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Journal

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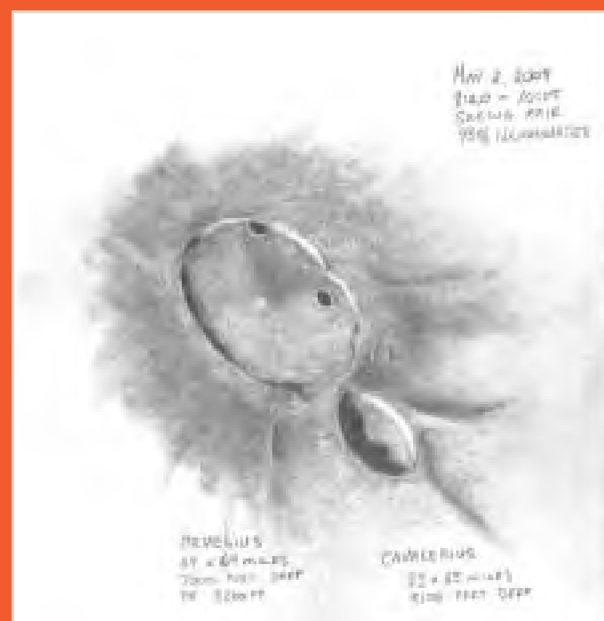

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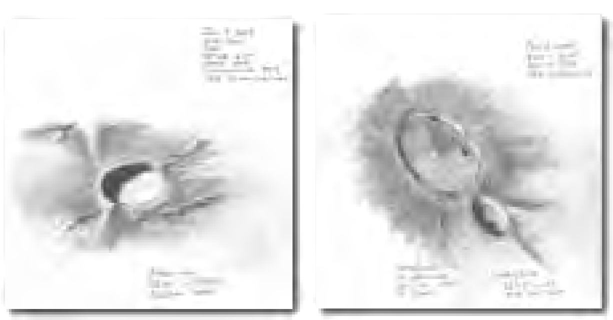
Royal Astronomical Society of Canada / Société Royale d'Astronomie du Canada

DEPARTMENTS/DÉPARTEMENTS

ACROSS THE RASC
DU NOUVEAU DANS LES CENTRES



Cover Images:
Sketches of the lunar craters Bianchini and Hevelius by Guy Mackie of the Okanagan Centre. In Guy's words, "Each sketch is done completely at the eyepiece, with no post-observation enhancements. Each is completed in about 45 minutes due to the relentless progression of nature's shadows."

COLUMNS/RUBRIQUES

President's Corner

by Scott Young, Winnipeg Centre (scyoung@manitobamuseum.ca)

It is a great honour to be writing my first President's Corner for the *Journal of the RASC*. I became President at the Ottawa General Assembly in May, the same host city of my first-ever GA in 1990. Congratulations to Debra Ceravolo and the Ottawa Centre for a great event!

Since I attained this post through acclamation, I never had to campaign. In some ways that's a good thing, since I didn't really come looking for this job. I always figured I'd take my turn helping to run the Society, but the chance came earlier than I expected. However, if I had needed a campaign speech, here's what I would have said:

"The RASC is at a key point in our history. We face continued financial pressures, we experience volunteer fatigue at the Centre and national levels, and we continually have to work to preserve our Society. At the same time, there is renewed interest in astronomy and space exploration, and technology once restricted to the realm of professionals can be had from the backyard. It's a great time to be an amateur astronomer.

"The RASC needs to deal with its overly-restrictive By-Laws, with its slow-moving governance, with its business model, and with escalating costs in order to survive as a business. This has been front and centre recently and will probably need to continue that way for a little while longer until we get things in order.

"To survive as a national astronomy organization, though, we need to deal with a completely different set of issues — things that can make a difference for our members, the lifeblood of the RASC. Many astronomy clubs have chosen to join the RASC recently; this May we welcomed Mississauga as our 28th Centre. The real role of the RASC is to make life easier for the Centres, to provide through economy of scale what they couldn't do on their own, to simplify membership and publications and programming and resources and finances so that the Centres can concentrate on being a local astronomy club. If the average member knows nothing about the national RASC beyond the name of their local club, we've done a good job. The national organization does the work it does so that most folks don't have to care about the details. That's what I and the new executive and committee chairs have signed up to work towards, and we look forward to working for you."

When I was a kid with a new telescope (my infamous 60-mm Tasco), the RASC's Winnipeg Centre took me in, gave me a few pointers and a kick in the pants, and got me out observing. I met people who were passionate about observing, about doing real science, and about science education. It was one of the defining points in my life, one that set my future career in science education and established my lifelong relationship with the night sky. I just want to say "Thanks."

Journal

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

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News Notes
En Manchettes

Compiled by Martin Beech and Russ Sampson

SEEING THE HOST GALAXIES OF HIGH-REDSHIFT QSOs

When quasi-stellar objects (QSO) were first discovered in the early 1960s they defied explanation. They appeared as star-like objects, some with extreme red shift. Their brightness varied over days or even hours, suggesting that their diameters were only about the size of our Solar System. If their redshift indicated their true cosmological distance, they were the most luminous objects in the Universe. However, what they were and what kind of cosmic environment they resided in was a mystery. At the time of their discovery, telescope technology had not advanced enough to resolve such far away objects.

Now engineering has begun to catch up to our desire to understand these enigmatic objects. High-resolution interferometers, adaptive optics, and space-based telescopes are now extracting the secrets of these objects — and showing us where they live. Today most astronomers agree QSOs "live" in the centre of galaxies and are produced by supermassive black holes that are consuming in-falling stars and gas clouds. Because of their intense brightness, some of these objects can be seen close to the edge of the observable Universe and less than a billion years after the birth of the Universe. Due to their immense distance, we know relatively little about the parent galaxies and the immediate stellar environment around the QSOs with the highest redshifts.

Now John B. Hutchings of the Herzberg Institute of Astrophysics in Victoria, B.C. has turned the sharp eye of the 8-metre Gemini North (GN) telescope on two of the most distant QSOs known. In doing so, Hutchings hoped to see what kind of galaxies they reside in (*Publications of the Astronomical Society of the Pacific,* November 2005). The two objects, SDSS 0338+0021 and WFS 2245+0024 have redshifts of z = 5.02 and 5.17 respectively. These extreme redshifts translate to a look-back time of about 12.7 billion years. This assumes a Hubble constant of 65 km/s/Mpc and a Universe that is flat and made of 1/3 normal matter. If these assumptions are correct, we are seeing these objects when our Universe was only 7 percent of its current age. Understanding these far-flung objects will provide astronomers with a tiny window into the state of the early Universe — when galaxies and their supermassive black holes were first starting to form. The current record holder is SDSS J1148+5251, a QSO of redshift z = 6.4.

Observing in the near infrared (J-band), Hutchings digitally extracted the quasi-stellar component from the image to reveal the faint glow of the surrounding galaxy (Figure 1). Extensive image analysis has revealed subtle signs of spiral structure even

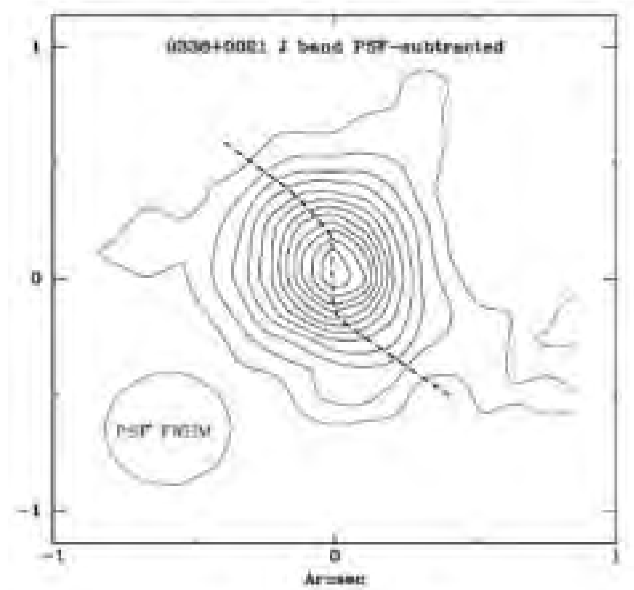

Figure 1 — Contours of the inner arcsecond of SDSS 0338+0021. The dotted line traces the long axes of the contours and indicates a bar or spiral-like structure to the underlying host galaxy. (Image courtesy of J. Hutchings).

though the objects are less than an arcsecond wide. When reached for comment Hutchings states "that these are the highest redshift resolved QSOs, and that the host galaxies are quite large and bright." Hutchings went on to add that "the previously largest redshift [QSOs] were at z = 4.7, which I also did on the Gemini telescope." To date there are hundreds of resolved QSOs, each one taking astronomers one step closer to finally understanding these strange and powerful objects (**RS**).

PLANET SEARCH BY *MOST*

The results are now in for the first search for Earth-sized planets using *MOST,* Canada's suitcase-sized space telescope. UBC astronomer Jaymie Matthews explained what has been "un-earthed" at the American Astronomical Society (AAS) Meeting in Washington, D.C. this past January.

Taking advantage of the *MOST* (Microvariability & Oscillations of STars) satellite's unique ability to measure minute changes in the brightness of stars, Matthews and other scientists from the team put a star 160 light years away under an astronomical "stakeout" to determine the possible existence of Earth-sized extrasolar planets that would escape detection by any other existing observatory.

MOST's target was a Sun-like star called HD 209458, already known to have a giant planet 15 times the diameter of Earth and 220 times its mass. Named HD 209458b, the planet orbits its parent star extremely closely — at only 1/20th of the distance the Earth orbits the Sun.

By timing the regular faint dips in brightness as this planet passes in front of the star, the *MOST* team can detect the effects of the subtle gravitational tugs of other smaller planets that might be hiding in the system. "We were able to rule out Earth-sized planets in some of the orbits where theorists believed they might be found," says Matthews, lead mission scientist of *MOST,* a Canadian Space Agency mission. The team's analysis of reflected light signals of the planet is also ruling out many possible models of its atmosphere and cloud cover.

Likening the observations to making weather forecasts for a planet 160 light years away, Matthews says the job poses major challenges. "Imagine trying to see a mosquito disappearing behind a 400-watt streetlamp, not at the next street corner or a few blocks away, but 1000 kilometres away," says Matthews. "That's equivalent to what we're trying to do to detect the planet's eclipse in the HD 209458 system."

While the *MOST* team cannot yet rule out or detect Earth-like planets in larger orbits around HD 209458, as the data accumulate in the coming years, Matthews says *MOST* may be able to determine whether or not there are potentially habitable worlds around that star. "Hugging so surprisingly close to its parent star, HD 209458b could never support life as we know it," says Matthews. "But does it have any Earth-like neighbours at a more comfortable distance? That's a question that no other observatory, on Earth or in space, can tackle at the moment, except *MOST*."

MOST is a Canadian Space Agency mission. Dynacon Inc. of Mississauga, Ontario, is the prime contractor for the satellite and its operation, with the University of Toronto Institute for Aerospace Studies (UTIAS) as a major subcontractor. The University of British Columbia (UBC) is the main contractor for the instrument and scientific operations of the *MOST* mission. *MOST* is tracked and operated through a global network of ground stations located at UTIAS, UBC, and the University of Vienna. For more information, visit `www.astro.ubc.ca/MOST`.

FASTEST-SPINNING PULSAR DISCOVERED

Astronomers using the National Science Foundation's Robert C. Byrd Green Bank Telescope have discovered the fastest-spinning neutron star ever found, a 20-mile-diameter superdense pulsar whirling faster than the blades of a kitchen blender. Their work yields important new information about the nature of one of the most exotic forms of matter known in the Universe.

"We believe that the matter in neutron stars is denser than an atomic nucleus, but it is unclear by how much. Our observations of such a rapidly rotating star set a hard upper limit on its size, and hence on how dense the star can be," said Jason Hessels, a graduate student at McGill University in Montreal. Hessels and his colleagues presented their findings to the American Astronomical Society's meeting in Washington, D.C. earlier this year.

Pulsars are spinning neutron stars that sling "lighthouse beams" of radio waves or light around as they spin. A neutron star is what is left after a massive star explodes at the end of its "normal" life. With no nuclear fuel left to produce energy to offset the stellar remnant's weight, its material is compressed to extreme densities. The pressure squeezes together most of its protons and electrons to form neutrons; hence, the name neutron star.

"Neutron stars are incredible laboratories for learning about the physics of the fundamental particles of nature, and this pulsar has given us an important new limit," explained Scott Ransom, an astronomer at the National Radio Astronomy Observatory and one of Hessels' collaborators on this work.

The scientists discovered the pulsar, named PSR J1748-2446ad, in the globular cluster Terzan 5, located some 28,000 light-years from Earth in the constellation Sagittarius. The newly discovered pulsar is spinning 716 times per second, or at 716 Hertz (Hz), readily beating the previous record of 642 Hz from a pulsar discovered in 1982. For reference, the fastest speeds of common kitchen blenders are 250-500 Hz.

The scientists say the object's fast rotation speed means that it cannot be any larger than about 20 miles across. According to Hessels, "if it were any larger, material from the surface would be flung into orbit around the star." The scientists' calculation assumed that the neutron star contains less than two times the mass of the Sun, an assumption that is consistent with the masses of all known neutron stars.

The spinning pulsar has a companion star that orbits it once every 26 hours. The companion passes in front of the pulsar, eclipsing the pulsar about 40 percent of the time. The long eclipse period, probably due to bloating of the companion, makes it difficult for the astronomers to learn details of the orbital configuration that would allow them to measure precisely the masses of the pulsar and its companion.

"If we could pin down these masses more precisely, we could then get a better limit on the size of the pulsar. That, in turn, would then give us a better figure for the true density inside the neutron star," explained Ingrid Stairs, an assistant professor at the University of British Columbia and another collaborator on the study.

Competing theoretical models for the types and distributions of elementary particles inside neutron stars make widely different predictions about the pressure and density of such an object. "We want observational data that shows which models fit the reality of nature," Hessels said.

If the scientists cannot use PSR J1748-2446ad to do that, they are hopeful some of its near neighbours will yield the data they seek. Using the GBT, the astronomers so far have found 30 new fast-rotating millisecond pulsars in the cluster Terzan 5, making 33 pulsars known in the cluster in total. This is the largest number of such pulsars ever found in a single globular cluster.

Dense globular clusters of stars are excellent places to find fast-rotating millisecond pulsars. Giant stars explode as supernovae and leave rotating pulsars that gradually slow down. However, if a pulsar has a companion star from which it can draw material, that incoming material imparts its spin, or angular momentum, to the pulsar. As a result, the pulsar spins faster. "In a dense cluster, interactions between the stars will create more binary pairs that can yield more fast-rotating pulsars," Ransom said.

The great sensitivity of the giant 100-metre diameter GBT, along with a special signal processor, called the Pulsar Spigot, made possible the discovery of so many millisecond pulsars in Terzan 5. "We think there are many more pulsars to be found in Terzan 5 and other clusters, and given that the fast ones are often hidden by eclipses, some of them may be spinning even faster than this new one," Ransom noted. "We're excited about using this outstanding new telescope to answer some important questions about fundamental physics."

Graphics showing how millisecond pulsars are formed can be found at `www.nrao.edu/pr/2006/mspulsar/mspulsar.graphics.shtml`

GEMINI TELESCOPE SPIES AN INTERSTELLAR CAVERN

Figure 2 — Gemini Legacy Image of superbubble complex N44. Composite colour image obtained with the Gemini South Telescope in Chile by Travis Rector, University of Alaska Anchorage.

Known as the N44 super-bubble complex, this cloudy tempest (Figure 2) is dominated by a vast bubble about 325 by 250 light-years across. A cluster of massive stars inside the cavern has cleared away gas to form a distinctive mouth-shaped hollow shell. While astronomers do not agree on exactly how this bubble has evolved for up to the past 10 million years, they do know that the central cluster of massive stars is responsible for the cloud's unusual appearance. It is likely that the explosive death of one or more of the cluster's most massive and short-lived stars played a key role in the formation of the large bubble.

WEB ACCESS TO THE 2006 ISSUES OF THE *JRASC*

The 2006 issues of the *Journal* can be accessed from the RASC Web site at `www.rasc.ca/currentjrasc` (userid="jrasc"; password="pelican"). Issues are posted immediately after the final production version is complete.

The Sun's Displacement from the Galactic Plane from Spectroscopic Parallaxes of 2500 OB Stars

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ABSTRACT. The Sun's vertical displacement from the galactic plane, $Z_\odot$, is determined model-independently from 3526 spectroscopic parallax distance estimates for 2488 OB stars within 1200 pc of the Sun. The result, 19.6±2.1 pc, agrees well with various other recent determinations. The distribution of stellar z-values as a function of galactic longitude shows a very scattered sinusoidal dependence with an amplitude of about 27 pc.

RÉSUMÉ. Le déplacement vertical solaire du plan galactique, $Z_\odot$, indépendament de modélisation est établi à la base de 3 526 estimations de distance, dérivées par parallax spectroscopique, de 2 488 étoiles OB à moins de 1200 pc du Soleil. Le résultat, 19.6±2.1 pc, s'accorde bien avec diverses autres déterminations récentes. La distribution des valeurs stellaires z en fonction de la longitude galactique indique une dépendance sinusoïdale très éparpillée avec amplitude d'environ 27 pc.

1. Introduction

The Sun's vertical displacement from the galactic plane, $Z_\odot$, is an important parameter in galactic-structure models and has been the subject of a number of investigations over the years; a selected sample of results is summarized in Table 1. The most recent is that due to Joshi (2005), who examined the distribution of interstellar extinction towards several hundred open clusters within 5° of the galactic plane. Based on an analysis of the displacement from the plane of maximum absorption as a function of galactic longitude he determined $Z_\odot = 22.8 \pm 3.3$ pc, a result consistent with the results of many other investigators. It should be noted that Table 1 is not exhaustive; Humphreys & Larsen (1995) summarize a number of other determinations of $Z_\odot$ dating from 1974, with, in most cases, results similar to those listed in Table 1; Joshi (2005) also summarizes a number of recent determinations of $Z_\odot$ in his Table 2.

Joshi's result for $Z_\odot$ derives from a fit to only seven points (see his Fig. 9), and the majority of the results listed in Table 1 are model-dependent in various ways. Consequently, it was thought that a fresh $Z_\odot$, determination that invokes as few assumptions as possible might be worthwhile.

The obvious stellar candidates from which to estimate $Z_\odot$ are solar-neighbourhood OB stars: they are well-concentrated to the galactic plane and have a small vertical-scale height. The *disadvantage* of OB stars, however, is that distance estimates to individual stars can be highly uncertain (~50% uncertainty is not uncommon) and so a large sample is required to get a meaningful average. Within the last few years two papers directed at determining $Z_\odot$ based on OB stars have appeared. In an earlier paper Reed (1997; R97) estimated $Z_\odot$ based on assigning average absolute magnitudes to a large sample of OB stars within 10° of the galactic plane and approximately 4 kpc of the Sun and assuming a barometric extinction model. The result ($Z_\odot \sim$ 10-12 pc) must be regarded as crude, however, as the stars were assigned absolute magnitudes on the basis of coarse objective-prism classifications that designated them as one of the three types OB^+, OB, or OB^-. Later, Maíz-Apellániz (2001) used *Hipparcos* trigonometric parallaxes for 3383 O-B5 stars with $|b| > 5°$, determining $Z_\odot$ = 24.2 or 25.2 pc depending on whether one adopts a self-gravitating isothermal or Gaussian disk plus parabolic-halo stellar distribution model. While both of these papers utilize large samples, both also invoked various model assumptions.

For some years I have been developing databases of published UBVβ photometry and MK spectral classifications for OB stars. These databases were originally restricted to stars catalogued in the southern-hemisphere Case-Hamburg galactic-plane surveys but were subsequently expanded to be an all-sky effort that now incorporates over 18,000 stars (Reed 2003). Instructions on accessing the catalogue, data files, and supporting documentation are available at `othello.alma.edu/~reed/OBfiles.doc.` "OB stars" here is taken to mean (O3-B2) V and (O3-B9) I-IV stars. At this writing (early 2006) the databases incorporate over 38,000 photometric observations and some 22,000 spectral classifications. This very extensive assembly of data for the OB stars opens up the opportunity of re-examining $Z_\odot$ on the basis of a large, model-independent sample. This is the purpose of the present work.

The selection of the sample is described in Section 2, with particular attention to explaining how sources of spectral classifications were judged for quality. The analysis and results are presented in Section 3.

2. Sample Selection

Since the present work depends on deriving distances via spectroscopic parallaxes, isolating the best-quality classifications is essential. The approximately 22,000 classifications in the database are drawn from over 500 sources. As might be expected, these classifications derive from photographic and electronic material obtained with a variety of instruments employing various dispersions and wavelength coverage. All sources were examined and assigned a classification quality code from A to E, with A being the highest. In brief, code A designates classifications deriving from observational material that adhered to the original MK criteria of wavelength coverage ~ 3500-5000Å, dispersion 60-125 Å/mm, and resolution 1-2Å. Code B designates classifications that nominally adhere to these criteria but that are suspected of possibly being of slightly lower quality, largely objective-prism spectra where obtaining the optimum exposure for each star can be difficult. Code C designates classifications derived from material that was obtained for classification purposes but that failed to meet the MK criteria in some way, for example, high-dispersion objective-prism or thin-prism classifications. Code D designates classifications deriving from material failing to meet the MK criteria and that was obtained for some other purpose such as radial velocity or abundance studies, and code E is a catch-all category reserved for cases where authors give little or no detail on their instrumental system and for which classifications could not be meaningfully assessed. Only code A, B, or C classifications are used in this work. While the original intent had been to apply some weighting scheme to these codes, this proved unnecessary as over 85% of the adopted spectroscopic parallaxes derived from A-quality classifications (see Section 3).

A program was written to merge the photometric and classifications files and to output a list of highest-quality useable classifications for all stars, with "useable" meaning a classification with both temperature and luminosity components. In a few cases B-quality classifications were adopted where A-quality ones lacked luminosity classes. If more than one highest-quality classification was found for a given star, each was retained and treated separately. A second program was written to read in the output of the first and assign absolute visual magnitudes and intrinsic B-V colours for the selected classifications from the calibrations of Turner (1980) and Schmidt-Kaler (1982), respectively (interpolating linearly across either or both of temperature and luminosity class where necessary) and to compute distances via spectroscopic parallax in the usual way. The interstellar absorption is assumed to be given by (Schmidt-Kaler 1982)

$$AV = [3.3 + 0.28(B\text{-}V)_o + 0.04E_{B\text{-}V}]\ E_{B\text{-}V} \qquad (1)$$

where $(B\text{-}V)_o$ is the intrinsic colour and $E_{B\text{-}V}$ the colour excess.

Since we are interested in determining the average of the stellar z-values, strict completeness of the sample to some limiting distance is not terribly crucial provided that we do not otherwise discriminate against some range of z values. An examination of the results of the programs described above revealed that the number of stars for which distances could be computed begins to decline for magnitudes fainter than V ~ 10. Now the intrinsically faintest members of the sample are B2 V stars, for which $M_V = -2.2$. Conservatively assuming a galactic-plane extinction of 1.5 mag/kpc (see R97), a B2 V star of apparent magnitude V = 10 would be at a distance of about 1200 pc. To avoid discriminating against low-z stars I adopt this distance limit for the purpose of determining $Z_\odot$. This choice has two further advantages: (i) it is large enough to render fairly inconsequential any effects due to Gould's belt while (ii) being small enough to avoid incorporating any confounding effect due to the galactic warp, which makes a distance of closest approach to the Sun of ~ 6 kpc (Reed 1996).

3. Analysis and Results

A total of 3526 classifications for 2488 separate stars yielded distance estimates within 1200 pc, with the numbers of (A, B, C)-quality classifications being (3016, 370, 140). In computing $\langle z \rangle = -Z_\odot$, distance estimates for stars with more than one estimate were weighted as the inverse of the number of estimates for that star in order that all stars are ultimately weighted equally. The data are available at `othello.alma.edu/~reed/N=3526.dat`.

The weighted mean for these 3526 distance estimates gives

$$Z_\odot = 19.6 \pm 2.1 \text{ pc},$$

where the error limit is the standard error of the weighted mean, computed as the weighted standard deviation divided by the square root of the sum of the weights. This result agrees closely with that of Joshi (2005) and falls comfortably at about the middle of the limits of those given in Table 1.

Figure 1 shows average z values for stars in 10-degree-wide bins of galactic longitude l as a function of longitude. The error bars are standard errors of the mean as described above but computed separately for each longitude bin. A very scattered sinusoidal trend is evident. Performing a least-squares fit via the Simplex method (Caceci & Cacheris 1984) to a curve of the form

$$Z = A \sin(l + \phi) - Z_\odot \qquad (2)$$

yielded $(A, \phi, Z_\odot) \sim$ (27.5 pc, 55°, 20 pc). Each point in the figure was weighted in proportion to the number of contributing stars. Given the scatter in Figure 1 and the fact that the Simplex method used here does not return meaningful error estimates, this result must be regarded with considerable caution at best. [For a sense of realistic uncertainties in the fit parameters, it can be noted that re-computing the fit with the point at $l \sim 206°$, $\langle z \rangle \sim -106$ pc deleted yields $(A, \phi, Z_\odot) \sim$ (20 pc, 50°, 17 pc)]. We also note that the direction toward the maximum displacement of the OB-star "plane" derived here, $l \sim 90° - \phi \sim 35°$, lies in the first galactic quadrant. Analyses of the directions of maximum upward tilt of the planes defined by the distribution of interstellar reddening and young open clusters similarly revealed first-quadrant maxima at $l \sim 60°$ and 50°, respectively (Pandey & Mahra 1987; Pandey *et al.* 1988) as did Joshi's (2005) analysis of the direction of maximum interstellar absorption per unit distance ($l \sim 48°$).

If Figure 1 really does reflect a tilting of an "OB-star plane" relative to the galactic plane, the effect is slight: an amplitude of 27.5 pc at a distance of 1200 pc implies a tilt angle of only about 1.3°. It is worth emphasizing that this effect has nothing to do with the Gould belt, a much more local phenomenon restricted to the brighter B stars (Lesh 1968).

Given the various assumptions underlying the results summarized in Table 1 and the inevitable errors in the spectroscopic parallaxes utilized in the present work, more-detailed interpretations are not warranted. However, it is gratifying to see that the present *model-independent* results are in good accord with the various *model-dependent* results summarized in Table 1.

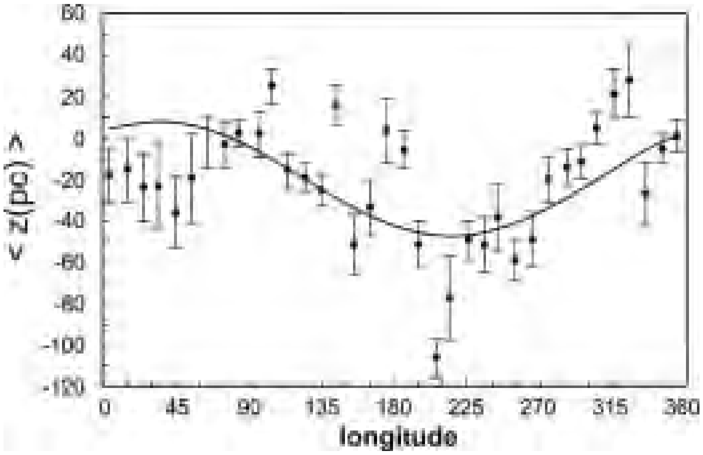

FIGURE 1 — Average z-value of OB stars within 1200 pc as a function of galactic longitude in bins of longitude of width 10°. The error bars are standard errors of the mean for each bin. The curve is a least-squares-fit sine curve described by equation (2) with A = 27.5 pc, ϕ = 55°, and $Z_\odot$ = 20 pc.

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Spectroscopic Parallax: The most common way of measuring the distance to a star when actual stellar parallax is not available. It isn't actually a parallax or angular measurement, but substitutes when a star's distance is too large for the parallax angle to be determined. From an analysis of its spectrum, the star's position on the Hertzsprung-Russell diagram can be determined. The H-R diagram relates the star's spectral type to its absolute magnitude. By comparing this absolute magnitude (M) to the measured brightness of the star (m), its distance (D) in parsecs (pc) can be determined using the standard formula

$$m - M = 5\log\left(\frac{D}{10\,pc}\right)$$

Gould's Belt: In the mid 1800s several astronomers noticed that many of the bright stars along the Milky Way trace a path that is tilted to the Milky Way itself. In 1879 Benjamin Gould conducted a detailed survey of bright stars and showed that a local subsystem of stars and gas existed in a rotating subsystem inclined at 20° to the plane of the Milky Way. The disk contains some very well-known objects — the Pleiades, Orion Nebula, Horsehead Nebula, Coal Sack, and Rho Ophiuchus star clouds. It may be related to shockwaves that occurred about 100 million years ago when a supercloud of gas collided with a spiral arm of our galaxy.

TABLE 1: SELECTED RECENT DETERMINATIONS OF $Z_\odot$

Reference	$Z_\odot$	Sample
Pandey & Mahra (1987)	~ 10	Interstellar extinction
Pandey *et al.* (1988)	28±5	Young open clusters within 1500 pc
Conti & Vacca (1990)	15±3	WR stars (N = 101) within 4.5 kpc of Sun
Cohn (1995)	15.5±0.7	*IRAS* point-source counts + point-source sky model
Humphreys & Larsen (1995)	20.5±3.5	Galactic-pole star counts (N ~ 10,000) plus Bahcall-Soneira galaxy model
Méndez & van Altena (1998)	27±3	Solar-neighbourhood reddening model plus star counts
Binney *et al.* (1997)	14±4	*COBE/DIRBE* surface-brightness analysis; double-exponential disk + power-law bulge
Reed (1997)	~10-12	OB stars with | b | < 10°; averaged M_B values for rough OB classes; assumed extinction model
Chen *et al.* (1999)	27.5±6.0	*COBE/IRAS*-based extinction model
Maíz-Apellániz (2001)	24.2±1.7	*Hipparcos* parallaxes for 3382 O-B5 stars (|b| > 5°) within ~ 350 pc, plus distribution model
Joshi (2005)	22.8±3.3	extinction analysis; open clusters with | b | < 5°
Present work	19.6±2.1	OB stars within 1200 pc

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The Cult Statue of Aphrodite at Palaepaphos: A Meteorite?

by Philip Mozel, Toronto Centre (phil.mozel@sympatico.ca) and Meg Morden (memorden@sympatico.ca)

Abstract

On display at the museum in Kouklia, Cyprus is a large, dark, conical stone. Excavated in the late 19th century, it once stood in the temple of Aphrodite at Paphos. It is an aniconic image of the goddess that, like other strangely shaped rocks from antiquity, is thought by some to be a meteorite. We look at the worship of aniconic objects and review the trail that led to the fallacious conclusion that the Kouklia stone is meteoritic. The origin of other ancient stones reputed to be meteorites is also presented.

The Myth of Aphrodite

The Greek goddess Aphrodite became the principle deity of the people of the island of Cyprus in the Iron Age (beginning around 1000 BC) when she was equated with a local goddess who had been worshipped since the Late Bronze Age, known simply by her Mycenaean Greek title *Wanasa* or "The Lady." Many authors interpret the worship of her in the Iron Age as the continuation of the age-old fertility cults that arose in the Chalcolithic Period and continued throughout the Bronze Ages (Maier 2004). According to the 7th-century BC poet Hesiod, Aphrodite was born from the foam surrounding the genitals of the sky god Ouranos after they had been severed and then tossed into the sea by his rebellious son Chronos. Aphrodite first stepped on shore on the island of Cyprus and ever after the island held a special charm for the goddess. This association is referred to in her epithets *Cypria* and *Cyprogenia* (Hesiod).

Aphrodite was the goddess of love and beauty. In Greek mythology she wields great power over immortals and mankind alike as the source of erotic attraction but is otherwise trivialized, unlike the goddesses of love and fertility in the Near East. These Eastern goddesses are multifaceted and multi-talented beings whose spheres of influence include all aspects of animal, vegetable, and earthly fertility as well as the arts of war and peace. The cult of Aphrodite on Cyprus reflects a fusion of east and west, in that *Wanasa* of Cyprus was a more complex deity than her purely Greek counterpart.

Cyprus was an important place in the myth of Aphrodite. Apart from being born here, she had several gardens that she loved to frequent, including the ones at Idalion and Yeroskippou. The Paradision at Idalion was the locale where Aphrodite dallied with her human lover Adonis and the site of his untimely end. Yeroskippou was important in the annual festival of Aphrodite where there was a procession that passed through the "Holy Gardens" on its way to Palaepaphos from Nea Paphos, a town founded in the 4th century BC that served as the capital of the island during the periods of Ptolemaic and Roman rule. However, Aphrodite's principal sanctuary was close to the place where she first emerged from the sea at the site of Palaepaphos, known today as Kouklia.

The Temple of Aphrodite

The sanctuary of Aphrodite at Paphos was in use from the Late Bronze Age to the closing of the pagan temples by the Christian emperor Theodosius I in AD 391. This long history is attested by the results of archaeological investigations of the site from the mid-19th century and principally by current excavations under the directorship of Dr. Frans Maier funded by the German Archaeological Institute. Although the sanctuary was badly destroyed by the building of a mediaeval sugar refinery over much of the site, remains have been found suggesting that the first temple was built in the Late Bronze Age and rebuilt or refurbished at least twice after earthquakes in 19/18 BC and AD 77 (Maier 1973). Much of the existing plan of the sanctuary dates to the Roman period, including the North and South Stoas (roofed colonnades). The earliest and most holy part of the site was at the south end, the area most disturbed by the mediaeval reworking of the site. Maier (2004) concluded that

> No vestiges of the holy of holies were discovered during excavation, despite a meticulous search. This lends plausibility to the hypothesis that the holy of holies was not a large solidly walled structure but rather a lofty, canopy-like construction of pillars supporting awnings. Such a light fabric would have left no lasting traces on the ground for

posterity, but might explain the strange yet persistent tradition (Tacitus reported that "though it stands in the open air, it is never wet by rain") about Aphrodite's altar at Paphos.

Finding the Cult Stone at Paphos

The British Cyprus Exploration Fund found the cult stone during the first serious investigation of the site in 1888 (Gardner *et al.* 1888). They trenched through the entire site, and although they stated that "the sacred cone itself has totally disappeared" (Gardner *et al.* 1888), they described finding a conical stone placed upside down in a pit cut into the bedrock in the South Roman Stoa. Although they concluded that it was considerably older than the Roman period and venerated by the Romans, it was not until 1913, during the visit to the site by the English archaeologist J.L. Myres, that the stone was recognized for what it was (Myres 1945). The South Roman Stoa could not be the original location of the stone as shown on the coin types (discussed below) but may be the site where the last priests of the cult of Aphrodite hid it at the time of the closure of the sanctuaries in AD 391. (Figure 1)

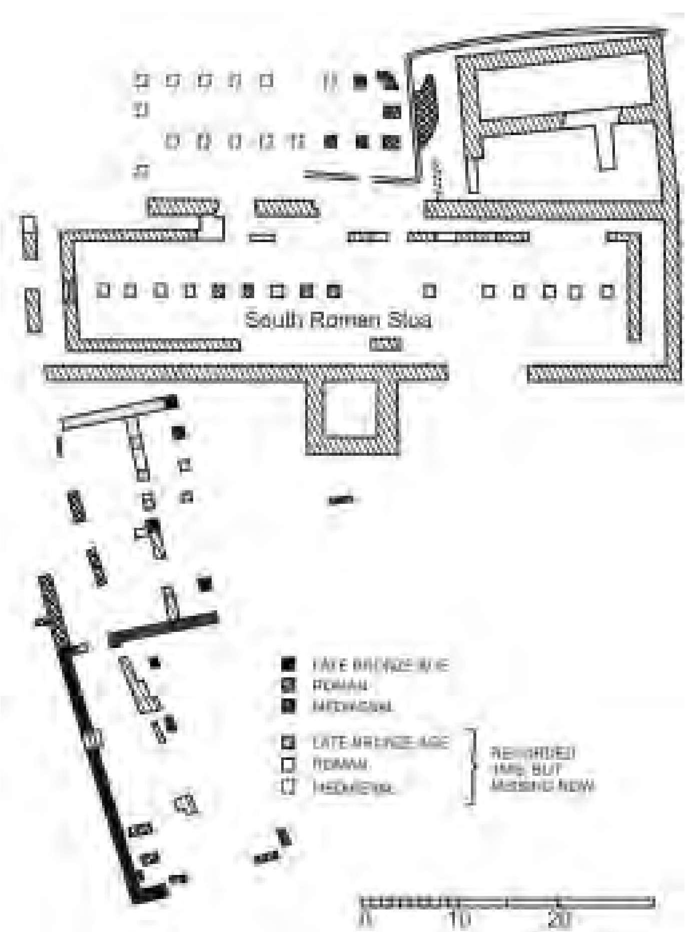

Figure 1 – Plan of Temple of Aphrodite at Palaepaphos

Other Ancient Baetyls and Fallen Cult Images

Baetyls, or sacred stones believed to be of divine origin, are venerated in many cultures. For example, in the centre of the Great Mosque in Mecca is the Kaaba, the black stone treasured by the Muslim people, which may indicate the existence of an earlier cult on the spot whose cult-image was subsumed into Muslim worship (Middleton 1888). In addition, in India there are many natural stones used as objects of veneration (Khanna 2004).

In the Classical world, using unworked baetyls was not as common, but there were a few notable exceptions. The most famous stone used as a focus of worship was the black baetyl of Cybele at Pessinus in Asia Minor. Cybele was the great mother goddess of Anatolia. She was a goddess of fertility with oracular powers, who oversaw the well-being of her people in all respects. She was a goddess of cures and warfare. She was the goddess of mountains and wild nature, symbolized by her attendant lions. The focus of the cult of Cybele in Phrygia was a conical black stone that was transported to Rome in 205-204 BC in accordance with the Sibylline Books to ward off the Carthaginian threat. This aniconic cult image may have been found during the excavations of the Palace of Domitian on the Palatine Hill (built between AD 82 and 96) when it was excavated under the direction of Franceso Bianchini in 1720 by the order of Francis I, Duke of Parma. Bianchini found a cone-shaped black stone, about three feet high, in the lararium (the shrine area in a Roman house). None of the scholars of the day who examined the find knew what it was and it has since disappeared (Moratti 1993). Cybele was known as the "Lady of the Mountain" and it may have seemed reasonable to use an unworked stone to symbolize the mountain as well as her power.

Another important cult stone was the beehive-shaped Omphalos of Delphi. Originally, it was associated with the myth of Zeus, being the stone that was wrapped in swaddling clothes and given to Chronos to swallow in place of the infant Zeus. The ruler of the Olympian gods later used it to mark the centre of the world, which was ascertained by releasing two eagles to fly in different directions to meet at Delphi. Middleton suggests that this stone represents a pre-historic deity worshipped here before the Greek cult of Apollo was introduced at the site (Middleton 1888).

There was also a baetyl used for the cult of Hera Pergeia in southern Turkey. This sanctuary has not been discovered but literary *testimonia* and coin types attest to a baetyl used as the image of the female deity. The *Oxford Classical Dictionary* describes this baetyl as "originally no doubt a meteoritic stone" (Hammond & Scullard 1970).

There was a conical black stone used as the cult image of the Syrian god El Gabal at Emesa, or Heliogabalus in Greek. It was transported to Rome by the Emesa-born emperor Elegabalus (ruled AD 218-222) and housed in a temple built on the east slopes of the Palatine Hill. After the emperor's death, it was returned to Emesa. El Gabal was a sky and Sun god (Scarre 1995).

Notable was the cult stone used in the temple of Adonis at Byblus, attested on coins of Macrinus, as this gives us a link between both the story of Adonis and Aphrodite and the use of aniconic cult images. (Figure 2 left)

Figure 2 – Ohnefalsch-Richter's coin illustrations showing conical stones in temples in Byblus and Cyprus. The right-hand image is similar to those published by Antoniadi and the Meteorite Impacts Advisory Committee (Ohnefalsch-Richter 1893).

Some of the aniconic images described by the ancient historians were in the shape of columns. The stone column in front of the temple of Apollo was related to the Omphalos and both were thought to represent the god and protect the sanctuary (Nilsson 1964).

The tradition of *xoanon,* or wooden cult images falling from heaven, is a common one in ancient Greece. The most sacred image of Athena on the Acropolis in Athens was a *xoanon,* originally an aniconic image that was draped with the peplos (Burkert 1985) thought to have fallen from heaven.

The cult stone of Aphrodite is the only cult stone that has survived in the archaeological record, which was attested by literary *testimonia* in the Classical world. Tacitus actually states that it is so unusual that it is not to be found elsewhere! (Figure 3).

Tracing the Nature of the Stone

Our research began when images of the stone were sent to a number of geologists and mineralogists for a decision on whether or not it might be a meteorite. All advised that a clear decision could be made only by analyzing a piece of the stone. Given the antiquarian importance of the object, receiving permission to remove a piece was unlikely (and, in the end, unnecessary).

Early in the investigation, colleagues traveling to Cyprus agreed to examine the stone closely (as one of us, MM, eventually also did), document it photographically, and test its magnetic properties (since most meteorites are composed of at least some magnetic minerals). It turns out that the stone is not very magnetic (Parks 2004, private communication).

In the meantime, the results of an Internet search suggested that this stone is a meteorite. For example, on the "Midwest Meteorites" Web site we read, "The stone that was at the center of this temple was found by archaeologists a short distance

Figure 3 – The Aniconic Cult Stone From the Temple of Aphrodite, Cyprus. Photos courtesy of Nathan Harper.

from the temple and has been confirmed to be a meteorite" (Heitz 2004).

On the "All About Meteorites" Web page is a Roman coin depicting the emperor Trajan. On the coin's reverse is the "stone of Aphrodite in the temple of Paphos" with the implication that it is a meteorite (Fectay & Bidaut 2004). According to the "Meteorite Stamps and Coins" site, "The Temple of Aphrodite at Paphos on Cyprus housed a conical stone (an *omphalos*) sacred to Aphrodite Uranos. This stone, which still exists, has been determined to be a meteorite." Further examples are also given (Burns 2003).

Elsewhere we read,

> In the ancient world, meteorites, or "fallen stars," were commonly associated with divinity: For example, a meteorite sacred to Cybele was transported from Asia Minor to Rome in 204 BCE in order to establish her worship there. Likewise, the astral nature of Aphrodite could be represented by a fallen star. Roman coins show the goddess in her aniconic manifestation as a meteorite in her foremost temple at Paphos (Moon).

A very clear statement of the stone's identity is provided on another site devoted to collecting ancient coins: "Many meteorites were venerated as cult symbols such as the Stone of Emesa, the Stone of the Temple of Aphrodite at Paphos (actually excavated and confirmed as a meteorite)" (Buggey 2006).

The Meteorite Impacts Advisory Committee (2004) states, "In the middle [of the temple of Aphrodite] is the pyramidal meteoritic idol of the goddess." Much of the relevant information on this site, including illustrations, is based on an article appearing in the May-June 1939 issue of this *Journal* (Antoniadi 1939).

The well-known astronomer E.M. Antoniadi deals in part with the Aphrodite stone in his article "On Ancient Meteorites, and on the Origin of the Crescent and Star Symbol." He quotes the Roman historian Tacitus, who described the stone as having "...no human form: it is a rounded block, larger at the base, and narrowing up to the summit like a cone." Antoniadi concluded, "...there can be no doubt that we have to deal here with a meteorite which has often been represented on numerous coins of Paphos" (Antoniadi 1939). (Figure 4)

Where did Antoniadi get this idea? There is no mention of meteorites in his biography (McKim 1993). However, the

Figure 4– A Cypriot coin depicting the conical stone in the temple of Aphrodite at Paphos (Antoniadi 1939).

biography did lead to a similar, earlier article appearing in the *Bulletin de la Société Astronomique de France*. Here, Antoniadi again writes as if the meteoritic nature of the stone is established fact (Antoniadi 1938).

A reference in the *Bulletin* article leads, in turn, to a book by the 18th-century Benedictine scholar Bernard de Montfaucon. Although providing illustrations (Figure 5) of the stone in its temple (one of which was used by Antoniadi), Montfaucon nowhere makes reference to the stone coming from the sky (Humphreys 1976). In any case, Montfaucon wrote well before the idea of rocks coming from space was generally accepted. Other leads were pursued. For example, the archaeologist Max Ohnefalsch-Richter (1893), in the late 19th century, wrote,

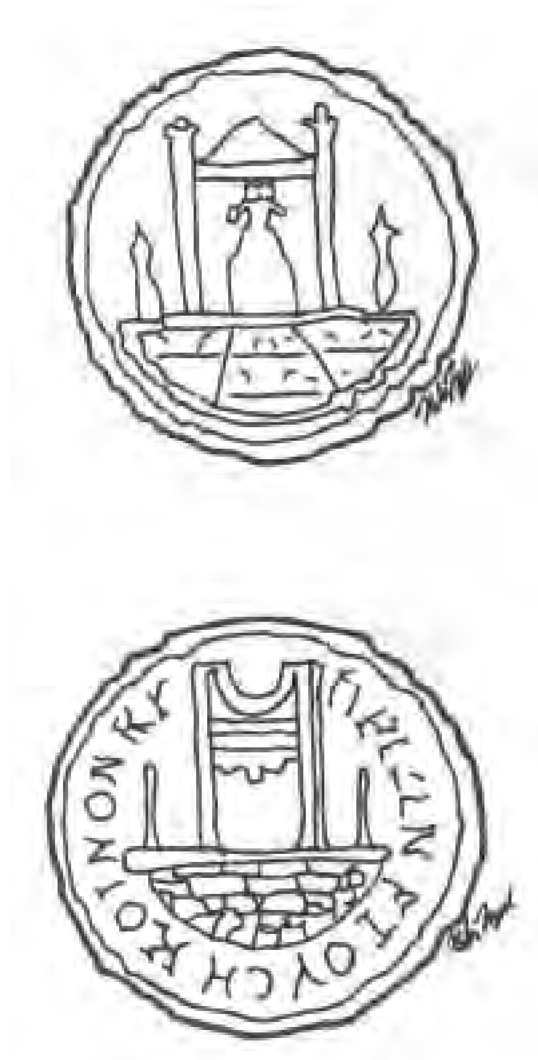

Figure 5 – Copies of Montfaucon's Illustrations of the Aphrodite Stone (Drawings by Robin Mozel after Humphreys 1976).

> Let us, in our treatment of this question, start from Aphrodite, the golden-haired goddess of love. No two things can be, it seems, more diverse than Cnidian Aphrodite of Praxitiles and the stone fetish in the form of a meteoric cone, which still in Roman times was, in the sanctuary of Paphos, venerated as the embodiment of Aphrodite-Astarte. At first the object of worship, the symbol of the goddess, was a meteoric stone of irregular shape, fallen from heaven. In process of time the original aerolith was either cut into a regular conic form, or replaced by a conic stone. The head-like appendage and the rudimentary arms, which we see on certain Paphian coins, are symptoms of still further modification, dating from a time when iconic worship was strong enough to demand concessions to its spirit. (Figure 2)

Ohnefalsch-Richter, in turn, references the mythographer W.H. Roscher (1884) who writes

> In Paphos it seems that rocks which have fallen from the sky (Meteorites) were put under the purview of Aphrodite. At least coins from Cyprus show a Stone with cone or pyramid shape...surrounded by lights and torches, which was certainly correctly interpreted by W. Baudissin...as a Meteor which according to the beliefs of the ancients had fallen out of the moon.

And what did Baudissin (1876), a professor of theology, actually say?

> Later, the symbols for male and female gods were not distinguished clearly anymore: One can still find tree symbols for the male god and the conical stone for the female one, as for Aphrodite in Paphos. But the meteorite, if at all sent by the gods of the stars, could have been sacred for the goddess of the moon as well as the god of the sun.

Clearly, many people have believed the stone to be extraterrestrial but a review of *The Catalogue of Meteorites* ("the world taxonomic database of all meteorite falls and finds") revealed no entry for it (Grady 2006). The *Catalogue's* editor, Monica Grady of the Natural History Museum, London, was also not aware of a large meteorite residing in Cyprus (Grady 2004, private communication). This result was, to say the least, incongruous and cast suspicion on all we had been finding in the literature.

During this period of information gathering and after some perseverance, contact was made with Dr. Vasiliki Kassianidou of the University of Cyprus' Archaeological Research Unit. We were informed that

> The conical stone that is believed to be the cult statue of Aphrodite, recovered during the excavation of her sanctuary at the site of Palaepaphos, Kouklia is currently exhibited at the museum. It is not a meteorite but a larger boulder of diabase which originates at the peak of Troodos mountains and is commonly found in the river beds that bring it down. Diabase was used since the Neolithic to produce groundstone tools and vessels (Kassianidou 2004, private communication).

Why Has the Stone Been Misidentified?

From earliest times, there have been reports, sometimes incorporated into myth, concerning stones falling from the sky. As noted above, Hesiod wrote of the ruse whereby Zeus' mother, Rhea, saved him from his father, Chronos, who swallowed his children at birth. Rhea wrapped a stone in cloth and presented it to Chronos who promptly gulped it down believing it to be Zeus. Eventually, "he spewed out what was the stone, the last he swallowed. Zeus fixed it in the wide-pathed earth at holy Pytho, [site of the Delphic oracle] in the glens of Parnassus, to be a monument thereafter and a thing of wonder for mortal men" (West 1988).

Much later, the AD 2nd-century traveler Pausanias described a stone located in the same spot: "Going on upwards...you come to a stone, not very large; they pour oil on it every day and every festival they offer unspun wool. There is an opinion that this stone was given to Kronos instead of his child, and Kronos vomited it up again" (Levi 1988).

This stone has been interpreted in terms of a meteorite: "Again, at Delphi there was an old Stone of Cronos which had fallen to earth when vomited forth by Cronos, and he was an old sky-god. As stones which fall from the sky are meteorites, the Stone of Cronos was clearly one also" (Wainwright 1935).

The writer and mythographer Robert Graves has also stated that "The stone at Delphi, used in rain-making ceremonies, seems to have been a large meteorite" (Graves 1985).

In another example, it was near the Greek city of Gythion that, "there had fallen the well-known rough stone...which was called...'Zeus fallen down', and which, therefore, was clearly a meteorite" (Wainwright 1930).

As for Aphrodite, Wainwright goes on to say that "Aphaca was...a spot sacred to Aphrodite at which a temple was built to her. Here she was a sky-goddess, for she had the title 'Urania'. As she was believed to fall at this place as 'fire like a star', we clearly have here a case of meteorite worship."

Adding a twist, Wainwright describes the temple of Aphrodite at Paphos as one that is subsidiary to the one at Aphaca. Since there were not enough putative meteorites to go around, "stand-ins," *i.e.* the conical stones, were used and revered as if each was the original (Wainwright 1935). In fact, the British archaeologists who found the Aphrodite stone at Paphos in 1888 also found many small white conical stones that were smaller representations, or stand-ins, for the large cult image (Gardner *et al.* 1888).

Clearly, the idea that sacred stones are meteorites has a long history. Besides the example from Paphos, there were other famous stones worshipped in antiquity (Farrington 1900, Bellemare 1996) as Antoniadi (1939), for one, was aware.

Many people over the years since the acceptance of the cosmic origin of meteorites in the 19th century (Burke 1986) have interpreted ancient records of objects falling from the sky as referring to meteorites. This interpretation is clearly a conflation of modern scientific knowledge with ancient religious thought. To the ancients, anything unusual or precious would have been a gift of the gods who reside in the heavens, and therefore their gifts fell to earth, whether they were seen to do so or not. When our rational minds read such ancient accounts, we draw the conclusion that such objects are meteors. This reasoning is not necessarily valid since solid evidence is lacking. Indeed, some of these objects were made of wood, as in the example of the xoanon or cult statue of Athena at Athens. In addition, as in the case described here, unless the object is still in existence, no definitive identification can be made. However, an interesting study might be made to trace the thinking as regards other sacred objects that have "fallen from the heavens."

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Johann Bayer

and the Relative Magnitudes of α and β Geminorum

by Anthony Barrett, Vancouver Centre (aab@interchange.ubc.ca)

The most familiar system for designating the relative magnitudes of the brightest stars in any one constellation is the use of the Greek alphabet, whereby the first letter α indicates the brightest star, the second letter β the next brightest, and so on. The scheme, over four hundred years old, was first devised by Johann Bayer in his *Uranometria, omnium asterismorum continens schemata* and published in Augsburg in 1603.

One feature of Bayer's catalogue has caused much comment and difficulty. In the case of the constellation Gemini, Bayer designates Castor as α and Pollux as β. In fact the visual magnitudes for these two stars are 1.94 for Castor (in reality a complex sextuple system) and 1.14 for Pollux. This has led to a general assumption that there has been a change in the relative magnitudes of these stars since Bayer's time and that Pollux has grown brighter or Castor dimmer (or both).

An examination of the text of the *Uranometria* will show that such an assumption is not valid. Although Bayer generally adhered to the system that he devised, he does occasionally abandon it. The designation of stars in Sagittarius, for instance, is erratic, at least in part it seems because of Bayer's dependence on the incorrect magnitudes supplied by Ptolemy. In the case of Ursa Major he appears to have had what he considered a logical basis for his arrangement, since the stars from Dubhe to Alkaid are designated α to η, without reference to true visual magnitudes but in perfect sequence along the line of the dipper/plough handle.

Accordingly, we cannot assume that Bayer's record for any one constellation was scientifically reliable, and in the case of Gemini, there are good grounds for admitting that he may not have followed a scientific principle. It might be noted that in ordinary speech the heavenly twins Castor and Pollux (Kastor und Polydeukes in German, Bayer's native language) are always referred to in that particular order. They are thus one of the many examples of doublets, from Rosenkrantz and Guildenstern to Laurel and Hardy, who are enshrined in a familiar and unalterable form in the language. The reverse variant Pollux and Castor (Polydeukes und Kastor) is a totally unnatural phrase and, to judge from citations, would have been so in the 17th century. So William Tindale's 1526 translation of *Acts* xxviii.11 reads "A ship of Alexandry, which had wyntred in the Yle, whose badge was Castor and Pollux," and in 1647 Nathaniel Ward wrote in *The Simple Cobler of Agawam* 38, "Truth and Peace are the Castor and Pollux of the Gospell." Bayer would thus have had a natural propensity to give Castor precedence.

Moreover this linguistic precedence would have been fortified in Bayer's mind by what he observed, since in their apparent motion around the pole Castor is always ahead of Pollux. This indeed is how Bayer described them (in Latin): *In capite Gemini praecedentis*...[Castor]; *in capite seu collo Gemini sequentis*...[Pollux] ("in the head of the twin who *leads*...[Castor]; in the head or the neck of the twin who *follows*...[Pollux].") It is to be noted that Bayer was maintaining an ancient tradition, since his descriptions echo almost exactly those of Ptolemy. It would thus have been "logical" for Bayer to place Castor before Pollux in the sequence, just as it was "logical" for him to list the sequence of stars along a definable line in Ursa Major.

Whether or not there has in fact been a change in the relative magnitudes of Castor and Pollux must, of course, remain an open question; what is clear is that such a change should not be posited on dubious evidence derived from a misunderstanding of Bayer's method.

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Pioneering Observatories of the British Isles

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

Quick! Name four great observatories in the British Isles. Over the past four years I have visited those that came to mind for me, famous for their role in groundbreaking discoveries — Royal Greenwich Observatory and Jodrell Bank in England, Armagh Observatory in Northern Ireland, and the Leviathan of Parsonstown (now Birr Castle) in the Republic of Ireland.

J.L.E. Dreyer used the latter two in gathering data to complete the New General Catalogue (NGC), work begun by Sir William Herschel and his sister Caroline, and carried on by his son, Sir John Herschel. In 1874, Dreyer became Assistant to Lord Rosse at Birr, where the giant six-foot-diameter Leviathan, then the biggest telescope in the world, was placed at his disposal. There, Dreyer began a systematic study of star clusters, nebulae, and galaxies.

Later, Dreyer was appointed Director of Armagh Observatory, where he continued his compilations using the newly installed Grubb 10-inch refractor. He remained at Armagh Observatory from 1882 to 1916. Dreyer's NGC, more properly named "A New General Catalogue of Nebulae and Clusters of Stars," remains the principal catalogue of nebulae and galaxies used by astronomers around the world, even though it has been over 115 years since its publication in 1888. He listed 7840 objects in the NGC, and then went on to publish the Index Catalogues in 1895 and 1908 with an astonishing 5386 further objects! Dreyer's original annotated NGC is shown in Figure 1.

Figure 1– Dreyer's original annotated NGC on display at Armagh Observatory.

Figure 2 – Troughton 2-inch brass equatorial telescope.

A little-known tidbit of history is that Dreyer personally published the complete works of Tycho Brahe, filling 15 volumes. He followed this compendium with *The History of the Planetary System from Thales to Kepler.*

Figure 2 shows the original Troughton 2-inch equatorial telescope installed at Armagh Observatory in 1795. The following is an interesting comment given by T.R. Robinson (third director and inventor of the cup anemometer) in 1844 concerning the state of the instrument,

> The West equatorial while in the hands of Mr. Troughton was injured by a frost which condensed on it moisture charged with the sulphorous vapours of the London smoke, and spotted it all over. I fear this change has increased with time, and may at last corrode the brass to some depth. I would therefore suggest that it should be painted and

varnished, which has been found sufficient to arrest such an injury in other instruments.

Figure 3 –"Leviathan" of Birr Castle, undergoing renovations on March 16, 2006. The white disc is the front cover. The object in the foreground is not the Leviathan, but the author.

Fifteen or so years ago it was "re-discovered" that the instrument was brass, and all the paint has since been removed, revealing the beautiful gleaming telescope, spots and all.

Getting back to Birr Castle, site of my most recent visit in March 2006 (Figure 3): there is where the 3rd Earl of Rosse, William Parsons, made magnificent discoveries using the 58-foot-long "Leviathan." With its great light-gathering ability he was able to discern that some nebulae, such as the Whirlpool Galaxy (Figure 4), had a spiral structure and give them the name "island universes," a name earlier suggested by Immanuel Kant. Lesser telescopes showed only a blob of light with little detail. The Earl's original drawings of M51 are displayed at the Science Centre on the castle grounds (Figure 4).

Figure 4 – M51, Lord Rosse's original drawing of the "Whirlpool Nebula" as he saw it through the Leviathan eyepiece.

Leviathan was refurbished in 2001 and is currently under further refinement to mechanize its operation. Instead of a six-man team, hydraulic motors will permit operation by one person from a single control.

In the week prior to my 2005 visit to Armagh, I had been to Jodrell Bank. This is the site of what was, for many years, the world's largest radio telescope (Figure 5). The fully steerable 250-foot (72-metre) dish is capable of "hearing" a cellular phone transmitting from the surface of Mars (Figure 5)! It's name — Lovell Telescope — honours Dr. Bernard Lovell, who conceived of the giant reflecting dish long before many of us were born! Prior to World War II, Lovell was working on cosmic rays at the University of Manchester. While working on the development of radar systems during the war, he postulated that cosmic rays were causing sporadic echoes in the British early-warning radar systems. He set up an experiment to study the echoes and Jodrell Bank was born. (A "bank" is a small river cutting across the Cheshire plain, this one named after the Jaudrell family.)

The first radio observations were made in mid-December 1945 and it soon became apparent to Lovell that the echoes were not from cosmic rays at all, but from the plasma trails of meteors burning up as they enter Earth's atmosphere. He and his students were able to show that many meteors are the dust particles released by a comet as it orbits the sun. Recent studies of these comet trails have resulted in accurate predictions of the occurrence and timing of meteor showers and even predictions of how many meteors will be observed per hour. Amateur radio astronomers regularly use properly tuned FM radio receivers to hear meteors showers — even in broad daylight!

Figure 5 – Jodrell Bank 250-foot steerable radio telescope.

Finally, I have to mention my first "great observatory," visited during a trip to England in June 2002. Royal Greenwich Observatory was established in 1675 at the urging of John Flamsteed. He supplied all the original instruments himself. Flamsteed's long-running dispute with Isaac Newton over the publication of his star catalogue is a story in itself. The place is steeped in history — Flamsteed, Halley, Bradley, Maskelyne, Airy — they all directed Greenwich Observatory and all influenced astronomy in big ways.

The Prime Meridian, from where all longitudes on Earth are measured, runs right through the building. The Time Ball continues to this day to mark 12 o'clock noon from atop Flamsteed House.

John Harrison, whose epic history is told in Dava Sobel's *Longitude*, designed and perfected the first clock capable of keeping accurate time while at sea. His "H" clocks, H1 to H4, are on display at Greenwich.

The people and instruments at these great observatories were in many ways the discoverers of the things many of us now take for granted — meteor showers, radio-active galaxies, distant nebulae, cosmic rays, supernova remnants, solar activity, and even accurate time. We owe an immense debt to those dedicated observers of times past who had the imagination and foresight to build and use these instruments to enlighten our knowledge of the Universe.

James Edgar is a man of many talents — a skilled woodworker, Production Manager of the Journal, *an indefatigable editor of many of the RASC's publications, and, of course, a member of the infamous Edgar clan.*

Seven Easy Steps to Sketching the Lunar Surface in Real Time

by Brian McCullough, Ottawa Centre (brian.brightstar@sympatico.ca)

Sketching the Moon through the eyepiece of a telescope has always been one of the most rewarding aspects of my hobby in astronomy. The close observation that is required to make a decent lunar sketch forces me to step away from the cares of the workday and focus on something that has a bit more significance in the grand scheme of things. It's a wonderful stress reliever.

The Moon is an obvious subject for astronomical sketching. It has bright, sharply defined features, and offers an ever-changing feast of glorious shadow detail. It's a sketcher's paradise if ever there was one. But how do you take advantage of it? People tell me all the time they can't draw, but to my way of thinking you aren't making a drawing so much as you are observing and sketching...there's a difference. And, yes, you can do it.

Once during an Ottawa Centre meeting I put an image of crater Clavius up on the big screen and asked all 120 people in attendance - from kids as young as 7 to adults in their 80s - to make a three-minute sketch of what they saw. It was an amazing experience to watch people "suddenly discover" their ability to sketch a lunar surface feature. We published many of these exciting sketches in our Centre newsletter *AstroNotes*. If they could do it....

People have different methods for producing lunar sketches that are both useful and pleasing. In his book, *A Portfolio of Lunar Drawings*, British Astronomical Association lunar observer Harold Hill uses his drawing of the crater Gassendi — a 110-km "walled plain" — to illustrate his exacting method of marking albedo numbers onto a raw outline sketch made at the eyepiece, then using this "paint-by-numbers" guide to produce the finished piece. The results are impressive, but the method leaves me cold. I prefer a less calculated approach to capturing lunar features in my logbook. To show you how I go about it, I have "deconstructed" my own August 8, 2003 sketch of Gassendi (Figure 1) into seven easy steps.

Step 1 — Decide what to sketch

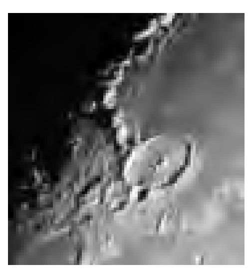

Figure 1– Gassendi

I'm probably not the best person to be telling this to anyone, but at some point you have to stop admiring the view in the eyepiece and get to work. I've let too many wonderful sketching opportunities slip through my fingers because I was playing tourist along the terminator. Begin by scouting out a primary target to sketch and observe its placement within the surrounding terrain. If this is your first attempt at a lunar sketch, look for a single, well-defined feature and aim to keep it simple.

Before I actually begin sketching, I often take a quick eyepiece shot with a digital camera so that I have something to check my sketch against later. I should note that I never use the photograph to grab details for my sketch that I might have missed at the eyepiece.

All set? Got your medium-lead pencil for details and a soft-lead pencil for shading? Got your art eraser and an unlined notebook? Then let's get started.

Step 2 — Make a rough outline of your primary target

Figure 2 – Step 2

Believe it or not, putting the first pencil mark on the page is the toughest part of this whole exercise. Lots of people get very uptight about making sure that first mark is absolutely perfect. I can think of better ways to get an ulcer, so here's how to get around it. Make a fast, light pencil outline of the crater. You don't need to fuss over it because you won't be keeping it. Compare what you've just drawn with the view in the eyepiece...then *erase* the outline. If you are anything like me, nine times out of ten it wasn't right anyway.

Now that you've dirtied up the page a bit, your mind will be free to begin sketching a more accurate rough outline with a more confident hand. This will be the basis for your final sketch, so log the start time into your notebook. If you are having difficulty keeping things in proportion, establish a few landmark points on the page and connect the dots. It seems to work for me. The rough outline should take you no more than a few minutes.

Step 3 — "Time-stamp" your sketch with shadows

Figure3 – Step 3

Houston, the clock is running! Keep an eye on the time. Because the day/night terminator advances noticeably across the lunar surface, shadow shapes will change fairly quickly. As a rule of thumb, plan on defining all major points, *including the darkest shadows,* within 15 minutes. You need to work carefully, but quickly. Sketch only what you see, not what you *think* you see. Refer constantly to the view in the eyepiece to make sure you are getting things right. Once the dark shadows are in place, the Sun angle (and therefore your sketch) will be "time-stamped" for posterity. Again, log the time in your notebook.

Step 4 — Add shading and context

Your sketch is about to "come alive" with depth. With your soft-lead pencil, begin shading in the tonal differences on the crater floor and along the walls. The brightest sunlit areas will be the white of your paper. You may be surprised at how, with even a bit of shading in place, your sketch suddenly takes on a more natural, three-dimensional look.

Figure 4 – Step 4

During Step 4 I also begin to define the context of the crater by sketching in a few of the closest adjacent features. Believe me, it is easy to feel overwhelmed by the sheer amount of interesting detail available in the immediate vicinity of a crater, so for the moment restrict yourself to adding just enough lines and shadows to give a bit of framework to your sketch. Until now the crater has been more or less "floating in space" on your page. Your goal here is simply to anchor it to the surface of the Moon by establishing where it fits among a few surrounding features.

At this point you may well decide to add nothing more to your sketch. You still need to make some final adjustments to the tone and contrast (Step 6), and annotate your drawing with the pertinent observational details (Step 7) - but you should now have a pleasing observational sketch of a lunar surface feature in your notebook. Well done!

Step 5 — Extend the Sketch

Figure 5 – Step 5

If you are up to it, extend the limits of your sketch to a few more of the nearby features, including the terminator or the lunar limb if they aren't too far away. Again, start with a quick outline and establish the dark shadows as soon as possible so that you don't inadvertently create multiple Sun angle time-stamps across your finished sketch. I ran into trouble with this myself with Gassendi. The sky clouded over right after Step 3, when I'd just time-stamped the shadows onto the crater. By the time the sky cleared up enough for me to sketch in some additional features more than an hour later, details toward the terminator that were previously in shadow were now blazing away in the morning lunar sunlight. This discrepancy is glaringly obvious if you compare the sketch with my very bad digital image (you see now why I prefer pencils to pixels). Many of the highlights sketched in near the terminator do not appear in the image I snapped at the beginning of the sketching run.

Step 6 — Finalize Tone and Contrast

You're almost done. Take a few minutes to compare the tonal values in your sketch with what you see in the eyepiece and adjust the shading as required. Use your art eraser to pull out any bright highlights that got drawn too dark. Now, look at your sketch with an eye to the overall contrast. Are your whites white? Are your darks dark? How does the overall effect compare to

Figure 6 – Step 6

the eyepiece view? Probably the easiest way to establish the final contrast in your sketch is to make the shadows as black as possible.

Most people tend to sketch far too lightly, probably because they aren't confident about what they are doing with the pencil. One of my great frustrations is looking back through my early logbook sketches and seeing all those ethereal images of galaxies, nebulae, star clusters, lunar craters.... They look like they were drawn by a timid ghost using near-invisible graphite. So be bold with that pencil and really establish those lines and shadows.

Now that your sketch is done, log the finish time into your notebook. All that's left is to add the observing data.

Step 7 — Record the Observational Details

Figure 7 – Step 7

Remember that you are creating an observational sketch. The details of the observation are all-important, so include them as part of your drawing. You'll want to note the date and time(s), sky conditions, temperature, what it is you have sketched, the observing instrument and eyepiece you used, and a directional arrow (missing from my Gassendi sketch - *yikes!*) to indicate north, south, east, and west. Having this information as part of the finished sketch helps me reconstruct the observation even years later. I also happen to like the look of a working sketch that contains this data as part of the overall image.

Gassendi and Mare Humorum

Gassendi is a beautiful example of a mare-flooded walled plain. You'll find this 110-km structure with its 1200-metre central peaks straddling the north shore of Mare Humorum (the Sea of Moisture), an ancient circular impact basin near the Moon's southwest limb. Poor seeing prevented me from capturing the fine detail of rilles along Mare Humorum and on the floor of Gassendi itself, but you can see all of this and more in the *Lunar Orbiter* images, and in some stunning close-up images taken earlier this year by the European Space Agency's *SMART-I* orbiter AMIE micro-imager. You might also be interested to know that Gassendi was a primary alternative landing site for *Apollo 17*. So get that telescope fired up, friend! You are GO for LOI.*

— Brian McCullough

(* Lunar Orbit Insertion)

And that's it!

Although I have described my technique in seven steps, I'm not nearly that methodical. The actual process ends up being a bit more fluid, but this is more or less how I go about sketching the lunar surface in real time. With a bit of practice you should be able to render detailed sketches of lunar surface features in 30 to 40 minutes. Just stay loose and be confident in your ability. Please let me know how you do.

Clear skies and happy Moongazing!

(P.S. Does the sketch at Step 5 look like a chocolate Easter Bunny to anyone else, or is it just me?)

Acknowledgments
My thanks to *JRASC* editor Jay Anderson for inviting me during the May GA to describe my method of sketching lunar features for the *Journal*, and to Bruce McCurdy for checking the accuracy of my information.

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Brian McCullough is the lunar-observing co-ordinator and a past president of Ottawa Centre. He is an enthusiastic astronomy educator in the Ottawa area, and "moonlights" as an evening astronomy and space-science educator with the Canada Science and Technology Museum.

A Quick and Cheap Way to Find Earth-like Planets around Other Stars

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

Finding an Earth-sized planet in the zone of habitability — the region where liquid water can exist on the surface — of another star would be a very exciting discovery, because it would hold out the possibility of life elsewhere. Unfortunately, it's a very difficult technical problem. For a typical solar-type star at a distance of about 10 parsecs (~33 light years), the planet will be ~0.1 arcsec from the star, and less than 1 billionth of the star's brightness. Current estimates for the cost of the proposed NASA Terrestrial Planet Finder mission (TPF) are now in excess of $10 billion, and the technical requirements are extremely challenging — in fact, they are not achievable with current technology. Webster Cash of the University of Colorado has a different approach, which can be done with existing technology and costs less than $1 billion (see the July 6, 2006 issue of *Nature*).

The idea is conceptually simple, and related to one of the approaches selected for the TPF mission: a coronagraph. Used in solar astronomy to simulate a total eclipse, a coronagraph places a black disk in the optical path of the light through the telescope. This allows for study of the Sun's corona outside of an eclipse. Placed in a space-based telescope, the idea is that the disk would block the star's light but allow the planet to be seen, just as the corona is revealed. But the optical surfaces of such an instrument would have to be exquisitely precise — very much better than the Hubble Space Telescope.

Cash's idea is to place the occulting disk outside the optical path of the telescope — blocking out the starlight before it ever enters the instrument. But this introduces a different problem — diffraction and scattering of light around the edge of the disk. A plain circular disk will not work by many orders of magnitude - far too much of the starlight will still enter the telescope, drowning out the light from the planet. Cash has found, however, that a "petal-shaped" occulter (see Figure 1) does block enough of the star's light to allow Earth-sized planets to be seen. It has the further advantage that it will also be easy to find Jupiter-sized planets in Jupiter-like orbits, which TPF would not be able to see. Cash has consulted with aerospace engineers and finds that we can make such an occulter with present technology. He proposes that it be used in conjunction with the James Webb Space Telescope, now under construction, and estimates that the total mission cost would be less than $1 billion (not including the JWST costs, of course), including launch.

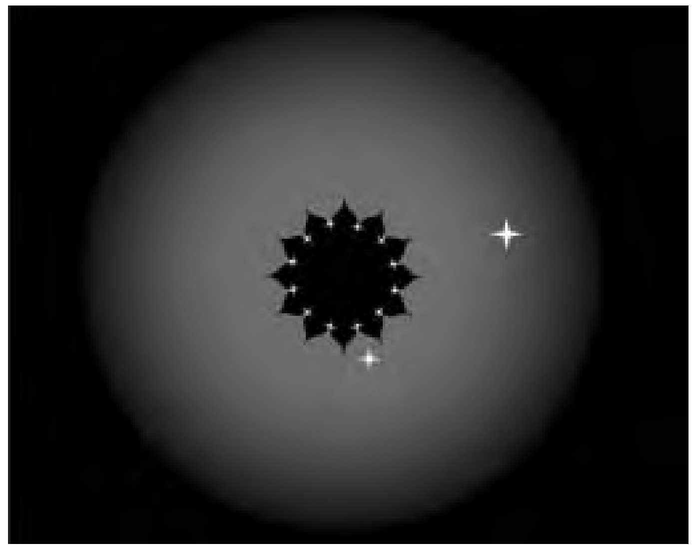


Figure 1– A simulation of the masking of starlight by a petal-shaped occulter, making two planets visible. Image courtesy of Webster Cash and *Nature*.

That's the good news. The bad news is that the occulter has to be big: 30-50 m in diameter, and it has to fly in formation with the JWST to an accuracy of a few cm, while separated from it by ~20,000 km. JWST will be sent 1.5 million km away from the night side of the Earth, where it will take about six months to complete its 0.5 million km diameter orbit about the L2 stability point. Cash and his colleagues have shown that an occulter can "stalk" the observatory around its orbit and achieve alignment and station-keeping without burning excessive quantities of fuel. The occulter will normally be used along a line of sight that is perpendicular to the Sun-Earth line so that JWST will view only its dark (unilluminated) side to minimize scattered solar light. This constraint allows all stars to be observed, but only at certain times of year. That, combined with the long travel times between observations, is the price one pays to avoid the daunting and expensive optics of TPF.

We have the technology; we can do this as soon as the JWST is launched (currently scheduled for no earlier than June 2013). Does the political will exist, and is there money? The political will has two components: 1) the general public, and 2) the astronomers who have already spent years working on TPF. The public in the US have been very supportive of space missions in the past, and I expect that to continue. The primary resistance probably will come from astronomers who do not want to see years of their work simply thrown out, though in effect it already has been, as TPF has been "indefinitely deferred" in NASA's jargon. To everyone else, that means the mission has been cancelled by the current NASA administrator. As the cost is only a tenth of TPF, in principle it should be affordable. I hope that the proposal is given serious consideration!

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.*

The Haloed Moon
And Leo's Capture

— Haloed moon:
You have captured Leo
and upset Orion.

— Alas, Orion,
in your hurry across the winter heavens
you missed the chase,
and now the haloed moon has captured Leo

Forgive me,
but a wise hunter would be more observant.

— Roar against the Milky Way, Leo.
You are captured at last,
and by the haloed moon.

You would roar less
if you thought on your fate
had Orion been your captor.

— Bryan Kelly-McArthur
March 18, 2006

Cosmic Bird Watching

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

If we amateur astronomers are, as Terry Dickinson has called us, "naturalists of the night," then one of our most beloved occupations might be called "cosmic bird watching." This term was coined by Jay Reynolds Freeman: "If galaxies were birds, then what we do would be called bird watching, not ornithology. 'Cosmic bird watching' might be a good catch-phrase for what deep-sky observing is all about." (`observers.org/beginner/deep.sky.html`)

Like regular bird watching, cosmic bird watching starts with a list of targets. There are many different lists of varying difficulty and focus; the RASC publishes a whole bunch of them every year in our *Observer's Handbook*. Why bother with a list? Most beginners have few ideas of what to look at beyond the Moon and planets. Observing a list of objects gives structure to observing, creates a sense of accomplishment, and encourages the observer to learn new parts of the sky.

By far the most famous list is that compiled by Charles Messier in the 18th century. The idea of attempting to observe all of the objects in Messier's catalogue was a product of the fertile mind of one of Canada's greatest amateur astronomers, Isabel Williamson of the Montréal Centre. I'll let her describe it for you:

> Our Messier Club came into being on Wilson Avenue in the early 1940s. Its main purpose was to stimulate members into becoming active observers instead of being content to look through the telescope at objects others had located.
>
> Messier's Catalogue with its 103 objects [now expanded to include 110 objects] was an excellent basis for a competition. There were a few rules, of course. The member had to find and identify each object himself. The beginner who had never operated a telescope was given a little help with the first few objects and then he was on his own. The objects had to be observed through a telescope. (Those viewed only through binoculars didn't count.) Setting circles were ruled out. (That was too much like shooting a sitting duck.) The purist would not even view an object that someone else had located until he had found it for himself. (It is much easier to find an object if you know what it looks like.) And so, through the Messier Club, members became familiar with the sky, learned to operate telescopes and find objects invisible to the unaided eye, and trained their eyes to detect fine detail.
>
> Ten members have observed all the objects in Messier's Catalogue [as of 1968]. The graduates, listed in the order in which they attained this status, are Tom Noseworthy, Professor T. F. Morris, Constantine Papacosmas, Geoffrey Gaherty, Dr H. E. Lehmann, Charles Giffin, Larry Anthenien, Alfred H. Capper, Dr George Fortier and David Levy." (*Fifty Times Around The Sun: A History of the Montreal Centre Royal Astronomical Society of Canada 1918 to 1968*)

Isabel's idea was spread far and wide by her friends Walter Scott Houston and James Mullaney. When Tom Noseworthy observed his last two Messier objects, he asked Isabel what he should do next, and she, jokingly, suggested the Herschel catalog. Thus, she is also the inventor of the Herschel Club. Only a handful of amateurs, including our own Father Lucian Kemble, have observed all of William Herschel's 2600 objects. Most go on instead to subsets of Herschel's catalog such as Alan Dyer's Finest NGC Objects (in the *Observer's Handbook*) and the Astronomical League's Herschel 400 list. (`www.astroleague.org/al/obsclubs/herschel/hers400.html`)

To anyone who has struggled with locating even some of the brighter Messiers, the thought of tracking down 400 fainter objects may seem daunting. It's not quite as bad as it seems since, by the time an observer finishes the "Messiers," they will already have observed some of the Herschel 400 because there's some overlap between the two catalogues. While Herschel tried not to duplicate any objects on Messier's list, he included 16 objects that currently have Messier numbers, mainly because of errors on Messier's part. If you have also observed the Finest NGC list, you will have an even greater head start, as 86 of these objects are duplicated in the Herschel 400. Only 298 to go!

Because nights suitable for observing faint deep sky objects are fairly infrequent in my part of Canada, I've found it wise to be well organized so that I can get the most out of those rare clear nights. I prepare planning charts in *Starry Night,* and photocopy the relevant pages from the *Millennium Atlas.* These are my personal favourites; your choice may be different. As an overall planning tool, I make extensive use of the magnificent database of over 10,000 deep-sky objects compiled by members of the Saguaro Astronomy Club in Arizona (`www.saguaroastro.org/content/downloads.htm`). I've imported this into a *FileMaker Pro* database and added fields to contain my observing notes. This lets me easily sort the objects by Right Ascension, Declination, chart number, and so on.

My Herschel 400 observations started many decades ago when I first observed the "Messiers" as part of the Montréal Centre's Messier Club. Like most graduates of the Club, I treated the Herschel Club as something of a joke, and only devoted three sessions to it, logging 16 "Herschels" in 1959 and 1962. When I returned to astronomy in 1997, I re-observed all of the "Messiers" and started in on the Finest NGC list, which I completed in March 2001. At this point I had logged 124 of the Herschel 400 list, since I'd serendipitously caught quite a few bonuses while starhopping to the Messier and FNGC objects.

I've found that, after completing a major project, I often need to spend some time doing some totally different kind of observing. As a result, I logged only four new objects during the following year, and it wasn't until the summer of 2002 that I began seriously hunting down "Herschels" again. Between May and December 2002 I logged 74 more objects in 11 sessions. This was followed by another fallow period, from January 2003 through August 2004 when I added only 11 new objects. There were two main reasons: I had no access to a good dark-sky site and Rick Huziak had introduced me to the joys of variable stars.

When we bought our farm in Coldwater, I once again had regular access to a dark sky, and I began observing the "Herschels" with a vengeance. With 11-inch and 12-inch Dobsonians at my disposal, I had very little trouble locating or seeing the objects. Between September 2004 and July 2005, I logged an amazing 155 objects in only 12 sessions! At that point, I ran out of objects in the current sky, and was forced to wait until the late-winter/early spring skies returned in April 2006. I then logged the final 32 objects in 3 marathon sessions, catching the last object, the galaxy NGC 3395, on April 25. All in all, it took 60 observing sessions spread over 48 years to get the whole 400!

In rereading what I've written, it occurs to me that it's mainly statistical, rather than descriptive. That's because of something I've discovered while completing these cosmic bird-watching lists: each list is rather less interesting than the last. The Messier list is packed with visual delights. The Finest NGC list has quite a few, but noticeably fewer. The Herschel 400 turns into a slog through tiny faint smudges of galaxies and thinly scattered clusters of stars. My hunch is that I'm rapidly approaching the point of diminishing returns in deep-sky observing, at least until I get a significantly larger telescope or move to the Southern Hemisphere, neither of which seems likely at present. So once again, I find myself going back to my other astronomical pursuits, variable-star observation and timing central-meridian transits on Jupiter, or thinking about a totally new venture, such as astro-imaging. Herschel hunting had its moments, but I'm ready to move on to something different.

As described above, Geoff Gaherty has returned to active status after a thirty-year hiatus in observing from the '60s to the '90s. A member of the Toronto Centre, he is gainfully employed working for the Royal Ontario Museum and Starry Night Software.

Astrocryptic

by Curt Nason, Moncton Centre

The solution to last issue's puzzle:

Deep-Sky Contemplations

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

One of the great accomplishments of astrophysics during the 20th century was acquiring a detailed understanding of the origin, structure, and evolution of stars. Not until we understood the origin and evolution of *our* star could we truly begin to understand the origin of our planet and of life on Earth. There are two approaches to understanding the stars: theoreticians construct mathematical models, and observers collect factual data. The two approaches are complementary. The observed properties of the stars establish the boundary conditions that constrain the theoretical models, and the models guide the observers in determining what data they must acquire in order to test the theory. The stellar systems that have played the most critical role in this harmonious intellectual duet are *star clusters,* especially *open star clusters.*

The value of using stars within clusters to probe the structural and temporal properties of stars is that members of a cluster share a common chemical composition and a common age (at least approximately). Hence, two variables are eliminated when attempting to explain the observable differences, especially differences in luminosity and colour, between the stars. Within a star cluster, the fundamental difference between one star and another is *mass*. The observed distribution of magnitude (luminosity) as a function of colour (surface temperature) over a range of mass contains distinctive *patterns* that provide a direct means for determining the age of a star cluster.

Amongst the few "deep-sky" objects detectable with the naked eye, open clusters such as M45 and M44 are among the most obvious. Scan the sky with binoculars and more clusters come into view. Use telescopes of increasing aperture and still more are revealed. Our Galaxy is home to *thousands* of open star clusters. Not all of those clusters are easily detected, however, even when close by. The Hyades, for example, is less obvious than its apparent neighbour, the Pleiades, because the Hyades is *too* close and its member stars too spread out to be obviously associated with one another. Other open clusters play hide-and-seek amongst the myriad stars within the Milky Way. Here, we

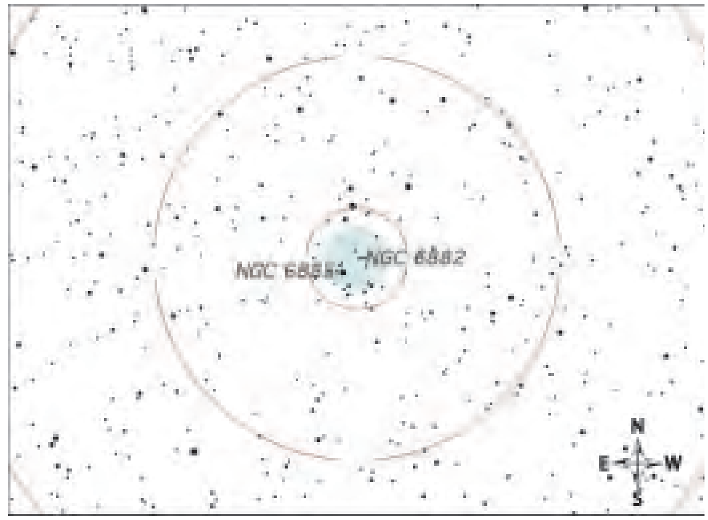


Figure 2 – Finder chart for NGC 6882/6885 shown with 0.5° and 2° Telrad circles (and part of 4° circle).

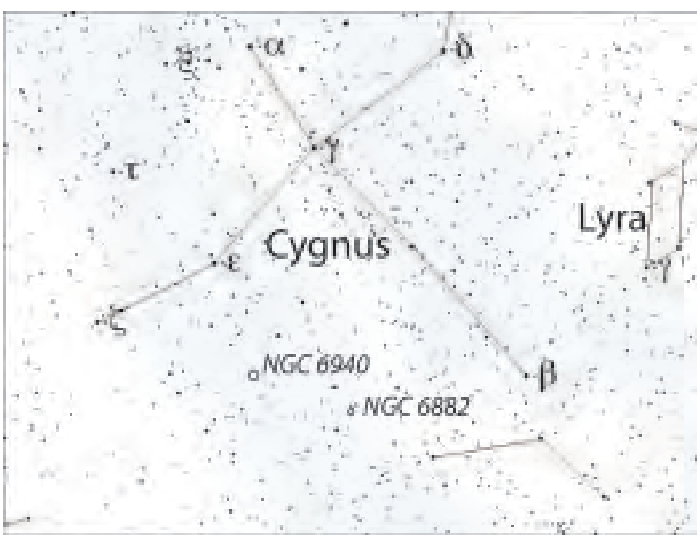


Figure 1 – Positions of NGC 6882 and NGC 6940 in Cygnus.

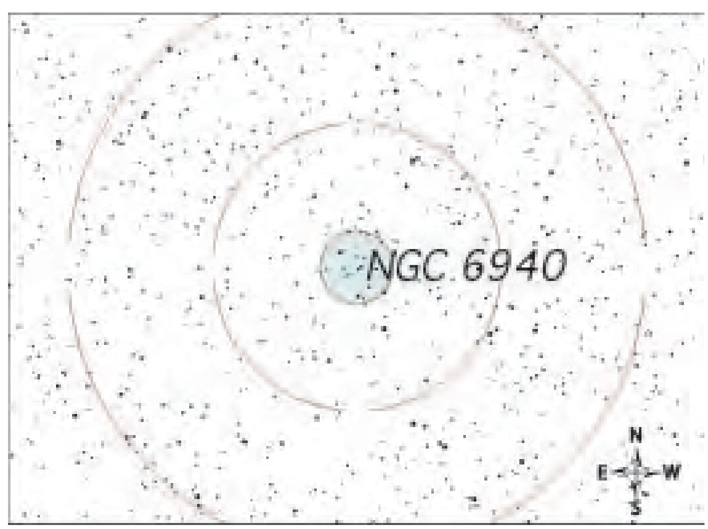


Figure 3 – Finder chart for NGC 6940 shown with 0.5° and 2° Telrad circles (and part of 4° circle).

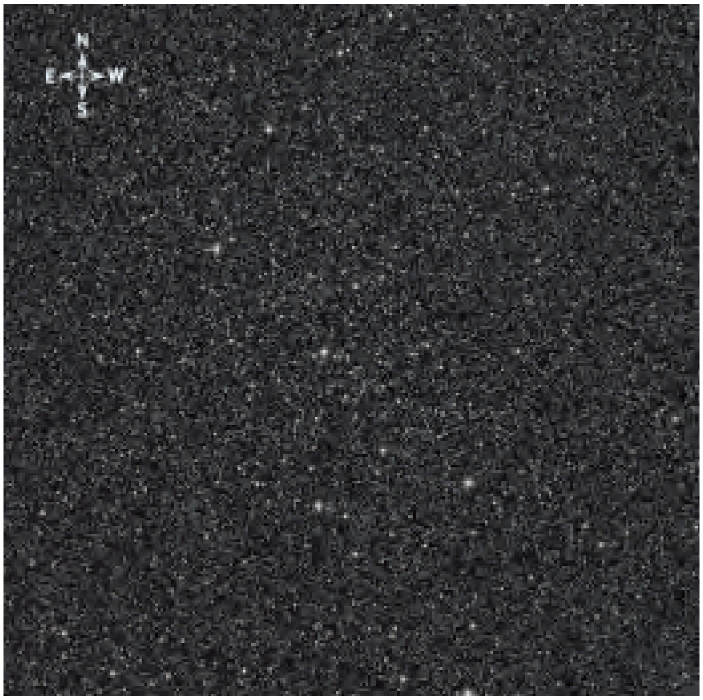


Figure 4 – 50´ × 50´ POSS image of the field that includes NGC 6940.

challenge you to find two (or maybe, three?) such elusive open clusters.

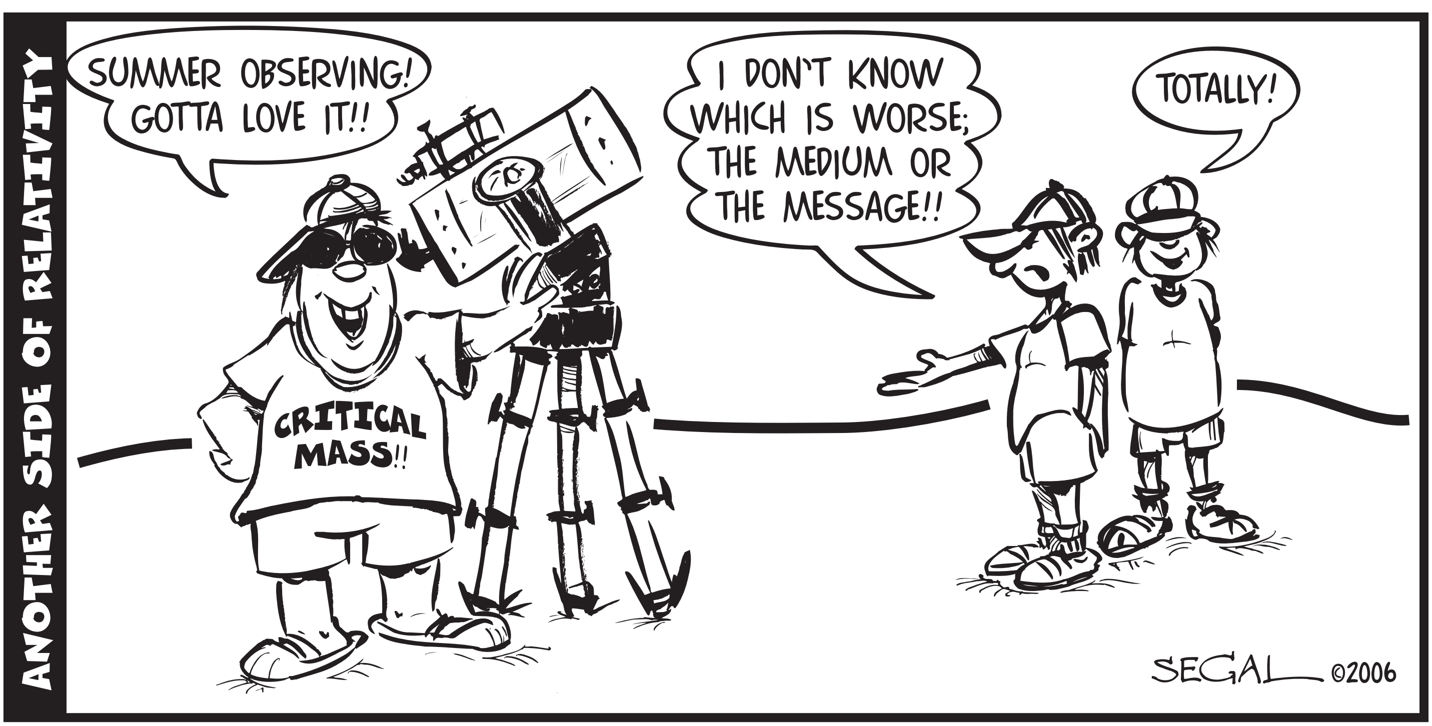
NGC 6882 [RA(2000) = 20^h 12.0^m, DEC(2000) = 26° 29.0´] and NGC 6940 [RA(2000) = 20^h 30.4^m, DEC(2000) = 28° 17.0´] are at comparable distances, 2000 and 2500 light years, respectively. They have comparable integrated magnitudes, but differ significantly in apparent and intrinsic diameters, 7´ (~4 light years) and 31´ (~20 light years), respectively. They are located between M27 and the Veil Nebula and, therefore, are conveniently placed for observing during summer months. Conveniently located, yes, but can you detect them?

Within the apparent boundaries of NGC 6882 is the magnitude 5.9 star 20 Vulpeculae, but it is not a physical member of the cluster. In some reference sources, *e.g.* "*Guide 8,*" the label "6882" does not appear, but "6885" does. In other sources, *both* labels NGC 6882 *and* NGC 6885 appear: there may be *two* open star clusters, one (6885) smaller and in the foreground superposed on the other (6882) as suggested in a paper published in 2005; or NGC 6885 may be a gravitationally unbound stellar association along the same line-of-sight as suggested in a paper published in 2004; or the answer may be that there is only one stellar grouping and a mislabeling has led to confusion. One or two clusters — what do *your* observations suggest? Indeed, do your eyes detect evidence of *any* clustering in that region?

There is no such uncertainty with NGC 6940. There is but one cluster, yet it is so thinly populated that its apparent density is only slightly greater than that of the background stars. Membership in such a cluster is firmly established not through direct visual observation or imaging but by carefully measuring brightness and colour of many stars in the field, examining the distribution of those parameters, and looking for the special patterns and relationships that theory predicts for a true family of stars that share a common origin and composition.

Next time you're out under the stars, point your scope at these ethereal open clusters and see what *your* eyes find.

*Warren Finlay is the author of "*Concise Catalog of Deep-sky Objects: Astrophysical Information for 500 Galaxies, Clusters and Nebulae*" (Springer, 2003) and is this year's RASC Simon Newcomb Award recipient. Doug Hube is a professional astronomer, retired from the University of Alberta.*



A Paean to Plumbing

by Don van Akker (don@knappett.com)

For generations astronomy tinkerers have searched hardware department stores for just the right combination of pipes and fittings for their projects. Drawing on this long and lustrous association between amateur astronomy and plumbing, we present this observing screen.

We built the screen because it so often seems that when finally there is a clear night without a Full Moon, there's a fresh breeze that makes the telescope tremble while the neighbour's porch light glares through the trees and blinds you unexpectedly whenever you turn your head. This screen alleviates both those problems, though usually only one at a time because the breeze and the porch light are never in the same direction.

For the uprights you need a full 20-foot length of one-inch schedule 40 (the thicker stuff) PVC pipe. Cut it in half to get it home. For the spreaders you need 10 feet of 3/4″ PVC pipe. You also need a handful of fittings (alright, both hands full), a small can of PVC solvent cement, a twin-size polyester bed sheet, and two eight-inch nails.

Figure 1 – The Framework

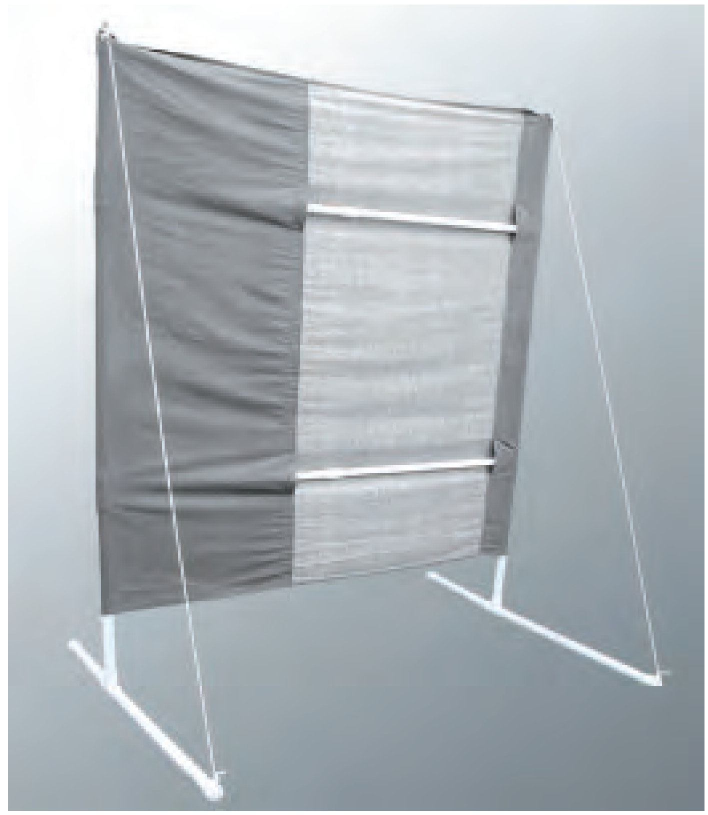


Figure 2 – Complete with sheet

Cut the pipe with a power miter saw if you have one, with a hacksaw if you don't. The total height should come to just above your eye level. It should be about five-feet wide. Assemble as shown in the drawing but don't glue anything yet.

One side of the base should be longer than the other. It faces upwind and has holes drilled at the ends so that the nails can be driven through and into the ground. The end caps on this side each have a screw turned into them. Cords loop over the screws, and corresponding screws at the top, to stiffen the frame when the breeze freshens. When the nails pull out of the ground, it's time to go home.

We used a bed sheet because neither of us is very accomplished with a sewing machine and a bed sheet already has four finished edges. Hem one end six inches and the other end so as to use up whatever is left after measuring the overall width of your frame. It should fit slightly snug. Stitch one end of each hem closed to form a pocket. Slide a side frame into each pocket, slide the spreader sections through holes left in the hems for the purpose, and socket them into the side frames. Fit the spreader sections end to end and that's all there is to it. When you take it apart everything rolls up into the wide pocket of the sheet. Decide how you will store it and glue all the joints that won't need disassembly again.

This screen works well to protect a scope that is taking photographs or to shield your eyes when you are trying to bag that faintest of the faint fuzzies. Will building it make you a plumber? No, but it will make you part of the tradition.

Don Van Akker makes his living digging holes and putting buildings in them. He observes from the rain coast with his wife Elizabeth so he has many free evenings to work on these ideas.

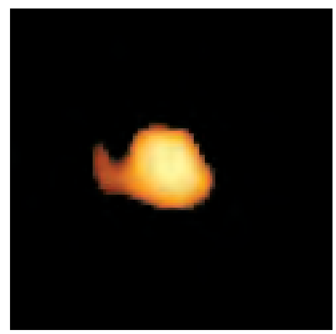
Ramblings of a Variable-Star Addict

Marvellous Miras!

by Rick Huziak, Saskatoon Centre (huziak@SEDSystems.ca)

In August 1596 Dutch amateur astronomer David Fabricius discovered a new star in the sky while observing the planet Mercury. Needing a reference point to mark the planet's position, he picked an unassuming 3rd-magnitude star. Two weeks later he noted that the star had brightened by a magnitude and two months later still, that it had faded from view. He assumed it was a nova. In 1603 Johann Bayer included the star as "omicron Ceti" in his famous star atlas but the star earned its immortality half a century later when Johannes Hevelius give it the name Mira ("The Miraculous" or "The Wonderful"), a name that reflected its amazing periodic appearances and disappearances in the sky. Mira was the first long-period pulsating variable discovered, and its discovery was due to the fact that at maximum this star can occasionally reach a blazing 2nd magnitude.

Mira has become the prototype for the class of regularly beating long-period variables — stars now collectively known as "Miras." Miras are part of a larger group of pulsating long-period variable stars known as "LPVs" that includes similar semi-regular variables. (Semi-regulars tend not to be as good timekeepers as Miras.) Mira keeps reasonably good time in going through a slow pulsation cycle every 331.96 days and through a magnitude range of 2.0 to 10.1V — a change in brightness of nearly 1700 times! As with most LPVs, both the period and the extremes of the magnitude change slightly from cycle to cycle. The given period is the average of many cycles and the magnitudes are the extremes of brightness. With such a large and bright range, Mira becomes a very easy variable for amateur astronomers to study, with most of the cycle being visible to the naked eye or with binoculars. Other Miras follow the same general rules — they have large amplitudes and are fairly easy to observe, at least near maximum light.



This *HST* image resolves the strange irregular shape of Mira and a small hook-like appendage extending outward. The hook may be material gravitationally drawn from Mira toward a companion star. Not all Miras are double stars, but all likely have equally bizarre shapes. Image courtesy Margarita Karovska (Harvard-Smithsonian Center for Astrophysics) and NASA.

Miras are the mainstay of the AAVSO visual observing program. Indeed, the program got its start monitoring Mira-type stars, a process that continues with many Miras today. Much of what is known about Mira periods and their evolution over time comes from tens of thousands of amateur magnitude estimates. Since the inception of the AAVSO in 1911, over 100 cycles of Mira have been monitored with over 550 observers contributing almost 60,000 observations. Hundreds of other LPVs have also been monitored in the AAVSO program.

Miras are red supergiant stars that once were Sun-like before their hydrogen fuel was exhausted; now they are bloated and burning the helium ashes left behind at their core. Helium-burning stars become unstable as the fight between gravity and radiation pressure in the centre of the star swings back and forth between the contestants, first gravity dominating, and then radiation. When the pendulum swings to gravity's side, the star is pulled inward, its core heats up, and helium burning turns on. The newly stoked central fire increases the radiation pressure in the stellar core and the outer envelope expands, cooling adiabatically until the helium burning stops. The stellar atmosphere, unsupported by the pressure from inside, collapses as the competition swings in gravity's favour, and temperatures on the surface cool. These on-again off-again nuclear fires in the core make Mira stars pulsate regularly and lead to their variable light output.

But this seems not to be the entire story. While some of the variability can be explained by changes in the core, theoretical models are unable to account, by helium burning alone, for the immense range of brightness changes seen in Mira stars. As Mira's rhythm goes on for thousands of cycles, heavier and heavier elements are created in the hot core as helium and other fuels are slowly forged up the periodic table. Miras somehow manage to loft these heavy core compounds into their upper atmospheres, eventually belching them out into the interstellar medium as "soot," or at least an extreme case of Cosmic Smog. Infrared observations have revealed titanium dioxide and graphite in the outer atmosphere of Mira variables, and theoreticians speculate that the molecules, good dimming agents, form as the envelope expands and cools. The star's light output is reduced (and diverted into the infrared). As the outer atmosphere reheats, the molecules dissociate and the brighter layers below shine through.

The Sun itself will likely become a Mira star in a few billion years, and may even swallow the Earth as it expands outward after the onset of helium burning.

Miras get very large in the process, with the largest expanding to a dimension equal to the orbit of Jupiter, even though they contain masses comparable to the Sun. Being so bloated, these variables show an appreciable size on the sky. If you have ever watched stars such as Mira get occulted by the Moon, you might have noticed that they take a few tenths of a second to disappear behind the lunar limb! The humungous size of some of the closer Mira stars has allowed their surfaces to be imaged by the *Hubble Space Telescope*. The outer atmosphere is so tenuous, and density at the surface so insignificant (approaching what we'd consider a good vacuum), that *Hubble's* images show the stars taking on strange shapes! It is believed that Miras have humps, depressions, and major deviations from the roundness we generally associate with normal stars. Miras also develop strong stellar winds that slowly reduce their mass as the atmosphere is puffed off into space. Sometimes, especially if the Miras are double stars, the stellar winds are funnelled in opposing directions, creating the marvellous shapes of planetary nebulae; eventually the outer coating is gone and their cores are exposed as extremely hot, blue-white dwarf stars.

Observing Miras is easy, but since Mira itself will not be in good position for observation when this article is published, I have chosen the fourth Mira to be discovered as this summer's target — χ (chi) Cygni. This star can reach magnitude 3.5, and fade as far as 14th. It will be near maximum light most of the summer. You will find that like most Miras, χ takes about one third of its cycle to rise to maximum, and about two thirds to fall back to minimum. Often Miras have "stalls" in the light curve, and χ tends to have a flat stall a week or two in duration before it rises up to maximum again. To catch the light-curve changes, you'll want to make an estimate every seven days or so, sufficient to show the star's slow light change. You'll find χ Cygni plotted on most star charts. It is the star that fills in the missing part of the Swan's throat just northeast of Albireo — or at least does so for a few months every 407 days or so.

LPVs are quite red — some are very red — and red stars can play tricks on your eyes. Red stars seem to get brighter the longer you stare at them, so if you take a long time to make your magnitude estimate, you may find that the value is too high when compared to measurements made by more-experienced observers. This brightening is known as the "Purkinje Effect." Johannes Purkinje was a Czech anatomist and physiologist who discovered that our eyes have blue-green sensitive rods and yellow-red sensitive cones. In dim light, the rods and cones change their sensitivity and the effect changes the colour balance that our eyes perceive.

Defocusing your field of view to spread the stars into small disks can minimize the Purkinje Effect. The defocused image tends to remove residual colour. You then estimate the brightness of the disk against the comparison star disks. The effect is most pronounced when the stars are the reddest, and you can see the result in the scatter of the data from different observers. Use the light curve generator (LCG) on the AAVSO Web site (`www.aavso.org`) to demonstrate this for yourself. If you choose very red stars such as U Cyg or RS Cyg, you will see that the spread of estimates can be a magnitude or more between observers. Don't panic, though — AAVSO data are usually averaged, and averaging removes much of the observed scatter. Luckily, most Mira stars are not as red as these examples!

Data on long-term behaviour of Miras will be part of the AAVSO business plan for some time to come. Since each cycle takes so long, decades and centuries are necessary to build up light curves that will demonstrate evolutionary changes in these stars. Timings of the maxima of Miras show some with periods getting longer and some that are getting shorter. In addition, periodic changes in the amplitude of the maxima and minima are intriguing. These changes reflect true physical changes in the interiors of the stars. No Mira has ever been seen to stop pulsating, but some have changed their periods by large percentages. The relationship between Miras and their semi-regular and irregular pulsating cousins is also not well understood. And then there are outstanding questions, such as "Do Miras produce flares or other short-term oscillations?"

As always, when you make an estimate, report it to the AAVSO. Every observation made is valuable, and it takes a lot of effort and dedication to monitor all of the 1600 Mira-type stars in the AAVSO database. An observation made and not reported is an observation lost!

Richard Huziak continues to study variable stars when the skies are clear. His current project is to sort out a few hundred suspected variable stars in Mira fields - stars that observers over the years have suspected are variable as they gaze nightly at the nearby Mira targets. To date, he has discovered about two dozen new variable stars in Mira fields, both visually and with CCD cameras.

References

AAVSO Variable Star of the Season:
(www.aavso.org/vstar/vsots/winter06.PDF)

Useful Web Sites

Charts for χ Cygni (and many other variables):
www.aavso.org (go to /charts, and then type in "CHI CYG," "OMI CYG," or any other star you want. χ Cyg charts have several different scales from naked-eye to deep-telescopic views.

The Purkinje Effect:
en.wikipedia.org/wiki/Purkinje_effect

Johannes Purkinje:
en.wikipedia.org/wiki/Johannes_Evangelista_Purkinje

Carpe Umbram

by Guy Nason, Toronto Centre (gnason@rogers.com)

"Why would you want to do a thing like that, Ollie?"
— Stan Laurel to Oliver Hardy, on numerous occasions.

"Let me get this straight," said a friend. "You went out and bought a whole bunch of stuff — you know, telescope, eyepieces, camera, tape recorder, TV monitor, video recorder, fancy radio, a mile or two of assorted cables, and other things — and you load it all into your van and you drive two or three hours into the middle of the night to some dark and lonely place that could be swarming with bears or snakes or, worst of all, humans? Then you unload all your thousands of dollars worth of gear and spread it out in plain view and fiddle with it for an hour or two, hoping that no one will attack you while you wait for a star to blink off and on? Alone? Are you nuts?? Why would anyone do a crazy thing like that???"

Well, since you put it that way, it does sound a bit odd, but in all my years of timing occultations, I've never

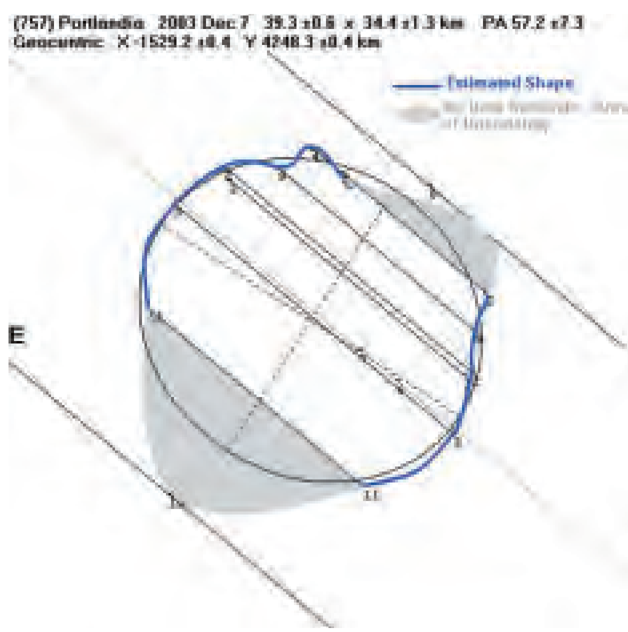


Figure 1 — Sky-plane plot for the December 07, 2003 occultation by asteroid (757) Portlandia of the star HIP 384. Eight observers' chords are plotted, but only a very rough shape and size of the asteroid can be inferred. More observers, particularly in the grey regions, would have helped define the shape and resolution of the profile.

had reason to fear for my safety. Well, almost never. One night in a lakeside park several springs ago, when I had just finished setting up my gear, a couple of guys in lumber jackets, dirty jeans, and gumboots drove up in a rusty old Dodge and promptly asked me how much all that stuff was worth. Seeing my reaction to the question they hastened to explain that they were undercover policemen looking for poachers who might be jumping the start of fishing season. Reassured, I explained what I was doing and said I'd be happy to show them a few celestial sights if they could just wait quietly for a few minutes until I completed the task at hand. They agreed, and after I recorded my observation (negative, as it turned out), we all enjoyed telescopic views of Saturn and other sights for an hour or so, their poachers and my nervousness long forgotten. I'll have more about safety in a future column, but the question here is: why would I want to do a thing like that?

First of all, it's astronomy. Witnessing a really neat celestial phenomenon is exciting and satisfying in itself. Even if there were no scientific reason to do so, I would still chase occultations. Just as some people chase solar eclipses for the sheer fun of it, so I enjoy asteroidal occultations for their own sake. They're not as viscerally thrilling as eclipses, but they happen more frequently and they're not nearly as big a strain on the bank account.

Secondly, I do this because it is science. It's one small way that I can contribute to the science of astronomy, to give back to a discipline that has given me so much joy over the years. Hey, I know it's not a cure for cancer, and I'm never going to win the Nobel Prize for Physics. I don't have the means or ability to reach those laudable heights, but I do have the patience and motivation to help in a very small way to beat back our ignorance of the world in which we live.

To do it right, though, we need as many participants as possible. An occultation observed by only one person, no matter how accurately timed, yields almost no information at all about the size or shape of the asteroid in question. It tells us whether the prediction was good or not, but that's about all. It does not tell us what part of the asteroid passed through that observer's line of sight to the star, and so we have no idea if the observer was on the centreline of the path or somewhere off to one side or the other. In other words, his or her timing cannot define the asteroid's size or shape, only its whereabouts. If, however, several observers are arranged more or less evenly across the predicted path, then we can get a good "sky-plane plot," or two-dimensional map, of the asteroid.

Third, the sport of occultation timing is fun. It is at the same time both a solitary and a team sport. In baseball, you are on your own when you're at bat, but overall success demands a coordinated effort by the whole team when on the field. Similarly, occultation timing is a solo endeavour when at the telescope, but success requires a whole team "in the field" and behind the scenes. Typically, we spread ourselves thinly on the ground, each observer on a different "track" (distance from the centreline), in order to acquire as much data as possible. I enjoy the quiet solitude and the responsibility of knowing that whether I succeed or fail depends on me alone. I can't blame anyone else if I forgot to check that my batteries were fully charged, or if I'm not ready when zero hour comes. My bad, as they say in the increasingly illiterate world of baseball. On the other hand, when things go right, the satisfaction is all mine. Hooray for me!

But it's not just me. It is a team event in the sense that the overall result — the final score, if you will — depends on the cooperation and performance of all the players. Maximum information about the asteroid comes with the greatest number of participants spread out across the occultation path. Even before game time, cooperation is required. The planning phase relies on many people: astrometrists and astro-imagers who work hard to produce the best possible predictions; the programmers who generate local maps and maintain up-to-date observer/station lists; and the planners who coordinate the observers to produce the best possible coverage. Afterwards, as results pour in, others step up to the plate. Data are reduced, plots are generated, and results are posted. And we move on to the next game in the endless season.

One of the things I like most about all this is the participation in a truly global endeavour. The players come from everywhere and do not restrict their activity simply because they live in different countries on different continents. But that's another story — or stories — that will have to wait.

In the meantime, here's a list of upcoming Canadian asteroidal occultations. Please check the list for events coming to a night sky near you and consider joining the team. Remember that these predictions may well be superseded a week or even a day or two before the events, so be sure to check Steve Preston's updated predictions at www.asteroidoccultation.com. Also, interactive Google maps for many events can be found at: www.poyntsource.com/BREIT_IDEAS/google/index.htm. Note that this address differs from the one given previously. Californian Derek Breit has taken on this task from New York's Charlie Ridgeway, so adjust your bookmarks accordingly.

Clear skies, good luck, and...*carpe umbram!*

Guy Nason, Toronto Centre's one-man team, is always trying to hit that elusive home run.

DATE 2006	TIME (UT)	ASTEROID	STAR	Δ-MAG MAG	MAXDUR (Secs)	PATH	*
Aug 16	07:25	407 Arachne	11.5	2.7	3.3	sSK–nMB	
Aug 16	08:43	601 Nerthus	12.0	2.2	6.7	cSK–sBC	
Aug 20	07:31	2429 Schurer	5.6	11.0	0.9	SK only	*
Aug 21	08:42	144 Vibilia	10.1	2.7	4.5	swON	
Aug 22	08:04	338 Budrosa	11.6	1.4	5.6	nMB–sBC	
Aug 30	07:1	567 Eleutheria	10.3	3.7	6.7	sSK–cMB	
Sep 02	08:03	132 Aethra	11.7	3.0	6.6	swBC	
Sep 05	07:10	474 Prudentia	10.4	2.4	6.6	NS	
Sep 07	07:35	46 Hestia	11.3	1.2	21.5	sSK–sMB	
Sep 08	03:38	218 Bianca	12.3	0.9	7.1	NB, Gaspé	
Sep 09	07:30	25 Phocaea	10.9	0.5	8.9	NB–NL	
Sep 09	08:09	161 Athor	11.0	3.4	1.9	sSK–cMB	
Sep 09	10:35	78 Diana	12.0	1.4	3.7	sBC–cSK	
Sep 11	08:54	42 Isis	11.8	1.4	4.0	sBC–cSK	
Sep 13	08:01	1448 Lindbladia	9.3	7.2	7.8	seBC–wAB	
Sep 19	07:50	435 Ella	11.5	3.5	1.8	sSK–cMB	
Sep 22	08:40	120 Lachesis	11.5	1.3	13.4	sON	
Sep 24	04:21	132 Aethra	11.0	2.4	14.1	eNS–swON	*
Sep 24	07:35	551 Ortrud	12.0	2.2	55.1	NB-wNL	*
Oct 01	10:10	1724 Vladimir	10.0	6.0	3.5	nBC–sSK	
Oct 03	00:51	25 Phocaea	8.8	1.6	6.3	eON	
Oct 04	07:45	74 Galatea	10.1	2.2	48.4	eQC–wNL	
Oct 06	12:38	144 Vibilia	11.6	1.2	8.9	sBC	
Oct 07	02:21	341 California	7.1	6.1	1.8	nON	
Oct 07	02:29	1605 Milankovitch	10.1	4.4	2.8	eNL	
Oct 07	05:47	119 Althaea	11.3	1.1	9.6	cON	
Oct 09	01:09	200 Dynamene	11.3	1.3	37.9	swON	
Oct 11	09:33	46 Hestia	11.7	0.6	21.9	nON–seMB	
Oct 15	04:40	208 Lacrimosa	11.9	2.5	4.5	seSK–swMB	
Oct 18	04:52	1116 Catriona	9.8	5.0	5.2	SK only	
Oct 18	06:20	755 Quintilla	7.6	7.4	2.5	NL–cQC–cON	*
Oct 18	06:20	755 Quintilla	8.8	6.2	2.5	NL–cQC–cON	*
Oct 22	09:56	88 Thisbe	12.6	1.0	10.3	sBC–cON	
Oct 27	01:52	1187 Afra	10.1	3.6	4.6	NL–QC–ON	
Oct 28	08:37	275 Sapientia	12.4	1.4	12.0	swNS	
Oct 29	12:06	101 Helena	12.3	1.3	6.1	sBC–wcSK	
Oct 30	03:28	4162 SAF	4.9	12.1	1.5	nBC–nON	*

*Notes:

Aug 20 Schurer: The target star's magnitude of 5.6 means that this is a binocular occultation. The star is the southern component of the _ Arietis pair. Note the very short maximum duration; don't blink!

Sep 24 Aethra and Ortrud: These paths will intersect in N.B. and P.E.I., so observers there could observe both events, just over three hours apart, from the same locations. Note the outrageously long maximum duration for the Ortrud event. It will present a test of observers' alertness and/or battery longevity. Use AC power if possible.

Oct 18 Quintilla: The asteroid will occult both components of the double star, HIP 4716. Pick one and let me know your choice, please.

Oct 30 SAF: A binocular occultation. The star is 70 Aquilae (mag 4.9).

Dr. Ray Jayawardhana

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

"So, what *is* a planet?" students regularly ask during my astronomy presentations. Are they small and rocky, like Earth? Well, sometimes. How about large and gaseous, like Jupiter? Can be. What, then? During the interview for this issue's column, I knew I would ask the same kinds of questions of Dr. Ray Jayawardhana.

Dr. Jayawardhana is interested in how stars and brown dwarfs form and in the origins and diversity of planetary systems. This includes, of course, extrasolar planets. The problem is that many newly discovered solar systems are at great distances and, therefore, difficult to study. Fortuitously, a newly recognized star cluster, the TW Hydrae association, is only a couple of hundred light years from Earth. (This group was not identified earlier because, in part, it is so close, covering a large area of sky. Deducing physical connections among its member stars was, therefore, initially difficult). One denizen of the cluster, 2MASS WJ1207334-393254 (or 2M1207 for short), recently caused a stir when it was found to be a brown dwarf apparently orbited by an extrasolar planet. A direct image was made of the object, a first for extrasolar planetary astronomy.

Well, a first *if* it is a planet. Dr. Jayawardhana is not so sure, suggesting 2M1207 may be a *pair* of brown dwarfs. Measuring such properties as the mass, size, and temperature of the two will help pin down their exact nature and to this end he and his colleagues **are** conducting spectroscopic observations to learn more.

If planets do form around brown dwarfs, Dr. Jayawardhana wants to know what the process is. The TW Hydrae association provides a perfect laboratory for finding out because not only is it nearby, it is also youthful, with an estimated age of about ten million years. This age falls in a previously unobserved gap in the stellar aging process. In fact, other nearby stellar associations similar to TW Hydrae, but of slightly different ages, have also been found. By examining the newly forming member stars and brown dwarfs of each, we essentially see a series of snapshots of star formation and learn how the process works in its early stages.

But do brown dwarfs, and their possible planets, form precisely as "normal" solar systems do? After all, Dr. Jayawardhana explains, brown-dwarf accretion disks are rather small scale, falling somewhere between Saturn's rings and stellar disks in mass. They may be something like "the disk that Jupiter must have had, out of which its moons formed." Dr. Jayawardhana has studied dozens of brown dwarfs and has taken a leading role in determining that they are, in fact, born with disks the way stars are. But the disks may be too small to produce planets. So what we have with 2M1207 may be two brown dwarfs forming side by side, one of which, at eight Jupiter masses, is one of the smallest ever detected. It presumably did *not* form from its partner's disk. So, if we call this small object a *planet,* it would not have formed the way planets in our Solar System did.

Dr. Ray Jayawardhana

Fine, fine. But *is* 2M1207 a planet? Some astronomers draw a dividing line between planets and brown dwarfs at 13 Jupiter masses, because, as Dr. Jayawardhana explained, more-massive objects can fuse deuterium early in their life while lower-mass objects cannot. Some say that to be a planet the object must orbit a star and have formed from the star's leftover material.

"Personally, I don't get too worked up about what we call it," Dr. Jayawardhana says. "New discoveries defy our preconceptions and historical definition of 'planets'.... There is just a greater diversity in nature than we had imagined."

However these objects are defined, Dr. Jayawardhana is looking for more, not only around brown dwarfs, but floating free, unassociated with any primary. He wonders how small they can be and how they formed. Hunting such tiny quarry is not as quixotic as it may appear since one will not have to contend with glare from a nearby companion star or brown dwarf. That will make it easier to detect extremely low-mass objects. The challenge will come in formulating a theory that explains not only the origin of Sun-like stars but these much punier cousins as well.

Earth-size planets accompanying brown dwarfs may be a possibility (although they will not likely be Earth-*like* due to the low temperature). These will be difficult to detect unless they transit their primary, causing detectable drops in light. Going after the smallest and faintest requires high-end equipment so Dr. Jayawardhana uses such instruments as the Keck, VLT, and Subaru optical-infrared telescopes. To measure dust grains around brown dwarfs, and see how they may combine to form planets, he uses the James Clerk Maxwell radio telescope and the *Spitzer Space Telescope*. In other words, this kind of research calls for the biggest telescopes and the best instruments. "Almost every new idea I have needs the biggest telescopes." In fact Dr. Jayawardhana is always thinking what can be done with the *next* generation of instruments and how his work can influence their design. "Pushing frontiers is fun!" he admits.

Born and raised in Sri Lanka, some of Dr. Jayawardhana's earliest memories are of space, if not specifically astronomy. He was four years old when told by his father that people had been to the Moon. He immediately felt a "sense of adventure" and decided, "We can do anything!" He read a variety of increasingly advanced space and astronomy books (which also helped improve his English-language skills) and joined amateur astronomy groups. The appearance of Comet Halley in 1986 prompted the formation of one such group in Colombo, which, of course, Dr. Jayawardhana joined. He was able to observe the comet from the southern tip of the island.

With wide interests in such fields as physics, astronomy, and anthropology, Dr. Jayawardhana decided to attend university in the United States. At this point, it wasn't a matter of necessarily becoming an astronomer; it was just that the liberal-arts courses were appealing. In fact, he might have become a writer instead having, for example, written for *The Economist* in London early in his career. It turns out that both goals were fulfilled since he is not only a professional astronomer but writes books and articles on the subject and is a contributing editor for *Astronomy* magazine.

Initially, he was aiming to become an observational cosmologist and study the large-scale structure of the Universe. However, while in graduate school he got interested in exploring star and planet formation with new infrared instruments. He eventually did his thesis work on how protoplanetary disks change and evolve. On his first thesis observing run, he found a disk with a large cavity around a young star, a hint that planets might be forming there. He went on to ask questions such as "How does this process work?" as well as "How long does it take?" and "What fraction of stars form singly or as multiples?"

Eventually, Dr. Jayawardhana may find answers to his questions and help us understand the origins of objects in deep space. More importantly, perhaps, will be the relevance of his work to understanding where our own planetary system, and ultimately we, came from.

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 and a member of the new Mississauga Centre of the RASC.

Two views of the March 29, 2006 Solar Eclipse & A Comet to Remember

Randy Attwood, Mississauga Centre, captured this image of the March 29 total solar eclipse from his observing site in Side on the Mediterranean coast of Turkey. Photo taken with a Canon Rebel, 100 ASA, at 1/500 sec through an Astrophysics 5-inch refractor.

Alson Wong of the Vancouver Centre constructed this composite image of the March 29 total solar eclipse from 31 separate photographs spanning 1/2000 to 1 second. From his location at Saloum, Egypt, Alson used a Borg 77-mm f/6.5 ED refractor and a Nikon D70 on a Kenko Sky Memo mount. More details can be found on his Web page at `http://webpages.charter.net/alsonwongweb/solar.htm`.

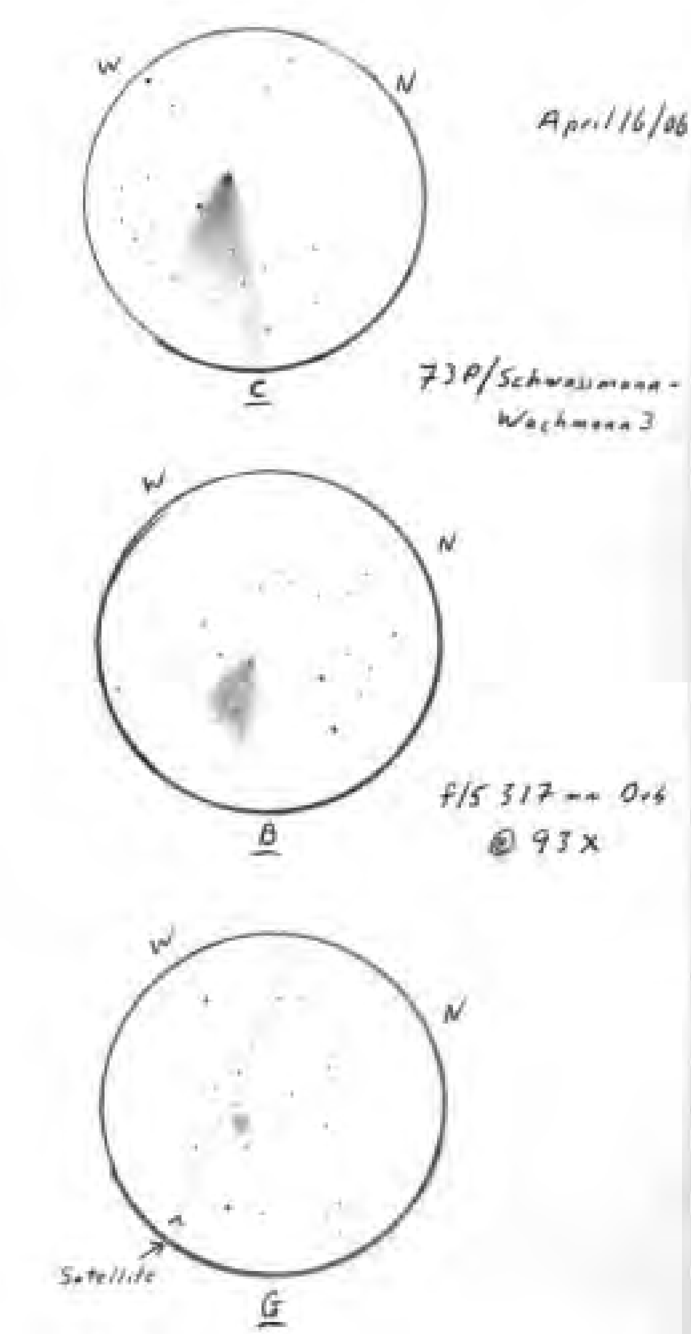


Figure 1

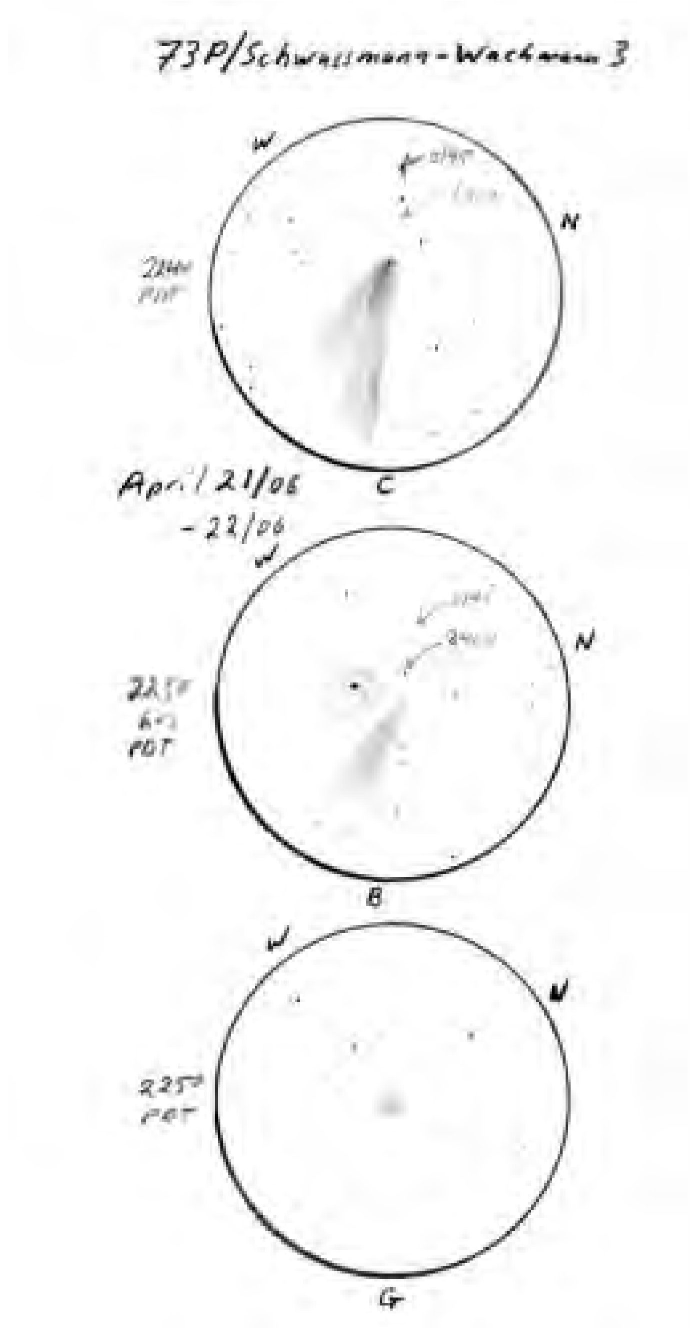


Figure 2

Figure 1 – Components C, B, and G of Comet 73P/Schwassmann-Wachmann 3 as sketched by Victoria Centre's Bill Weir on April 16. Bill notes: "C was the largest and brightest sporting an easily seen tail, an elongated coma, and a very bright condensation at its head. B had a tail showing but its overall brightness had faded from when I had observed it about a week earlier. The coma was less bright and the head no longer had a bright condensation. G was little more than a small faint squarish haze with no tail or central condensation noted. The line represents a satellite that passed through the FOV. I just found it interesting seeing two interlopers to the FOV, one fast, and one slow." Bill used a 31.7-cm f/5 truss-tube Dobsonian telescope at 98x to observe the comets.

Figure 2 – Components C, B, and G as seen on April 21. Bill's comment: "I did this sketch to show how much the comets move against the background stars over a period of time. I only did it for the two brighter components. The arrows mark where the head of the comets had advanced over approximately 1.5 hours each time."

Transit Twins and Trios

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

That sly Cellenius introduced a fog to cover the Earth and then appeared sooner and smaller than expected so that he could pass by either undetected or unrecognized. But accustomed to the tricks he played even in his infancy, Apollo favored us and arranged it so that, though he could escape notice in his approach, he could not depart entirely undetected. It was permitted me to restrain a bit his winged sandals even as they fled.... So, to speak briefly, I am more fortunate than so many of those Hermes-watchers who looked for the transit in vain, and I saw him where no one else has seen him so far, as it were, "in Phoebus' throne, glittering with brilliant emeralds."

— Pierre Gassendi

A rock by any other name...

With a variety of pseudonyms — Cellenius, Apollo, Hermes — Gassendi refers repeatedly to elusive Mercury, finally but unmistakably captured within the disc of the Sun. Gassendi was the only successful observer of the Transit of Mercury on 1631 November 7, the first such observation in history. It was a spectacular validation of the planetary theory of the recently deceased Johannes Kepler, the Maestro of the Spheres, who had predicted the transit in a small tract issued just two years previously.

As seemingly befits such events, Gassendi made his observation through intermittent clouds, and was nearly fooled by Mercury's unexpectedly small size. "But when the sun shone again, I discovered further movement, and only then did I conclude that Mercury had come in on his splendid wings." (Gingerich, 1992)

To my surprise, in recent years the Winged Runner (not to be confused with the Ringed Wonder) has become one of my favourite planets. I guess I find it easy to relate to an orbital eccentric. That this innermost rock transits the Sun occasionally is but one of its charms.

Transits of Mercury are both less rare and less spectacular than those involving Venus. While few would chase one to the ends of the earth, with 13 to 14 transits per century, the patient astronomer can expect to see one at the home observatory eventually.

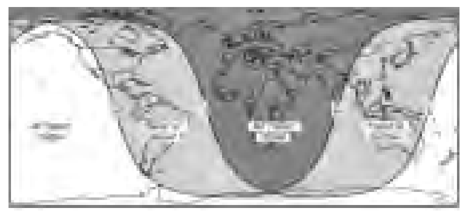


Figure 1: Global visibility of the 2006 Transit of Mercury reproduced from the *Observer's Handbook 2006*. (Espenak, NASA/GSFC, 2005) Virtually all of Canada is favoured to observe the opening stages of the transit in the hours before sunset.

Such is the case for Canadian astronomers this upcoming November 8. The entire country except the Far North will be positioned to see the beginning of the transit, with those on the west coast favoured to see the entire event. (See Figure 1)

If this seems vaguely familiar, a very similar scenario unfolded seven years less seven days previously on November 15, 1999, when Mercury made a grazing transit that was visible across most of North America. Theoretically visible, that is. I spent the afternoon with fellow RASC volunteers at the Observatory, telescopes at the ready, only to be completely foiled by an apparently sunless slate-gray sky. Nothing intermittent about *those* clouds.

Alas, lousy November weather can be expected not only for the upcoming transit, but for about two-thirds of all crossings of that sly Cellenius. Like transits of Venus, there are two windows of opportunity — the nodes on opposite sides of Mercury's orbit where its path crosses the ecliptic. Unlike Venus, the nodes are not created essentially equal. Roughly twice as many transits occur at the ascending node than the descending: an inferior conjunction of Mercury during the November 6-15 window will result in a transit, while at the opposing node, the window is much narrower, currently May 6-11.

Why the difference? Disciples of *Orbital Oddities* — and I know you're out there somewhere? – will anticipate the answer. While Venus has a near-circular orbit, that of Mercury is highly eccentric (e = 0.206). At present the perihelion of Mercury is only 29° from the ascending node, 151° from the descending. (Meeus, 2004) Therefore Mercury is much closer to the Sun during inferior conjunctions in November. Those in May occur further from the Sun and relatively closer to Earth, which increases the effect of Mercury's inclination. The slope of Mercury's apparent path across the ecliptic appears roughly twice as great in May as in November.

The interval of seven years is a case in point. The ratio between the periods of Mercury and Earth is close enough to 29:7 that Mercury's behaviour in Earth's sky is similar after such an interval. In the November window, the vertical shift with respect to the nodes is about 1400″ (arcseconds), whereas the Sun's diameter is about 1940″. It is therefore possible for two (but no more) consecutive transits to occur at this interval—a transit pair, similar to those of Venus.

At the descending node, the situation is different. Due to Mercury's relative proximity to Earth, after seven years the equivalent vertical shift is >2700″, much greater than the Sun's diameter (which in early May appears slightly smaller at ~1900″). This means that not only are two consecutive transits impossible, there won't necessarily be one in either window, resulting in long gaps between May transits. The differing patterns at the two nodes form a fascinating interweaving tapestry that we will examine next time.

With respect to the more plentiful November transits, northern hemisphere observers face more than unfavourable weather, with the Sun low in the sky and the days short. It would therefore seem to beat the odds that those of us in western North America could be well-positioned to see both members of a seven-year pair. But this is almost inevitable.

In his seminal pamphlet *Transits* (1989), RASC Honorary Member Jean Meeus lists the geocentric phases of all Mercury transits 1600-2300 in Dynamical Time. Here are the mid-times of twinned transits around the present day:

1907 Nov 14 **12h06m51s**	1914 Nov 7 **12h03m23s**
1953 Nov 14 **16h54m17s**	1960 Nov 7 **16h53m27s**
1986 Nov 13 **04h07m57s**	1993 Nov 6 **03h57m31s**
1999 Nov 15 **21h41m57s**	2006 Nov 8 **21h42m09s**
2032 Nov 13 **08h55m22s**	2039 Nov 7 **08h48m04s**
2078 Nov 14 **13h43m36s**	2085 Nov 7 **13h37m22s**

Of the 17 pairs listed on Meeus' table, the maximum time difference is under 14 minutes. The period can be placed at 2550.00 ± .01 days, almost precisely 7 years less 7 days (assuming two leap days). The 1999-2006 pair is exceptionally close at only 12 seconds difference, and in fact it is the only pair where the second event occurs (slightly) later than the first. However, it is not even the record holder — the pair of November 11, 1736 and November 5, 1743 both had mid-transit at precisely 10h30m02s!

Transit twins are not identical. The mid-times do not tell us about their character, which occur on opposite hemispheres of the Sun at different separations from its equator. The event of 1999, for example, was a near-grazing transit with a total duration of under an hour. That of 2006, intermediate between equator and pole, lasts a leisurely five hours, effectively extending the visibility zone that can see part of the transit, but actually reducing the area that can see the entire event. In Edmonton we are still well-placed for mid-event in 2006, but this time will not see last contact. Conversely, observers in Halifax, shut out in 1999, will at least be able to see the early stages of this event.

Folks in central Canada will have had the rare opportunity to view *three* transits in that same seven-year period! Occasionally a November pair brackets a lonely May transit, such as that of May 7, 2003. For that event, last contact was visible in the eastern half of North America (meaning another frustrating near-miss for me!). A theoretical observer in Toronto (yes, that's a joke) would have had first and last contacts respectively of the 1999 and 2003 transits occur just five degrees above the horizon. Because of its greater duration, first contact in 2006 will occur with the Sun a more comfortable 22° up (Espenak 2004).

Such trios are a dying breed. At present they are barely possible; a panorama of trios in the years 1000-3000 reveals that they only recur after the very accurate periods of 46 and 217 years:

1085, 1089, 1092	1131, 1135, 1138
1302, 1306, 1309	1348, 1352, 1355
1519, 1523, 1526	1565, 1569, 1572
1736, 1740, 1743	1782, 1786, 1789
1953, 1957, 1960	1999, 2003, 2006
2170, 2174, 2177	
2387, 2391, 2394	
2604, 2608, 2611	

The distribution of transit trios by millennium confirms that they have been petering out for some time:

-2000 to -1001	25
-1000 to -1	21
0 to 999	17
1000 to 1998	9
1999 to 2999	4

...after which there will be no further trios for over 15,000 years (Vitagliano, 2006).

What is the cause of this change? The May transit occurs halfway around Mercury's orbit from the November pair, and those two halves are not created equal. As mentioned above, the ascending node is 29° from Mercury's perihelion, and in accordance to Kepler's Laws the Winged Runner moves faster through that node-to-node part of its orbit containing its perihelion. Furthermore, those points are slowly diverging, increasing this inequality. While the first and last events at the same node are consistently 2550.0 days apart, that at the other node is "early" by about a week. For example, the transit of May 7, 2003 occurs just 1268.4 days after the 1999 event, but 1281.6 days before that of 2006.

Because of this asymmetry, trios are currently possible only if at least one of the events is close to a graze, as occurred in 1999. As the last series of triples peters out, the May events become increasingly marginal: 924″from the solar equator in 2174; 944″ in 2391; and 961″ in the *partial* transit of 2608. After that, transit trios become impossible for many millennia, even in Toronto.

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Bruce McCurdy has a long-standing fascination with dynamic events within our solar system. Having been skunked in his only opportunity to date, he welcomes correspondence from readers who have previously observed one or more transits of Mercury.

Net Astronomy

by Paul J. Langan (Paul@Langan.ca)

Our Solar System Explained

Figure 1– Courtesy NASA.

What gets most people interested in Astronomy? The answer is probably "seeing the Moon and planets through a telescope" — and once they've had that first glimpse of the rings or a string of Jovian moons, they'll probably want more. That's where the *Nine Planets Solar System Tour* hits its stride. The site is loaded with Solar System data — high-resolution JPEG images of the planets and their satellites, planetary data, articles on how orbits are calculated, a full description of the missions that brought the glory of the Solar System back to Earth, and for history buffs, a discussion of the historical role of planets. The site has sound clips and interesting movies for those who like to absorb information by eye and ear. Though it's a bit dated in this era of weekly Cassini images, the site is one of the most comprehensive sources of planetary information that I have ever seen on the Internet. This site can be utilized as an astronomy search engine for anything Solar System related. Author Bill Arnett even has a matching site for the younger set — *The Nine Planets, Just for Kids.*

`www.nineplanets.org and kids.nineplanets.org`

Simulations, Simulations, Simulations

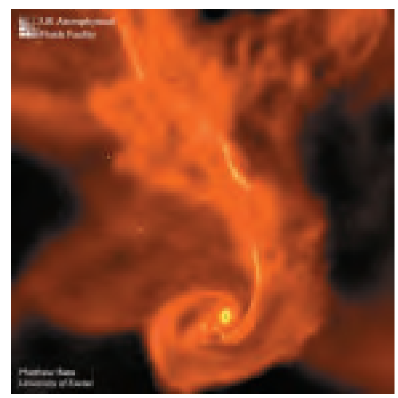

Figure 2 – Courtesy Matthew Bate, University of Exeter.

For all of us who wish that we could see a star cluster form, planetary discs interacting, or merging neutron stars, then the UK Astrophysics Fluids Facility is the go-to destination. This site, managed by the University of Leicester, is a fountain of super-computer simulations that will take your interest in astronomy to a whole new level. The movies are offered in several formats: AVI, QuickTime, and occasionally MPEG. While the simulations take a while to load due to their size (more than 200 Mb in some cases), the wait is very worthwhile. The titles themselves will tempt the wary: "Jets and cooling flows in galaxy clusters," "Formation of a star cluster," or the ever-exciting "Accretion disc in a binary-star system." While the written word may appeal to many of us, the drama of a movie presentation cannot be denied. Some of the links are missing, but there is still enough material here to impress.

`www.ukaff.ac.uk/movies.shtml`

Astronomical Oddities

Black holes are cropping up everywhere. Once restricted to theoretical ramblings, they now seem to be an essential part of every galaxy, ubiquitous through the Universe. Ever since theory brought them into existence, they have been of great interest to amateur and professional astronomers alike. Now we have a great site for people to learn about black holes — "Jillian's Guide to Black Holes." Jillian is a fourth-year astrophysics student with a penchant for black holes, gravity waves, and dragons (and not a bad artist either). She has assembled an award-winning site that gives viewers a detailed (and text-intensive) look at black holes in a personal and engaging style. It's not technically and scientifically profound, but the site contains an enormous amount of detail about black holes — you'll discover answers to questions you never thought to ask. The information on this site is well-presented and is supported by both impressive images and links to the "Science" supporting the contents. This site is definitely worth a stop for anyone interested in Black Holes, and especially those confused by the more technical sites available on the subject.

`www.gothosenterprises.com/black_holes`

Paul Langan is President and CEO of a multinational company and a Fellow of the Royal Commonwealth Society, but his heart is more directed to the stars. If you have recommendations for future site visits, please email him at the address above.

Across the RASC
du nouveau dans les Centres

International Astronomy Day 2006 at the RASC-Kingston Centre

by Hank Bartlett & Kim Hay, Kingston Centre (kimhay@kingston.net)

The Kingston Centre celebrated International Astronomy Day at the Isabel Turner Library with visual displays and solar observing during the daytime and a talk and observing session at the Little Cataraqui Creek Conservation Area in the evening.

With poor weather in the preceding days, it was a great relief that Friday's forecast for Saturday called for variable cloudiness and a 10° C temperature. But when I awoke on Saturday morning, it was POURING. Was I surprised? Nope! But there was still hope — six hours to go until the set-up.

When I arrived at noon, volunteers were already assembling displays inside and scopes outside, though under an improving but less-than-favourable sky. Our space at the Turner Library was just right for the display we own and the location at the entrance was very good for traffic. I was told we had about 40 to 50 people per hour through the room with interest coming from every age group and every walk of life. We had a table full of hand-outs and magazines, PowerPoint displays, astronomical cards for sale, solar imagery and displays, meteorites, and more. Volunteers were ample we are pleased to say; it was great to see so many turn out to help. To capture the attention of the younger set, Kim Hay suggested that in the future we develop a "Kid Kit" — something to interest and inspire the sub-teen group.

The day crew consisted of Kevin Kell, Diane Torney, Susan Gagnon, Leo Enright, Graeme Lees and his daughter Brenda, Paula Smith, Steve Hart, Kim Hay, and Astronomy Day Chair

Figure 1 – Members of the Kingston RASC share a view of the Sun with a junior sky-watcher on Astronomy Day. Photo by Kevin Kell.

Hank Bartlett. Terry Bridges made a special appearance bringing the Queen's University Coronado Solarmax 70 Hydrogen-alpha telescope.

In the evening the crew (minus a couple of members but joined by Norm Welbanks) set up at the Little Cataraqui Conservation Area. Centre members out-numbered the public, probably because of the Park fees, or the weather, or both. Hoping for late arrivals, we started the evening presentation late. Our opening talk, "A History of Astronomy," was followed by "The

Sky Tonight," leaving 40 minutes for observing — ample time, given the size of the crowd. Clouds were moving out, giving us views of the waxing gibbous Moon (64% illuminated), Jupiter, Saturn, and some Messier objects, in spite of the city lights brightening the sky to the south.

As we loaded our vehicles at 10 p.m., listening to the sounds of the night, we were treated to a view of the International Space Station passing silently overhead.

Overall we were very pleased with the volunteer participation, especially our newest helpers. The day displays and observing were very well received, though in retrospect, the move to the Park for evening viewing should be re-assessed in view of the small crowd. Perhaps in future we should hold the night observing at the Queen's University Observing Deck. Although plagued with light-polluted skies, it has full facilities, is more accessible, and allows us to start earlier and stay later. Nevertheless, in spite of the inclement weather this year, we are looking forward to the next Astronomy Day.

Kim Hay is President of the Kingston Centre and an enthusiastic proponent of public education and outreach. Hank Bartlett, also a member of the Centre, is engaged in the latter stages of his quest for a Messier Certificate when he's not building garden-scale solar systems.

Education and Outreach is Worth the Effort!

by Mary Lou Whitehorne, Halifax Centre (mlwhitehorne@hfx.eastlink.ca), Don Kelly, Moncton Centre (donald.kelly@rogers.com)

Why should we do education and outreach? There are lots of good reasons. We'll paraphrase Dr. John Percy[1] and name just a few:

- Astronomy is embedded in almost every culture around the world.
- Astronomy has practical applications like time-keeping and navigation.
- Astronomy roots us in time and space.
- Astronomy sparks a sense of curiosity, imagination, exploration, and discovery.
- Astronomy is interdisciplinary and crosses the entire school curriculum.
- Astronomy enhances awareness, understanding, and appreciation for science and technology.
- Astronomy promotes rational thinking and an understanding of how the science process works.

It all boils down to improving the overall scientific literacy of the population - something that is becoming more and more important if citizens are to be able to make informed decisions in today's increasingly complex world.

The Education Committee conducted an informal educational needs survey over the past year. As well as some of our active educator-members, the survey polled 37 teachers. Most of the teachers were astronomy workshop participants, and therefore interested enough in the subject to attend a workshop. Eighteen teach in the grades 5-8 range, 17 teach in the grades 9-12 range, and 2 teach at the post-secondary level. The survey produced two main findings:

1. **Almost all teachers (89 per cent or 33/37) want lesson plans for hands-on activities they can use in the classroom.** This is exactly what *Skyways* offers. Most teachers (32/37) said prepared classroom activity kits-in-a-box would be of use to them. After the kits, print and video resources (24/37) were cited as being most useful, with Web resources (22/37) next, and software resources (13/37) being of the least interest. Fourteen per cent (5/37) said they needed materials in French. *Skyways* is also available in French under the title *Explorons l'astronomie, Guide pédegogique.*

2. **Fifty-seven per cent (21/37) of respondents want professional-development opportunities such as workshops.** Regarding expertise and comfort level with astronomy, most teacher respondents were universally cautious. A large majority of them acknowledged some knowledge and comfort. Five per cent (2/37) bravely admitted little or no knowledge and comfort with the topic, while fifteen per cent (5/37) felt very knowledgeable and comfortable with astronomy. The rest (30/37) have some knowledge and are comfortable with the subject.

Regardless of the teacher's grade level, teachers want or need information to help them teach their astronomy units. They look to guest speakers, in-service sessions, and other resources such as *Skyways, Starry Night Middle School, Starry Night High School,* RASC Education site, Web sites, software, print materials, and CD/video programs. Such resources heighten

[1] Percy, J.R. 2002, "Outreach: Why You Should Do It, and How To Succeed," JRASC, 96, 196.

their students' opportunities to engage in high-quality hands-on astronomy activities and enable the teacher to present demonstrations that motivate and inspire their students.

Our results correlate closely with a similar survey recently conducted by the Canadian Astronomical Society. CASCA[2] found that the most teacher-requested resources were, in decreasing order:

1. Curriculum-linked student activities (lesson plans)
2. Audio-visual materials
3. Online resources
4. Guest speakers
5. Teacher workshops

CASCA also found that Ontario's science consultants and coordinators wanted the following resources, in decreasing order:

1. Curriculum-linked professional development workshops
2. Curriculum-linked online resources
3. Video resources
4. School visits by astronomers

Both the RASC and CASCA surveys show that the majority of teachers want activities and demonstrations closely connected to science curriculum requirements. With reference to programs offered by guest speakers, the RASC survey indicates that the importance of matching the curriculum diminishes. Half of the respondents want the connection with grade-level outcomes; it doesn't matter to the other half. It seems that student experience is the main concern and learning outcomes can be developed outside the guest speaker's visit. One of these experiences mentioned by most teachers is an observing session for their students, preferably conducted during the evening as opposed to a daytime observing session.

Topics requested by middle-school teachers, from the most to least number of requests are:

1. The Milky Way
2. The Solar System
3. Moon phases
4. Eclipses
5. Tides
6. Constellations
7. Stars
8. Seasons
9. Galaxies
10. Day/night
11. The Universe/Cosmology

Topics requested by high-school teachers, from the most to least number of requests are:

1. Galaxies
2. Stars
3. The Universe/Cosmology
4. The Solar System
5. The Milky Way
6. Moon phases, eclipses, and tides

The survey revealed that RASC members rely heavily on slide or PowerPoint presentations. Overall, teachers, youth leaders, and students were seeking RASC members' expertise in conducting observing sessions as well as providing and using an astronomical telescope.

RASC members surveyed indicated an even split as to how they were contacted to be a guest speaker. The teacher or youth leader approached half of them. The other half initiated the visitation themselves, often as a result of having their own children in the school or youth group. Our astronomer members were also split on day- versus night-observing sessions. Approximately one-half of the respondents used hands-on activities or demonstrations with students or youth groups.

There seems to be little awareness of the resources available in *Skyways* by those who completed the survey forms. The RASC needs to do a better job of:

1. Familiarizing our members with *Skyways* and what it offers members and teachers
2. Promoting *Skyways* as a primary resource for outreach programs both in the classroom with students and in teacher workshops
3. Encouraging Centres and members to show and sell *Skyways* to teachers and youth-group leaders with whom they work.

There is a clear need for more astronomy outreach in Canada's schools. There is support for outreach and education programs within our membership. The RASC could be doing more outreach and educational programming than it presently does. In the recent membership survey[3] conducted by our own Membership and Promotion Committee (MAP), education and outreach was frequently mentioned in the comments section as something of which we should be doing more. In fact, in order to keep our national charitable status (and all of its concomitant savings and benefits to the Society) we must maintain a substantial amount of community involvement.

We now have a good idea of the needs of teachers when it comes to the astronomy in their curricula. We also have the resources to address those needs. We have a countrywide

[2] Percy, J.R. 2005 personal communication with M.L. Whitehorne

[3] Grey, Denis and Hrycak, John, 2004 Membership Survey results parts 5a and 5b, `www.rasc.ca/private/reports/survey2004/`

network of knowledgeable people. We have a curriculum-linked teaching resource full of lesson plans for student activities. It is available in both official languages. It can be used as a basis for presentations and activities in the classroom and with youth groups. It can be used to develop curriculum-linked professional development workshops for teachers. It takes time and effort to prepare effective presentations and workshops, but much of the work has already been done. Why not use it? What better way to invest in Canada's future than to contribute to the scientific literacy of the next generation?

Mary Lou Whitehorne is an astronomy educator, a "lifer" in the society, an occasional contributor to JRASC, chair of the Society's education committee, and author of Skyways. *These days, when she's not doing RASC volunteer work, she develops and writes curricula for the North American market through Starry Night.*

Don Kelly is a retired science teacher, outdoor-education coordinator, and science consultant. He is a founding member of the William Brydone Jack Astronomy Club located in the Planetary and Space Science Centre, University of New Brunswick, Fredericton Branch, and is a member of the Moncton Centre. He currently writes science curriculum, juvenile novels, and poetry.

2006 Society Awards

by Peter Jedicke, London Centre (PJedicke@fanshawec.ca)

The Chant Medal to Ed Majden

Figure 1 – Image courtesy Ed Madjen

Ed Majden of Courtney, B.C. is well-known for his work in meteor spectroscopy. He acquired his first spectrum in 1955 while a member of the Regina Astronomical Society. In 1972, he started his own program and obtained two spectra within the year, a significant contribution to the limited number of spectra available to professional researchers. In 1997 Ed conducted successful experiments with thin-film holographic gratings, opening the field of meteor spectroscopy to other amateurs. Not content to rest on his laurels, he then adapted intensified video recorders to obtain much fainter spectra. Recognition of his achievements soon followed and the American Meteor Society asked Ed to set up a meteor spectroscopy program in which amateurs could participate.

Besides his work with meteor spectra, Ed also operates a Sandia All-sky Patrol Camera, searching for fireballs from his backyard. When he captures one, he alerts Canada's Meteorite and Impacts Advisory Committee (MIAC), which tracks fireball activity over Canada. Ed has also made a name for himself for two asteroid discoveries (2004MV2 and 2005NX55) with the Spacewatch Fast-Moving Object (FMO) project.

For his valued work and original investigation on meteor spectroscopy, Ed Majden is a worthy recipient of the Chant Medal.

The Plaskett Medal to Dr. Lauren MacArthur

Figure 2 – Dr. James Hesser presents Plaskett Medal to Dr. Lauren MacArthur. "Image courtesy Dr. Lauren MacArthur"

The Awards Committee of the Canadian Astronomical Society recommended, and the CASCA Board of Directors agreed, that Dr. Lauren A. MacArthur receive the 2006 Plaskett Medal for her doctoral dissertation, *Stellar Populations in Spiral Galaxies, broadband versus spectroscopic viewpoints,* which was completed at the University of British Columbia under the supervision of Prof. Stephane Courteau. Dr. MacArthur has recently moved to a postdoctoral position at California Institute of Technology, joining the research group of Prof. Richard Ellis. The Plaskett Medal was presented to Dr. MacArthur at the CASCA meeting in Calgary. A summary of her thesis can be found at

`www.ism.ucalgary.ca/meetings/casca06/english/schedule/plaskett.html`

The Service Award to Kevin Kell, Kingston Centre

Kevin Kell has been a member of the Kingston Centre since 1990, serving in many capacities — as KC librarian (1994-96), KC Webmaster (1996-03), *Regulus* editor (1996-03), and the main force behind all other publications created by the Centre since the mid-90s. Working with the ATM group at the Centre, he participated in the assembly of more than thirty barn-door trackers, a telescope-grinding machine, and several large mirrors.

Kevin is an avid promoter of responsible lighting, and an indefatigable member of planning committees for public events and star parties. One of his key projects has been the introduction of the Observational Astronomy for the Novice program to Kingston, with help from the Prince George Centre.

Figure 3 – Peter Jedicke presents Service Award. Image courtesy Jason Rickerby, Vancouver

Members of other Centres have also benefited from Kevin's enthusiasm and energy. He is a member of RASC's Information Technology Committee and the National Webmaster since 2000. He has opened the history of the RASC to all members by working with others to archive past RASC reports and minutes electronically. This richly deserved Service Award is recognition of Kevin's dedication over the past 15 years and a vote of thanks from the members of the Kingston Centre.

The Service Award to Mark Kaye, Hamilton Centre

The Hamilton Centre nominated Mark Kaye for the Service Award for outstanding service, not only to the Hamilton Centre, but to the Society as a whole. The Hamilton membership has come to know Mark quite well in the decade that he has been a member, in spite of his quiet and unassuming manner. He served on the Board of Directors of the Hamilton Centre every year he was eligible, as the National Representative for many of them, and President for three consecutive years.

Figure 4 – Peter Jedicke presents Service Award. Image courtesy Les Nagy - Hamilton

One of Mark's most visible accomplishments is helping to run the RASCList. As one of the moderators, he does such a superb job that only occasionally does the list get off-topic. He also manages all of the Hamilton Centre's lists, including the Board list, the announcement list, and the general chat list.

Mark is a master of construction and repair. As an example, he took an old 10-inch mirror in an ancient rickety mount and turned it into a fine classic Dobsonian. The scope, built like a tank, is an absolute joy to use. Mark's attention to detail and skill turned an unused liability into one of Hamilton Centre's most useful telescopes. As a consequence of the many talks that he has given to Centres across the country, Mark's cottage, with the telephone pole through the bathroom, has become an icon. Mark Kaye would be an asset to any Centre in the country. There is no doubt that Hamilton Centre, and the Society as a whole, would be a much poorer place without him.

The Service Award to Ted Bronson, Thunder Bay Centre

In Thunder Bay, Ted Bronson's name is synonymous with Astronomy — since the early '70s Ted has been promoting astronomy within the community. When the Thunder Bay Centre of RASC formed in 1988, Ted was one of the founding members and has been a vital part of its operation ever since.

Figure 5 - Peter Jedicke presents the Service Award to Ted Bronson. Image courtesy Jason Rickerby, Vancouver

Ted's interest in astronomy started at an early age. He acquired his first 2.5-inch reflecting telescope in 1962 for the Comet Seki-Lines and fell in love with the science; he still has this reflector in his vast collection of telescopes. While living in Southern Ontario in the 1960s and early 1970s, Ted was busy at the David Dunlap Observatory grinding mirrors and helping the facility. In 1972, Ted found his passion for astronomy could be expanded even further and joined the RASC.

Ted was instrumental in the formation of the Thunder Bay Centre of the RASC in 1988, and every year since has held at least one position on the executive — in 18 years, every executive position available. Ted continually shares his insight, passion, and knowledge of astronomy, making over 200 presentations to the Centre and as many more to the public in schools, clubs, and other public engagements.

From his regular astronomy column in the local newspaper to a long history of television, radio, and newspaper interviews, Ted is truly "Mr. Astronomy" in the region. He has been the cornerstone of the Thunder Bay club, the voice of our members, and our window on the astronomy world. His generosity and the tireless efforts he made to the club and to the community are deeply appreciated and for those qualities, the Society expresses its appreciation.

The Simon Newcomb Award to Warren Finlay, Edmonton Centre

The Simon Newcomb Award is intended to encourage members of the Royal Astronomical Society of Canada to write on the topic of astronomy for the Society or the public, and to recognize the best published works. This year Warren Finlay of the Edmonton Centre, author of *Concise Catalog of Deep-Sky Objects* (published by Springer-

Figure 6 - Image courtesy Dr. Warren Finlay

Verlag in 2003), is acknowledged for his literary abilities. *Concise Catalog of Deep-Sky Objects* contains astrophysical information for 500 galaxies, clusters, and nebulae, and has received favourable reviews in popular magazines such as *Sky and Telescope, the Observatory,* and the *Journal* of the RASC.

Astronomy is not Warren's only writing coup. Since 1987 he has been an engineering professor at the University of Alberta where he was the founding director of the Aerosol Research Laboratory. He published numerous journal articles on the mechanics of inhaled pharmaceutical aerosols and other engineering topics, and was author of *The Mechanics of Inhaled Pharmaceuticals Aerosols: An Introduction (2001).* In 2001 he received the International Society for Aerosols in Medicine Young Investigator's Award, and in 2004, a Killam Professorship. Dr. Finlay is also a regular contributor to this *Journal.*

Peter Jedicke, immediate Past President of the Society, took extensive notes while reflecting on his EVA (Executive Vanishing Act) at the Ottawa GA in May.

Instructions to Authors

The *Journal of the Royal Astronomical Society of Canada* (JRASC) publishes both popular and peer-reviewed articles on astronomy, subjects related to astronomy, and news and announcements of interest to the members of the RASC. The *Journal* is published in both paper and electronic forms and is distributed widely to libraries and institutions around the world, and to the members of the Royal Astronomical Society of Canada (RASC).

The *Journal* is a science-based publication written in English and French with translations into the other language provided for abstracts and other key features. Submitted articles should be written in a relaxed prose style, but conforming to proper English or French grammar and spelling rules as commonly practiced in Canada. Canadian spelling can be found in the *Oxford Dictionary of Canadian English*. Grammatical and other rules can be found in, for example, *Fowler's Modern English Usage, the Canadian Press Stylebook,* or Strunk and White's *The Elements of Style*. Those writing in French may wish to consult *Nouvelle Grammaire française, applications, 2e édition by Grevisse, Goosse and Tasset.* A *Journal* style guide for authors and an annual publication schedule is located at `www.rasc.ca/journal`.

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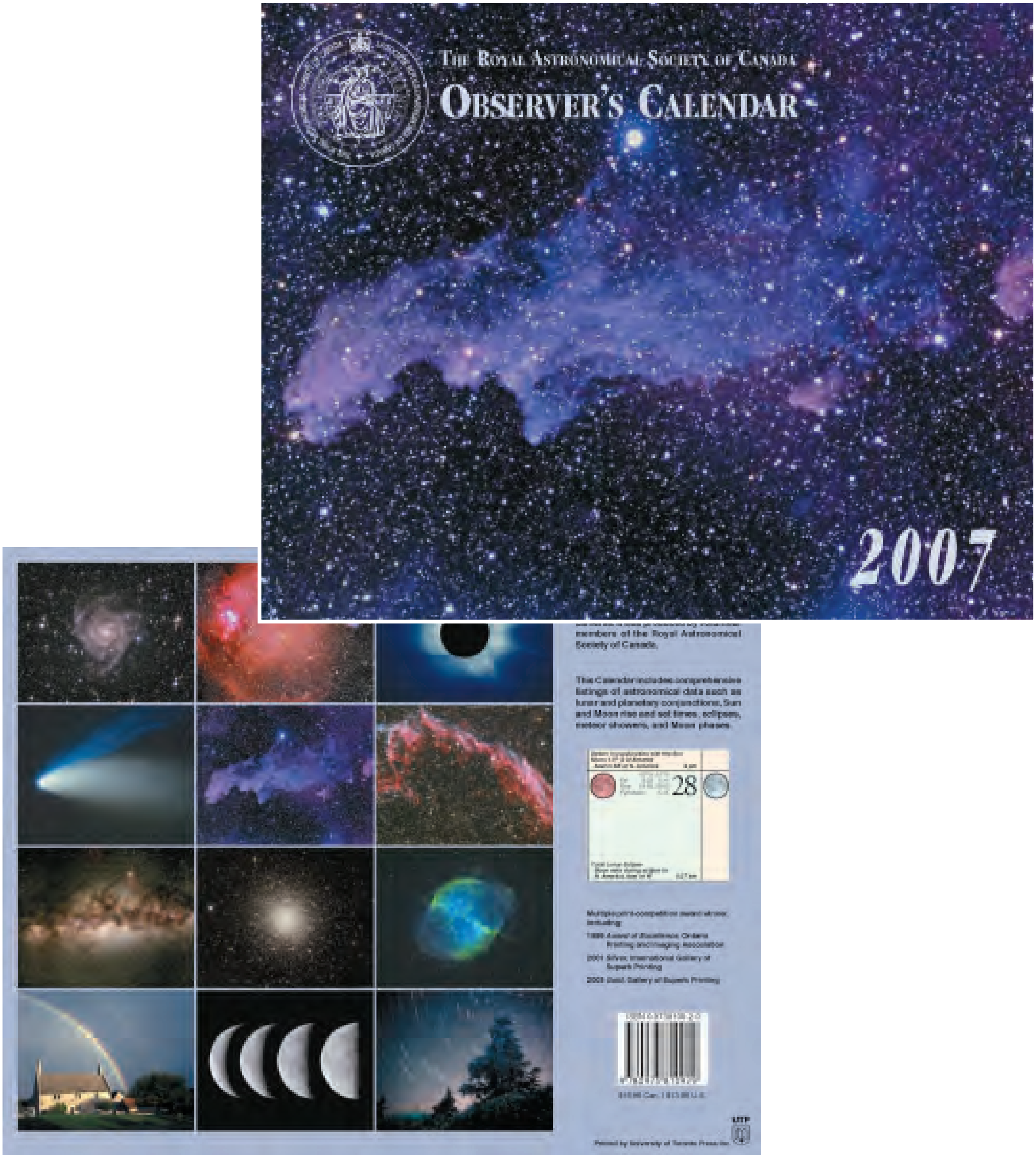

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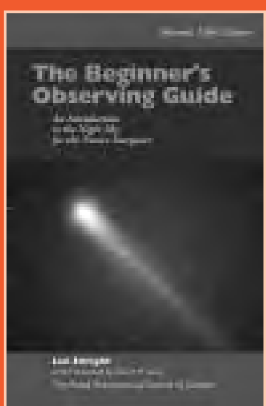

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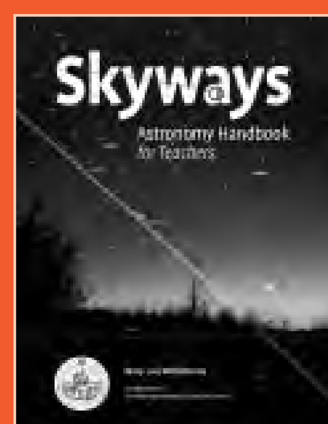

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