. Barred Owl is the star known as Arcturus, and Blue Jay and Pigeon are several of the stars between Arcturus and the handle stars of the Big Dipper. The handle stars represent the hunters as Robin, closest to the bear, Chickadee in the middle, carrying a pot (the star known as Alcor) for cooking the bear, and Moosebird farthest from the bear. After the long and lean winter, the hunters are all eager for the meat and fat of the bear and so they pursue the bear all summer long across the northern sky. By autumn, the trailing hunters begin to lose the trail and gradually drop out of the hunt, leaving only Robin, Chickadee and Moosebird to continue the hunt. Eventually, during mid-autumn, the three hunters overtake the bear, the bear becomes angry, rears up on her hind legs in the west, and Robin shoots her with an arrow. The bear's blood spatters all over Robin, who then flies up to a nearby maple tree and shakes off most of the blood, except for a spot of red that remains on Robin's breast. The blood causes the leaves of the maples to turn red and eventually fall from the trees, and the bear's white fat eventually covers the land as snow. Meanwhile, the skeleton of the bear lies on its back low in the northern sky, and the life spirit of the bear returns to the bear's den (represented by the constellation known as Corona Borealis) to occupy the bear sleeping in the den. The following spring, the bear will emerge from her den, and the cycle repeats.

A variation is the legend of the Fox peoples (in the vicinity of southern Michigan), in which three hunters set out chasing the bear first toward the north, then toward the east, and then toward the west, and end up following the bear into the sky before they realize that it is too late to return to Earth, and so the three hunters perpetually chase the bear around the sky (Bastion and Mitchell 2004).

Legends of the Iroquois peoples were generally similar in reference to hunters chasing the great bear, and the Big Dipper was Nya-gwa-ih, or the Celestial Bear. In one legend (Miller 1997), three hunters and their dog came tantalizingly close to killing the bear but the bear always outran them. They vowed to never stop until they overtook and killed the bear. The bear led them far to the north and into the sky, where they can be seen as the three handle stars with the dog near the middle star, and the bear as the bowl stars of the dipper.

Another theme that recurs in various mythologies is the general theme of seven children, fleeing from some form of harmful pursuers, who escape into the sky to become the Big Dipper stars. The Blackfoot legend (from the northern Great Plains region) involves seven brothers and their sister. A woman changed into a bear and chased seven brothers and their sister into a tree. (The reason is a long story with no significant relevance to the stars and constellations but more details can be found in Wissler and Duvall 1995.) One of the brothers waved his medicine feather and they all escaped to the sky and became the Big Dipper star group, and the sister became the star that we call Alcor. The "Last Brother" was the star at the end of the handle of the dipper, and the Blackfoot peoples used the position of the Last Brother relative to the bowl stars to mark the time.

A legend of the Assiniboin peoples (in the vicinity of Lake Winnipeg) also referred to seven children (six brothers and a sister) chased by a woman trying to kill them, and who escaped into the sky and became the Big Dipper (Miller 1997).

In a similar legend of the Cheyenne (who moved from the region west of the Great Lakes westward to the Great Plains), seven brothers and their adopted sister, Quillwork Girl, were pursued by a thundering herd of bison who wanted to take Quillwork Girl for themselves. The brothers and adopted sister scrambled up into a tree. The youngest brother had special powers and made the tree grow larger and taller, and they all climbed into the sky just as the angry bison forced the tree to fall. The brothers and sister are visible as the stars of the Big Dipper. Quillwork girl is the brightest star and she is decorating the sky with her patterns and designs. (Miller 1997)

A legend from the Penebscot peoples (in the St. Lawrence valley region) was different from the Mi'kmaq legend but strikingly similar to the Blackfoot legend. In the Penebscot legend, six brothers went out on a trip and their older sister became a bear that killed everyone in the village except for the two youngest children. When the six brothers returned, they were all able to escape into the sky and became the Big Dipper (Miller 1997).

A significantly different legend for the Big Dipper stars evolved for the eastern Cree, Ojibway, and Menominee peoples north of the St. Lawrence valley and near the central Great Lakes region. They saw the Big Dipper stars as Ojeeg annung, the Fisher, and so this legend could refer to the "Fisher Stars" rather than the "Big Dipper" stars. The legend features a young boy crying because there is no summer, and so the people of the north country hold a council and decide to go and secure the summer for the north country. After a long journey to a remote island, they eventually reach a long wigwam and find that summer is contained there in the form of the Birds of Summer. Several of the summer creatures are assigned to guard the Birds of Summer but after a plan has been worked out to steal the summer, and after some conflict (with many details not significantly related to constellations), the people of the north country escape with the Birds of Summer and with the guards in pursuit. The north-country people send Otter and Fisher to distract the pursuers, and Fisher gets shot in the tail with an arrow, runs up a tree to escape, and eventually leaps into the sky. Eventually the summer and winter creatures agreed to share the summer. Meanwhile, Fisher can be seen every night as a hero who helped to secure summer for the north country (with an arrow still in his tail) (Miller 1997 and Virtual Museum of Canada).

Several other interpretations of the Big Dipper stars included giant caribou as seen by the Polar Inuit (with some legends including three wolves pursuing the caribou), and diving loons as seen by the Klamath peoples (in the British Columbia plateau region). To the Tahltan peoples in northwestern British Columbia, the stars of the Big Dipper were the Grandfather Stars. Grandfather Stars told the Tahltan people that as long as he continued to go around the northern sky, everything would be well. The Ntlakyapamuk, or Thompson, peoples in the southern British Columbia Interior region saw three hunters (in the handle of the dipper) pursuing a grizzly bear.

Looking to a wider perspective across the continent, some other interpretations included an elk and three hunters (Salish, Pacific coast region), two grizzly bears and five wolf brothers (Spokane, western plateau region), men chasing rabbits into a net (Northern Paiute, great basin region of western USA), seven geese that had been homeless boys (Chumash, southern California coast), coyote's fishing net (Mariposa, southwestern desert region), and a big canoe (Alabama, southeastern USA).

Summary of some Similarities and Contrasts in the Big Dipper Sky lore Mythologies

Different variations in the legends of the Big Dipper star group reflect regional variations in geography, climate and the significant natural creatures relied on for sustenance. The most common theme in the legends noted above is the annual bear hunt (or other major animal relied upon for survival, whether caribou or elk) and this combines the annual cycle of death in winter and renewal of life processes in spring with some explanations for the colour of the robin, the reddening of maple leaves in autumn, and the snow that eventually falls. The theme of the children fleeing from harm and escaping to the sky occurs in the mythologies of various native peoples spanning different language families, and may have evolved as an instructional example of the harm that may come to children who stray too far from acceptable customs. The mythologies of the Big Dipper group also include (to some extent) the ideas of journeys of humans to the sky, creation of the stars, and some aspects of seasonal cycles.

References

Bastion, D.E. and Mitchell, J.K. 2004, Handbook of Native American Mythology (ABC-CLIO, Inc.: Santa Barbara)

Clark, E.E. 1960, Indian Legends of Canada (McClelland and Stewart Inc.: Toronto)

MacDonald, J. 1998, The Arctic Sky: Inuit astronomy, star lore, and legend (Nunavut Research Institute: Iqaluit)

Miller, D.S. 1997, Stars of the First People (Pruett Publishing Company: Boulder, CO)

Monroe, J.G. and Williamson, R.A. 1987, They Dance in the Sky (Houghton Mifflin Company: Boston)

Rockwell, D. 1991, Giving Voice to Bear: North American Indian myths, rituals and images of the bear (Roberts Rinehart Publishers: Lanham, MD)

Virtual Museum of Canada, online at www.virtualmuseum.ca/Exhibitions/Cosmos/english/html/skystories.html

Wissler, C. and Duvall, D.C. 1995, Mythology of the Blackfoot Indians (University of Nebraska Press: Lincoln)

Frank Dempsey has been a member of the RASC Toronto Centre for more than three decades and observes variable stars and everything else in the sky. He is an Ojibway and member of Dokis First Nation, and uses cloudy nights for researching and collecting constellation starlore.

A Moment With…

Dr. James Hesser

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

In 1609, Galileo turned a telescope heavenward for the first time and began the modern era of astronomy. He quickly went on to observe and theorize about mountains and craters on the Moon, the phases of Venus, the moons of Jupiter, the rings of Saturn, and so on. Next year marks the 400th anniversary of those first Earth-shattering observations and a wide variety of events and celebrations will be taking place around the world. Leading the co-ordination of Canadian activities is Dr. James Hesser.

Born in the United States and now a Canadian, Dr. Hesser's interest in astronomy began at a very young age, with the stars arresting his attention as early as grade four. He found further inspiration in an excellent seventh grade science teacher, and it wasn't long before Dr. Hesser was building his own telescopes. After studying at the University of Kansas and at Princeton, he left the U.S. for nine years' employment at Cerro Tololo Inter-American Observatory in Chile. For the past thirty years, he has been working in Canada at the National Research Council's Dominion Astrophysical Observatory (DAO) in British Columbia and is currently its Director.

As a sometime variable-star observer, I was interested to learn of Dr. Hesser's experience in tracking down a faint star that varied in a period of not months, days, or even hours, but mere minutes: ZZ Ceti. According to theory, white dwarfs could show oscillations in brightness over a span of mere seconds if they pulsated radially. Dr. Hesser and his colleagues began observations at Princeton to see if they could confirm this premise by making observations with then-new techniques. Dr. Hesser made observations at night and ran the Princeton Observatory's molecular spectroscopy lab during the day,

Dr. James Hesser

enduring much sleeplessness along the way. The observing was not particularly fun — in fact, it was quite boring, as interminable hand guiding was required. Many negative results were obtained under the light-polluted skies of New Jersey.

After he moved to Chile, his colleague Dr. Barry Lasker developed a photometer for their use under the pristine southern skies. After installing it at Cerro Tololo in 1969, they used it to monitor many stars, collecting data for subsequent Fourier analysis, months later, on computers at the Kitt Peak National Observatory headquarters in Tucson (there being no computers at Cerro Tololo when they started their programme there). More null results ensued.

The photometer was then taken to Kitt Peak where, finally, seeming success: one object was investigated that gave positive results. Unfortunately, it was very faint, with periods of 10-27 minutes rather than the tens of seconds expected. The complex, low-amplitude light curve with its long period was reminiscent of a star observed a few years earlier by Dr. Arlo Landolt. During a 1970 meeting in Scotland at which Dr. Hesser presented the results, a theoretician encouraged Drs. Lasker and Hesser to keep searching for what they were after. They decided to have one more shot at running down their quarry, this time concentrating on a narrow colour (temperature) range corresponding to the projection of the Cepheid instability strip into the white dwarf regime. (The instability strip is a region of the Hertzsprung-Russell diagram where stars may undergo self-excited oscillations).

On Halloween night in 1970, Dr. Hesser was standing by the 0.9-m telescope as numbers spat from a teletype machine connected to the photometer, then trained on the faint white dwarf R548. Subconsciously he sensed a pattern in the printout. He plotted the data. Amazing! A brightness change of 0.01 magnitudes with a period of about 200 seconds was revealed! (During subsequent analysis, they discovered two periods, 213 and 273 seconds, in their data.) Dr. Hesser ran to the other domes on Cerro Tololo with the news, urging other observers to visit his telescope to see his plots demonstrating the existence of a new class of variable star.

While Dr. Hesser observed on Cerro Tololo, Dr. Lasker started their Fourier analysis program running on the brand-new IBM 1130 computer in La Serena, Chile. They converted their many rolls of punched paper tape into tall stacks of machine-readable punched cards. A paper describing the results was submitted for publication within a week. This was an exciting time and, well, just plain fun! The International Astronomical Union subsequently designated R548 as ZZ Ceti, the prototype for a class of white dwarfs that pulsates in periods as short as 30 seconds with brightness changes as small as 1/1000th of a magnitude.

Dr. Hesser has always had a passion for star clusters, even as an amateur astronomer. For many years, he worked with his colleagues throughout Canada and the U.S. to measure accurate ages and chemical compositions for globular clusters in the Milky Way. To this end, they used, for example, the *Hubble Space Telescope* and large ground-based telescopes in Chile and Hawaii, such as the Canada-France-Hawaii Telescope and the Gemini Observatory. The information gained aids in determining how and when the Milky Way formed and how the chemical elements built up in our galaxy. How long did it take to form? Did it condense from a single huge cloud of gas and dust? Did many, smaller, pre-existing galaxies collide and accrete onto what became the Milky Way? Is the truth somewhere in between? While much work remains to be done, the globular cluster data helps to anchor current thinking on the age of the Universe and the process of galaxy formation. The globular cluster observations are consistent with data from the *Cosmic Background Explorer* (COBE) satellite, indicating a Universe 13.5 billion years old.

In the past six years, Dr. Hesser has been putting his international experience to work as Canada's representative on the Board of Directors for the Atacama Large Millimetre/submillimetre Array (ALMA). He describes this instrument as the world's first truly global telescope, supported by Europe, Asia, the U.S., and Canada. Located in the Chilean Andes at an altitude of 5000 metres, the array will consist of up to 66 fully steerable dishes when completed in 2012. ALMA will look at cold objects in the Universe with resolutions up to ten times better than the *Hubble Space Telescope,* thereby helping astronomers understand star and planet formation in galactic molecular clouds and star-forming regions, as well as the goings-on in extremely dusty regions of distant galaxies.

After many years of studying the stars of Local Group galaxies and the like, Dr. Hesser has taken on a new project: Canadian Coordinator for the 2009 International Year of Astronomy. Planning in this country is progressing jointly with the RASC, Canadian Astronomical Society (CASCA), and La Fédération des astronomes amateurs du Québec (FAAQ). Dr. Hesser explains that the major goal for the year will be to get as many Canadians as possible to reconnect to the night sky. It is hoped that, with the RASC and FAAQ leading the way, a million Canadians will be able to observe the heavens and have a "Galileo moment." There will be a strong emphasis on youth, highlighting available careers in science and technology. Overall, the partners aim to engage all Canadians in an astronomically meaningful experience during 2009 while creating legacies that will last far beyond the 400th anniversary of the astronomical telescope.

Other major themes include

- the production of a student astronomy kit
- a partnership with Canada's First Nations to bring their astronomical perspectives before a larger public, alongside current research findings
- increasing the number of dark sky preserves and raising public awareness of light pollution
- producing new public planetarium shows and science centre activities with a Galileo and/or astronomical theme
- creation of new arts and cultural programming incorporating astronomical themes, such as a new production by *Taflemusik,* programming for youth by the Victoria Symphony, productions accompanied by inspiring imagery of Holst's *The Planets,* etc.
- engaging public lectures by "Canadian Astronomers at the Research Frontiers," highlighting the excellence of Canadian astronomical research

That Dr. Hesser should be involved in such programs should come as no surprise. In his career, he has expanded and improved the outreach program at the DAO, visited schools throughout British Columbia as a volunteer with the B.C. *Scientists in the Schools* program, (forerunner of the national *Innovators in the Schools*) and, served as president of the Astronomical Society of the Pacific (with its focus on public education and outreach), as well as of the Canadian Astronomical Society. For this kind of educational outreach, Dr. Hesser was presented with the Michael Smith Award for Science Promotion in 1997. For his astronomical research, asteroid 39791 was named Jameshesser in his honour.

Philip 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.

First Glimpse of a White Dwarf Before It Explodes?

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

Supernovae fall into two broad classifications: a massive star exploding at the end of its life, and a white dwarf that has exceeded a critical mass and destroys itself in a thermonuclear detonation. The latter are known as type Ia supernovae, and it is these that are being used to investigate the accelerating expansion of the Universe. All other designations (Ib, Ic, all type IIs, long gamma-ray bursts, x-ray flashes, etc.) involve massive stars in some way. While they are all interesting in their own right, the type Ias are of keen current interest because the critical mass establishes an underlying unity that allows astronomers to use them — after some corrections — as standard candles that can be seen with current telescopes to a redshift of ~2 (or a look-back time of about 10 billion years). At least, that's the picture that has evolved. In fact no one has seen the progenitor of a type Ia supernova, so the pretty cosmological picture could be built upon a house of cards. Rasmus Voss of the Max Planck Institute for Extraterrestrial Physics, near Munich, and his collaborator Gijs Nelemans of Radboud University in the Netherlands, have now placed this cosmology on a firmer basis by tracking down the progenitor of supernova 2007on in the elliptical galaxy NGC 1404 (see the February 14 issue of *Nature*).

There are in fact two possible ways to get a white dwarf star to explode, and as they involve potentially different mass scales, it's actually quite important to sort out if one or the other is preferred, or if both happen. The first method involves a white dwarf orbiting a companion star that is now in the giant phase. This probably occurs quite often, as the masses of the individual stars in the system are rarely the same, so stellar evolution proceeds at a different pace for each. One star evolves into a giant, then goes through the planetary nebula phase, and finally settles down as a cooling white dwarf. If the companion is sufficiently close to the white dwarf, then when the companion puffs up into its giant phase, its outer atmosphere will be dragged into an accretion disk around the white dwarf, and gas from that disk will gradually accumulate on the white dwarf's surface (Figure 1). The white dwarf's mass therefore grows over time.

Figure 1 — An artist's illustration of what an accreting white dwarf might look like. The system pictured is undergoing a nova explosion, when gas that has accumulated on the surface detonates. The gradual accumulation of material could lead to an eventual supernova, where the entire star detonates in a thermonuclear explosion. Image credit: ©David A. Hardy / www.astroart.org

Alternatively, a binary system with two white dwarfs could occur when the giant doesn't dump enough of its gas onto the white dwarf, and completes its evolution into a white dwarf independently. If the binary were compact enough, the emission of gravitational waves (a general-relativistic effect) would lead the white dwarfs to spiral in towards each other and merge.

I have to diverge from the main story for a moment to explain what keeps white dwarfs stable. Imagine the mass of the Sun shrunk into a tiny ball about the size of the Earth. Its density is about a million times that of water. What stops it from collapsing to an even tinier neutron star, where the electrons are squeezed into the atomic nuclei to form neutronium? Electrons and protons are "fermions" — that's a fancy way of staying that they don't like to be in the same space at the same time. This quantum-mechanical effect provides the pressure to support the white dwarf against collapse. But if the mass of the white dwarf exceeds about 1.4 solar masses, then that quantum-mechanical pressure is insufficient and the star does start to collapse towards a neutron star. It doesn't make it there, though. During the collapse, thermonuclear reactions - similar to those in a hydrogen bomb — blow it apart.

Getting back to the main story, a white dwarf could exceed the critical — "Chandrasekhar" — mass either through accumulating gas slowly from its companion, or through the merger of two white dwarfs. If the total mass of the two dwarfs exceeded 1.4 solar masses, then collapse and detonation would also occur. Therein lies the problem for cosmology. Type Ias are useful because of the 1.4 solar-mass limit, but if they arise from two merging white dwarfs it may not be possible to correct for the varying masses in a way that's truly believable. Evidence for a "super-Chandrasekhar" explosion was reported in 2006 (2006 July 18 issue of *Nature*), and there is now growing belief that there are indeed two types of type Ia supernovae, increasing the pressure to find a progenitor.

Voss and Nelemans have been searching the archives of the *Chandra X-ray Observatory* and the *Hubble Space Telescope* to see if they have earlier observations of the regions around recent type Ia supernovae. They hit the jackpot with SN 2007on, which went off in NGC 1404. There was an X-ray source at the location of the supernova in 2003, but nothing in the optical wavelengths. This led them to conclude that the X-ray source was the signature of gas from a giant falling onto a white dwarf — the first known progenitor of a type Ia.

There is a model wherein the lower mass white dwarf in a pair could break up, form a disk, and then bleed matter down onto the more massive dwarf, also producing X-rays, but the best calculations seem to show that the X-ray luminosity of such a disk would be at least a factor of ten less than what was observed.

Now astronomers have a new way to track down supernova progenitors. Perhaps the various orbiting telescopes should factor this into their "legacy" programmes, to ensure that we have high-resolution images of as many galaxies as possible, providing astronomers with a good database to search after a supernova goes off.

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.*

Deep-Sky Contemplations

What You Don't See

by Doug Hube (jdhube@telus.net) and Warren Finlay (warren.finlay@interbahn.com), Edmonton Centre

Nothing personal, but you are a baryonic beast. As it happens, so too is your telescope, your toothbrush, and the paper — or computer terminal — on which these words appear. Baryons are the massive particles of ordinary matter, specifically protons and neutrons. Baryons are the principal constituents of people, planets, and stars. Surprisingly, baryons are *not* the principal constituents of galaxies nor, indeed, of the Universe.

Approximately 70 years ago, Fritz Zwicky found the first observational evidence for the existence of "dark matter," that still-mysterious, non-luminous, gravitating "stuff" that is responsible for the dynamical behaviour of matter within galaxies and of galaxies within clusters of galaxies. More than 20 years ago, Vera Rubin and her collaborators began to accumulate data on the rotational velocity curves of spiral galaxies. Many others have contributed in subsequent years.

Classical Newtonian gravitational theory tells us that in a system with structural and dynamical symmetry such as is found in a spiral galaxy, the rotational velocity at a distance r from the centre is governed by the gravitational mass, M, interior to r according to $v_{rot}^2 = GM/r$, where G is the gravitational constant. (The same expression applies to planets revolving in the Sun's gravitational field). Leaving out many details (!), within a galaxy v_{rot} can be measured using the Doppler effect, and r can be determined if we know the distance to the galaxy. Hence M can be calculated. We can also combine apparent brightness and distance to compute the luminosity, L, of a galaxy, or of a portion of a galaxy. The mass-luminosity ratio, M/L, is a useful parameter in describing the nature of matter. Using *solar units,*

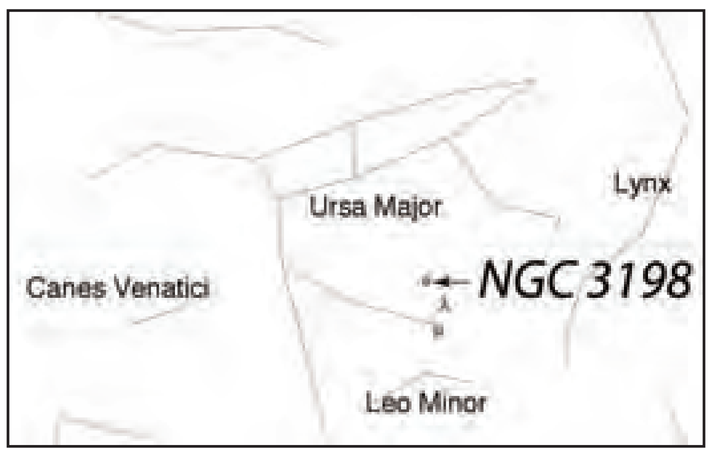


Figure 1 — Position of NGC 3198 in the night sky.

Continued on page 68

Figure 1 — *The Astronomer,* 25 x 35 cm, watercolour by Mary Lou Whitehorne.

This painting was inspired by the impending closure of the David Dunlap Observatory, an institution with which the RASC and the University of Toronto share a long and rich scientific history. In my own mind, I cannot separate the DDO from thoughts of Bob Garrison. Bob has a 39-year history of observing at the DDO, and this relationship continues today. He is our Society's Honorary President, he has long been a leader in the area of amateur-professional cooperation — in short, a stellar astronomer if ever there was one! I wanted to capture the deep and abiding passion for the stars embodied in Bob, along with "his" observatory, in honour of both him and the telescope that has achieved so much for Canadian astronomy.

— Mary Lou Whitehorne, Halifax Centre

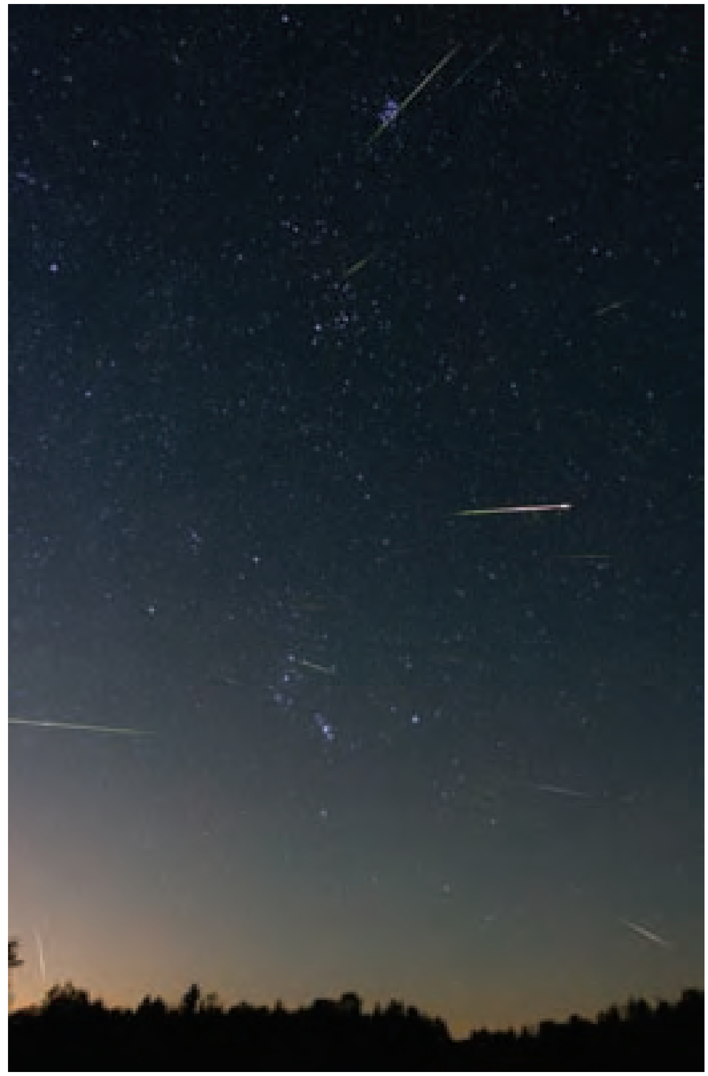


Figure 2 — Orionid Shower by Pierre Martin

Several meteors were captured under the dark, moonless morning hours of 2007 October 21, including at least 27 Orionids, 1 sporadic, and 1 Leo Minorid. (The Leo Minorid is the bright streak entering the field from the left side).

Photo by Pierre Martin of the Ottawa Centre using a Canon 30D at ISO 640, 8-mm f/2.8 lens. This image is a digital composite of all meteors appearing in the camera's field of view over the course of several short exposures.

Figure 3 — IC 443

Wayne Malkin of the Edmonton Centre captured this photo of IC 443 in Gemini, the remnant of a 5000-light-year-distant supernova that occurred 30,000 years ago. The expanding shell of heated gas resulting from the incredible explosion is interacting with a large nearby molecular cloud (Sh2-249), generating red light as hydrogen in the cloud is ionized by the shock front of the supernova. A neutron star has also been identified at the centre of IC 443, all that remains of the source star.

This image was composed from 3h 40m of Hα data and RGB exposures of 20 minutes each. The Hα data was processed separately, mixed in to the red channel, and then gradually mixed in as luminance as well. Equipment: Pentax 400-mm, and an SBIG STL-11k.

Figure 4 — M100 (NGC 4321)

Taken 2005 April 9 by Bob Anderson, Mississauga Centre at Nirvana, Ontario's Irvine Airstrip, with a 175-mm APO on a Paramount ME, using a Starlight Xpress SXV-9 for five hours exposure.

North on this image is up and to the left. I think my polar alignment was not on, causing V-like stars, which looks like a bit of the lens on the refractor was being pinched, though I did a 60-sec unguided image and the stars are round. The ground was soft, (spring thaw), and the almost 250-lbs of telescope weight did settle a bit during the night as the level was off when I checked it before taking the rig apart in the morning.

Continued from page 65

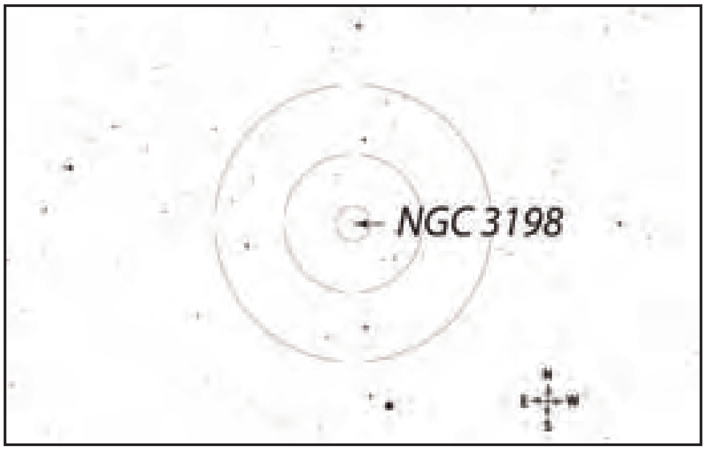


Figure 2 — Finder chart for NGC 3198 shown with 0.5°, 2°, and 4° Telrad circles.

the mass-luminosity ratio of the Sun is 1 (by definition).

With this balance between gravity and v_{rot} in mind, let us consider NGC 3198, a nearly edge-on spiral galaxy with apparent magnitude 10.3, at a distance of approximately 45 million light years, located in Ursa Major [RA = 10^h 19.9^m, Dec = +45° 33′]. It is quite ordinary *in appearance* but not at all ordinary in its material content. It is a typical example of a spiral galaxy with a *flat rotation curve:* the value of v_{rot} rises smoothly from a low value near the centre of the galaxy, reaches a value close to 150 km s^{-1} at a radial distance of r = 10 kpc — and then remains nearly constant and close to that velocity out to a distance of more than 30 kpc. If the mass were truly concentrated toward the centre of the galaxy as is the distribution of luminosity,

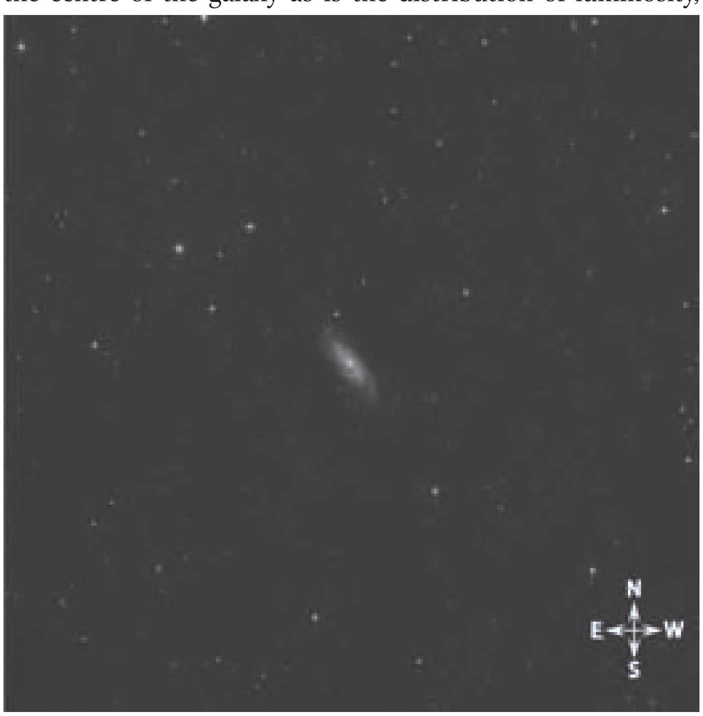


Figure 3 — 50′ x 50′ POSS image centred on NGC 3198.

Figure 4 — Image of NGC 3198, courtesy of Mike Noble, obtained with a stack of twenty 5-minute exposures on 2008 January 7 near Edmonton, Alberta. Equipment used was a CGE-mounted C14 and a Canon 20Da.

the value of v_{rot} would monotonically *decrease* as one moved away from the centre, just as the orbital speeds of the planets decrease the further one is from the Sun.

In the central regions of NGC 3198, the value of *M/L* is of order 5. In the outer regions, where the rotation curve reveals the presence of substantial mass but the "eye" does not detect a correspondingly large amount of radiant energy, the value of *M/L* exceeds 50. In those outer regions, then, there must be of order 10 times more mass than can be ascribed to ordinary matter, *i.e.* to stars composed of baryonic matter. Studies of the internal dynamics within clusters of galaxies reveal values of *M/L* in excess of 200.

Quite literally, there is more, *much* more, to NGC 3198 than meets the eye. The same can be said of most (all?) other spiral galaxies including our own Milky Way. Indeed, the same can be said of the *entire Universe.* One of the great challenges of science is to discover the nature of dark matter, a problem that is being tackled from several directions including astrophysics, cosmology, and high-energy particle physics. When you point your telescope at an ordinary galaxy such as NGC 3198, let your mind "see" what your eye cannot.

Acknowledgements. Figure 3 is a Digital Sky Survey image produced at the Space Science Institute under U.S. Government grant NAG W-2166.

Doug Hube is a professional astronomer actively retired from the University of Alberta, and Associate Editor of this Journal. *Warren Finlay enjoys visual astronomy at night, but is a professor of engineering by day.*

Southward Bound

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

In a couple of weeks, Louise and I will be flying down to New Zealand and Australia to visit our son, who is doing a semester as an exchange student at Swinburne University in Melbourne. I cleverly planned this visit to coincide with the "Deepest South Texas Star Safari" being held close to Coonabarabran, New South Wales, Australia (`www.ozsky.org`). This event is being organized by the Three Rivers Foundation in Texas and hosted by a number of experienced Australian amateur astronomers, including my old Internet friend, John Bambury, plus some guy from Calgary named Alan Dyer. In the spirit of family compromise, we won't be spending the full ten nights there, but still hope to have several nights under dark Australian skies.

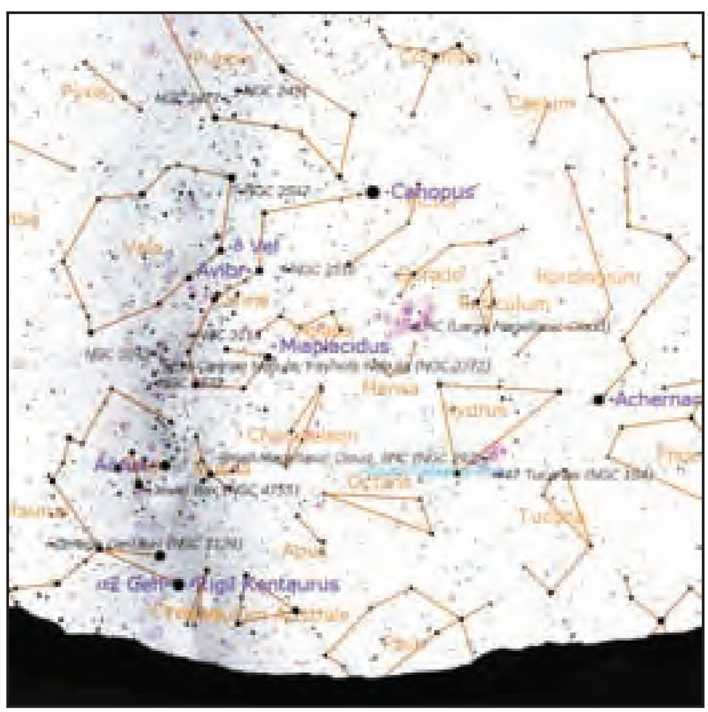
This won't be my first time south of the equator, but it will be the first time with my astronomical interest in high gear. I was in southern Africa twice in the late sixties doing anthropological research, but my only astronomical memory was a night in Kenya's Amboseli National Park, when I saw alpha and beta Centauri and the Southern Cross for the first time in an inky-black African sky. Later, in 1973, I slept for a couple of nights on the deck of an Ecuadorian fishing boat anchored in the Galapagos Islands, with the same constellations over my head. But I've never seen the Magellanic Clouds or any of the southern deep-sky wonders.

As I write this, the winter winds are roaring past my window in Coldwater, but my thoughts are on the southern skies. My copy of *Starry Night* is set to Warrumbungles (31° 16´ 24˝ S, 149° 11´22˝E) and I'm paging through the only charts in my star atlases that aren't dog-eared and covered with my scribbling. Those of you who've been reading my columns here know that I'm a great believer in planning my observing sessions, and this seems especially important before venturing into what is unknown celestial territory for me. So much to see, so little time!

My observing plans always centre around a list. In this case, I needed to look no further than our own *Observer's Handbook,* which in recent years has contained Alan Whitman's list of Southern-Hemisphere Splendours. This list contains 73 objects, which is 'way more than I can hope to cover in a few nights of observing. To help me prioritize, Alan has rated all his objects with one, two, or three exclamation points. As I do with all my observing lists, I've entered Alan's list into my *FileMaker* database, based on the Saguaro Astronomy Club's excellent resource (`www.saguaroastro.org/content/downloads.htm`). This has served me well for many years both as a planning tool and as a place to record all my deep-sky observations.

I find two levels of charts useful in planning and conducting deep-sky observations. I long ago replaced my planisphere with charts generated for a particular time and place with *Starry Night;* I'm sure other software will do as well, but *Starry Night* is what I've always used. What I do first is determine the end of evening twilight and the beginning of morning twilight. There are lots of ways of doing this, but usually I just turn on the NGC-IC catalog in *Starry Night,* and see what time all the objects appear and disappear. I set the date to 2008 March 1, when I'll be arriving in Warrumbungles, and found that the sky becomes totally dark at 9:00 p.m. Daylight Time, and starts to lighten at 5:30 a.m. I printed charts for both these times, and a third set halfway in between. I usually print a set of four charts with a 90° field of view facing north, west, south, and east. This gives me a large enough scale to be comparable to the actual sky; one of the reasons I abandoned planispheres is their small scale. In this case, it's the south-facing charts that are most important. Here's a sample chart, facing south at 9 p.m.:

This chart serves two purposes. First, it gets me oriented under an unfamiliar sky, showing me the locations of bright



stars like Canopus and Achernar, and the new constellations I need to learn in order to starhop to my targets. Notice how Puppis and Columba, usually lost in the murk of our Canadian southern horizon, are right up in the zenith. The South Celestial Pole is about a third of the way up the sky, with no bright star anywhere near to mark it. Most of the stars in this chart are circumpolar but, unlike our northern circumpolar stars, they rotate clockwise. This tells me that I must mainly concentrate on the right side of the chart, because these are the stars that will be setting first. As the night goes on, the stars on the left side of the chart will become better placed.

This leads to the second purpose of these wide-field charts: prioritizing my observing targets. First up is obviously the Small Magellanic Cloud, located just above the brilliant globular cluster, 47 Tucanae, and soon to be slipping beneath the South Celestial Pole. The second priority is the Large Magellanic Cloud, now at its highest, but swinging around and down to the right. The southern Milky Way is still rising on the left; plenty of time for that later.

This level of chart is perfect for naked-eye and binocular observing. When I switch to using a telescope, I'll need charts that are more detailed. In recent years, observing Alan Dyer's Finest NGC Objects list and the Astronomical League's Herschel 400 list, I've come to rely on the highly detailed and deep charts of *The Millennium Star Atlas*. However, for this trip I'm back to observing bright, easy objects, so a more suitable atlas is Sky & Telescope's *Pocket Sky Atlas*. This atlas contains most of Alan Whitman's Southern-Hemisphere Splendours, has a large enough scale and wonderfully legible labels, and is a convenient size and shape for airline travel. This has quickly become my favourite general atlas. It covers the southern circumpolar constellations in eight charts, -55° to 90°. There is also a detailed chart of the Large Magellanic Cloud.

Charts in hand, the next question is about equipment. Telescopes I don't have to worry about, as the organizers of the Star Safari have arranged for a number of large Dobsonians. I will certainly bring my 10×50 binoculars, as I rarely travel anywhere without them, and probably my 15×70s as well. I'll surely bring my Hydrogen beta filter, as the horrible winter weather this year has so far prevented me from trying for the Horsehead Nebula (see my column in the December 2007 *JRASC*) and it will be high overhead in Australia.

By the time you read this, I should be back home, hopefully full of wonderful memories of southern skies!

Geoff Gaherty is currently celebrating his 50th anniversary as an amateur astronomer. 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. Though technically retired as a computer consultant, he's now getting paid to do astronomy, providing content and technical support for Starry Night Software.

Balancing a Lightbridge

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

The big new Lightbridge was pretty exciting. We were seeing things we had never seen before and seeing the things we had seen before in a whole new way. Especially the stars around the edge of the field. Who would have thought they would be shaped like that?

It took a while, and an expert opinion on our mirror, before we learned that if you were going to have a mirror that big (16″) and that fast (f/4.5), then you were going to have coma as well, and that you could either learn to live with it or you could get a coma corrector.

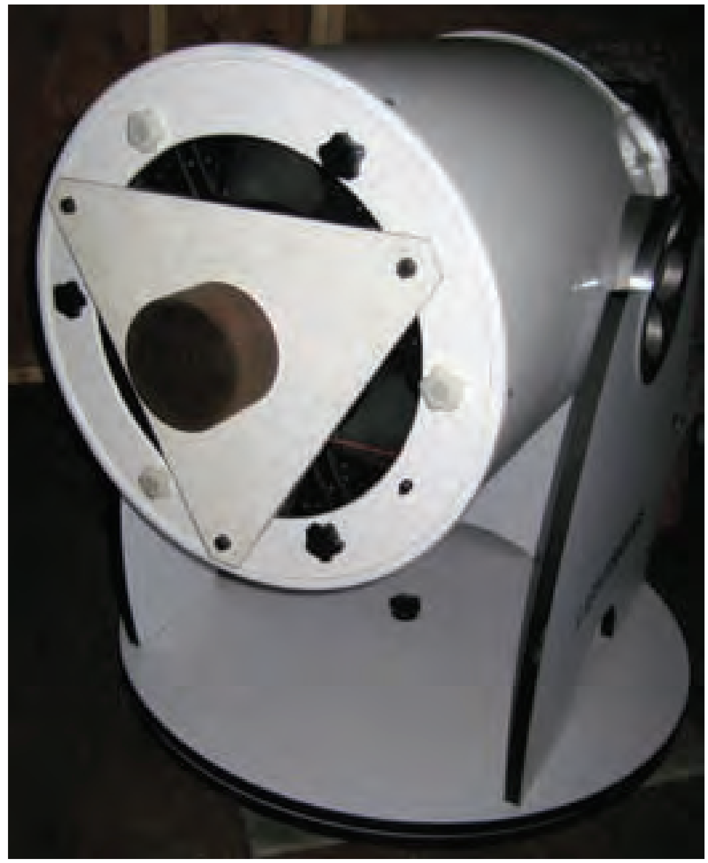
We got a Paracorr and the difference was astonishing. Combined with a big Nagler eyepiece, we got pinpoint stars across the entire field and resolution we'd never dreamed of. We also got a nose-heavy telescope that dropped like a stone. Without a stick to hold it up, you almost couldn't use it at all.

I thought the answer might lie in a 2 ½″-long slice of 4″diameter steel rod that I'd pulled out of a scrap bin once, and which has been getting in the way ever since. I thought that if I could mount it behind the mirror it just might be heavy enough to balance the scope. The question was how.

When I looked at the back of the Lightbridge, it seemed as if it had been designed with me in mind. Ringed around the perimeter of the tube end were three collimating knobs, three lock knobs, and three rubber feet, all equally spaced, all arranged in triangles. The rubber feet unscrewed to leave three 8-mm threaded holes and the rest was obvious.

I cut a triangle from 3/16″ aluminum because that's what I had. You could use something a bit thinner or thicker, in aluminum or steel, or even plywood. I drilled the centre of the counterweight and tapped it for a 3/8″ bolt and made some offset spacers by drilling out three ¼″ coupling nuts to slide smoothly over 8-mm bolts. I put the whole works together like you see it in the photograph and bingo, the scope was balanced and I was a hero.

This project came together for me a little more quickly than most. I lucked out on the size of the counterweight and I lucked out on the fact that there was room enough under the end of the tube when vertical to install this assembly, but you can use some variation of this idea on almost any nose-heavy Dob. You probably don't have a handy slice of 4″-diameter steel rod, but look around at what you do have. If you can't find anything at all, Metal Supermarkets is a last resort, but a project like this is most fun if you can manage it without paying for anything.



Don Van Akker didn't remain a hero for long because he couldn't get into the tights. He observes with his wife, Elizabeth, from Salt Spring Island, and they are members of the RASC Edmonton Centre. Don is happy to answer questions on this or any Gizmos project. Email don@knappett.com.

A Stressful Success and an Easy Failure

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

It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness..., it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us...

— Charles Dickens, A Tale of Two Cities

This is a tale of two occultationists and their contrasting experiences on consecutive cold January nights. For Alister Ling in Edmonton, it was indeed the best of times. He had everything before him. For me, near Toronto, it was the worst of times. I had nothing before me. Alister was in pursuit of the occultation of a faint star by the asteroid (583) Klotilde on the night of 2008 January 23 mst. I went after a similar event involving the asteroid (441) Bathilde less than 24 hours later on 2008 January 24 est. Here is Alister to tell his tale:

"If there are different silver linings to a dark cloud (having a trip to a New Orleans conference that is important to one's assignment cancelled), one of them is being the first to record an accurate diameter of an asteroid, and having it bigger than expected!

"But it almost didn't happen. When it comes to asteroid occultations, lots of things can go wrong, not the least of which are clouds or a significant shift in the predicted path. The event time was at 11:19 p.m. local time, only 19 minutes after a lower probability occultation event (by unnamed asteroid 14553) — all I need to do is starhop to the right place after the first comes and goes.

"I hadn't expected to be in Edmonton at all, so I had forgone the usual reminders on the email chat list until 5:00 that afternoon, leaving it up to the announcement in our newsletter that was given at the meeting two evenings earlier: mistake number one. Now that the (583) Klotilde event was predicted to pass over Edmonton in the latest orbit update, I could stay in my backyard. However, it was going to be only 13° above the southwest horizon, near trees. So earlier in the evening, I checked my planetarium program to see what stars were located now where the event was going to be a few hours later in order to find a spot to avoid the trees. I had to shovel some snow in my backyard in order to shift my scope to that spot where I could see both events — not enough time to relocate my scope in 19 minutes and starhop, switch to the video camera, refocus, and centre!

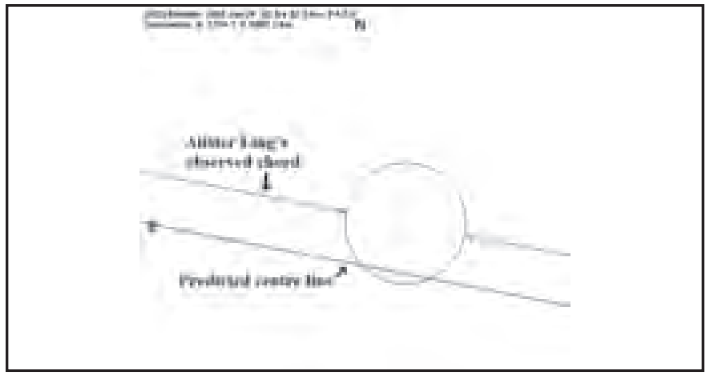


Figure 1

"The first asteroid, 14553, was predicted to occult a star about 10° south of the Pleiades, not hard for locating. Since I was all ready for it, my video time inserter blinking away and my VCR humming away on record, I had time to check out the field for Klotilde first. Of course, it hadn't quite cleared the trees yet, so I never saw Klotilde's target star before I had to get back to the first event with only 15 minutes to go. This sounds like a lot of time, but surprising things happen when you are under pressure! Clean miss, dang — I'd like to bag two separate events in one night, let alone a few minutes apart.

"Now a quick swing over to the Klotilde target star. I can't see the 4th-magnitude anchor — it's only 15° off the horizon. When I printed the finder charts, I figured on seeing 6th-mag stars in the finderscope, but being so low, they were not to be found! It is a challenge starhopping 2.5° when one's field of view is 2/3 of a degree. Hop, hop, hop, T-6 minutes...eek, I'll never do it...wait a minute...ha! Only two more degrees to go, come on baby...thar she be, the 9th-mag field star, 0.9 of a video field away. Gingerly, with chilled fingers, swap the camera head for the eyepiece, adjust the focus, and shift the star to the edge of the field, and there it is. Wow, two minutes to go. Hey! The TV monitor began spazzing out and I had not finished centring my target star! The best I could hope for was that the Poncet drive would hold it in place for the short time and that a clean video signal was feeding into the VCR.

"With failure likely and the time just about 11:30 on a work night, the better part of being reasonable was to pack it all in and wait for the next evening to see the video. When I got around to digitizing it from the VCR through the USB cord into the computer, the star on the screen winked out a mere two seconds early! Quickly transferring the video to my computer downstairs, I loaded the file into the freeware analysis program *LiMovie* to get the times. Disappearance: 2008-01-24 06h 19m 42.75s. Reappearance: 2008-01-24 06h 19m 46.89s, a full 0.2 seconds longer than the maximum expected! Klotilde is bigger than the pros estimated.

"The newest update to Dave Herald's free *Occult* software includes historical observations, and no one has yet seen 583 Klotilde occult a star — making me the first! As of this writing, no one else from Edmonton gave it a try. Because the path came across north-central B.C., even visual timings with their lower accuracy would have been useful in delineating the asteroid's shape and position. So where was everybody? Either at the observers' group meeting talking over a coffee, or driving home from it! Ah, savour the irony."

My own experience the following evening was in stark contrast to Alister's. Big old clouds obscured the target star 15 minutes before the predicted occultation of an 11th-magnitude star in Crater by asteroid (441) Bathilde. Pity. Until then, everything was going according to Plan B and I had every reason to be optimistic. Plan B was invoked because, while checking my equipment earlier in the day, I discovered a major fault with my TV/VCR combination unit, which I use to view and record the signal from the "surveillance" video camera sitting at prime focus of my telescope. It would not record. So, I abandoned it and reverted to the tried-and-true eye-and-voice method. This involves the use of a short-wave radio receiver tuned to a time signal, and a portable tape recorder. (The idea is to record both the radio's output and my voice on audiotape, so that the exact times that I yell "Gone" and "Back" to indicate the disappearance and reappearance of the target star can be determined). The loss of the video system meant a decrease in the accuracy and "review-ability" of my observations, but it was not an entirely bad thing. Without the combo unit and its 25-kilo monster batteries (yes, plural: one main and one backup), I could travel far lighter than usual.

I found a great spot inside the predicted path and set up in plenty of time. Because the faint target star would be rising only 16° above the eastern horizon at occultation time, giving me little time to find it, I decided to use a different method to put the star in the field of view at the right time. On his Web site (`www.poyntsource.com/New/index.htm`), Derek Breit lists a series of "pre-point stars." These are stars on or very near the same declination as the target star, but whose right ascensions are up to two hours or so west of it. As luck would have it, second magnitude Alphard (α Hya) was exactly 2 hours 3 minutes 59 seconds west of — and 20 arcminutes north of — my target star. So, I simply centred on it, nudged my scope a bit south and, at the appointed second, turned off the drive, and let the stars slip-slide away westward. Now, with Earth as my clock drive, all I had to do was wait for the target to drift into view. With a one-degree field of view, the star would be visible for four minutes — plenty of time to see both the disappearance and reappearance. What a lazy way to do an occultation!

Back in the car, engine running, heater on. Waited. Listened to Diana Krall (*Popsicle Toes* was singularly appropriate, since the ambient temperature was -18 C°). Checked a couple of reference asterisms at their predicted times, just to be sure that the Earth was turning as it should (it was). Found a good short-wave signal at 10 MHz. Warmed up my portable tape recorders in the blast from the heater vents. Waited. Waited. At T-minus 30 minutes, I detected a few little clouds approaching from the north, but they were

Here is a list of possible occultations over populated parts of Canada for the next several weeks. For more information on events in your area, visit the IOTA Web site, `www.asteroidoccultation.com`. It is very important that you advise me or another IOTA member if you plan to observe and time an event so we can avoid duplicating chords.

DATE(UT) 2008	ASTEROID #	Name	STAR MAG	Δ-MAG	MAX DUR	PATH
Apr. 4	547	Praxedis	11.6	2.8	4.3	nwON - nSK
Apr. 6	2825	Crosby	10.3	7.8	2.5	eQC - NS
Apr. 8	667	Denise	9.7	4.0	9.3	sON - cQC
Apr. 16	259	Aletheia	10.9	1.3	16.1	NS - BC
May 4	490	Veritas	11.6	1.9	8.4	NS - eQC
May 4	3198	Wallonia	9.7	5.5	1.1	sQC - sON
May 7	416	Vaticana	11.6	0.4	12.4	swBC
May 13	29	Amphitrite	9.9	1.4	5.0	sSK
May 21	5468	Hamatonbetsu	9.3	6.4	3.1	ON
Jun. 7	790	Pretoria	12.2	0.8	12.8	QC

on course to pass to the east of the target, so I wasn't too concerned. However, five minutes later, those baby clouds' bigger brothers came swaggering into my playground and ruined everything. Bullies! They chased away all the stars in their path, including my target, and even convinced the nearly full Moon to make itself scarce. T-time came and T-time went, but the big old nasty clouds hung around. Disappointed, I gave up and went home, grumbling all the way, hoping others had better luck.

Unluckily, other occultationists elsewhere did not have better luck. I know of at least four others who were either clouded out or who suffered equipment problems. No one filed a positive report with IOTA. As IOTA coordinator Brad Timerson wrote, "We all took a bath with Bathilde."

So, what it all comes down to is that I had an easy failure, while Alister had a stressful success. He fought off a series of difficulties and brought home the data. He was indeed the first and — since no other occultation reports were submitted to IOTA — the only person ever to observe this or any occultation by (583) Klotilde. Moreover, Alister showed that the asteroid is a few kilometres larger in diameter than previously thought, assuming a spherical profile. He also demonstrated that the actual path of the occultation had shifted a bit northward (Figure 1). Clearly, more occultations by Klotilde need to be observed in order to refine further its size and shape. Well done, Alister!

Orbital Oddities

Halley's Hailstones

by Bruce McCurdy, Edmonton Centre (bmccurdy@telusplanet.net)

–I am like a slip of comet,
Scarce worth discovery, in some corner seen
Bridging the slender difference of two stars,
Come out of space, or suddenly engender'd
By heady elements, for no man knows:
But when she sights the sun she grows and sizes
And spins her skirts out, while her central star
Shakes its cocooning mists; and so she comes
To fields of light; millions of travelling rays
Pierce her; she hangs upon the flame-cased sun,
And sucks the light as full as Gideon's fleece:
But then her tether calls her; she falls off,
And as she dwindles shreds her smock of gold
Amidst the sistering planets, till she comes
To single Saturn, last and solitary;
And then goes out into the cavernous dark.
So I go out: my little sweet is done:
I have drawn heat from this contagious sun:
To not ungentle death now forth I run.

— Gerard Manley Hopkins, *"I am Like a Slip of Comet..."*

On the morning of October 21 2007, a spectacular magnitude -5 or better Orionid fireball flared bright enough to cast shadows on the ground, leaving behind a drifting train that persisted for several minutes. Photo by Pierre Martin, Ottawa Centre: Canon 30D at ISO 640, 18-mm f/2.8 lens, 2-minute exposure. See also page 66.

It was Halley's Comet that finally drew me out to *fields of light.* I had been interested in the famous comet since my brother Dave had studied it in grade school twenty years previously and told me of its "once-in-a-lifetime" return. We calculated how old we would be in 1985 and in 2061. I was interested in its periodic nature even then, and resolved not to miss my one chance.

The timing of Halley's return was perfect. That fall of 1985 I had joined the RASC. The recent opening of the Edmonton Space Sciences Centre just a couple of kilometres from my home had sparked a latent lifelong interest into action. I was enraptured with the sky. Halley's Comet was as good a place to start as any; already I knew that the comet would come and go, but that I was in it for the long run.

That Dave had died, far too young, before Halley's return simply doubled my resolve to see it. But when the time came, I had unexpected company: my Dad. Turned out he had wanted to see Halley since hearing *his* Dad describe the spectacular 1910 apparition.

The best observing window came in early January. Conditions were crisp but clear as we headed for dark country roads, equipped with modest 7 × 50 binoculars and a finder chart. I was still learning the constellations, so my first job was to find a new star field, the asterism known as the Water Jar of Aquarius, through which Halley was passing. It proved to be a fairly simple task to sweep up the Y-shaped asterism and the little fuzzball beneath it. Simple for me, that is; Dad was less than two years removed from a massive stroke that had nearly killed him, had just one hand to hold the binoculars and, I suspect, just one eye through which to look. He had trouble holding the binoculars steady in the cold, and wasn't entirely certain that he had indeed seen the comet. But there was no doubting his enthusiasm of looking at the big sky, something he had enjoyed frequently as a boy growing up on the farm but, like so many of us, had lost touch with in the bustle of urban life.

From then on Dad understood, even appreciated, my passion for astronomy. Never again did he join me at a dark site, but he did look through the telescopes at the Observatory or mine in the backyard from time to time. After my parents moved to Victoria, he remained keen to see naked-eye spectacles like lunar eclipses, planetary conjunctions, and Great Comets. A voracious reader, he devoured the occasional books I sent him, especially those chronicling astronomy's glorious history. He was a particular fan of Sir Edmond Halley.

All too soon, Halley's Comet had receded *into the cavernous dark,* never to return in my lifetime. I was delighted to discover later I had by no means seen the last of it. The famous comet can still be observed twice a year in meteor showers, one disintegrating particle at a time.

It was Edmond Halley himself who, after observing a great fireball in 1686, first suggested an extraterrestrial origin of meteors (Kronk 1988). Surely he had no way of associating them with comets, let alone with the one that would later bear his name, but it's appropriate that Sir Edmond can be considered a founding father of both cometary science and meteoritics. As both disciplines progressed, a causal relationship was established; it was determined that particles in the expanding debris trail of Comet Halley are the source of not one but two annual meteor showers, the eta Aquarids of early May and the Orionids of late October. Halley plays the role of "parent comet"; the meteors are (pardon the pun) its "descendants."

I first discovered meteor observing in the late '80s at the Edmonton Centre's annual Perseid watch, an event I have participated in eagerly ever since. Over time, my enjoyment and interest in viewing meteors broadened and I began to pursue other showers. The visual method is simplicity itself: one simply relaxes in a lawn chair and drinks in the naked-eye sky, watching and waiting for the quick flash of an interplanetary interloper. In essence, the observer is monitoring the interface between the heavens and the Earth, the link being provided by the meteors themselves.

I consider meteors among the most beautiful sights in nature, and their observation is a strangely addictive pursuit. The latest, most advanced phase of my observing program was precipitated by two nights under the exceptionally rich, bright, and long-lived Orionids of 2006. While conducting a scientific count is at one level a dry, clinical exercise, a good session under an open sky is for me hardly a dispassionate endeavour. I have been rewarded with many intensely personal experiences. Some of the best have occurred in solitude with relatively few meteors, including both Halley showers in 2007.

In early May, I headed to the Beaver Hills Dark Sky Preserve to pursue the eta Aquarids, elusive sister shower to the Orionids. These appear to radiate, appropriately enough, from the Water Jar of Aquarius, which I will always associate with the parent comet. The best shower of the year for the southern hemisphere, it's extremely sparse for those far in the north due to its unfavourable geometry. The radiant rises shortly before the Sun, so the time window is narrow and the radiant low. For an hour or so there is an opportunity to see the occasional "Earth grazer," a meteor striking the atmosphere at an oblique angle and inscribing a long, graceful trail across the sky. The operative word being "occasional": in three previous attempts (2002, 2005, and 2006) I had observed a total of one **suspected** eta Aquarid. This time, after a wait of an hour, I finally observed an unambiguous eta Aquarid, a zeroth-magnitude beauty that cruised through the zenith like a rare tropical bird.

That expedition to a nature preserve in the heart of springtime offered much more than that single rewarding meteor. "The sound of the world waking up is worth the trip!" I exclaimed to my tape recorder at one point. The Avian Symphony was in full chorus, accompanied by crickets and coyotes. Waiting for the fireball that never came, I watched distant Deneb dissipate into rising daylight, my troubles vanishing right along with it. Once it got too light to observe, I went for a long walk on one of the nearby trails. I monitored the wildlife as I walked, learning a little about the birds and the beavers, revelling in the solitude, feeling profoundly **alive** and attuned to the world. A couple hours later I reluctantly headed for home, sleepless but spiritually replenished, already planning to return for the (Moonless) eta Aqs of 2008. I was on an emotional high for days thereafter.

Six months later on the opposite side of Earth's orbit, the Orionids returned (see Pierre Martin's image on page 22), and the Global Meteor Observing Forum ("MeteorObs") was abuzz. One list member had published a paper concluding that the 2006 outburst was associated with dust trails ejected from Halley some 3000 years previous, and that enhanced activity was anticipated through 2009 (Sato & Watanabe 2007).

Alas, the only observing for me involved reading my computer monitor. Four nights my alarm woke me in the middle of the night, and four times I looked out my window to heavy clouds. The last time I determined to go out regardless: clearing was forecast from the west before dawn, the Orionid window was slamming shut, and there was the attraction of the remarkable new Comet Holmes that compelled me to leave my warm bed on a cold Thursday morning. A day before 17P/Holmes was completely unknown to me...but in that day, it brightened by a **million-fold** to suddenly achieve naked-eye prominence, bright as Mira at its finest. More surprising still, the "nova comet" was a recurrent nova, having had a similar eruption in 1892, back around the time its namesake (Sherlock) was taking the plunge at Reichenbach Falls — a seemingly catastrophic event from which he too survived to shine another day.

The sky looked unpromising to say the least. The only thing shining through the low cloud was the towering Hunter's Moon, which hours later would be the biggest, baddest Full Moon of 2007. But, as I headed for a secondary observing site to the southwest of the city, the back edge of the cloud arched above the western horizon, and by the time I was comfortably ensconced in my sleeping bag and observing chair, the skies were opening up as promised. I had positioned myself on the lee side of the car, which also shielded me from direct moonlight, and surveyed a most remarkable sky.

Guest luminaries highlighted three constellations famous for their meteors: Saturn and Venus fresh off their triple conjunction in Leo; Mars gleaming red in the heart of Gemini; and the nearly stellar Comet Holmes high overhead in Perseus. Orion, host of the present meteor shower, was standing straight up in the south. Within seconds, my persistence was rewarded as the Hunter also hosted a bright, brief visitor, a first-magnitude meteor that flashed near Betelgeuse and dropped right by Mintaka. A true Orionid, my first of the year, short, but very sweet. I thought of Halley's Comet and of my Dad.

The goose egg broken, I turned my attention and my 15×70 binoculars to the astonishing new comet for an extended examination, followed by an hour's meteor count in the rising twilight. Of course, I gazed in the direction of Perseus Plus One, which also enabled me to keep the radiant within my field of view. I was pleasantly surprised to get no fewer than 5 Orionids within 20 minutes, indicating that the radiant still had some life in it well over 3 days past the peak.

The standout Orionid was a bizarre coincidence, a particle from that most famous of comets whose fiery demise appeared by chance line of sight to spark directly out of the amazing newcomer. I was staring right at it, a truly astonishing sight that suddenly and unexpectedly moved me to tears for a few moments.

That weekend I phoned Victoria and spoke with my Dad. I mentioned the remarkable new comet, my observation of the extraordinary Orionid meteor and its true origins from an entirely different comet. We briefly reminisced about our trip to see Halley's Comet over 20 years before.

It was the last time we spoke. A week later, as sudden as a meteor, as quiet as a comet, Dad slipped away in his sleep to *not ungentle death*. I grieve him still, but his guiding light shines on in my mind like the memory of a Great Comet.

So I go out: my little treatise done.

Dedication:

This column is dedicated in loving memory of Sherburne McCurdy (1924-2007), family man, educator, community leader, veteran, music lover, sports fan, and stroke-unit volunteer. His determination and undiminished joie de vivre *in the face of serious disabilities inspired all who knew him.*

References:

Kronk, G. 1988 Meteor Showers: A Descriptive Catalog, Enslow Publishers Inc., Hillside NJ, p. xix

Sato, M. & Watanabe, J-I. 2007 "Origin of the 2006 Orionid Outburst," Publications of the Astronomical Society of Japan, **59,** L21-L24

Bruce McCurdy marked the return of Comet Halley by rejoining the RASC in 1985, and has since represented the Society with pride in many aspects of public outreach. In 2007, he was honoured to receive the National Service Medal, Edmonton Centre's George Moores Award for Excellence in Public Education, and a permanent star in Telus World of Science Edmonton's Galaxy of Fame recognizing 20 years of volunteer service. He observed two spectacular comets and hundreds of meteors from dozens of radiants. It was almost a good year.

WEB ACCESS TO THE 2008 ISSUES OF THE JRASC

Access previous and current versions of the *Journal* on the Society Web site at www.rasc.ca/journal/currentissue.shtml.

Issues are posted immediately after the production version is complete and at the printer. You can see the images presented here in full colour.

Username and password are sent by email to RASC members, so it is important to keep National Office up-to-date with your current email address.

Archived *Journals* from 1998 to 2007 are available to the public at www.rasc.ca/journal/backissues.shtml.

Crystal-Clear Temptation: AstroPhysics and TMB Apo Refractors

by Gerry Smerchanski, Winnipeg Centre (smerch@mts.net)

When my benevolent editor suggested to me that I should do a review of some high-end apochromatic refractors, I winced. I winced for two reasons. The first is that I am a *non*-recovering "scope-aholic" and to spend time with apochromatic refractors (henceforth, "apo" refractors or just "apos") would be to travel down a path of temptation that I could ill afford. The second issue concerns my reluctance to talk about the high-end refractors in general, as it draws the attention of a particular segment of the telescope-owning public. Noted telescope reviewer, Ed Ting, has similar perceptions of this and summed up the problem nicely:

> *Apochromatic refractor users are a breed apart. In some ways, they remind me of audiophiles who will only listen to single-ended triode amplifiers. In both cases, users will shell out enormous sums of money for a device that, at first glance, seems to lack any kind of power.*
> — Ed Ting (`www.scopereviews.com/page1s.html#1`)

As a veteran of the early audiophile wars of the 1980s, I have no desire to rekindle that sort of behaviour in the world of high-end telescopes. The silliness and cultist behaviour of audiophiles will be of no benefit to those who are interested in telescopes and astronomy. And, while there are, sadly, too many instances of "brand loyal blindness" and "optical design bigotry," we are better off by stifling that behaviour at every chance we get. It is very difficult to kill a myth once it has taken hold.

With that caveat in mind, I would like to approach this review by taking a historical perspective. The two high-end apo refractors here are the venerable *AstroPhysics Starfire EDF 130* and the new *TMB Signature Series 130-mm triplet APO.* These can be thought of as representing two generations of apo refractors and the main question to be asked is, "Can the new design, at 2/3rds the price, give the same view as the previous generation?"

Figure 1 — A front view of the two telescopes, showing the reflections from the front lenses.

Descriptions

As can be seen in the photograph, these telescopes have much in common and both would naturally be considered by anyone looking for an apo refractor in this aperture range. Both have triplet objectives and both have comparable focal lengths.

AstroPhysics Starfire 130EDF Specifications

Clear aperture	130-mm (5.12") f/6 oil-spaced triplet
Focal length	780 mm (30.7")
Coatings	Multi-layer, overall transmission greater than 97% in peak visual wavelengths
Tube assembly	White, 5.5" aluminum tube, baffled, flat black interior, engraved push-pull lens cell
Focuser type	2.7" I.D. Feathertouch/Astro-Physics rack & pinion focuser, 105 mm travel.
Telescope length	724 mm (28.5") with dew shield retracted
Weight with dew cap	6.8 kg (15 lbs)

TMB-130 130-mm f/7 Triplet APO Specifications

Clear aperture	130-mm (5.1") f/7 air-spaced apochromatic triplet using FPL-53 ED glass
Focal length	910 mm
Coatings	All surfaces are multicoated with low reflection coatings
Focuser type	Feathertouch rack-and-pinion 3.5" diameter focuser, fully rotatable, with 2-speed focusing (normal focus, and a 10-to-1 reduction), 115 mm travel.
Telescope length	740 mm with dew shield retracted.
Weight with dew cap	8.2kg (18 lbs)

Both have similar dimensions and comparable weights, with the slightly larger TMB scope being the heavier. The only noteworthy physical differences are that the TMB at f/7 has a focal length of 910 mm while the f/6 AstroPhysics has a focal length of 780 mm. The focuser is the other major difference: the TMB has a larger rotatable 3.5-inch focuser while the AP has a 2.7-inch version. As can be seen in the specifications chart, both are rather heavy and require a solid mount for high power or imaging duties. The TMB also has a dew shield that slides up into place, while the AP dew shield has to be flipped around from its storage position. The fit and finish of both are excellent. The lens coatings are both very good, though the TMB does have less reflectance when viewed from the front.

Performance

As might be expected, both of these telescopes show exemplary performance at low-to-medium power. There is virtually nothing to choose between them in this regard. There was the slightest reduction in flare on bright objects with the AP and its pinpoint stars seemed slightly better defined, but this minuscule difference could be attributed to a slight difference in magnification. In tests of faintest magnitude, the AP reached slightly deeper. With optics this good, the slightest difference in magnification is readily apparent and careful matching of eyepieces to produce similar power was necessary to rule out the difference. Higher magnification in either telescope produced images less distinct than the other.

Figure 2 — AP (left) has a 2.7″ rack-and-pinion two-speed (10-to-1) focuser, while the TMB (right) has a 3.5″ rack-and-pinion two-speed (10-to-1) rotatable focuser.

The first revelation is, that when it comes to high-powered planetary viewing, these heavy refractors take some time to cool down. First tests were done in September when the temperature was still around 5 °C. Smaller and lighter refractors would have been serviceable within half an hour, but these relatively massive refractors took some time to lose the last of the tube currents and surface turbulence. However, they were slightly faster in acclimating than the larger, heavier 150-mm Maksutov Newtonian (Mak/Newt) that I used as the control in these medium-cool tests. The TMB also seemed to take longer than the AP to reach equilibrium in these milder conditions. Heavy dew is common at this time of year, but surprisingly, the two refractors held clear despite autumn dew running off the tube exteriors for several hours — most impressive.

But the *raison d'être* of these high-end refractors is to deliver the best images possible in demanding situations. There are few situations more demanding than high-powered planetary viewing and it is here that these scopes are expected to make their mark and justify their price tags. Another demanding situation for telescopes is related to dealing with weather conditions, and refractors have long been touted as the scope design best suited to dealing with elements such as extreme temperature and humidity. This winter, with Mars a month past opposition but still riding high in northern hemisphere skies, I was provided an opportunity to test the limits of these two apos. Revealing Martian detail is a tough test for any telescope and doing so during a Canadian prairie January makes for a severe test environment. In order to provide a familiar reference for seeing conditions and Martian detail, my well-used 150-mm Mak/Newt was also enlisted. Visual memory for subtle detail lasts only seconds, so that using the Mak/Newt established a reference point in the test conditions, and made the comparison more relevant in other viewing circumstances.

It is under these other and more extreme circumstances that some distinctions between the apos became apparent.

The acclimation time from a cool room temperature of 15 °C down to an outdoor temperature of -15 °C took far longer than expected. Both refractors were not totally acclimated even after 1.5 hours, although the AP was giving acceptable views by that time. The TMB did not show any detail at this point, while the AP and the Mak/Newt were struggling to give some Martian details. The details in this early stage in the Mak/Newt were as good as the smaller AP, but the AP did not throw up as much flare around the bright planet. It would have been the better choice for hunting Deimos and Phobos.

After two hours, the TMB had settled down and was yielding detailed views, though it showed the planet as much more orange than either the AP or the brighter image in the Mak/Newt. Perhaps this was due to better colour transmission, but more likely the saturated colour was due to the TMB giving a slightly dimmer view of the Red Planet. In the warmer fall-time testing, the AP had shown itself able to reach a slightly deeper magnitude than the TMB.

Figure 3 — Three frosty tubes lined up in the snow at -28 °C. The 150-mm Maksutov Newtonian (left) is my main planetary telescope, and was used as the control to evaluate seeing conditions and Martian detail. The TMB on a Losmandy G-11 mount (centre) is a nice sturdy combination, while the AP (on the right) on a relatively sturdy alt/az mount proved to be a bit frustrating for high-powered planetary observing. Mars is high overhead.

By 2.5 hours, the out-of-focus images showed no internal turbulence, indicating that both refractors had reached some form of thermal equilibrium (but see below) and both gave good in-focus detail of a rather small (~13 arc seconds) image of Mars. The defocusing test was done with some effort, as the temperature had fallen to -28 °C and the two rack-and-pinion focusers in the apos were getting very stiff — the opposite of what was happening to the Crayford focuser on the Mak/Newt, which required only a slight twist on its tension knob, and then remained delightfully smooth and effortless. The TMB focuser did remain slightly easier to turn, but that could be due to the relative tension that was preset on each and something that I left untouched so as not to incur the annoyance of the scopes' owners. The two screws for securing the diagonal of the TMB were much more assuring than the single screw of the AP, but both worked without incident. The placement of the screws on the TMB required that gloves be removed for access between the large focuser tube and the diagonal, which was a painful experience at these temperatures.

To compensate for the differences in focal length of the two apos, a very good Speers-WALER 5-8 mm zoom eyepiece was used to allow for quick compensation of the focal-length differences between the scopes. It, along with some orthoscopics and Naglers, was used to keep magnifications as close as possible, as magnification differences are telling in these telescopes. These eyepieces, along with a TeleVue Everbright diagonal, were transferred back and forth between the two scopes for many repeated comparisons. When the eyepiece (in the case of the Mak/Newt) or the eyepiece and diagonal (in the case of the TMB) were put into place, there was always some tendency to fiddle with focus. Not so with the AP: installing the eyepiece and diagonal usually led straight to observing. This might suggest that the views in the first two perhaps were not as sharp as that experienced in the AP but close inspection showed that everything that was visible in one was seen in the others — just with more effort or time required. The views through the AP throughout the tests from September to January, while sometimes matched, were seldom bettered by either the TMB or the Mak/Newt, although the differences, once conditions stabilized, were very small.

A binoviewer with a 2× triplet Barlow was also employed, as using both eyes is one of the biggest improvements that can be made in planetary viewing. This allowed a great view of Mars and, with more power, made the differences between the scopes more apparent. The AP handled the extra magnification with ease; the other two were also capable with higher powers, but perhaps not with as much comfort.

An interesting sideline test provided itself in the form of the rising Moon. When it was about 30 or so degrees above the horizon, all three scopes were directed toward it, and used at high power were directed towards it. Curiously, the 150-mm Mak/Newt, which had acquitted itself so well with the overhead Mars images, showed much more atmospheric turbulence than the two smaller 130-mm refractors. The amount of turbulence seemed much more than one would have expected from the mere 20-mm difference in objective diameters, yet there it was. The views of the Moon through the TMB were preferable to the views through the Mak/Newt, even though the reverse was true for views of Mars when it was high overhead. Such a turn of events speaks loudly for those who feel that objective size is a relevant factor in "cutting through the seeing conditions." It should be added that the best views of the Moon that night were rendered by the AP.

The TMB seems to suffer from a long cool-down period that keeps it from performing as well as it can. With the two scopes being so similar otherwise, this was puzzling. A possible answer lies in details of the optical design. While most optical designers are rather reticent to talk about such subtleties, a Hungarian optical company is willing to venture an opinion on the issue.

> *The problem is that air is a very bad heat conductor (about 1000x worse than oil), and especially if the air space is wide, the internal member of the triplet lens is separated from the environment thermally.... When we take such a lens out to the cooler environment, the center member can lose only very limited amount of energy through the air spaces, but its edge is in contact with the metal cell of the lens, which cools down quickly. This way, the center of the middle element remains warm for a long time, while the edge of this middle element start to cools down suddenly. The result is under-correction, and this remains there for a long time, because the center member loses a significant amount of energy at the edge over the entire cooling process. On the contrary, oil spaced lenses are good heat conductors internally, so their center elements can lose a lot of heat over the front and back surfaces of the lens. So, they cool down much faster, and also, during the cooling process, the internal heat distribution of the lens is much more homogenous compared to an air spaced lens, as most of the heat is lost through the front surface and less at the lens edge. So, these optics can better and quicker adapt to the changing temperature, thus they can deliver high resolution images sooner than their air spaced brothers.*
>
> — *GPU Optical*

Perhaps the superior thermal equalization of the AP can be attributed to its oil-spaced objective, versus the TMB's air-spaced one. It would be interesting to test this theory out with the newer air-spaced triplet objective that is now found in the newer AP telescopes.

Star tests of the two apos in the deep-freeze situation also showed a distinct difference. The AP tested as near to perfect as I am familiar with. There was the slightest of colours to be seen either side of focus, and I have seen more distinct diffraction rings, but the even intensity of the rings on both sides of focus showed excellent figure. The TMB star test showed more distinct diffraction rings than the AP. This is suggestive of a very smooth surface, but the inside rings also showed less intensity when inside focus. This is described by H.R. Suiter as indicative of under-correction (see page 182 of *Star Testing Astronomical Telescopes*), in agreement with the explanation given from GPU Optical. Perhaps the TMB never reached total equilibrium and its cold-weather performance was thus compromised. To control for purported temperature effects on the TMB, an artificial star test was conducted indoors and it continued to show some under-correction. Indoor test conditions were insufficient to conclusively decide the issue.

Conclusions

Make no mistake, these two apos are very good telescopes. They provide views that are as good as any other telescope of this size and some that are larger. At only 2/3 the cost, the TMB represents an encouraging step forward in the annals of quality refractor viewing. At its price, it still might not be "an apo for the masses," but it has brought that much-desired design closer to affordability. But the AstroPhysics apo still delivers a performance that makes it the more competent of the two. If cost is no consideration, then it would seem the desired choice. With cost a factor, the choice is not so clear and options open up that are wholly dependent on the particular person.

Time with these wonderful telescopes has done nothing to cure me of scope-aholism. In fact, it has worsened the condition somewhat. However the close performance of the Mak/Newt, at 1/3 the cost of the less expensive of the two refractors, will be enough to keep me out of apo-heaven. The TMB and the Mak/Newt were quite close in performance for much of the testing and I have learned to live with some of the larger closed-tube's shortcomings — especially now that I have some appreciation for just how long these heavy refractors take to achieve thermal equilibrium themselves. Yes, I will still have to go through the sacred collimation ritual on rare occasions, but not so often as to have it take away observing time.

And for those who are incensed by my apo-atheism, I offer even more fuel for the inquisition. *Pareidolia* is a psychological phenomenon involving a vague and random stimulus such as an image or sound, being perceived as recognizable and meaningful. Common examples include images or figures in clouds. A famous example these days is the "Face of Mars" picture.

Figure 4 — The Face on Mars. Courtesy NASA.

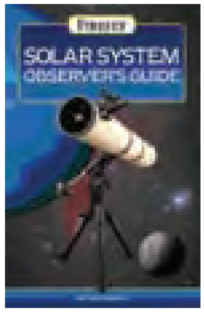
Pareidolia is a form of ***apophenia,*** which is described as the "experience of seeing patterns or connections in random or meaningless data." So, with apologies to psychologists, I would like to propose a new definition: "***Apo apophenia,***" which is to be defined as "the experience of seeing what is deemed to be superior images based on the cost or prestige of a design or brand of telescope." Those suffering from such an affliction should be excluded from the debate.

Acknowledgments
I thank Jay Anderson and Ray Andrejowich for the gracious loan of their telescopes, and their trust that I wouldn't drop them or more likely run off to a tropical hideout with them.

Gerry Smerchanski's interest in astronomy extends at least as far back as his second spoken word, which was "Moon," but it took a leap forward when he obtained his first department-store telescope in 1969. Gerry is a scope-aholic and suffers from "ocularosis," which is defined as the inability to ignore eyepieces and other optical equipment. He is now in early stages of "apo-withdrawal."

Reviews
Critiques

Solar System Observer's Guide, by Peter Grego, pages 256; 13 cm × 20 cm, Firefly Books Ltd., 2006. Price $17.95 paperback (ISBN 1554071321).



Being a planetary observing enthusiast, I eagerly accepted a friend's request to review the latest book dedicated to the subject, published by Firefly Books Ltd. Aptly titled *Solar System Observer's Guide,* the book is intended for specialists in the visual exploration of the planets. While amateurs solely interested in planetary imaging will no doubt find much useful information within its pages, it is written in the spirit of visual planetary study, an impression gained right from the front cover. Pictured is an equatorially mounted, 8-inch Newtonian reflecting telescope with a curved-vane secondary holder and a low-profile Crayford focuser, an ideal visual planetary instrument.

I must admit that I became a big fan of the uncomplicated beauty of visual planetary study from the first time I saw the gas giants through the eyepiece. With such a beginning, I feel I can relate to the author's direction. Limited information is given to Webcam and other forms of imaging. Instead, Grego describes the joy and value of sketching at the eyepiece. He includes some very well done sketches and encourages readers to try their hand at it themselves. He explains his reasons for drawing in Chapter 2:

> *...why go to the trouble of spending an hour or two observing and drawing astronomical objects when the CCD can apparently capture it all with great accuracy in a fraction of a second? Why observe at all, when images captured by a CCD will bring the scene live to one's computer screen indoors? These are great questions, but they are asked only by those who don't get a thrill from seeing the heavens for real.*

I can hardly argue the point. After all, is that not why we all got into astronomy in the first place?

The book starts out with a basic description of our Solar System's place within our Galaxy, and moves on to describe the motion of the inferior and superior planets relative to Earth's orbit. A brief introduction to each planet is given to whet one's appetite for more detailed information in future chapters. Chapter 2 deals with the tools necessary for planetary observers, from an understanding of vision to telescope and accessory selection. An unfortunate oversight is the lack of a description of the Maksutov Newtonian which is a fine visual instrument, it is shown in a photo, but is not described anywhere in the text. Not mentioning the advantages of binoviewers, especially for visual work, is another omission. In contrast, the author's comparison of parameters such as telescope resolving power and the limiting magnitude of varying apertures versus the corresponding sizes of lunar features and planetary objects is well done. For example, resolving power is related to appropriate-sized lunar craters, and limiting magnitude to different planetary moons. Such comparisons are a clever inclusion and appreciated by this reader.

As one might expect, each Solar System body, including comets and asteroids, is given a separate chapter. Each chapter contains useful information, including tables of future oppositions, favourable elongations, *etc.* from the present to 2016 and beyond in some cases. The tables alone make the book worth its cost, as it makes it a handy reference guide for years to come.

As much as I enjoyed flipping through the pages, I did notice a few shortcomings. Most notably, the book was published just before the astronomical community made its decision to demote Pluto to the status of a dwarf planet. Here the author is a victim of bad timing. Unfortunately, it does date the book. In the Mars chapter, the author describes surface features without having a proper map divided into longitude and latitude grids for reference, which is just plain confusing. For Jupiter, the nomenclature of cloud features (festoons, rifts, bars, ovals, *etc.*) is described in text only, without any graphical reference, which makes identification of such features more challenging. The inclusion of sample observing templates, or at least an address where to find them on the Web, would also have been a useful addition. Lastly, I feel an expanded topic dedicated to atmospheric seeing conditions is a "must" in any planetary observing book. In fairness, the author did have a few paragraphs about the subject, but it was not nearly enough. As every experienced planetary observer knows, the telescope is not the limiting factor when observing the planets — it is our atmosphere. Some general guidelines such as how to assess sky seeing conditions quickly by evaluating the amount of star scintillation, or locating one's observing site away from heat currents rising from roof tops and concrete slabs, should have been included. All are valuable tricks of the trade for optimum observing experiences. Other important rules of thumb such as letting one's telescope cool to the ambient temperature, and maintaining proper collimation, are equally as important, but were somehow missed.

Despite such issues, *Solar System Observer's Guide* is a very attractive and well illustrated book in an easy-to-read format. It contains much useful information, without too much technical jargon to confuse the beginner. More importantly, I believe it allows the novice to cultivate an appreciation for planetary study. Should it be the sole source for planetary observing in your library? I would have to say no, since there are more-comprehensive books available, but it does earn a place on my bookshelf to supplement my collection.

Mike Karakas

Mike Karakas is an Architectural Technologist by profession and planetary observing enthusiast by choice. He disregards the comments from his fellow astronomy friends who say that planets are light pollution, and enjoys both sketching and imaging planets from his backyard in Winnipeg, Manitoba.

The Telescope: Its History, Technology and Future, by Geoff Andersen, pages 248; 16.5 cm × 24.5 cm, Princeton University Press, 2007. Price $29.95 US hardcover (ISBN-13: 978-0-691-12979-1).

Inspired by the upcoming 400th anniversary of the invention of the telescope, Geoff Andersen has set out to write an ambitious book on the subject. Any of the aspects of telescopes mentioned in the subtitle — "its history, technology and future" — could become the subject of a separate book, or even a series of texts. As if that were not enough, Andersen also wants to address the entire range of telescope usage, from department store toy telescopes used for casual stargazing, right up to our flagship professional optical instruments, and even to address military applications that reach to the barrier of state secrets. The goals and scope (pardon the pun) of his effort are breathtaking, and leave the reader with great expectations.

For the sake of general reader accessibility, Andersen has also restricted his use of mathematical formulae and technical descriptions. To help the reader explore some of the issues more thoroughly, he has included several appendices to aid the uninitiated in understanding concepts and terminology used in astronomy and other telescope applications. He also provides an introduction that coaches the reader to treat each chapter independently so that a front-to-back reading of the book is not required. The book is intended for those unfamiliar with telescopes, and yet will provide veteran telescope enthusiasts with some new insights.

The first two chapters give the reader an historical introduction to the development of telescopes, starting from unaided-eye observations and the first telescopes pointed toward the sky by Galileo. Several major figures in astronomy (Brahe, Kepler, and Newton) are included in the brief history lesson of astronomy during that period of discovery. If the reader is hoping for a more comprehensive history of telescopes of this period rather than astronomical advances, there will be disappointment. Other than a comparison of the original Galilean telescope with modern department-store refractors, there is little description of the instruments of that period or the eras that followed. No mention is made of the odd and unwieldy attempts by Huygens, Hevelius, and others to overcome the limits of their technology with aerial telescopes and other extreme long-focal-length refracting instruments. Although some attention is given to the difference between Galilean and astronomical telescopes in a later section on how telescopes work, no mention of Kepler or Christoph Scheiner is made in documenting technological improvements to refractors of this early period. Similarly, while the reflector designs of Gregory and Cassegrain are talked about in later chapters, their place in the historical development of the instrument is left out. Other omissions include the contributions by Chester Hall, Joseph Fraunhofer, and more modern opticians, such as Bernhard Schmidt, Dmitri Maksutov, and Joseph Petzval, all of whom have made significant contributions to modern telescope design. Moreover, could any historical account of telescopes be adequate without the mention of the Herschels (William, Caroline, and John)? So the history of the telescope is given short shrift. That might be agreeable to readers who are looking for a broader and more digestible perspective, but it is a pity, since Andersen's style would have made for a good version of this more technologically oriented and much overlooked history.

Andersen does an admirable job of conveying the basics of telescopes to the reader in chapters three through five. His accounts of diffraction and telescope aberrations are very understandable, especially the italicized description of Airy discs and just what a perfect image affected by diffraction would look like. And yet, all accounts, including Andersen's, could still use some forceful explanations emphasizing that an Airy disc is also the result of "perfect focus" to drive home the point that telescopes do not render stars as "points."

When it comes to expressing the technological aspects of modern telescopes, Andersen gives us a broad and comprehensive account that takes the reader into applications that one does not normally associate with telescopes. Most readers having some familiarity with optics might be acquainted with interferometry, but Andersen's clear account will advance that understanding and extend it in ways not considered. Those new to the subject might find the section daunting. Andersen also takes the reader on a whirlwind tour of unconventional uses of telescopes, including military and intelligence applications, another subject that is much overlooked in most accounts.

One odd chapter is entitled suggestively, "So you want to build an observatory?" Despite the title, he has little to say about the practical considerations of building an observatory. Instead, he gives us a cursory rundown of the considerations that have to be dealt with in the construction and location of world-class research facilities. Again, the material presented, while relevant to the topic, is not quite in accord with the chapter title and shows us just how large a subject the investigation of telescopes can be.

His final section addresses the future of telescopes, and again Andersen gives us a wonderful glimpse into the future of telescope development without engaging in wild speculation. Instead, he focuses on large mega-projects that hopefully will come to fruition. He also delves into the promising aspects of adaptive optics and what that will mean for large Earth-based telescopes. It would be nice if he turned his crystal ball on the upcoming innovations in image processing that might be useful for amateur telescopes and professional observatories. No doubt the subject is complex, but the startling accomplishments of amateur astroimaging have consequences beyond the creation of pretty pictures. He also tries to bring the astronomical research enterprise down to Earth by talking about non-scientific issues such as political wrangling, national prestige, and scientific one-upmanship.

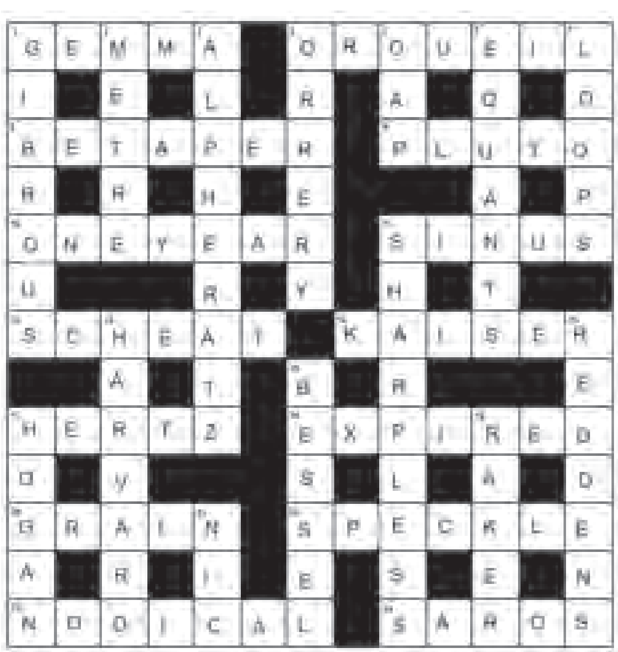
So, of the three aspects of telescopes mentioned in the subtitle, Geoff Andersen delivers two and gives us the "light" version of the history. It would have been more in keeping with the theme of the book if the history section had concentrated more on the technological developments of telescopes and not strayed into the well-worn path of astronomical exploration and achievement. But two and a half out of three is not bad. He also tries to be inclusive by addressing the concerns of amateur astronomers — a large topic that is not easily covered in books dedicated to the subject, let alone in a book such as this that tries to be much more. Some readers might find their perspective jarred by switching from contemplating the engineering problems of multiple space telescopes trying to hold station in orbit, and then changing gears to consider where they should be placing their roll-off roof observatory. Others may find such a wide swath of subject material to be more a lack of focus of subject material. That would be unfair, given that Andersen does bring his particular perspective to bear on astronomy, but the task he has set himself is very broad. Choices had to be made between depth and breadth. One hopes readers will understand that not all chapters will have the same relevance to their interests. With such ambitious goals, there are going to be many instances where it is found wanting. Perhaps a much larger version of the book is in order? If the largest failure of the book is that its reach exceeded its grasp, then that is the kind of shortcoming to which all authors should aspire.

Gerry Smerchanski

Gerry Smerchanski is a member of the Winnipeg Centre of the RASC. His interest in astronomy extends at least as far back as his second spoken word, which was "Moon," but it took a leap forward when he obtained his first department-store telescope in 1969. His formal education in history and philosophy of science from several universities causes him to take a broad historical approach to most subjects, including astronomical equipment. Gerry is a scope-aholic and suffers from ocularosis, which is defined as the inability to ignore eyepieces and other optical equipment.

Astrocryptic

The solution to last issue's puzzle, by Curt Nason



Society News

New Treasurer

by Scott Young, President

I am pleased to announce that Mayer Tchelebon of the Toronto Centre has been appointed by the Executive to serve as the Society's Treasurer, replacing Alan Whitman who resigned last fall. Mayer is a professional accountant with extensive experience in the financial affairs of not-for-profit organizations, having served as treasurer of two other NFPs. He also worked as a budget analyst for a large city in the GTA before "semi-retiring" a few years back. Mayer is looking forward to the challenge of the position, and I am excited to work with him.

As per the Society By-Laws, Mayer was appointed between Council meetings by the Executive rather than at the next meeting of Council, since we need him to work on the Society's year-end statements, and that cannot wait for March. Mayer is appointed to serve out the remainder of the previous term, which means his term will expire at the GA in 2010.

Our Journal World

by James Edgar, Secretary (jamesedgar@sasktel.net)

The members of the *Journal* production team come from many and varied backgrounds, which makes the flagship publication of our Society such a rich and interesting magazine. There is something for everyone, articles of interest to novice and professional alike. Below is a map showing where each of us calls "home." Of course, some of the larger locations have several contributors. We could hardly be farther apart, yet, through the wonders of the Internet, emails, long-distance telephone, and data transfer, we are all connected. It's a wonderful world! (Thanks to Google Maps for the image.)

Plan Now to Attend the 2008 General Assembly!

The 2008 General Assembly will be hosted by the Hamilton, Mississauga, and Toronto Centres and will be held on the campus of York University in Toronto. This year's theme **"Astronomy Night in Canada"** is meant to help focus our efforts on the International Year of Astronomy coming up in 2009, when up to 365 "astronomy nights" can be held across the country. The IYA will be a once-in-a-lifetime opportunity to showcase astronomy for our friends, families, and communities, and we hope this year's GA will help to bring the incredible talents and resources of our Society to bear on this international festival of astronomy.

This year's early-bird registration deadline is **April 30** and regular registration will be available until **June 15** after which late registration fees will apply. Registration is now open at the official GA Web site at `www.rasc.ca/ga2008`.

This year's GA is being held in partnership with the **Department of Physics and Astronomy at York University.** In addition to helping us with logistics and event management, the department will also be providing tours of their campus observatory facilities and participating in the GA program. As Canada's National Astronomy Convention, the RASC General Assembly is open to everyone and anyone who is interested in astronomy, and there will be excellent speakers as well as social opportunities to enjoy.

Special Events

Each General Assembly features its own unique combination of events and activities. Here are some highlights for 2008:

- **Observatory Tours** – York University's Department of Physics and Astronomy will offer guided tours of their 24-inch telescope during both Friday and Saturday evenings.
- **National Members' Night** – An informal opportunity to talk astronomy with your fellow RASCals hosted by the Mississauga Centre.
- **Tour of *Walking Mars*** – A brand-new exhibit at the Ontario Science Centre will feature the red planet and our plans for its exploration.
- **Hamilton Centenary Banquet** – The Hamilton Centre turns 100 in 2008 - join them to celebrate this milestone at the Ontario Science Centre.
- **Closing Banquet** – A highlight of every General Assembly is our opportunity to "toast the Queen," as well as to honour some of our brightest and best. Outgoing President ***Scott Young*** will provide a keynote address to the Society.

Registration and Accommodations

The Society has a block of rooms reserved on-campus at York University's Vanier College, which is steps from the University's transportation hub served by GO Transit, York Region Transit, and the Toronto Transit Commission. Discounted parking passes are available for out of town participants, and Toronto's Pearson Airport is only a short hop away from the University.

Registration fees start at only $125.00 for the whole conference. Day passes are also available if you can only participate in part of the GA weekend. Be sure to register by 2008 April 30 to get the lowest possible prices for meals, events, and activities. Registration will be on-line shortly at `www.rasc.ca/ga2008`. Visa and MasterCard will be accepted, or a cheque can be remitted to National Office.

Call for Papers

The General Assembly is a unique opportunity for RASC members from across the country to share their results, programs, insights, and accomplishments. Members are invited to "take to the ice" to share their insights with the assembled delegates. There are four ways that you can participate:

- **Paper Sessions** – A 20-minute presentation to the entire assembly on either Saturday or Sunday of the General Assembly.

- **Poster Sessions** – Posters will be displayed in the Olga Cirak Common Room where the Friday and Saturday evening events will be held. Posters can highlight research, Centre programmes, or other activities. Presenters will have an opportunity to highlight their poster for five minutes at the National Members' Night (Saturday).

- **Panel Discussions** – Where appropriate, the panel discussion format will be used to highlight topics of interest to the entire General Assembly. Please put forward your suggestions for topics and panellists to the organizing committee.

- **National Members' Night** – A more informal series of short talks from members across the country, which is scheduled for Saturday evening.

If you have an idea or a programme suggestion that does not easily fit into the categories noted above, then please contact the General Assembly organizing committee at `ga2008@rasc.ca` and we'll work with you to elaborate it.

Three Centres – Three Times the Welcome!

The Hamilton, Mississauga, and Toronto Centres are looking forward to welcoming RASCals from across the country to join us in Toronto this summer. We have an excellent programme planned and Toronto is exceptionally easy to get to with direct flights from just about everywhere in Canada. York University's Department of Physics and Astronomy is a full participant in this year's General Assembly, and the entire event promises to be a memorable part of your astronomical year in 2008 — rain or shine! We look forward to welcoming you to the GTA this June!

John Williamson, President, RASC Hamilton Centre
Randy Attwood, President, RASC Mississauga Centre
Denis Grey, President, RASC Toronto Centre

2008 General Assembly
Program at a Glance

Pre-Game: Friday 2008 June 27
- National Council Meeting (9 - 4 p.m.)
- Posters Available for Viewing
- Indoor/Outdoor Cocktail Reception
- Tour of York University Observatory
- Visit to MDA's Space Exploration division in Brampton (Optional)

1st Period: Saturday 2008 June 28
Mississauga Day!
- Paper Sessions (a.m.)
- Posters Available for Viewing
- Keynote Speaker and Official Opening
- Paper Sessions and Panel Discussions
- All-star" Hockey!
- BBQ and National Member's Night
- Tour of York University Observatory

2nd Period: Sunday 2008 June 29
Hamilton Day!
- Paper Sessions (Morning)
- Posters Available for Viewing
- Transfer to Ontario Science Centre
- Viewing of *Facing Mars* (Afternoon)
- Hamilton Centenary Banquet

3rd Period: Monday 2008 June 30
Toronto Day!
- RASC Annual General Meeting
- Panel Discussion - Making the Most of the International Year of Astronomy
- Helen Sawyer Hogg Lecture – **Phil Plait**
- Closing Banquet

Overtime: Tuesday 2008 July 1
- Celebrate Canada Day in Toronto
- Visit to the Carr Observatory near Collingwood

Call for Nominations

RASC PRESIDENT, 1st VICE-PRESIDENT, & 2nd VICE-PRESIDENT

Are you a leader? Do you want to see the RASC grow and excel into the future? Do you want to contribute to that success? Here is your chance to make a real difference in our Society by getting involved in the issues that matter!

The three presidential positions (President, 1st V-P, and 2nd V-P) must be filled by election or acclamation at the RASC Annual Meeting on 2008 June 30. Names of candidates must be presented to the Secretary at least 60 days prior to the Annual Meeting by the RASC Nominating Committee or by a private nomination supported by the signatures of five members of the Society.

As chair of the Nominating Committee, I invite you to send suggestions for these positions to me for the Nominating Committee's consideration. Please send any suggestions by email, no later than 2008 April 30.

The duties associated to these positions are specified in the Society's bylaws, which are available in the password-protected portion of the RASC Web site.

Peter Jedicke *(pjedicke@yahoo.com)*
Chair, Nominating Committee

RASC NATIONAL SECRETARY

Are you looking for a meaningful way to contribute to the RASC? Why not get involved and help determine the future direction and success of your Society? Here's how:

The position of Secretary will be filled by election or acclamation at the Society's Annual Meeting, scheduled for 2008 June 30 during the General Assembly. Names of candidates must be presented to the Secretary at least 60 days prior to the Annual Meeting, either by the Society's Nominating Committee, or by a private nomination supported by the signatures of five members of the Society.

The Secretary is a member of the Society's executive committee, and his/her duties include, among others, the following:

- Conduct the correspondence of the Society and report thereon to Council,
- Have custody of the seal and the current minutes and documents of the Society,
- Send to all members of the Council and to the Secretary of every Centre the minutes of all Council meetings.

The term of office for the Secretary is normally three years. More information about this volunteer position can be found in the Society's bylaws, which are available in the password-protected portion of the Society's Web site.

As chair of the Nominating Committee, I invite you to send suggestions for this position for the Nominating Committee's consideration. Please send any suggestions by email, no later than 2008 April 30.

Peter Jedicke *(pjedicke@yahoo.com)*
Chair, Nominating Committee

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

NATIONAL OFFICERS AND COUNCIL FOR 2007-2008/CONSEIL ET ADMINISTRATEURS NATIONAUX

Honorary President	Robert Garrison, Ph.D., Toronto
President	Scott Young, B.Sc., Winnipeg
1st Vice-President	Dave Lane, Halifax
2nd Vice-President	Mary Lou Whitehorne, Halifax
Secretary/Recorder	James Edgar, Regina
Treasurer	Mayer Tchelebon, Toronto, MBA, CMA
Librarian	Robert Garrison, Ph.D., Toronto
Past Presidents	Peter Jedicke, M.A., London and Rajiv Gupta, Ph.D., Vancouver
Editor of *Journal*	Jay Anderson, B.Sc., MNRM, Winnipeg
Editor of *Observer's Handbook*	Patrick Kelly, M.Sc., Halifax
Editor of *The Beginner's Observing Guide*	Leo Enright, B.A., Kingston
Editor of *Observer's Calendar*	Dave Lane, Halifax
Executive Secretary	Bonnie Bird, M.L.Sc., 136 Dupont Street, Toronto ON M5R 1V2 Telephone: (416) 924-7973

CENTRE ADDRESSES/ADRESSES DES CENTRES

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

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

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

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

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

Halifax Centre
PO Box 31011, Halifax NS B3K 5T9

Hamilton Centre
576 - Concession 7 E, PO Box 1223, Waterdown ON L0R 2H0

Kingston Centre
PO Box 1793, Kingston ON K7L 5J6

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

London Centre
PO Box 842 Stn B, London ON N6A 4Z3

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

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

Montreal Centre
18455 Meloche St, Pierrefonds QC H9K 1N6

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

Niagara Centre
PO Box 4040, St. Catharines ON L2R 7S3

Okanagan Centre
PO Box 20119 TCM, Kelowna BC V1Y 9H2

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

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

Québec Centre
2000 Boul Montmorency, Québec QC G1J 5E7

Regina Centre
PO Box 20014, Regina SK S4P 4J7

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

Sarnia Centre
c/o Paul Bessonette, 160 George St, Sarnia ON N7T 7V4

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

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

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

Vancouver Centre
1100 Chestnut St, Vancouver BC V6J 3J9

Victoria Centre
333 - 1900 Mayfair Dr, Victoria BC V8P 1P9

Windsor Centre
2831 Alexandra Ave, Windsor ON N9E 2J8

Winnipeg Centre
PO Box 2694, Winnipeg MB R3C 4B3

This Issue's Winning Astrophoto!

2006 Solar Eclipse Expedition in the Sahara Desert — Photo by Patrick MacDonald

Taken 2006 March 29 in the heart of the Sahara Desert in Libya with a Canon EOS 20D just after a successful viewing of the solar eclipse. Members of the expedition organized by the RASC Toronto Centre gather around the Eclipse Expedition Banner, upon which is recorded all the places it has been taken for solar eclipses. Two members, Marvin Goody, and myself (kneeling), Patrick McDonald, have adapted aspects of local dress to cope with the climate.

I have been with the Toronto Chapter of the RASC for many years. My main focus is variable stars, but I have travelled to six solar eclipses and one transit of Venus, though not always with the RASC. I am semi-retired from teaching; other interests include playing the bagpipes, cycling, and chess.