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Journal

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Journal

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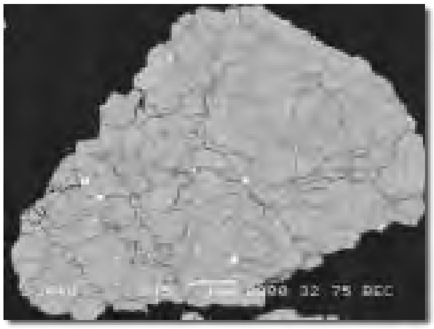
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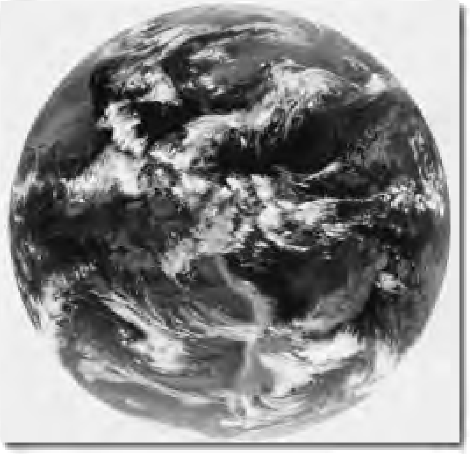
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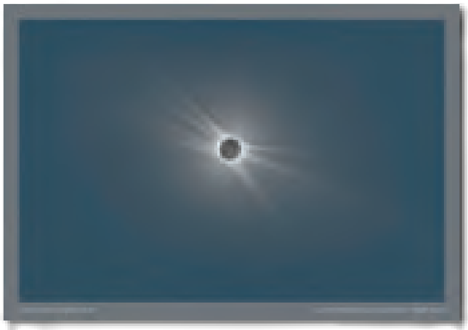
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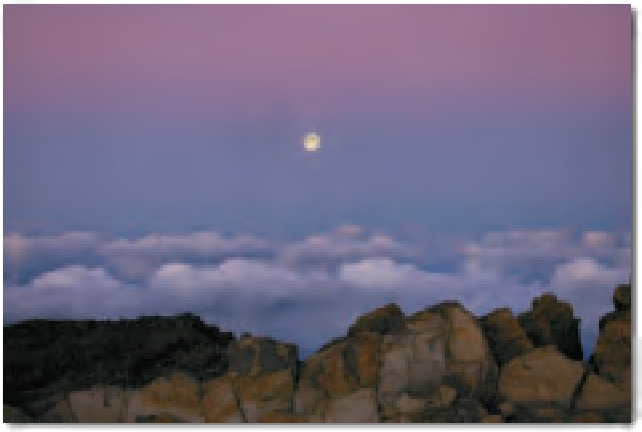
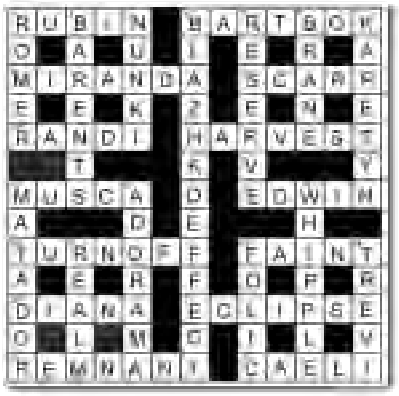


On the Cover:

John McDonald of the Victoria Centre took this photo of the Moon rising over Haleakala in December 2006 from the top of the 10,000-foot caldera on Maui. It is a combination of two exposures, one with a zoom lens at a 45-mm focal length, and the other with a 400-mm telephoto lens. The separate images were scaled and combined in Photoshop.

COLUMNS / RUBRIQUES



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Editorial

The Joys of a Really Big Telescope

by Jay Anderson, Winnipeg Centre (jander@cc.umanitoba.ca)

In April, Ray and I completed our latest telescope project. It all started as a bit of a joke after Ray finished his previous project, an 18-inch Dob. “Hey Ray,” I said, “Now it’s time for a 24-inch.” Well, as it turned out, it was a 25-inch. He found a mirror in New Jersey, and we finished the construction in April, just in time to haul it to Arizona’s mountains in our annual pilgrimage to warmer temperatures and dark skies. It’s perfectly balanced, and can be easily loaded into the back of a van by a single person — provided the single person is named Arnold. It assembles easily and only requires an 8-foot ladder.

I’m a photographer when it comes to deep-sky stuff, mostly because photography shows me things I can’t see, especially with my lousy eyesight. “Faint fuzzies” is a name well-known to all of us. Ever since my first three-inch cardboard Edmund Scientific telescope, deep-sky stuff has been largely a group of faint fuzzies. Except for globulars.

No more.

My photos show M51 as a marvellous spiral structure, with ruby-tinted arms turning mathematically into the embrace of a companion galaxy. Bluish haloes surround the two embracing galaxies, and the neighbourhood is littered with the cast-off stellar spawn of the relationship. But the spiral arms are the captivating feature and the main reason for its Whirlpool nickname.

A big telescope provides a different view of the Whirlpool. The spiral arms lie on a grey bed of background stars, losing much of the distinctiveness that marks their pixel prominence. The features captured by CCD are revealed to my eyes, and more, because now M51 has all of the appearance of a nest of stars holding the delicate spirals in soft feathers. I half-expect some ginormous bird to make an appearance and rearrange the spiral threads into a new form.

M57 glows with its usual distinctive ring, but now the central void is filled with a delicate light, masking the central star by its brightness. Orion has colour, not in the central parts, but in the spreading wings that curl away from the Trapezium. It’s not a brilliant H-alpha red, but a dull-brick shade, barely noticeable, and confined to the sharper edges of the turbulent gas clouds. The Dumbbell is completely gone, replaced by a prolate, spheroid-shaped object that could more aptly be named the “rugby ball.” The dumbbell structure is still present, but masked by the fainter background that springs to view in a really big scope.

Little planetaries begin to show structure at 400×, and while *Hubble*’s colours are absent, the outflows stabbing out to

Journal

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the sides of the central core now become visible. Faint intersecting bubbles of gas speak of gentle stellar puffs. The Veil is no longer a misty ribbon of light, but twisting and intertwined tendrils of smoke that, by their sheer size, hold mute testimony to an explosion much larger than a planetary's puffs. Omega Centauri at 600x envelopes the watcher, filling the field with thousands upon thousands of stars. The planetary NGC 2438, superimposed on M46, feels three-dimensional, an illusion likely related to its apparent size and not to its much closer distance. M13, like Omega, envelopes the viewer, but now the viewer feels as if he or she is looking through the globular, and half expects background galaxies to make an appearance.

Saturn in a 25-inch is almost indescribable. Tiny moons orbit above the rings, using their gentle gravity to coax wayward particles back into line. It's not *Hubble* any more, it's real time. Cassini's Division is a given, and Encke morphs into view and then fades away. Gossamer interior rings put a haze on the planet's clouds. Jupiter overwhelms with details, too much to track and follow, as sub-threshold storms blossom into awareness and then fade away into the background again. Moons exhibit a disk, and there is a hint, or perhaps a hope, of detail. Skies were not the best, and magnification was limited to 650×, but someday we'll crank it up to 1000× and really take a look. There's a whole book of Hickson-group galaxies and another of Abell planetaries to explore and "the worst of NGC" has yet to be written. I wonder if I'll get that tiny 17-inch in the basement finished?

News Notes
En Manchettes

Compiled by Martin Beech (beechm@uregina.ca) and Russ Sampson (sampsonR@easternct.edu)

"HANG-LOOSE BINARY" HAS UNCERTAIN FUTURE

Gemini Observatory, Hilo, Hawaii: Astronomers have serendipitously discovered a record-breaking pair of low-mass stars with an extreme orbital separation (Figure 1). The petite objects, each of which has a mass less than 100 times that of Jupiter, are separated by more than 5000 times the distance between the Sun and Earth — a value that breaks the previous record by a factor of 3 and leaves the duration of their future together highly uncertain.

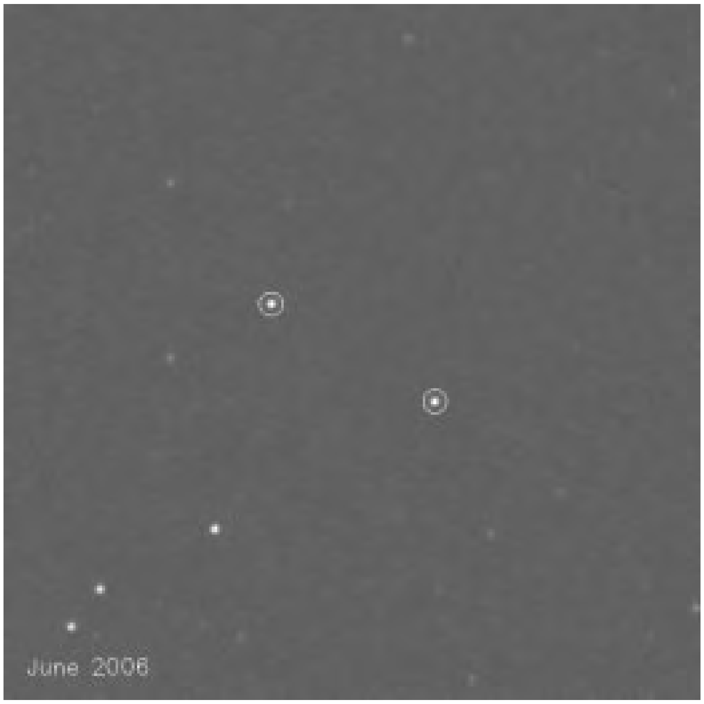

Figure 1 — The nicknamed "Hang-loose Binary" system in the southern constellation of Phoenix, as seen in June 2006. The actual stars (circled) are designated by the catalogue names 2MASS J012655.49-502238.8 and 2MASS J012702.83-502321.1.

The celestial duo is tethered by a weak gravitational link that results in an orbital dance so slow that it takes about 500,000 years to complete a single revolution. Scaled down, this system would be like 2 baseballs orbiting each other about 300 kilometres apart.

The characterization of the system was made using near-infrared spectroscopic data taken with the Gemini South telescope, in conjunction with earlier discovery and confirmation observations made at the Cerro Tololo Inter-American Observatory 1.5-metre telescope operated by the Small and Moderate Aperture Research Telescope System (SMARTS), and archival data from the 2-Micron All-Sky Survey (2MASS) and the Digital Sky Survey (DSS). The result was published in the 2007 April 10 issue of the *Astrophysical Journal Letters* by lead author Étienne Artigau, a Science Fellow at Gemini Observatory, and a team that includes astronomers from the Université de Montréal and the Canada-France-Hawaii Telescope.

The discovery came as a surprise because the only other known binaries that have similar or greater separations are significantly more massive systems. Since mass determines how strongly objects pull on each other, the more massive stars in the known systems have strong gravitational attractions. In contrast, the stars in the newly discovered system have extremely low masses (thus low gravitational attraction). How this occurs is a real mystery.

Equally intriguing is how the discovery came about. "The technique we used to make this discovery was born over a nice dinner and a couple of drinks," said Artigau, who first thought of it when he was a graduate student at the Université de Montréal. "The next morning, the technique didn't seem so crazy after all, and, in fact, it led to this discovery."

To discern the nature of the new binary system, the researchers obtained the infrared "spectral fingerprint" of each member using the Gemini Near Infrared Spectrograph (GNIRS) on Gemini South. The data revealed that both stars are likely red dwarfs (M dwarfs) with temperatures around 2200 °C and a probable age of about a billion years.

Interestingly, the pair is seen juxtaposed against a group of stars called the Tucana-Horologium (T-H) association, which presents the tantalizing possibility that the binary is part of this group. If true, then the stars would be significantly younger than the one-billion-year estimate, and could then be categorized as even less massive brown dwarfs.

"If the new binary system truly belongs to the T-H association, and is not a chance alignment," said team member David Lafrenière of the Université de Montréal, "then the stars are not one-billion-year-old red dwarfs, but are much younger brown dwarfs of the same age as the association. Unlike red dwarfs, these brown dwarfs wouldn't have enough mass to ignite hydrogen into helium at their cores, so they are destined to loosen their weak embrace more quickly, slowly cool, and fade away."

However, if they were not members of the T-H association, these stars would indeed be more massive red dwarfs and could stay in embrace for perhaps a billion years or more. To resolve their nature, observations are being proposed, using the Gemini facilities, to look for lithium in the stars' atmospheres, which will help better to constrain their ages and masses. Until this is determined, the future of this celestial pair remains uncertain.

The Gemini Observatory is an international collaboration with two identical 8-metre telescopes. The Frederick C. Gillett Gemini Telescope is located at Mauna Kea, Hawaii (Gemini North) and the other telescope at Cerro Pachón in central Chile (Gemini South); they provide full coverage of both hemispheres of the sky. Both telescopes incorporate new technologies that allow large, relatively thin mirrors under active control to collect and focus both optical and infrared radiation.

Further details and images can be found at `www.gemini.edu`.

NRC'S BAND 3 RECEIVERS — MOST SENSITIVE YET

The National Research Council of Canada has designed and built the most sensitive and precise radio detector ever built for millimetre-wavelength operation (Figure 2). Called Band 3 millimetre-wavelength radio receivers, these devices promise to revolutionize studies of the cold Universe, notably about the birth of stars and planets.

Figure 2 — The nucleus of the Band 3 receiver is a superconductor-insulator-superconductor (SIS) tunnel diode mixer, which down-converts the radio frequency (RF) signal collected by the radio telescope to an intermediate frequency (IF) signal centered at 8 GHz with a bandwidth of 8 GHz. The SIS detector must operate at a temperature of 4° Kelvin. A cryogenic high-electron-mobility transistor amplifier is used to amplify the IF signal by 40 dB before it is delivered to the ALMA Back-End System. Further details can be found at `www.hia-iha.nrc-cnrc.gc.ca/atrgv/alma_e.html`.

Created at the National Research Council of Canada's Herzberg Institute of Astrophysics (NRC-HIA), the Band 3 receiver systems will be installed on the world's largest and most sophisticated radio telescope — the Atacama Large Millimetre Array (ALMA) being built in the Chilean Andes (Figure 3). A receiver will be installed on each ALMA antenna for research purposes and will also ensure that atmospheric disturbances are corrected across the entire ALMA array (Figure 4). ALMA is the highest priority for a new ground-based astronomical facility in the Long Range Plan for Canadian Astrophysics. The first scientific results should be available in about three years. Researchers expect spectacular images of young stars and galaxies using the Band 3 receivers.

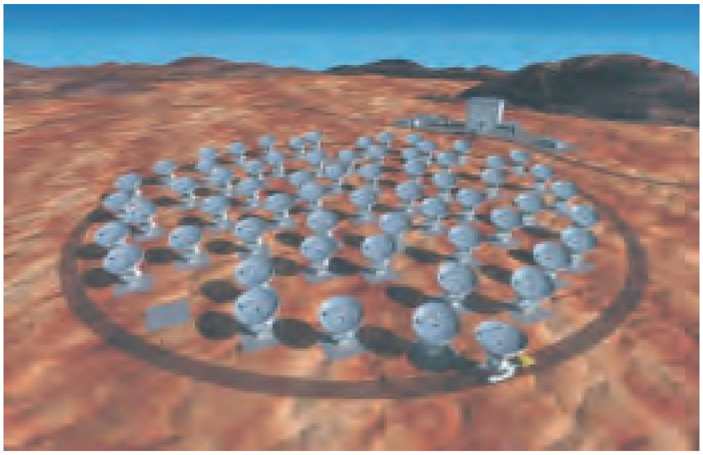

Figure 3: Artist's impression of the ALMA telescopes. ALMA is a unified collection of more than 50 high-precision radio dishes, 5 kilometres above sea level on the Chajnantor plain, which will be used by an international consortium for radio astronomy. Image courtesy of NRAO/AUI and ESO.

Gregory Fahlman, Director General of NRC-HIA, comments: "The international ALMA community has placed a great deal of faith in NRC's ability to deliver stable, reliable receivers. I am very proud that we have designed and built the highly precise

Figure 4: Artist's impression of the antennae for the Atacama Large Millimetre Array.
Image courtesy of NRAO/AUI and ESO.

electronic and mechanical components necessary for reliable operation under extreme conditions." Band 3 operates at a temperature of -269 °C to suppress noise in the internal electronics, a condition necessary in order to obtain maximum sensitivity. The system is designed to operate unattended at the highest site on the Earth's surface used for astronomy. Fred Lo, Director of the U.S. National Radio Astronomy Observatory, stated, "Band 3 will be a leading workhorse for producing the exciting scientific discoveries we expect from ALMA."

The Band 3 receiver can also be used in other applications. The design has been licensed to Nanowave Technologies of Ontario. Units have already been sold to the French atomic energy agency for use in advanced-materials research.

"In addition to creating what we believe is a unique Canadian industrial capability to serve the needs of the worldwide radio astronomy and physics communities, the transferred technology provides Nanowave with the additional tools to access the much larger commercial and defence radar and satellite communications markets," comments Justin Miller, President.

"We're very excited about the outstanding performance of the Band 3 receiver. It's the most sensitive receiver ever produced for this wavelength range, and clearly marks NRC as a leader on the technological frontier," said Adrian Russell, ALMA's North American Project Manager. "We deeply appreciate the dedicated efforts of the Canadian team that produced this receiver," Russell added.

Further details and images can be found at the NRC-HIA Web site `www.hia-iha.nrc-cnrc.gc.ca/media/band3-bg_2007-04-20_e.html`. The Canadian ALMA project Web site can be found through `www.almatelescope.ca`.

SCIENTISTS DISCOVER VAST INTERGALACTIC PLASMA CLOUD

LOS ALAMOS, N.M., 2007 April 19 – Combining the world's largest radio telescope at Arecibo, Puerto Rico with a precision-imaging, seven-antenna, synthesis radio telescope at the Dominion Radio Astrophysical Observatory (DRAO), a team of researchers led by Los Alamos scientist Philipp Kronberg have discovered a new giant in the heavens — a giant in the form of a previously undetected cloud of intergalactic plasma that stretches more than six million light-years across. The diffuse, magnetized, intergalactic zone of high-energy electrons may be evidence for galaxy-sized black holes as sources for the mysterious cosmic rays that continuously zip though the Universe.

In research reported in the April 19 issue of *Astrophysical Journal* (659: 267-274, 2007), the team of researchers from Los Alamos, Arecibo, and the DRAO in Penticton, British Columbia, describe their discovery of a 2- to 3-megaparsec zone of diffuse intergalactic plasma located beside the Coma cluster of galaxies. The combined use of the 305-metre Arecibo radio telescope to make a base scan of 50 square degrees of sky, and the DRAO to make 24 separate 12-hour observations over 24 days of the same sky area, resulted in an image comparable to that of a 1000-metre radio telescope. After Arecibo had mapped the larger cloud structure, DRAO data was used to enhance the resolution of the image.

According to Kronberg, "One of the most exciting aspects of the discovery is the new questions it poses. For example, what kind of mechanism could create a cloud of such enormous dimensions that does not coincide with any single galaxy, or galaxy cluster? Is that same mechanism connected to the mysterious source of the ultra-high-energy cosmic rays that come from beyond our galaxy? And separately, could the newly discovered fluctuating radio glow be related to unwanted foregrounds of the Cosmic Microwave Background (CMB) radiation?"

The synchrotron-radiating plasma cloud is spread across a vast region of space that may contain several black-hole-harbouring radio galaxies. The cloud may be evidence that black holes in galaxies convert and transfer their enormous gravitational energy, by a yet-unknown process, into magnetic fields and cosmic rays in the vast intergalactic regions of the Universe.

Kronberg's work also provides the first preview of small (arc-minute level) features that could be associated with unwanted and confusing foregrounds to the CMB radiation. Because these same radiation frequencies are to be imaged by the *PLANCK CMB Explorer,* corrections to the observed CMB signal for foreground fluctuations (the so-called microwave "cirrus clouds") are vitally important to using the CMB fluctuations as a probe of the early Universe.

Story from:
`www.lanl.gov/news/index.php/fuseaction/home.story/story_id/10251`.

A draft version of the paper by Kronberg and co-workers is available at
`http://arxiv.org/PS_cache/arxiv/pdf/0704/0704.3288v1.pdf`.

THE CHASSIGNY METEORITE AND FIREBALL: A FORENSIC STUDY

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Abstract: The Chassigny meteorite fell to Earth in the early morning hours of 1815 October 3. It is the "C" (Chassignite) archetype in the SNC Martian meteorite classification scheme, and it is one of the rarest of known meteorites. A meteoroid ablation model, constrained according to the limited eyewitness accounts, has been used to determine a pre-atmospheric size of the Chassigny meteoroid of 15 to 20 cm across, with a corresponding initial mass in the range of 5 to 15 kg. We have conducted a scanning-electron-microscope study on a polished fragment of the Chassigny meteorite and find a porosity of 4.5% ±0.5. The effects of this porosity on the fireball characteristics have been investigated, but are found to be negligibly small. The fireball associated with the fall of the Chassigny meteorite is estimated to have achieved a peak brightness of magnitude −10, and the conditions for simultaneous (electrophonic) sound production are found to have been satisfied for about ten seconds.

Résumé: Le météorite Chassigny est tombé sur terre durant les premières heures du 1815 octobre 3. Il est l'archétype "C" (Chassignite) de la classification SNC des météorites martiens et il est aussi un des meteorites les plus rares connus. Un modèle d'ablation de météorite, contraint par le nombre limité de rapports visuels, a été utilisé pour déterminer la grandeur pré-atmosphérique du météorite d'environ 15 à 20 cm de largeur, dont la masse correspondante initiale est de 5 à 15 kg. Nous avons entrepris une étude d'un morceau poli du météorite Chassigny à l'aide d'un microscope électronique à balayage et nous avons constaté une porosité de 4,5% ±0,5. Les effets de cette porosité sur les caractéristiques du bolide ont été étudiés et ils sont estimés être négligibles. Le bolide associé à la chute du météorite Chassigny est estimé avoir eu une luminosité maximum d'une magnitude de −10, et les conditions de la production simultanée de son (électrophonique) ont eu lieu durant environ dix secondes.

Introduction — The forensic approach:

To the eyewitness, the fall and discovery of a meteorite is both sudden and unexpected. It is not surprising, therefore, that the assembled eyewitness reports on how a particular meteorite was either found or observed to fall are often confused and contradictory. Did the meteorite fragment during atmospheric flight and were there any accompanying sounds? Did the meteorite actually fall where it was found? Have natural forces transported the meteorite from its fall site (as in Antarctica), or has it been displaced by honest (or dishonest) human activity (*e.g.* as in the case of the Willamette iron meteorite (Burke 1986))? The answers to such questions are important since they relate to the meteorite's physical structure, its possible association with a strewn field, provenance, and potential commercial value. With respect to the issue of atmospheric fragmentation and strewn field formation, Trieman (1992) has discussed the idea of "forensic meteoritics" where "characteristic telltales of terrestrial geological, geochemical, and biological processes" are all considered with respect to identifying meteorites with common parentage. Lipschutz, Wolf, and Dodd (1997) have also applied a "forensic-style" approach in their efforts to identify meteorite streams. Here we extend the idea of meteorite forensics to "re-create" the possible characteristics of the fireball associated with the fall of the Chassigny meteorite. The fireball model results are then used to derive an estimate for the size of the original "rock" ejected from the surface of Mars.

The Circumstances of the Chassigny Fall

The Chassigny meteorite fell to Earth at about 08:30 (local time) on 1815 October 3. No eyewitness accounts of an associated fireball were recorded, but reports of loud "musket-discharge-like" sounds being heard at the time of the fall were widespread throughout Chassigny and its surroundings (Pistollet 1816; Phipson 1867; Kichinka 2001a; Kichinka 2001b). Most sources state that some 4 kg of material fell at Chassigny and indeed, Pistollet (1816) records that "all the pieces that were collected were weighed and their total weight is close to 4 kg" [our translation of Pistollet's original French text is given throughout this article]. Pistollet then continues, however, "I am even very tempted to think that what we collected was only a fragment of a much larger rock that exploded in the air. I possess a piece of it weighing 1 kilogram, which is only the half of a corner, from which one may suppose that the rock weighed at least 8 kg." The 8-kg estimate is pure speculation on Pistollet's behalf, however, and it may or may not be a true or reasonable value. In both the practising-historian and forensic-study sense of dealing with only the data that one can be reasonably sure about, since 4 kg was the actual measured mass of material, this is the mass we take to have fallen, but where appropriate we allow for up to two times this mass (*i.e.* 8 kg) to have reached the ground.

Phipson (1867) describes a small mass of the Chassigny meteorite, viewed at the British Museum, in the following terms: "this most remarkable stone is distinguished from most aerolites by its pale yellow colour. Indeed, I never saw an aerolite that exactly resembled it." Likewise, upon conducting a chemical analysis, Vauqelin (1816) commented "L'absence du nickel est d'autant plus remarquable dans la pierre de Langes [Chassigny], que ce metal s'est, je crois, constamment montré dans toutes les autres." Indeed, from the very outset it was apparent that there was something odd about the Chassigny meteorite (Burke 1986). That the Chassigny meteorite was derived from the planet Mars, however, was not to be realized until some 150 years after its fall date.

The eyewitness reports that were provided to Pistollet (1816) suggest that the Chassigny meteorite broke into a large number of fragments upon hitting the ground. However, from the available, albeit limited, information there is no strong or compelling evidence to suggest that Chassigny is associated with an extensive strewn field and it would therefore appear that no significant atmospheric fragmentation took place. Certainly Pistollet (1816) speculates on the possibility that the "aérolithe" fragmented and perhaps "exploded in the air" before hitting the ground, but no hard evidence is presented to support such claims — they are just his opinions. Indeed, Pistollet comments, "if various reports are to be believed, it would seem that at the same moment other rocks were thrown in different directions, but not having been found, this fact has not been adequately confirmed." We should also remember that Pistollet only arrived on the scene some two days after the fall, allowing ample time for fragments to be moved and eyewitness accounts to have become confused or to have converged on a particular story line (as is still the case with eyewitness accounts of meteorite falls to this very day).

With respect to composition, we now know that the Chassigny meteorite comes from the planet Mars and, indeed, it is the "C" (*i.e.* Chassignite) archetype in the SNC Martian meteorite classification scheme. The Chassigny meteorite is derived from material that crystallized ~1.3×10^9 years ago, and cosmic-ray exposure analysis indicates that the material responsible for the meteorite was ejected from the surface or near-surface of Mars ~11 ± 1 Myr (Eugster *et al.* 2002).

At present, only two Chassigny-type meteorites are known; these being Chassigny itself and the recently recognized NWA 2737 meteorite found in Africa (Meyer 2005; Beck *et al.* 2005; Mikouchi *et al.* 2005). Interestingly, Misawa *et al.* (2005) find that the crystallization age of NWA 2737 is the same as that for Chassigny (*i.e.* ~1.3×10^9 years). Both Chassigny and NWA 2737 are cumulate rocks predominantly composed of olivine, and they may accordingly be classified as dunites (> 90 modal % olivine; McSween and Treiman 1998). Although, on the Earth, the ultramafic igneous rock type, dunite, represents part of the mantle (*i.e.* peridotite), it can on rare occasions form within crustal rocks. Such rocks are known to occur at the base of large mafic-ultramafic intrusions, where effective fractionation and crystal sorting (olivine has a higher specific gravity) has resulted in the accumulation of olivine crystals. Slivers of the Earth's mantle (as dunite) may also be transported to the surface or to higher levels within the crust through tectonic (faulting or obduction — the latter process relating to the over-thrusting of continental crust by oceanic crust or mantle rock at a destructive plate boundary) and/or volcanic (as xenoliths) activity, so the possibility certainly exists, by analogy with the Earth, that Chassigny is actually part of the Martian crust rather than its interior (mantle). Indeed, studies of melt inclusions within cumulus olivine grains of the Chassigny meteorite have provided important clues to the petrogenesis of the meteorite (*i.e.* the crystallization depth and temperature). For example, the work of Johnson *et al.* (1991) suggests that the Chassigny meteorite

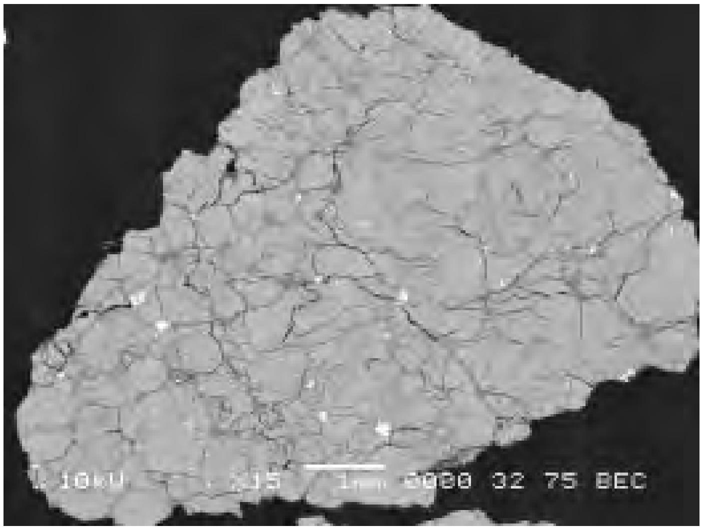

Figure 1 — Scanning-electron-microscope backscatter-electron images of a small Chassigny meteorite sample (Natural History Museum, London: 1985, M, 173) showing the predominance of olivine crystals (light grey) within the meteorite. Small amounts of pyroxene, chromite, and feldspathic glass (dark grey and bright areas) are also present. The dark veins indicate the void-space corresponding to the porosity.

formed at relatively low pressure (<< 5 kbar), implying that it crystallized close to the Martian surface, and not within the mantle. More recent work on rare pyroxenes contained within the Chassigny meteorite has further refined these estimates, such that it has been possible to estimate cooling rates for the meteorite; such studies shows that rapid cooling may have occurred (35 - 43 °C/yr), corresponding to burial depths of only 15 metres (Monkawa *et al.* 2004). Clearly, then, it is quite plausible that Chassigny represents part of the Martian crust.

In summary, from the historical accounts we infer the following about the Chassigny fall: the meteorite had a recovered mass of somewhere between 4 and 8 kg, and that the parent body did not undergo significant fragmentation in the Earth's atmosphere to produce an extensive strewn field. Modern-day analysis further tells us that the Chassigny meteorite is predominantly composed of olivine (Figure 1) and that it was ejected from the surface of Mars some ~11 ±1 million years ago. While it is acknowledged that we know very little about the circumstances of the Chassigny fall for certain, we do, in fact, have enough detail to make a reasonably good "forensic" reconstruction of the meteorite's associated fireball and pre-atmospheric size.

The Atmospheric Interaction

The time-variable characteristics of a meteoroid descending through the atmosphere are described by the equations of meteoroid ablation (*e.g.* Bronshten 1983). We need not consider the detailed equations here, but suffice it to say that the variation in the meteoroid's mass and velocity, along with the variation in the associated fireball's brightness, can be solved numerically (*e.g.* Passey & Melosh 1980). Computer-generated solutions to the ablation equations can be found, provided an atmospheric-density versus height profile is described, the initial meteoroid mass and the atmospheric entrance velocity are specified, and the meteoroid's composition and atmospheric entry angle are known. In addition, a series of efficiency terms need to be specified in order to complete the calculation.

The essential forensic information that we have to work with is the fall mass and composition of the Chassigny meteorite. With these physical quantities described, we may proceed to the construction of plausible Chassigny fireball models by specifying the remaining unknown terms according to reasonable or most likely values. To solve the equations of meteoroid ablation the following, assumed constant, terms must be specified: the energy transfer efficiency (Λ), the momentum transfer efficiency (Γ), the enthalpy of fusion (Q), the meteoroid density (δ), and the entrance angle of the meteoroid into the Earth's atmosphere (Z). The heat and momentum-transfer efficiency terms are usually combined to form the so-called ablation coefficient σ, where $\sigma = \Lambda / (2\Gamma Q)$. The initial mass ($M_\infty$) and velocity ($V_\infty$) of the parent meteoroid are treated as variable quantities to be specified. Without belabouring the details here, we adopt the following values in our analysis: $\Lambda = 0.02$, $\Gamma = 1.0$, and Z = 45° (following Passey & Melosh 1980; Melosh 1989; Artemieva & Shulalov 2001). This being said, we certainly acknowledge that the evaluation of the efficiency terms is a complex problem and in general, the terms will vary according to velocity, composition, meteoroid shape, and meteoroid structure (Bronshten 1983). To reiterate our approach, however, we adopt typical or most likely parameter terms and recognize that the adopted values may require adjustment if compelling new observational evidence indicates that a revision is required. The atmospheric entry angle, Z, for example, can in principle vary between $90 \geq Z(\text{deg.}) \geq 0$, but Halliday *et al.* (1989) find a median zenith angle of 51° for a "typical" meteorite-producing fireball. With no observational constraints in the Chassigny case, however, we simply set it to a value of 45° (as argued for by Hughes 1993). The meteoroid density and the enthalpy of fusion are determined according to the composition of meteoroid material. We may estimate these latter two quantities on the basis that the Chassigny meteorite is dunite. Accordingly, the characteristics of the Chassigny meteorite should fall somewhere between those expressed by the two end members of the olivine group of minerals: fayalite (Fe_2SiO_4) and forsterite (Mg_2SiO_4). In fact, Meyer (2005) notes that Chassigny contains olivine Fo_{68}, so we would expect the meteorite to have more forsteritic than fayalitic characteristics. Beck *et al.* (2005) also find that the olivine in NWA 2737 is Fo_{79}, so it too should have physical characteristics similar to those exhibited by forsterite. The density and enthalpy of fusion for fayalite and forsterite are given in Table 1.

Component	Density (kg/m^3)	Enthalpy of fusion (J/kg)	Ablation coefficient (s^2/m^2)
Fayalite	4393	4.52×10^5	2.21×10^{-8}
Forsterite	3214	9.50×10^5	1.05×10^{-8}

Table 1 — The density and enthalpy of fusion for fayalite and forsterite. Data taken from the Basaltic Volcanism Study Group (1981). The ablation coefficient assumes $\Lambda = 0.02$, and $\Gamma = 1.0$.

Having specified the basic physical and thermal characteristics of the meteoroid model, the final two variable terms are the initial mass and the initial velocity. The initial entry velocity of a meteoroid can in principle fall between the Earth's escape velocity (11.2 km/s) and the combined Earth orbital velocity and the heliocentric escape velocity at 1 AU (71.9 km/s). In practice, however, it has been found that the transport of material ejected from Mars to the Earth (Gladman 1997) results in encounter velocities that vary between $20 > V_\infty\text{ (km/s)} > 11$ for cosmic-ray-exposure ages (that is transport times) less than ~15 Myr.

The Parent Meteoroid to the Chassigny Meteorite

Figure 2 shows the variation of the initial-mass to final-mass ratio versus initial velocity for fayalite and forsterite meteoroids. The calculations assume initial masses in the range $10 < M_\infty\text{(kg)} < 500$. As the initial velocity increases so too does the initial-

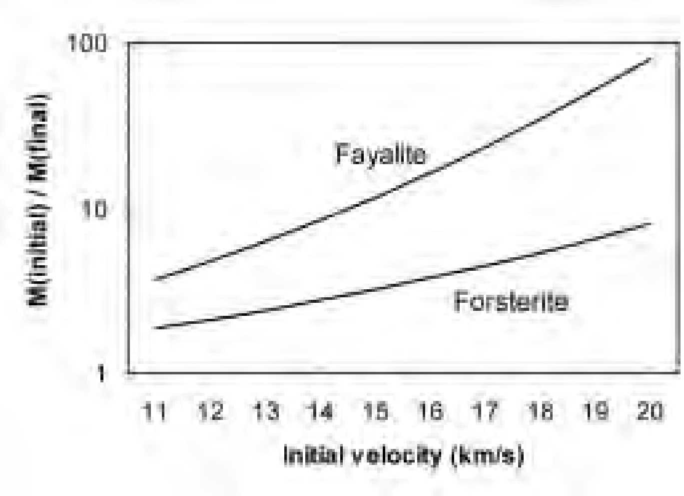

Figure 2 — Initial- to final-mass ratio, M_∞ / M(0), versus initial velocity, V_∞, for forsterite and fayalite meteoroids.

mass to final-mass ratio. This follows logically, since the higher the initial velocity, the greater the initial kinetic energy of the meteoroid, and the more vigorous the ablative mass loss, resulting in smaller amounts of material surviving to reach the ground. We may, in fact, express this result analytically since the mass and velocity of a vigorously ablating meteoroid at atmospheric height, h, are related according to the equation: $M(h) = M_\infty \exp\{\sigma[V^2(h) - V^2_\infty] / 2\}$, where σ is the ablation coefficient (see *e.g.* Bronshten 1983). The final-mass to initial-mass ratio is accordingly $M(0) / M_\infty$, where the assumption is made that $M(0) \equiv M(h = 0) = M(h = h_{DF})$, where h_{DF} is the height at which dark flight begins. It also assumed that the ablation coefficient remains constant. The condition adopted for the onset of dark flight is that the velocity has dropped below 2 km/s, and accordingly $V^2(h_{DF}) = 4$. We also observe, from the form of the mass-velocity relationship, that the higher the initial velocity, the higher the initial mass must be in order to produce a given meteorite mass M(0) on the surface of the Earth.

From Figure 2 we determine that, in terms of the initial-to final-radius ratio, at 11 km/s entry velocity, the change in radius amounts to a decrease by a factor of 1.2 for forsterite and a decrease by a factor of 1.5 for fayalite. At 20 km/s initial velocity, the decrease in the radius amounts to a factor of 2 for forsterite and a factor of 4.3 for fayalite. Taking the recovered Chassigny mass to be 4 kg we find that the pre-atmospheric mass of its associated meteoroid was of order $20 > M_\infty(\text{kg}) > 5$. Given that Chassigny has a predominantly forsteritic composition, we might expect a slightly lower upper bound on the initial mass with perhaps $15 > M_\infty$ (kg) > 5. In terms of the initial (that is pre-atmospheric) size of the Chassigny meteorite, we find the constraint: 20 > Dia. (cm) > 15. Again the upper limit might conceivably be lowered to ~17 cm on the basis of the forsteritic composition of Chassigny.

In their analysis of potential Martian meteorite source crater characteristics, Head e*t al.* (2002) assumed an initial diameter of 17 cm for the Chassigny parent meteoroid, and the analysis presented above indicates that this was seemingly a good assumption. Artemieva & Ivanov (2004) have modeled Martian meteorite ejection via oblique-angle impacts with a three-dimensional hydrodynamic code, and find a number of possible size distributions for the ejected material (see their Figure 10). Indeed, the various size distributions peak (in the sense of the amount of material ejected at a given size) in the range between ~5 to ~25 cm, with the largest particles being ejected having sizes ~75 cm. These numbers are based upon the model that "follows" a 200-m-diameter asteroid impact into the surface of Mars at 10 km/s. Such an impact results in the formation of a ~3-km-diameter crater from which it is estimated that some 10^7 kg of material escapes from the Martian gravitational potential well (*i.e.* achieves a final velocity greater than 5 km/s).

Artemieva & Ivanov (2004) also consider the effect of fragment interactions with the impact-generated vapour plume and the Martian atmosphere, with the conclusion that fragments smaller than ~10 cm probably do not escape from Mars. Our estimate for the pre-atmospheric size of Chassigny sits nicely, therefore, between the lower limit (~10 cm) and the most probable size of fragments (14 to 25 cm) ejected from Mars, as set by Artemieva & Ivanov (2004).

An estimate of the pre-atmospheric size of the Chassigny meteorite has been derived by Eugster *et al.* (2002) from krypton isotope measurements. They find an initial diameter of 50 cm for the Chassigny parent meteoroid, indicating a pre-atmospheric mass of order 200 kg. For this initial mass, the recovery of a meteorite(s) with a mass of between 4 to 8 kg would require an entry velocity between 25 to 28 km/s. While entry speeds this high are not impossible, as we demonstrate below, fragmentation within the atmosphere would inevitably result under such encounter conditions. As no extensive strewn field appears to exist in the vicinity of Chassigny, the Eugster *et al.* initial size estimate seems to provide an upper bound on the size of the Chassigny progenitor body.

The Fireball

Sunrise over Chassigny was at 06:39 local time on 1815 October 3. At the moment of the meteorite fall (08:30) the Sun was at an elevation of 22 degrees above the horizon, in the southeastern part of the sky. The meteorite fell, therefore, in broad daylight. According to Pistollet (1816), a man working in a vineyard "some distance away from Chassigny" actually saw the meteorite fall to the ground and "hot as if [warmed] by strong sunlight" fragments were collected from the area surrounding a "0.27-m-deep" plunge pit.

It appears that sounds and detonations were heard in the area surrounding Chassigny, but no reports of any accompanying fireball were collected (Pistollet 1816). While sounds of one sort or another will always accompany the fall of a meteorite (Beech 2004), it is not uncommon for an accompanying daytime fireball to go completely unnoticed by the vast majority of potential observers (*i.e.* anyone situated outside of a building). Pistollet

(1816) writes, however, that the sounds "appeared to come from a cloud above the north-east horizon. The cloud had no particular form, and was of a grey colour." The "grey cloud" described by the Chassigny eyewitnesses may have been a dust trail composed of ablation products, but there is insufficient data to be truly sure. If, however, the cloud was an ablation dust trail then the eyewitness accounts imply that the fireball-observer-Sun angle must have been about 90 degrees.

Even though no reports of the fireball are extant, we may still estimate how bright the Chassigny fireball might have been from the constraint that at least 4 kg of material was recovered. For initial velocities in the range $20 > V_\infty$ (km/s) > 11, we find from the numerical models that initial masses in the range $500 > M_\infty$ (kg) > 50 are required to produce a single 4- to 8-kg meteorite when the composition is pure fayalite. For a forsterite meteoroid, we find that initial masses in the range $40 > M_\infty$ (kg) > 10 are required to produce a 4- to 8-kg meteorite. In each case, the higher initial mass is associated with the higher initial velocity. The estimated peak brightness of the various fireballs associated with the trails just described range from magnitude −8.5 to −13 in the case of the fayalite meteoroids, and magnitude −5 to −10 in the case of the forsterite meteoroids. These magnitudes are based upon an assumed constant luminous efficiency of $\tau_0 = 0.001$. Given the essentially forsteritic composition of the Chassigny meteorite, it would appear that an upper limit of order magnitude −10 to −11 is set on the possible peak brightness of the fireball. With the Sun at an elevation of 22 degrees at the time of the fall, unless an observer chanced to be looking straight at it, the Chassigny fireball would probably not have been an especially eye-catching object.

A recent event with comparable viewing characteristics to those suggested for the Chassigny fireball is that of the Genesis Sample Return Capsule re-entry over northern Nevada on 2004 September 8. The re-entry took place at 09:52 (MDT) when, in Nevada, the Sun was at an altitude of ~28 degrees. The peak brightness of the re-entering capsule is estimated to have reached magnitude −8, and yet only a very few observers, even among those located within a 100-km radius of the ground track and who knew where to look, made a visual sighting of the associated fireball (Beech & Murray 2005). The entry velocity of the capsule was ~11 km/s, and its diameter was ~1.5 m.

Figure 1 reveals that the Chassigny meteorite has a noticeable porosity, and this property can potentially alter the meteoroid ablation characteristics. Specifically, the porosity, which is a measure of the void space within the meteorite, will reduce the bulk density but increase the ablation coefficient and the area undergoing heat transfer. The meteoroid bulk density will be modified according to the relationship $\delta = \delta_{np}(1 - P)$, where $0 \le P < 1$ is the porosity, and where we have explicitly taken the void space to be empty and δ_{np} is the bulk density of the non-porous material (olivine in the case of Chassigny).

Britt & Consolmagno (2003) quote a porosity of 7.5% for the Chassigny meteorite based upon a model calculation reported by the Geological Survey of Finland. Consolmagno & Strait (2002), however, report a smaller model porosity of 3.2%. From a scanning-electron-microscopy (SEM) investigation of Chassigny sample 1985, M.173 (see Figure 1), on loan to us from the Natural History Museum, London, we determine a measured porosity P = 4.5% ± 0.5 (Coulson, Beech, and Nie 2007). Details of our SEM procedure can be found in Beech & Coulson (2005). A series of ablation models, that include the effect of porosity, have been evaluated and, as one would expect, the end mass decreases with increasing porosity (for a fixed initial mass and velocity). Increasing the porosity also results in a shorter-duration, brighter fireball. For small values of the porosity, P, it can be shown that for a fixed initial velocity the meteorite mass, M(0, P), varies as:

$$M(0,P) = M(0,0)\left[\frac{M_\infty}{M(0,0)}\right]^{-P(P+1)} \tag{1}$$

where M_∞ is the initial mass and M(0,0) is the meteorite mass when the porosity is zero. For the porosity values appropriate to Chassigny, negligibly small corrections to the single-body ablation computations are required.

Sound Generation

The various sounds that accompany meteorite falls can be grouped under two main headings: sonic booms and simultaneous sounds. The sonic booms are due to the propagation of a shock wave produced by the meteoroid in the lower atmosphere, and these sounds typically are heard several minutes after the fireball has disappeared from the sky. Simultaneous sounds, in contrast, are heard at the same time as the fireball is seen in the sky, and their origin is possibly related to an interaction between the fireball plasma column and the Earth's magnetic field (Keay 1980; Beech & Foschini 1999). Sonic booms are typically heard by observers at ranges up to 100 km from a fireball's atmospheric path. Simultaneous sounds, on the other hand, have been reported at ranges in excess of 200 km.

It has been argued by Keay (1980) that electrophonic (also called simultaneous) sounds can proceed once the plasma column generated by an ablating meteoroid enters a turbulent flow regime. The condition for the onset of turbulence is taken to be the attainment of a Reynolds number *(Re)* greater than 10^6, where the Reynolds number is a dimensionless quantity given by the ratio of the inertial and viscous forces in the flow. The Reynolds number can be evaluated at each step of the numerical integration of the ablation equations (Keay 1992), and we accordingly find times at which electrophonic sounds may well have been generated by the Chassigny meteoroid. Both fayalite and forsterite meteoroids capable of producing 4- to 8-kg-mass meteorites appear to undergo electrophonic sound-generating conditions for periods lasting between ~10 to 15 seconds. Within the range of initial masses and velocities considered in this study, the larger the initial mass and the higher the initial velocity, the greater the time over which electrophonic sounds might be generated. This result follows from the fact that the Reynolds number that describes the onset of turbulence condition is determined according to meteoroid size and velocity. Specifically, $Re = VR/\mu$, where V is the velocity, μ is the kinematic viscosity, and R is the radius of the meteoroid. Since μ varies only slightly with atmospheric height, the magnitude of Re is determined via the product VR.

It is well established that sounds were heard before the fall of the Chassigny meteorite (Pistollet 1816), but it is not clear from the eyewitness accounts if they were electrophonic sounds or sonic booms, or a combination of both.

Fragmentation

A meteoroid will break apart and fragment during its atmospheric flight if the ram pressure of the oncoming airflow exceeds the compressive strength of the meteoroid material. The condition for fragmentation may be expressed as $P_{ram} = \Gamma \rho V^2 = \sigma_{com}$, where ρ is the atmospheric density, and σ_{com} is the compressive strength of meteoroid material. The variation of the ram pressure as a meteoroid descends through the atmosphere can be followed during the numerical integration of the ablation equations and accordingly the maximum ram pressure experienced by 10- and 100-kg initial-mass meteoroids are shown in Figure 3. The maximum ram pressure increases with increasing initial velocity; it also increases with initial mass, since larger-mass objects, with the same initial velocity, penetrate more deeply into the Earth's atmosphere where the density is higher.

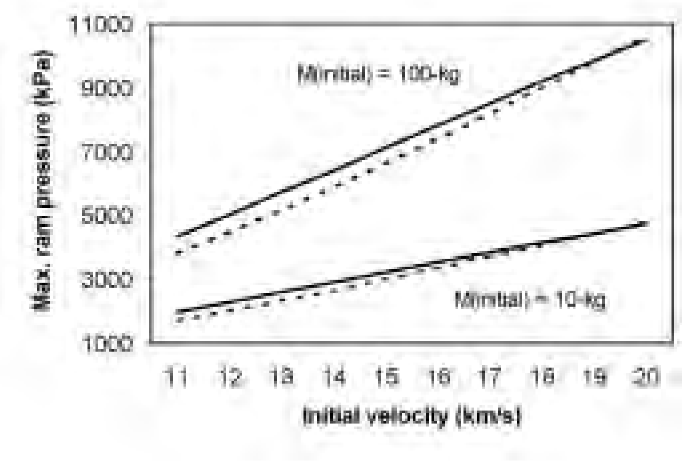

Figure 3 — Maximum ram pressure (in kPa) experienced by forsterite (dashed line) and fayalite (solid line) meteoroids versus initial velocity, V_∞. Initial masses corresponding to $M_\infty = 10$ and 100 kg are illustrated. Larger-mass meteoroids will experience correspondingly larger maximum ram pressures.

No physical measurement of the compressive strength of a Martian meteorite has ever been made. Ordinary chondrite and iron meteorites have, however, been tested in the laboratory and a whole range of compressive strengths, ranging from 10^6 to 10^7 Pa, are found (Buddhue 1942; Tsvetkov & Skripnik 1991; Svetsov, Nemtchinov, and Teterev 1995). Estimates of the ram pressure at the times of fragmentation for instrumentally observed meteorite falls, however, indicate that ram pressures in the range 10^5 to 10^6 Pa are typically required for initial breakup to begin. This observational result is important, since it implies that it is not so much the crushing strength of the meteoroid material that is the issue, but instead the extent of structural defects within the meteoroid before it encounters the Earth's atmosphere that dictates the condition for initial breakup. This being said, Svetsov, Nemtchinov, and Teterev (1995) argue from the available observational data that fragmentation should inevitably occur once the ram pressure exceeds $\sim 5 \times 10^6$ Pa.

Figure 4 shows the boundary line separating the single-body ablation and fragmentation zones in the initial-mass, initial-velocity plane for forsterite meteoroids (*i.e.* ones that should closely match the Chassigny fall). The boundary line corresponds to an attainment of a maximum ram pressure of 5×10^6 Pa. Also shown in Figure 4 are the loci corresponding to the production of 4-kg-mass and 0.5-kg-mass (forsterite) meteorites. Figure 4 indicates that for a 0.5-kg meteorite (*i.e.* one similar to NWA 2737), fragmentation is not predicted to occur for initial velocities < 20 km/s. For a 4-kg-mass meteorite, however, fragmentation is predicted to occur if the initial velocity is greater than ~17.5 km/s. For an 8-kg-mass meteorite, fragmentation is predicted for initial velocities in excess of 16.5 km/s. Figure 4 also reveals that forsterite meteoroids with initial masses greater than 275 kg will inevitably undergo fragmentation, since the ram pressure will exceed 5×10^6 Pa for all entry velocities greater than the 11-km/s minimum value.

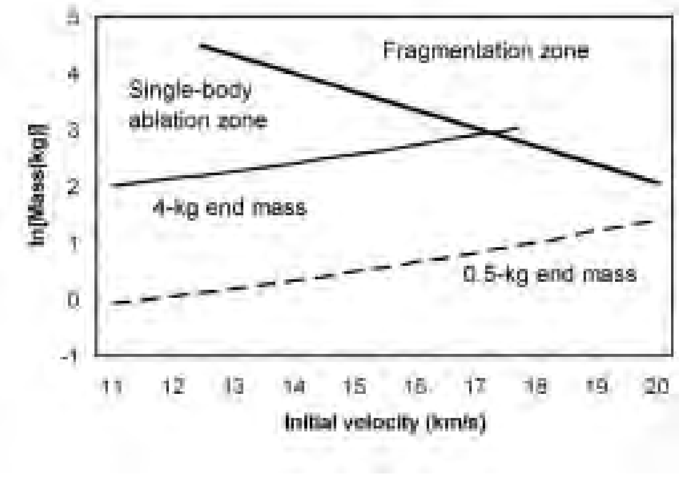

Figure 4: Single-body ablation and fragmentation zones for forsterite meteoroids. The loci for 4-kg end mass (solid line) and 0.5-kg end mass (dashed line) are shown. The fragmentation boundary is set according to the attainment of a maximum ram pressure of 5×10^6 Pa (see text for discussion).

Conclusions

In this study we have attempted to determine the likely pre-atmospheric size of the Chassigny meteorite. We have taken the minimum recovered meteorite mass to be 4 kg (as weighed and described by Pistollet 1816), but have also allowed for twice this amount to have fallen. Accordingly, for a forsteritic composition we estimate that its initial size was most likely in the range of 15 to 20 cm across and that its initial mass was in the range of 5 to 15 kg. We estimate that the fireball associated with the fall of the meteorite may have attained a maximum brightness of order magnitude −10, and that simultaneous (electrophonic) sounds may well have persisted for about 10 seconds. From a scanning-electron-microscope study of a polished sample of Chassigny we find a porosity of 4.5% ±0.5, but find that this level of porosity does not significantly affect the results derived from the single-body (zero porosity) ablation calculations. The lack of any significant strewn field associated with the Chassigny fall suggests that the initial velocity of the Chassigny meteorite was less than 17 km/s.

Acknowledgments

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Playing the Odds: Forecasting for Astronomy

by Jay Anderson, Winnipeg Centre (jander@cc.umanitoba.ca)

Clouds are the Bugbear of astronomers. They are uncannily linked to the purchase of a new telescope or to new telescope accessories. Like computer glitches, they have a seemingly unnatural ability to respond to critical need, appearing despite the most optimistic forecast, and disappearing when the time-sensitive event is past.

Or so it seems.

We live in an era of unprecedented access to global meteorological information. Satellites probe our skies from above every 15 minutes. Radar scans for precipitation at ten-minute intervals. Surface stations report on the hour, with special observations in between when the situation warrants. Computer models tackle the future, feeding the Clear Sky Clock, and disgorging an enormous amount of digital and graphical information. The Internet delivers this cornucopia of information to our desktops and TV weather displays an endless loop of opinion and pretty announcers to explain it all.

The big challenge is to find it, understand it, and use it. You won't be an expert when you reach the end of this article, but you will be able to navigate through the critical parts of the data glut and perhaps dig out those bits and pieces that will help your observing to be more successful. To get the best information from the forecast, you have to go where forecasters go — to the original source.

Meteorologists have a set of *ad-hoc* scales that they use to describe atmospheric phenomena. For the most part, these scales are based on size — global-scale, synoptic-scale, mesoscale, microscale, and a few others of lesser interest. While there is a time-dependence in these categories, as astronomers we are usually more interested only in "when it will clear" rather than "how big is this patch of cloud?" Long-range planning, for an eclipse trip perhaps, requires climatological information. A star-party expedition, or a short trip to drier and friendlier observing climates, requires information on a weekly scale. Tonight's observing requires information for today, and time-critical observations, such as an occultation, may depend on the sky condition at hourly intervals. There are data sources for each one of these scales.

The Long-Distant View: Climatological Data

The cloud cover maps that I provide for the *Handbook* (p. 66-67) or for the NASA eclipse circulars are largely derived from satellite observations of the Earth. Clouds are not the only element that interests us in our quest for clear nights, but they are certainly the most important. For wind, temperature, humidity, and other elements, we can go to the data collected from surface stations, extrapolating to the site we've picked for our telescope. In my capacity as a meteorologist, I am frequently questioned about the chances of observing an eclipse or some other distant astronomical event, but my ability to provide a precise answer is limited by the quality of the data observation. Let's take clouds for an example.

Geostationary and polar-orbiting satellites examine the Earth in great detail every day, usually at kilometre scales. Polar satellites make four passes a day in most locations, one about noon, another at midnight, and two others at sunrise and sunset (at high latitudes, the rate is much higher — perhaps 10 or 12 per day). They are the only weather satellites that can look at the Earth straight down, a distinct advantage when observations are required above latitudes of 60° north or south. Geostationary satellites take observations every half-hour usually, but full-Earth scans that cover the north only occur hourly. The problem with geostationary satellites is that they sit over the equator, so clouds are seen at quite an oblique angle at typical Canadian latitudes and at locations well to the east or west of the satellite sub-point (Figure 1). Thunderstorms over northern Alberta (or Alaska) are actually seen from the sides. Perspective effects, just as for the human observer on the surface, make cloud amounts appear to be heavier toward the horizon, so data derived from geostationary satellites will have a tendency to show higher cloud amounts toward the four horizons. Polar satellites suffer from the same bias toward the east and west sides of their image

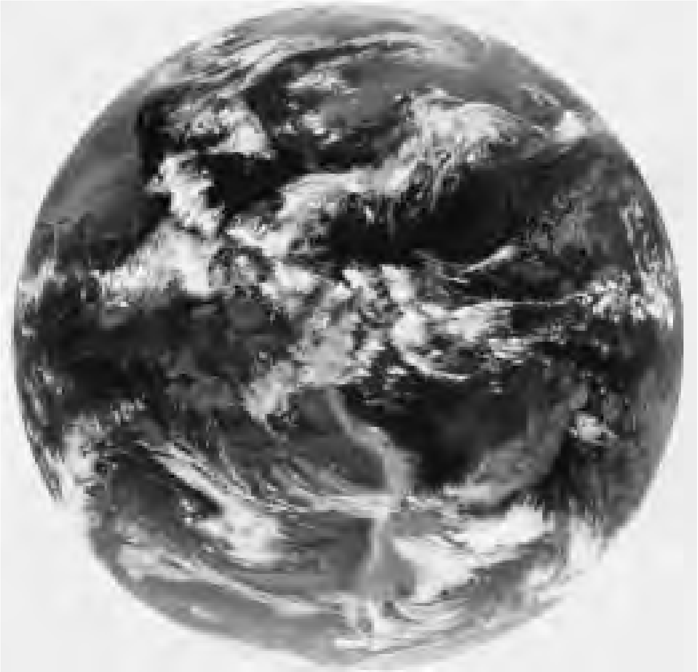


Figure 1 — A full-disk infrared image of the Earth taken by the GOES East weather satellite. Clouds seen toward the edges of the disk appear to be heavier than those below the satellite.

sweep as the Earth curves away from their orbital track.

It is not a simple process to automatically detect cloudiness from a set of infrared satellite radiance measurements and reflected visible light. The cloud algorithm must handle varying light levels between day and night, and temperatures according to season and time of day. It must account for the angle of the observation, and the proportion of the scanned pixel that is cloud-covered. It must be able to handle thin high cloud and thick low cloud. At times the cloud lies on top of a snowy landscape, or a surface that is colder than the cloud itself. Sensors differ in their sensitivity, and they all have to be calibrated against one another. What seems easy for an astronaut looking out a window is much more challenging for software.

If satellite observations leave something to be desired, how do surface observations fare? There are no problems with temperature, humidity, and pressure observations, and only a little concern for instrument-derived visibility reports (visibility is measured over a distance of about 1 metre). Human observers, the source of much of the world's climate data, are imperfect cloud-detection instruments, mostly because of biases introduced by perspective effects. Cloud always looks heavier toward the horizon. Human observations of cloud at a site are almost always higher than satellite observations, in large part because the horizons are much farther away for satellites.

Humans are still a part of Canadian and U.S. weather observations, but only at major airports, and not with the same rigour as in the past. Nowadays we rely on instruments. Cloud detection is done by capturing the return signal from laser beams that are fired upward from the observing site; the time of travel is an accurate measure of cloud height and the hourly frequency of "hits" is a measure of cloud amount — a poor measure of cloud amount. Clouds in layers are imperfectly detected, the biggest lasers have a range of only 20,000 feet (cloud heights are still measured in feet), and falling snow and modest rainfall confuse them utterly. Lasers will miss cloud that isn't directly over the observing site, and they are going to miss the higher clouds.

A typical hourly METAR or weather report from a weather station (Regina) looks like this:

```
METAR CYQR 102300Z CCA 09013KT 15SM FEW030TCU BKN280
23/16 A2965 RMK TCU2CI2 SLP044=
```

This type of report, generated largely for the aviation industry, is collected internationally and is the source of nearly all of the cloud climatologies in the world. The METAR above reports a lower cloud deck amounting to 1or 2 oktas at 3000 feet and a high broken layer at 28,000 feet (FEW030TCU BKN280). Cloud layers are summed from the bottom up, so that several scattered layers can add up to a broken layer, as is the case here. Cloudiness is measured in eighths of sky cover (oktas), with specific definitions for each class. FEW is used for cloud amounts of 1 or 2 oktas, SCT for 2 to 4 oktas, and BKN for 5 to 7 oktas. CLR and OVC represent 0 and 8 oktas respectively. A CLR sky cannot have any cloud whatsoever, and any break is sufficient to change OVC to BKN.

Interpreting cloud observations poses a bit of a problem for astronomers because clouds can be transparent or opaque. For a serious astrophotography expedition, transparent cloud can create a significant problem, even when fuzzy stars are visible almost to the horizon. For an eclipse expedition, transparent cloudiness, though unwelcome, would not ruin the event for most folks. The section FEW030TCU BKN280 is reporting on cloud amount, defined by Environment Canada as "the portion in eighths of the whole sky that is observed to be covered (not necessarily concealed) by a layer aloft or concealed by a surface-based layer."

There is a second cloud report at the end of the METAR, in the remarks column. This portion, TCU2CI2, is a report on cloud type and cloud opacity. Environment Canada defines opacity as "the portion in eighths of the whole sky that is observed to be concealed (hidden, rendered invisible)...." In this example, note that both the lower and upper layers cover 2 oktas of the sky each, for a total of 4 oktas. Thus in one weather report there are measures of cloudiness that will satisfy both the astrophotographer and the eclipse chaser.

Alas, Canada seems to be the only country that observes and reports cloud opacity, and it is not saved in our climate archives. All cloud climatologies are based on cloud amount, thick or thin. The net result is that national climate statistics make the world seem more gloomy than it really is. Satellite-based climatologies may have a similar problem. At night, cloud observations are based only on infrared radiances. Infrared is strongly absorbed and re-emitted by clouds, so cloud amounts from space look much heavier than is actually the case. This can be resolved by a strategic choice of wavelengths, but the problem is not completely solvable.

What is the best strategy for using cloud climatology to (say) plan an observing trip to an eclipse, or for an expedition to observe a meteor shower?

The most useful approach is to use the data comparatively. We can make a loose assumption that all nations treat data in a relatively similar fashion, following the guidelines laid down by the World Meteorological Organization. The weakness of this assumption is occasionally evident by a comparison of two neighbouring stations that straddle national borders — the frequency of FEW, SCT, BKN, and so on might be quite different between the two. Temperatures, winds, and humidity will all agree, but cloudiness is a subjective observation that often falls victim to human judgement rather than measurement standards. Often other evidence (satellite observations) is available that will suggest which of the station reports to believe. Nevertheless, my first choice for cloud climatology is that derived from satellites, as the biases are better understood, less random, and, in lower latitudes or over oceans, unaffected by the presence of snow and ice.

Finding Climatological Data

Satellite cloud climatologies are located at the International Satellite Cloud Climatology Project, which can be found by searching on "ISCCP." Their site includes JavaScript routines to make maps of monthly cloud cover for both day and night for the entire globe at a 5° × 5° resolution. Alternatively, NOAA's CLASS Web site (`www.class.noaa.gov/saa/products/welcome`) contains a portal to the Pathfinder project (in the drop-down list), from where higher-resolution cloud statistics can be obtained. Pathfinder cloud algorithms are not as robust as those at the ISCCP, and cloud amounts can differ considerably between the two (sigh...), but the relative cloud amounts and global cloud patterns tend to be quite similar. Data are readily available only for individual months of a single year from the ISCCP, so if you wish a long-term monthly climatology, you'll have to go to my Web site (`www.eclipser.ca`) where you'll find some maps showing the 20-year averages. These averages are those used to produce the cloud charts in the *Handbook*.

For station data, the only site really worth visiting is the National Climate Data Center (NCDC) in Washington, though in a pinch you could go to Environment Canada for Canadian data. NCDC is a huge clearinghouse for data, but most of it has a cost. Typically, yearly data has to be downloaded and compiled into a climate average; it isn't done for you. Some countries publish climate statistics on their Web sites, and a very few have international climate collections (Hong Kong in particular). For the most part, you won't find cloud cover statistics separated into day and night observations, so you must assume that the daily average is at least representative of the night amount. This is not a very good assumption, as summer days are usually quite a bit cloudier than nights, especially in the sub-tropics and mid-latitudes.

An old CDROM-based compilation of climate data that goes by the name of *International Station Meteorological Climate Summary* (NCDC 1996) is still available from a number of sources for about $120 US. I use it frequently, but it's getting a little long in the tooth.

For eclipse expeditions, the mean daily cloud or the frequency of cloud amounts in the various categories (clear, scattered, broken, overcast), either from satellite or surface observations, will give a pretty good idea of the weather prospects, but the best statistic of all is the "percent of possible sunshine." Because it is a daytime-only observation, and, because sunshine recorders work in thin cloudiness, the statistic is an accurate measure of the true probability of seeing an eclipse. Unfortunately, the number of stations that record sunshine amount is relatively limited. The Hong Kong Observatory is a very good source for international sunshine readings, usually in the form of "hours per month."

Traditionally, an appropriate time interval for a "climatological" average is considered to be 30 years, spreading out annual variations into a smoother curve. Satellite data are still a decade away from this limit, so users of climate statistics based on orbital observations will have to accept shorter time frames. Ten years is probably useful and 20 should get rid of a significant part of the variance. Events such as El Niño will make a mockery of too-short climate averages in some parts of the globe, such as Peru or Indonesia. It should not be necessary to warn against using this year's weather alone as a proxy for next year, though if you keep an eye on daily satellite imagery, it will provide you with an idea of the movement of typical weather systems.

The Mid-Range: From 2 to 15 Days

Each spring, I travel southward to either Texas or Arizona with some of my fellow Winnipeg Centre members to observe and photograph under the un-wintery skies of the American Southwest. The area is chosen because of its climatology, and you can see why if you look at page 66 in the *Handbook*. We go every year, because the climate is reliable, but our biggest concern is the jet-stream cirrus that frequently plagues Arizona in the spring. Such cirrus seldom appears in the sunshine record, but it's a real pain to discover after 36 hours of non-stop driving. We have the option of diverting to McDonald Observatory in the west Texas highlands — a decision we can actually make on the way, in New Mexico, if we have to. So how do we make the decision, especially as we are expecting to spend 5 to 9 days on site?

The secret here is a computer model.

Computer modelling is one of the great scientific breakthroughs of the last century. Weather models use a set of "primitive equations" that describe the hydrodynamic flow on a sphere. Models are a good approximation of the Earth's atmosphere, and can be improved (or modified) by various manipulations to give useful and generally accurate values for the standard meteorological elements: wind, temperature, cloud, precipitation, and so on. The equations themselves predict only five variables (two components of the wind, vertical motion, temperature, and the geopotential), but additional parameters can be extracted quite easily from these. Moisture, for instance, can be injected mathematically into the flow at some initial state and followed thereafter, extracting some as precipitation, and adding more through evaporation.

Models are complex beasts and take an enormous amount of calculation, observation, and verification. The equations are solved on a 3-D grid of points that span the globe and the depth of the atmosphere. In Canada, we generally use a variable-resolution "Regional" model that incorporates a fine-scale, 59-level, 15-km grid over North America and a coarser grid over the rest of the globe. The time step in the model is 450 seconds, giving a total of 2.5 billion time-space points at which the primitive equations must be solved (by iteration) in order to produce a 48-hour global forecast. This process takes about three hours on the Canadian Meteorological Centre's (CMC) supercomputer. The output from this model is used, among many other functions, to supply the Clear Sky Clocks upon which we have become so reliant.

CMC has a second version of the Regional model that is also readily available to the public. This model, known as the "Global," has a coarser resolution, but provides forecasts out to 10 days into the future, though only the first 144 hours are available on Environment Canada's Web page (`weatheroffice.ec.gc.ca`). Four other models can be found at the Web site of the National Center for Environmental Prediction (NCEP) in the United States, and one of these — the one we will use for our example above — goes out for 15 days. This is the GFS model, which is available at `www.nco.ncep.noaa.gov/pmb/nwprod/analysis`.

Model outputs are usually offered at standard atmospheric levels that are designated by their pressure value, typically expressed in millibars (mb). Higher pressures represent lower layers, and the "MSL" layer (mean sea level) is the surface. The most important levels for astronomical decision-making will depend on your goals; we'll have a look at them one-by-one.

The MSL charts from NCEP are available at four time periods each day, labelled according to UTC. Each time represents a new model run that incorporates the latest data from the thousands of sensors that probe the Earth each hour. CMC provides two daily updates, at 00 UTC and 12 UTC (in meteorological code, 00Z and 12Z).

For our Arizona forecasting problem, we will want to know several things. Will it be cloudy? Where is the jet stream? We observe at 7000 feet in the Chiricahua Mountains — will it be windy? Of lesser importance is the temperature (it's almost always warmer than Winnipeg), but precipitation is useful to know, as it can leave snow on the access road and peaks. We have to use separate charts to answer each of these questions, but usually I begin at the surface to get a feeling for what is coming.

The surface chart for 5$^1/_2$ days in the future (132 hours; Figure 2) gives me a forecast of the surface pressure, accumulated precipitation over the past 6 hours (in shades of green), and the thickness — the depth of the atmosphere between 2 set pressure levels. Thickness is a measure of the average temperature between the two levels; warm air tends to have a large thickness and cold air a smaller one. The distinction is made more evident on the chart by the use of blue contours in the colder air, and red in the warmer. Forecasters can use the thickness pattern to pick out frontal zones, but we won't get that sophisticated. The charts show us that the prognosis for 5$^1/_2$ days hence seems quite promising — precipitation is predicted for the Great Plains but nothing seems threatening in the Arizona area. The thickness pattern shows that our observing site is embedded in warm air — in fact, under a large upper ridge, a very favourable situation indeed.

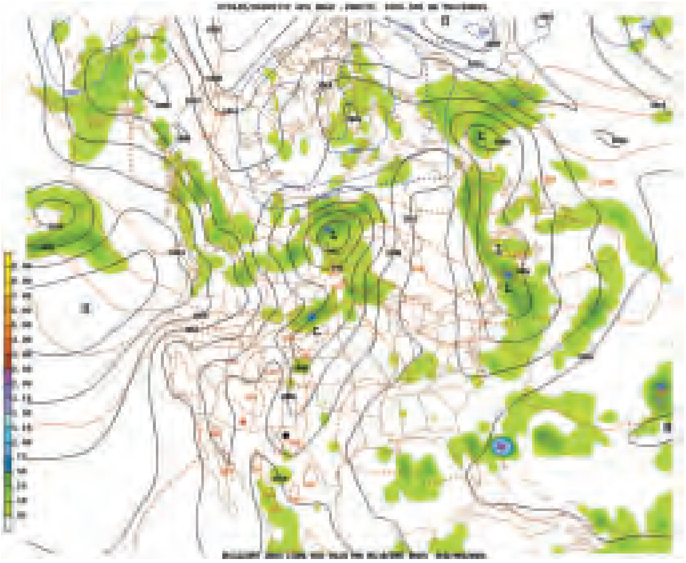


Figure 2 — The 132-hour surface chart from the GFS model. Surface pressure contours are shown as fine black lines. Six-hour accumulated precipitation is coloured according to the scale on the left. Thickness contours are drawn as dashed red lines. The Arizona observing site is marked by a red dot and McDonald Observatory with a black dot.

The next question is cloudiness. Here we are at a bit of a disadvantage, as cloud can form at any level in the atmosphere, and the GFS model only provides us with a moisture prediction at one level. This is at the 700-mb pressure level, where the model forecast of relative humidity for that layer is displayed. The 700-mb level is in the middle part of the atmosphere, and cloud here is generally representative of the larger weather systems, but not of small-scale patches of fog, mountain cloud, or leftover bits of thunderstorms. To find the 700-mb maps, we have to go to the top of the NCEP Web page and click on the "Upper Air" graphics tab.

A new page opens that includes the 700-mb relative humidity (RH), and we click on the tab for the 132-hour mark. A chart with the height of the 700-mb pressure above sea level and contours of relative humidity appears (Figure 3). Humidities above 70% are coloured light green, and those above 90%, dark

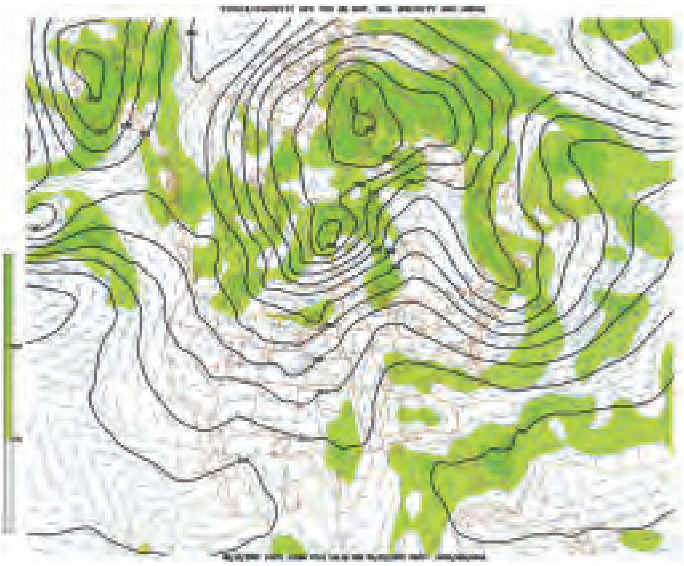


Figure 3 — The 700-mb level chart. Dark black lines are the height contours of the pressure surface, akin to pressure fields at the surface. Fine green lines outline the relative-humidity field; the contours are filled with a light-green shading at the 70% contour and dark-green shading at 90%. Faint blue barbs show the wind field.

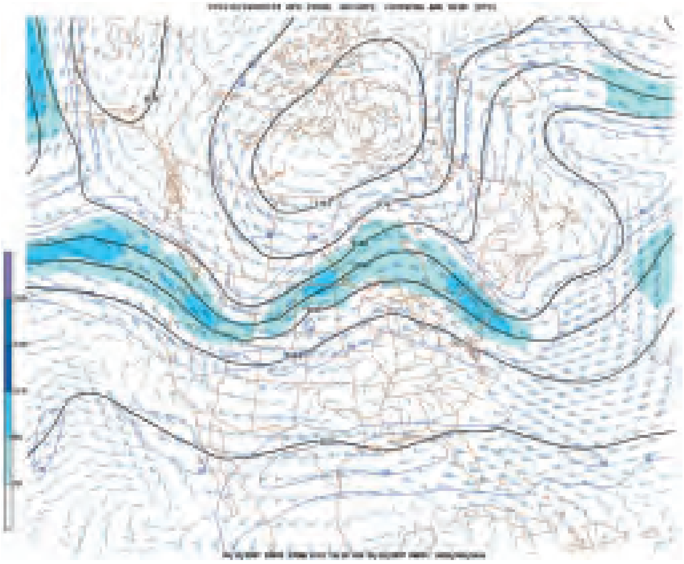


Figure 4 — The 200-mb pressure level. The height of the pressure level is shown using dark black lines (about 12 km). Fine blue lines show the wind speed contours with speeds about 70 and 90 knots shaded in light and dark blue respectively. The sub-tropical jet is revealed by the 50-knot contours stretching from the Baja, through central Texas, to Florida.

green. Forecasters typically expect cloud wherever the model has an RH above 70%, so the coloured contours trace out the most likely mid-cloud regions. It looks good — there is cloud in west Texas, but nothing in southeast Arizona. The 700-mb chart also contains a forecast of wind, which appears in the form of small blue barbs (see sidebar).

Since we're on the Web page for upper-air data, we'll take a look at the 200-mb level where the jet stream lurks (Figure 4). The sub-tropical jet is usually found high in the atmosphere, so I go right for the top; I'd probably look a little lower in Canada (250 or 300 mb), especially in winter months. The polar jet over Manitoba and Ontario is obvious by its coloured contours, but, sure enough, there is also a sub-tropical jet stretching from the Baja, across Texas, to Florida. Jet streams carry a lot of high-level cirrus cloud, especially on their north side. It looks as if the McDonald Observatory area could have a problem, but Arizona is far enough from the jet to escape its influence.

One more thing to do: check the winds at mountaintop. Because the Chiricahua observing site (the parking lot actually) is at 7000 feet, I want to take a look at a model level that lies close to that level. A convenient one is the 850-mb level (Figure 5), about 1.5 km above the surface. The 850-mb chart provides me with temperatures at the level, black contour lines that represent the height of the 850-mb pressure above MSL, and the usual blue barbs for wind. The chart promises a light westerly flow of about 10 knots at the site, a tad high for good photography, but the parking lot we use has a few places to tuck out of the wind. McDonald Observatory is about the same, though there are some 25-knot winds just to the west.

All of the ducks are lined up. The weather for Arizona is very promising, and the expedition seems like a sure bet. Of course, I would check through other days and hours too, to see how long the good weather will last, and whether I'll have problems during the drive. With a long trip planned, I could be examining the GFS model for ten or more days into the future.

Hold on. Just how good is this model, or any other, $5\frac{1}{2}$ days into the future? As it turns out, 5 or 6 days out is probably pretty reliable in this case because the weather pattern I am using as an example is so benign. Eight days is getting a bit dicey, and the 15-day forecast is almost certainly going to require major adjustments. Models can't see thunderstorms very well into the

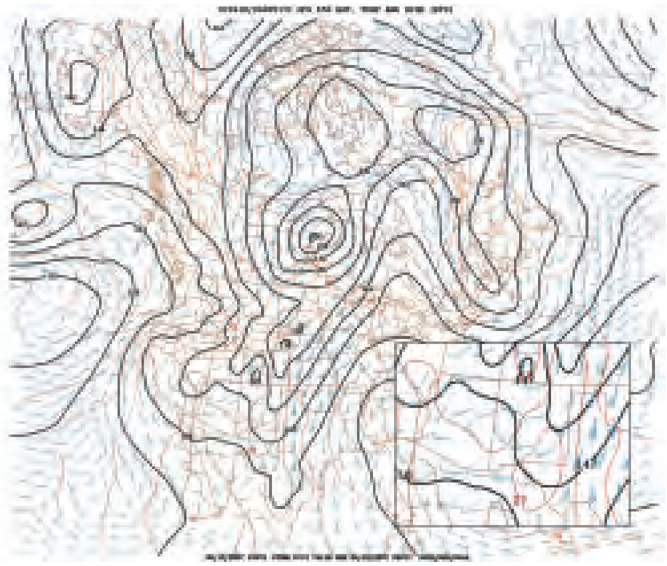


Figure 5: The 850-mb pressure level. Level heights are contoured with dark black lines. Temperatures are shown using fine red lines. Blue wind barbs reveal the wind field. The inset is an enlargement over the Arizona area.

future for instance, and the predicted quiet weather could be quite different when the day finally arrives. So we have a bit of a dilemma here: how do we evaluate the reliability of the model?

Two strategies can be used. The first is to compare the GFS model with another. For our five-day forecast, we can take a look at the Global model from CMC. Most of the meteorological models available from various institutions display the same elements on the same pressure levels, so it's a relatively easy process to compare the 700-mb chart from NCEP with a 700-mb chart from CMC. Figure 6 shows the two 120-hour precipitation forecasts from the GFS and Global models. While both agree in keeping Arizona dry, there are significant differences over west Texas and in the rainfall south of the Great Lakes. While I don't know which one will be correct, we'll accept the lowest risk and plan on going to Arizona, where they agree.

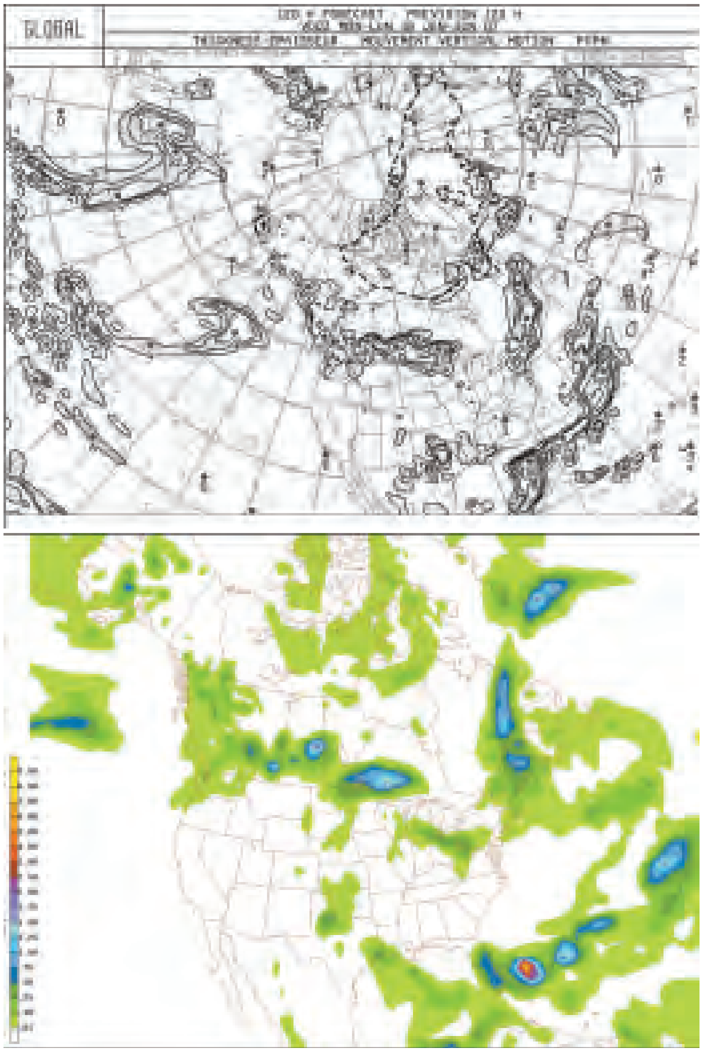


Figure 6 — A comparison of the precipitation fields forecast at 120 hours by the Global model (above) and the GFS model (below). Each chart shows the preceding 12-hour forecast rainfalls. Amounts shown on the Global model chart are in mm; those on the GFS chart are in inches.

The second strategy is to wait a day and take a look at the GFS model or whichever one being used, and see if it is still forecasting the same pattern. You will probably be surprised (or perhaps not) how much a five-day forecast can change when it becomes a four-day forecast, but once again, look for common elements that seem to be stable, and make flexible long-range plans to take advantage of the possibilities. While this seems like a bit of a lame strategy, especially if the models don't settle down until the weather is only a day away, the contingency planning will very likely increase your chances of success by giving you alternative possibilities. At some point, likely around three days, the models will stabilize and come together, and planning will become more certain. The important point is not to make firm decisions on travel and equipment until the latest possible moment, but use earlier model runs to develop a set of contingency plans.

There are many models — American, Canadian, European of every stripe, Russian, Chinese, Australian, and so on. Some are easy to find, some are not (Russian and Chinese are a challenge). It's best to stick to a few favourite Web addresses unless you are quite practiced at deciphering these numerical oracles. Unisys has a pretty good site (`http://weather.unisys.com/index.html`) that provides access to several U.S. and one European model, and, if you click on the GFS tab, you'll find that model coverage is available for much of the globe. You'll have to explore the site, as there is just too much in it to show here.

Today, Tomorrow, Tonight: Short-Range Forecasting

Forty-eight hours is the bailiwick of the Clear Sky Clock. In fact the CSC and its presentation of cloudiness and transparency is so convenient that there is a temptation to quit looking at other models altogether. Clouds modelled in the CSC are the integration of all of the atmospheric moisture in the Regional model, and there is no longer a need to tease out probabilities based on the 700-mb relative humidity. The modelling "home" of the Clear Sky Clock is at the Canadian Meteorological Centre (`www.weatheroffice.gc.ca/astro/index_e.html`) where maps and animations of North America showing the numerical forecasts of cloudiness are available. The maps are also accessible by clicking on the hourly cloud rectangles on the CSC display.

Anecdotal reports suggest that the CSC is accurate about 70% to 80% of the time. Usually the error is in the timing of the arrival or departure of cloudy skies, a problem that originates with the Regional model. For this reason it is sometimes useful to compare the 700-mb chart from the Regional with those from another model, a process that might reveal some upcoming problems before they arrive. Now that we are forecasting for only a day or two, new models can be tapped for information. In addition to the high-resolution Regional model, the NCEP site provides the NAM (North American Model). You will notice right off that it seems to have more detail than the GFS model.

The CSC (via the Regional model) has problems with low-level clouds, fog, and thunderstorms, and with the timing of onsets and endings generally, in large part because cloud edges are fuzzy rather than sharply delineated. As we approach the time for our expedition (even if it's into the back yard), it is time to replace model data with the real thing — satellite imagery.

Satellites observe in both visible and infrared (IR) wavelengths. For nighttime, only the IR will be useful, though daytime visible-light images can show the cloud structure ahead of nightfall in finer detail. My favourite site for satellite images is that hosted by the College of DuPage. They have an active meteorology department that conducts several storm chases during the summer months (yes, you can join them in their chases, for a relatively small cost of about $800 to $900 US). In support of these chases, they maintain a very good Web page for satellite imagery (`weather.cod.edu/analysis`).

Infrared radiances detected by the satellite sensors are thermal emissions from clouds, ground, and atmospheric gases — in other words, they show the blackbody temperatures of structures in the atmosphere and on the surface. The satellite images usually show cold stuff as white or shades of light grey, and warm stuff as dark grey or black. It's relatively easy to distinguish high and low clouds by their shade of grey, as high-level stuff is usually pretty cold. The College of DuPage also offers colour-enhanced infrared images on their Web page, and the temperatures are shown in a scale on the right side of the page if you really need to know.

If there is no temperature difference between cloud layers, or between low cloud and the ground, then the satellite will show them as having the same shade of grey and they will become indistinguishable. This is a problem for fog detection, as fog is so close to the ground that it typically has little presence in a satellite image. That aside, the infrared satellite imagery is directly comparable to the cloud maps that come from the Regional model via the Clear Sky Clock, because the model calculates the emitted radiances in the 10-µm band where the satellite sensors operate. The satellite images can be used to check up on the Regional model on an hour-by-hour basis, and short-range adjustments can be made in the CSC where appropriate.

In Figure 7, we see a side-by-side comparison (shown here stacked for readability and space considerations) of the 25-hour pseudo-satellite forecast from the Regional model and the verifying satellite image. The clearing over southern Manitoba is progressing more slowly than predicted, and the pattern is not quite correct over Wyoming and Utah. On the other hand, the leading edge of the frontal band south of the Great Lakes appears to be pretty accurate. The model errors can usually be extrapolated for a few hours into the future to improve the timing of the CSC.

A word of caution is appropriate here. The satellite images are real-time; they reflect what is happening now. The CSC and Regional model predictions are predictions of a future event, and sometimes they "see" something we can't. At times, the predicted clear skies turn out to be right, in spite of the appearance of the satellite images and the animation loops. Keep a close eye on the trends in cloudiness as well as the movement of cloud patches when you are second-guessing the Clear Sky Clock.

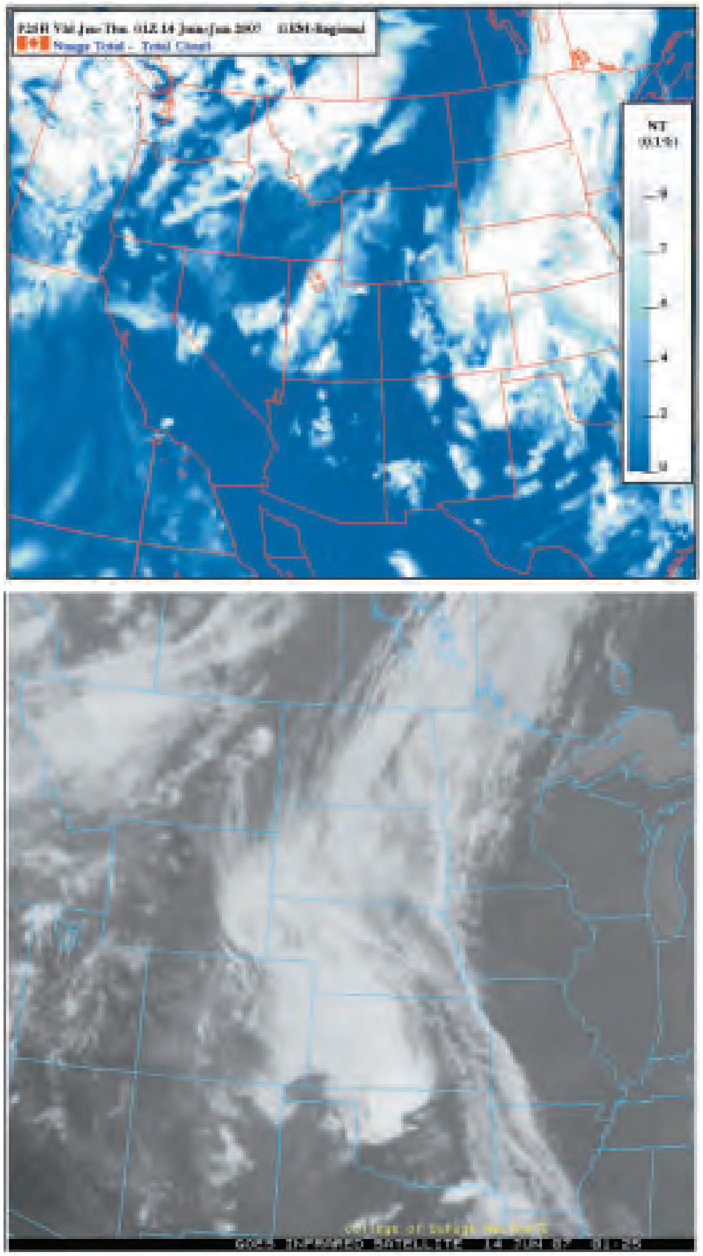


Figure 7— A comparison of a 25-hour forecast of cloud cover by the Regional model (used to produce the Clear Sky Clock) and the verifying infrared satellite image.

The CSC output also includes a forecast of sky transparency. Transparency is directly related to the amount of moisture in the atmosphere, and satellite imagery can help us out here too. Some infrared wavelengths are strongly absorbed by water vapour, and emissions that reach the satellite can only come from the middle and high levels of the troposphere. These radiances are collected to form water vapour images of the atmosphere. They are especially helpful in that they show moisture levels in both clear and cloudy skies, and thus reflect the transparency we will see when we finally get the cap off the telescope. High-moisture areas are given lighter tones in water-vapour images, and dry areas are coloured in dark tones. Water-vapour images available from the College of DuPage use red to show the driest areas, and blue the wettest. There is a very strong correlation between cloud and water vapour, of course, but you will be able to assess the transparency of your skies in the clear areas by a look at these images (Figure 8). They are beautiful images, especially when animated, and are wonderfully useful.

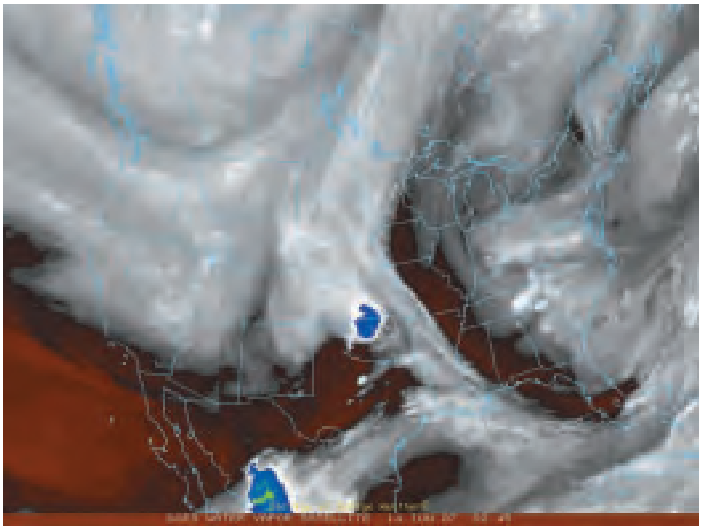


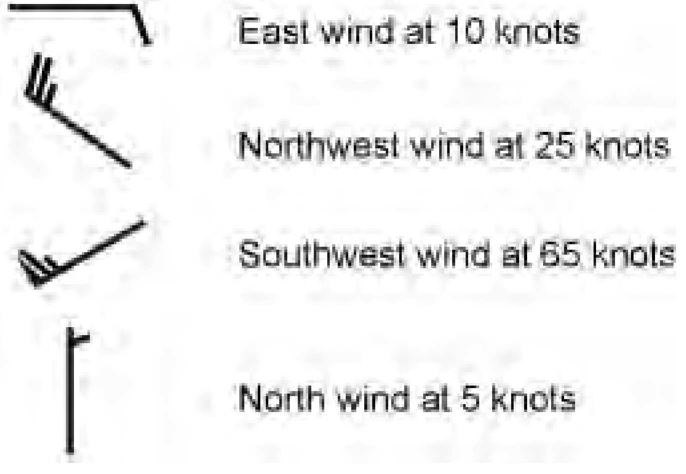
Figure 8 — A water-vapour image taken about one hour after the right-hand image in Figure 7. Dark and reddish areas have little water vapour through the upper troposphere; skies will usually be very transparent in these regions. Increasing amounts of water vapour are depicted as increasing bright regions. Blue-coloured areas are very moist and are likely the top of thunderstorms.

In Figure 8, there is a very dry region stretching from the tip of Lake Superior to Florida. Observing in this region — over Iowa for instance — would be very good, with deep transparent skies. Just to the east of the darkest region, across Wisconsin and Illinois, skies are still clear (see Figure 7), but now we have a thin haze of greyness indicating that there is a small amount of moisture in the upper atmosphere. While skies will still be very good there, they will not have the clarity of those a hundred kilometres to the west. Transparency as good as that over Iowa demands really deep astrophotography, or a search for the most-challenging visual objects. The CSC may point the way, but the satellite images will lock in your forecast for the night.

As I write this article, a burst of email traffic reminds me of a daylight grazing-occultation of Regulus coming up in the evening, four days from now. Environment Canada's fifth-day forecast is simply "sunny." The Global model shows that the day may indeed be sunny, but the evening will be invaded by considerable cloudiness from the south and west. The graze track runs to the NNW past Winnipeg and it might just be possible to squeeze in a view by going north, if the cloud arrives as scheduled.

The 108-hour forecast chart from the GFS model also brings in evening cloud on the day of the graze, but more from the west than the south, promising better conditions near the U.S. border. Both models agree that staying in Winnipeg is not likely to work out, so I'd better plan on collecting my gear together and loading the van. I'll keep an eye on the model updates, and make a preliminary decision on the site in two days, when the reach of the GFS and Regional models extends to the graze date. The Clear Sky Clock will help when we reach two days out, but final movements will be dictated by the satellite observations. Now where the heck is the Web cam?

Jay Anderson is a meteorologist, eclipse chaser, and the Editor of this Journal. *He went south and saw the graze.*



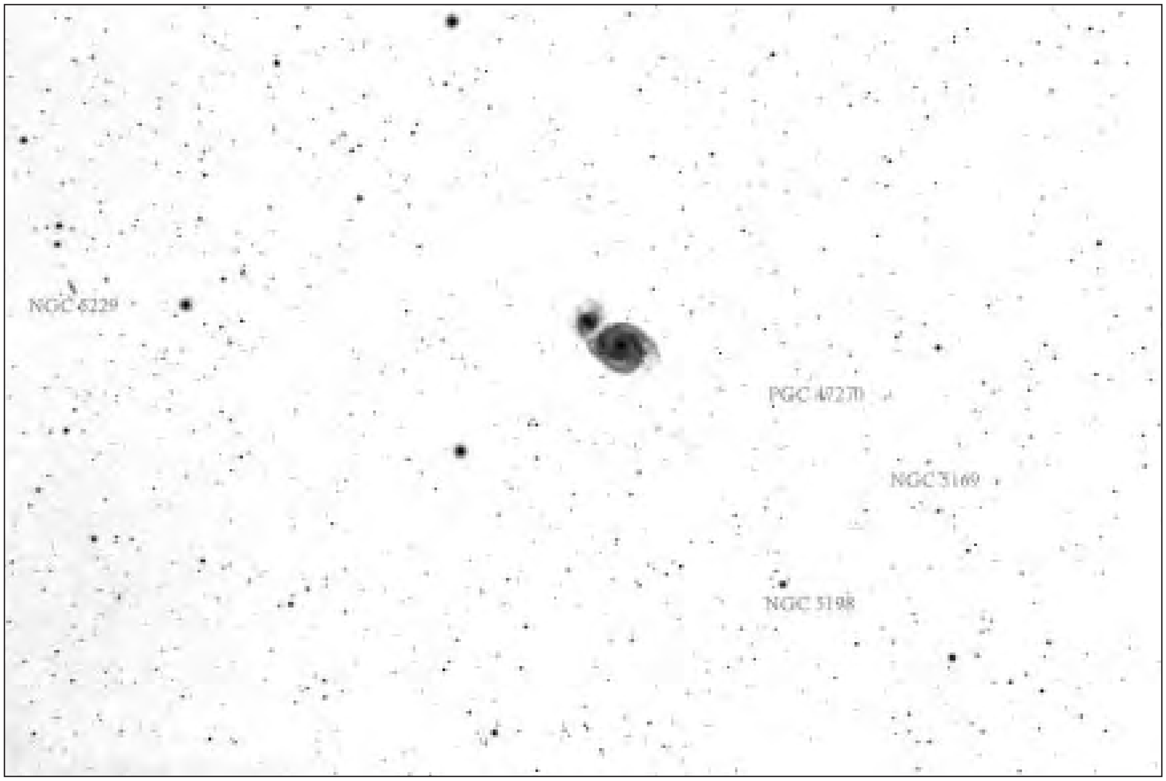
Winds are depicted in weather charts by the use of wind barbs that indicate both direction and speed. Winds are always shown according to the direction from which they blow, and the standard unit is the knot, or nautical mile per hour (1.9 km/h). A long barb on the tail of the wind symbol represents 10 knots, and a short barb, 5 knots, so that the total wind is determined by adding the barbs together. Increments of 50 knots are indicated by a filled triangle in place of the single barb.

A Spectacular Solar Eclipse Image

This image, created by Miloslav Druckmüller of the Czech Republic, may be the best solar-eclipse photograph ever taken. It shows 220 stars and the solar corona up to 13 solar radii; the extent of the solar corona and the visibility of the dark Moon's surface is beyond the capability of human vision. It was created from 231 images taken by him and Peter Aniol (Germany) in Libya during total solar eclipse on 2006 March 29. Images from five computer-controlled Canon EOS 5D cameras with lenses ranging from 200 mm to 1640 mm. Druckmüller used his own specialized software for the complete processing. The work on this particular image took him, with breaks, nearly one year. Druckmüller's work has become legendary in eclipse-chasing circles. His Web site at `www.zam.fme.vutbr.cz/~druck/Eclipse/index.htm` displays many more spectacular eclipse images.

Victoria Centre Photos

Jim Cliffe of the Victoria Centre caught this image of Comet McNaught as it set over the forest horizon. He notes that "Overcast skies blocked any views of the comet until practically the last day it was visible. I took my camera (an Olympus E-500 DSLR) to work with me and set up as the Sun set around 17:00. It felt like arctic cold, being right beside the salt water, but the pictures were worth it." In this image, the tail stretches nearly to the top of the frame.



Victoria Centre's John McDonald sent us normal and inverted copies of this wide-field image of M51 and its surroundings, but he prefers this view because of its ability to show faint objects more distinctly. This photo was taken from his backyard in April using a Canon 30D DSLR camera, a 0.8× focal reducer, and a Williams Optics 105-mm telescope. He has identified the fainter galaxies in the field.

Raymond Koenig, Founding Member of Kitchener-Waterloo Centre

by Alen Koebel, Kitchener-Waterloo Centre (akoebel@rogers.com)

Raymond Koenig, a founding member of the K-W Centre, passed away on April 1, 2007 at the age of 76, following a lengthy illness.

Ray was a physics professor at Wilfred Laurier University (WLU) in Waterloo, Ontario, where he had been teaching since 1963. He was one of the first full-time science professors there, having joined the faculty when the institution was known as Waterloo Lutheran University. In fact, several of the current professors in the Physics and Computer Science Department were hired by Ray.

Ray was best known at WLU for teaching astronomy. His classes were always well attended. Greatly respected as an educator, his colleagues at WLU have described him as tenacious and highly moral. They also say he was hard-nosed but fair with his students. Being involved in astronomy on both the amateur and professional levels, Ray naturally kept up with developments in the field. According to his colleagues, he had a special research interest in spectral analysis. He was also keen on the history of astronomy and could talk at length from memory about great astronomers like Galileo and Kepler.

Ray was a mentor to many individuals at WLU and in the K-W Centre over the years. His obvious passion for astronomy inspired many past and present club members to learn more about the Universe. As John Beingessner, a former President of the club, remarked "He's one of the reasons I got interested in astronomy in the first place. I took his first year astronomy course in 1981, and that kindled a long-time interest that I still have."

Ray had been many times the President of both the K-W Centre and its predecessor, the Grand Valley Astronomers (GVA), the club that became the 19th Centre of the RASC in 1980. Ray can rightly be considered one of the founders of the K-W Centre, since it was largely his arguments for the benefits of membership that lead to the GVA's transformation into a RASC Centre.

The GVA's roots go all the way back to 1952, when it was founded by Carl Arndt under a different name. As best as can be determined, Ray joined the club around 1969 or 1970. Shortly thereafter he arranged for club meetings to be held at WLU on a nearly permanent basis (they're still being held there!). Construction of the club's observatory near Ayr, Ontario, which started in 1974, also occurred under Ray's leadership.

During his years in the club, Ray was an avid astrophotographer. As far back as the early '70s, long before personal computers, CCDs, or digital cameras, Ray was taking outstanding celestial photographs on colour film, a challenging undertaking at best. He was quick to recognize superior equipment when he saw it, purchasing a Celestron C8 Schmidt-Cassegrain telescope and an Olympus OM-1 35-mm SLR camera shortly after they were introduced. He also acquired one of Celestron's legendary 5.5-inch f/1.65 Schmidt cameras.

Ray was also something of an eclipse chaser, although he wasn't obsessive about it. He visited Gimli, Manitoba in 1979 and the Baja peninsula in 1991, to witness the total solar eclipses viewable from those locations. Totality for the latter event was almost seven minutes — nearly as long as it can be. It must have been glorious, but Ray didn't let the experience turn him into an eclipse fanatic.

To honour Ray's memory, WLU has established the Raymond Koenig Physics Award. Donations to the award can be directed to the Physics and Computer Science Department at WLU or through the K-W Centre.

Sketching the Sky

by Bill Weir, Victoria Centre (wcweir@telus.net)

There are many times that I feel somewhat out of the loop as I head out with my simple Dobsonian telescope, sketchpad, and box of pencils. All around me at the Victoria Centre, people are buying fancy digital cameras, fine apochromatic refractors, and the latest in digital-processing software. Myself, I'm happy when I get a nice, new, clean eraser.

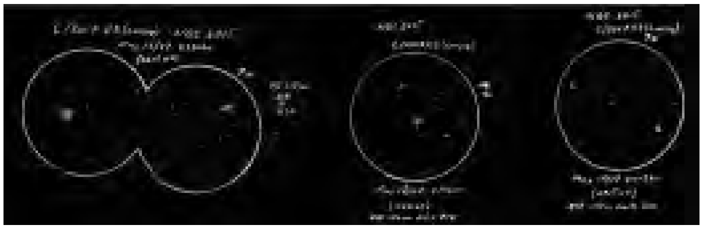


Figure 1— Comet C/2007 E2 (Lovejoy) as seen over the three consecutive nights of 2007 May 16-18, as it passed by the galaxy NGC 6015 in Draco. Two different telescopes and three different magnifications were used to maintain the two objects within the same field of view. Inversion of scanned sketch.

My sketching started out simply enough with a desire to improve my visual observing. Sometimes it was simply about field identification, when I wanted to be sure of the object that I was seeing. Mostly what I enjoy now is documenting the progression of celestial events. The progression sketches are often somewhat quick and dirty as I tend not to touch them up, or, if I do, the correction is minimal. I like them to stay as they were when created at the eyepiece. For publication to the Internet, I will often invert the scan of the sketches, then place them side-by-side as a single image. I feel that the inversion often very closely represents the appearance at the eyepiece.

Comets provide great material for these sketches. Just this past May, the insignificant and rather faint comet C/2007 (Lovejoy) happened to pass right by the equally unimpressive galaxy NGC 6015 (Figure 1). Surprisingly, the two together actually made quite an interesting sight, as they were similar in size and magnitude. Observing conditions were iffy for two of the three nights that the two objects were close enough to be observed in the same field of view. Because it is a simple task to carry my small Dob and a sketch pad out to take advantage of momentary breaks in the clouds, it was easy to capture the event on all three nights. The daunting task of having to set up an imaging platform would have probably made me question the project. Now that this particular project is done, I feel I have a document that demonstrates well how quickly a comet moves through a star field.

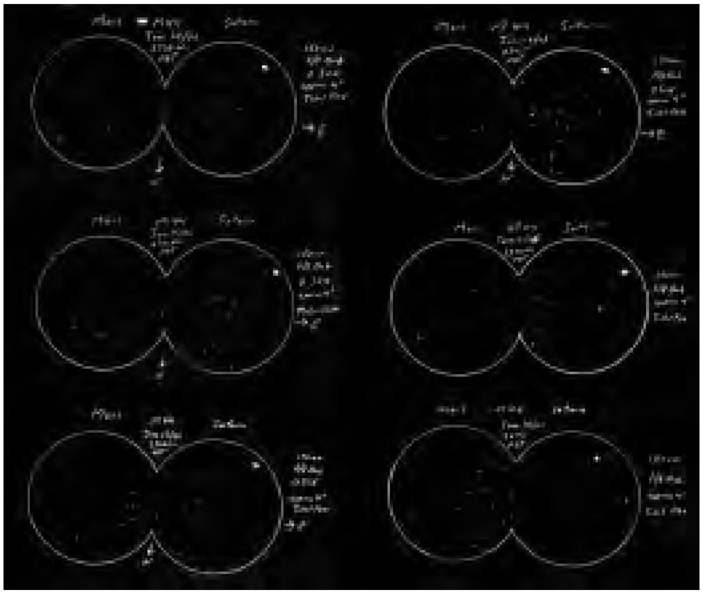


Figure 2: Mars, M44, Saturn Conjunction. Six sketches that were done between the dates of 2006 June 10-18, as viewed through an f/8 6-inch Dobsonian telescope at 30x magnification. Inversion of scanned sketch.

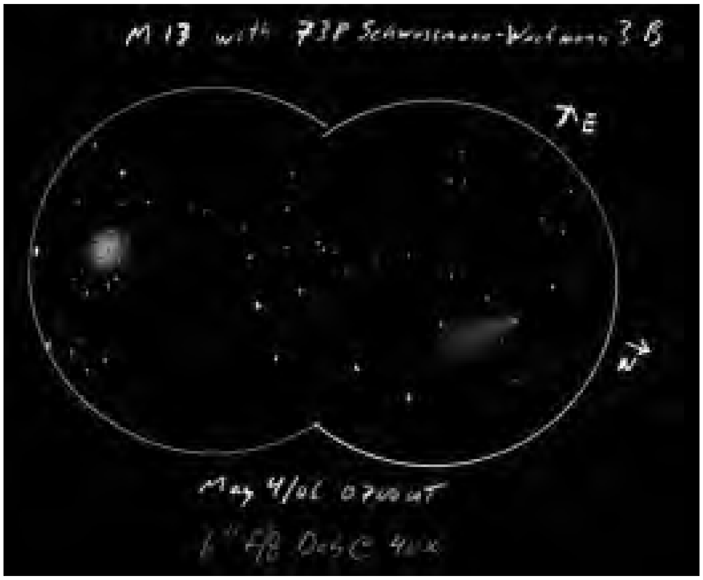


Figure 3 — Comet 73P Schwassmann-Wachmann 3B as it passed by M13 as viewed through an f/8 6-inch Dobsonian telescope at 40x magnification. Inversion of scanned sketch.

Figure 4 —The complete surface of Mars sketch is a composite of over a dozen sketches done around its 2005 opposition.

In 2006, there were two wonderful events that allowed me to sketch the progression of astronomical objects. My favorite was in mid-June, when Mars and Saturn both met and passed by each other in the vicinity of M44 (the Beehive Cluster). Over an eight-night period, I managed a total of six sketches that chronicled the event (Figure 2).

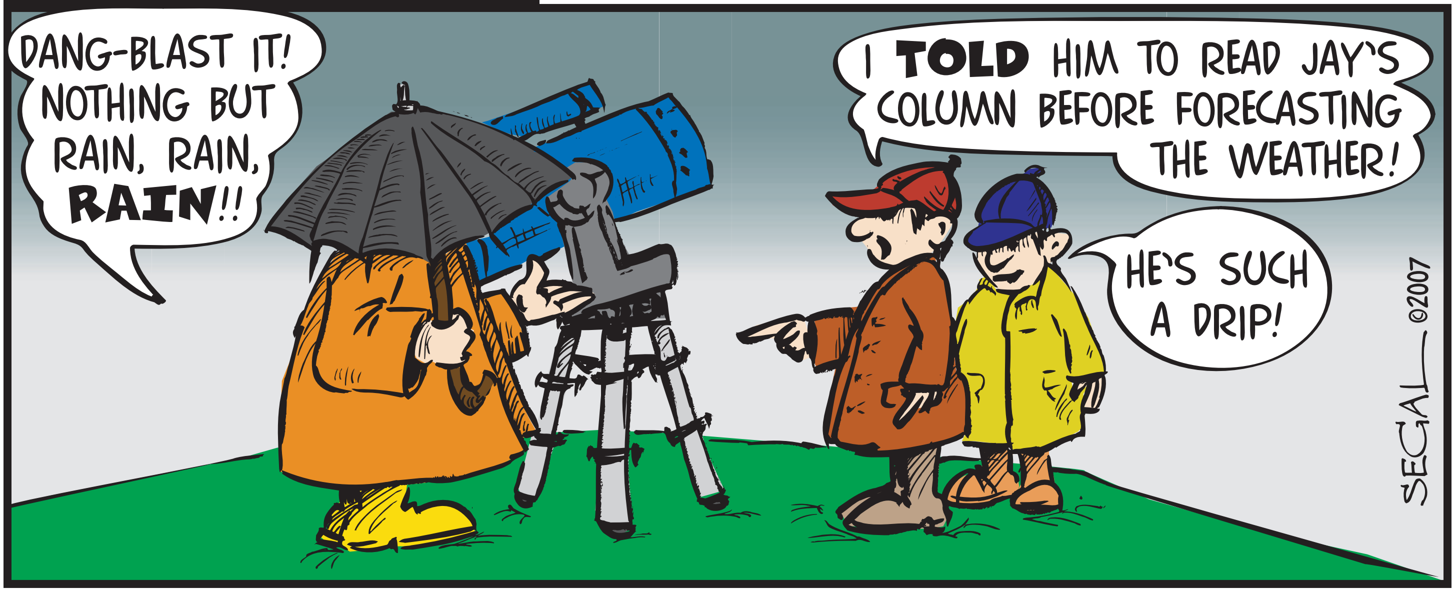
The other fabulous sketching opportunity of 2006 revolved around the wonderful fractured comet 73P Schwassmann-Wachmann. The ever-changing characteristic of the two brightest components provided ample fodder for my pencils and paper. I even managed to capture both moments when they were in the vicinities of M13 and M57. [Figure 3]

Sketching the planets has also been an area that I've worked on. In 2005, I took on the task of trying to sketch as much of the surface of Mars as possible. Out of over a dozen sketches I was able to compile a linear map of the complete visible surface of Mars. I did this in memory of the late Victoria Centre member Ernie Pfannenschmidt. Ernie had been an avid observer of Mars and had accomplished a similar map in 1950. [Figure 4]

Sketching may not be as flashy or as sexy as modern astro-imaging, but I still feel that it has plenty to contribute to the hobby. If anything, it is certainly more affordable.

Bill Weir has been a member of the Victoria Centre for nine years. He lives, observes, and sketches from his reasonably dark-sky, rural community of Metchosin, on the very southern tip of Vancouver Island. It's all about location, location, location.

ANOTHER SIDE OF RELATIVITY



Lynne’s Scope

by Ron Berard, Winnipeg Centre (rcberard@gmail.com)

I have a touching story to share. It speaks a good deal about how our efforts to reach out to the public affect people in meaningful ways — ways that we might not have expected. I received a call at about 8:30 one evening. It was a woman. I couldn’t quite tell her age, but she sounded just a touch nervous. After politely explaining that she was referred to me by Scott Young, she quickly came to the point — that she had a telescope to donate.

“A very nice one! I can assure you, it’s a good-quality one.”

“Goodness, thank you!” I exclaimed, surprised by her promptness. “And who might I be speaking to?” She hadn’t even introduced herself at this point.

She apologized and quickly gave me her particulars as if being mindful of my time. The surname was not familiar at all, and she hadn’t mentioned that the telescope belonged to a former member as is often the case with donations. In fact, she never once alluded to her motives at all, but I sensed a slight tension in her voice, that there was something special behind her gesture. As tactfully as I could, I asked what might have moved her to donate the telescope to our club.

She replied “Oh, the story behind the telescope is very short. You see, about nine years ago, my daughter was dying. She wanted so much to have a telescope. So we bought her this telescope. It’s a very good one. I can read the name to you?”

I hear papers rustle in the background.

“Oh no, its not here. But I can go downstairs to tell you the name on the telescope.”

I was dumbfounded at this point that she would think she had to convince me it was a worthy scope to accept. I could actually hear her feet going down the stairs.

“It’s an Om-con. Is that a good one?”

I didn’t ask for further details. I told her it was a very good scope, that I was touched by the story, and honoured to accept the donation on behalf of the club. I thanked her profusely. I then gathered my nerve, and asked her if her daughter got to look through it.

“No,” she replied. “But she got to see it, and jumped up and down about it. She reeeally wanted that telescope, so we got her a good one.”

Lynne Lanctot

There was a slight pause. “I had been looking for a good home for it. A friend of mine saw your display at The Forks, and I could see that you people would use it properly.” I assured her we would, and we went on to arrange a meeting for the exchange. I don’t care how big the aperture, or how good the optics, this telescope has already given me the best possible kind of view — perspective!

Since then, we have decided to plan for a dedication of this telescope as a symbolic gesture to the original owner. Her name was Lynne Lanctot; she died nine years ago, three weeks after her birthday. It was her final birthday wish, so we have decided that it is still her telescope, and it shall be known as “Lynne’s Scope.”

WEB ACCESS TO THE 2007 ISSUES OF THE *JRASC*

The 2007 issues of the *Journal* can be accessed from the RASC Web site at `www.rasc.ca/currentjrasc`. Issues are posted immediately after the final production version is complete. Username and password are sent by email to RASC members.

A Lunar Observatory?

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

Telescopes on the Moon have been a staple of science fiction almost since the genre was created. During the heady late-1960s, as the *Apollo* program was reaching its climax, many people predicted that there would soon be a permanent lunar colony, including an observatory. There is as yet no permanent colony, but there are some interesting new developments in plans for a potential observatory. Ermanno Borra, of Laval University in Québec, and his colleagues have successfully coated an ionic liquid with silver — an achievement that could be the basis for a rotating liquid-mirror telescope operating in the optical and infrared (see the June 21 issue of *Nature*). Potentially, such a mirror could be 100× to 1000× more sensitive than the *James Webb Space Telescope* now under construction. A liquid/silver mirror could be anywhere from 20m in diameter to a very ambitious — but very capable — 100m.

The general idea of a rotating liquid mirror on the Moon is not new (Borra himself proposed a spinning metal-alloy mirror in the early '90s), but coming up with one that could work in the infrared is new. Since the time of the *Infrared Astronomical Satellite (IRAS)* in the early-mid-'80s, it has become increasingly clear that the infrared is where the astronomical "action" lies. However, observing in the infrared requires that the mirrors be cold; otherwise, thermal heat from the instrument will drown out the faint signals. In order for a lunar telescope to be useful in the infrared, the optics must be at a temperature of <130° K. The preferred location is at the lunar poles. (There is also some wishful thinking about the presence of water ice in a permanently shaded crater near the lunar south pole, but I won't get into that here.)

The immediate challenge then becomes one of figuring out what kind of liquid would be stable in a vacuum at the required temperature. An ionic liquid is one where almost all of the molecules are ionized. This gives it extremely low volatility, suitable for working in a vacuum. Borra and his colleagues used the liquid 1-ethyl-3methylimidazolium ethylsufate, which solidifies at 175 K, for their experiments. They coated the liquid with chromium and then with a layer of silver. The layers appear stable on a timescale of months. Although the particular ionic liquid used in the experiments solidifies at too high a temperature to be useful for an infrared telescope, Borra is confident that a suitable one can be synthesized for use on the Moon, given the large number of available ionic liquids.

But how far towards a real lunar observatory does this get us? As is usual when NASA and its money are involved, it's hard to separate hype from fact. First of all, take a look at the "back to the Moon" initiative at NASA, which is trying to do better than *Apollo* with essentially no new money. Let's say that the return will cost ~$200 billion (the original *Apollo* program cost more than $300 billion in today's dollars). In order to achieve the target date of 2018, that means something like an average of $18 billion will need to be spent each year over the next 11 years. NASA's current budget is about $16 billion, and it does many things other than the return to the Moon (the biggest drain right now is the *Shuttle* and the *Space Station,* which together take up about half of NASA's budget). But let's suppose that the return does happen, with the establishment of a small permanent base by 2020.

The mass of the ionic liquid is considerable in its own right, even putting aside the backup structure, the superconducting elements needed to make the spinning frictionless, and so on. Even if the layer of liquid is kept to be only 0.5-mm thick, that's still ~4000 litres, with a mass of about 4000 kg, that has to be boosted into space! The usual cost quoted to low-Earth orbit is ~$25,000 per kg, so the transport cost for the liquid alone would be at least $100 million for a 100-m mirror (a 20-m mirror would of course be a factor of 25 less mass for the liquid). While Borra makes a case that the incremental cost of adding an observatory to an existing permanent base is small (I would agree with that), in absolute terms, it is still a lot of money that will have to be diverted from somewhere else.

Would the spinning-liquid approach have cost and other advantages over other schemes, such as a thin sheet of Mylar, or a deployable mirror that opens up like petals on a flower? That's where a hard-headed engineering analysis is needed. Direct comparisons of costs, difficulty of fitting materials into the available launch vehicles, and technical readiness for the major subsystems all need to be compared for the proposed telescopes. There are also operational questions: how rapidly will dust settle on any lunar mirror for instance? If the mirror needs to be cleaned each year, will the ionic liquid need to drained and filtered? Any astronomer reading Borra's paper will have these and other questions in mind.

Yet, we cannot let ourselves be so convinced that a project is impossible that we cease to think about ways around the problems. Simon Newcomb, a Canadian-born Harvard astronomer, famously wrote in October 1903 that a mechanical flying machine seemed very improbable. Less than six weeks later he was shown to be wrong by the Wright brothers. So, while my head tells me not to hold my breath for a lunar observatory, my heart hopes that I will see it happen. ◆

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

Deep-Sky Contemplations

Dusty Galaxies

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

The subject of the previous two columns in this series was dust in *our* galaxy, manifest as reflection nebulae and as obscuration of distant stars by nearby dark nebulae. In addition to those concentrations of interstellar dust, passing reference was made to the general distribution of dust throughout the plane of the galaxy. As has been true of all efforts to map the large-scale structure of our galaxy, the determination of the nature and distribution of the interstellar dust has been made especially difficult by the simple — and unavoidable — fact of our location within the galaxy. How much easier it would be to answer questions about galactic structure if we could step outside its boundaries and look back.

In order to understand the structure and dynamics of our galaxy, we have often taken advantage of the fact that it is in no way extraordinary. Many other galaxies can serve as analogues to the Milky Way. The presence of interstellar dust in other galaxies is at least suggested by visual observations of them, and is apparent in deep images. Any telescope with sufficient light-gathering power to reveal spiral structure in bright galaxies such as M31 and M51 may reveal, as well, the lumpiness of the arms. Much of that lumpiness is due to discrete *luminous* objects, including HII regions, star clusters, and stellar associations; some, however, is due to the uneven distribution of clouds of *dark* interstellar dust.

We know that dust is especially prominent in spiral galaxies that are viewed edge-on. When observed from the side, the most striking feature of a spiral galaxy is often the dust in its central plane. Two examples that are conveniently located for observing during the second half of the calendar year are described here. (Three others, suitable for observing in the New Year, will be featured in a later column in this series.)

NGC 891 [RA(2000) = 2^h 22.6^m, DEC(2000) = +42° 21′, V = 9.9, 13.1′ × 2.8′] [Figures 1a & 1b] could serve as the prototype of the classical edge-on spiral. The dark layer of dust in its plane of symmetry almost perfectly bisects the glow from stars that are distributed above and below the plane. Discovered by William Herschel in October 1784, NGC 891 is located in Andromeda at a distance of approximately three megaparsecs (Mpc). Having the same declination as Gamma Andromedae, NGC 891 is most easily found by centring on that star and sweeping eastward 3.5 degrees. NGC 891 is in a cluster of galaxies having a dozen or so members.

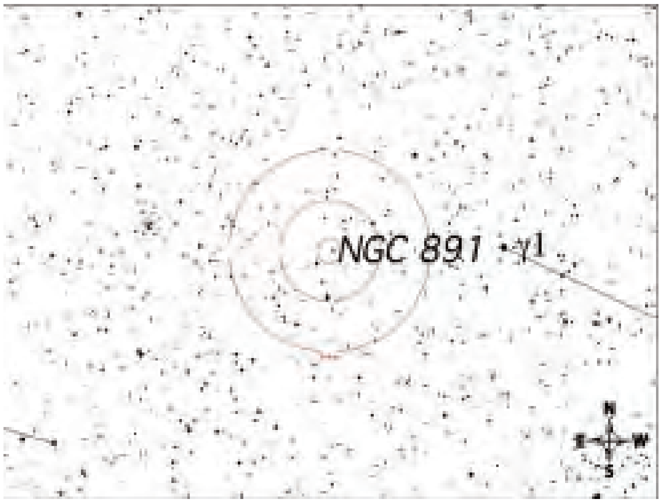


Figure 1a — Finder chart for NGC 891 is shown with Gamma Andromedae and 0.5°, 2°, and 4° Telrad circles.

Figure 1b — 50´ × 50´ image from the POSS centred on NGC 891.

NGC 1055 [RA(2000) = 2^h 41.8^m, DEC(2000) = +0° 27´, V = 10.6, 7.6´ × 3.0´] [Figures 2a & 2b] is very slightly tipped out of the line-of-sight so that the obscuring band of dust does not precisely bisect the glow from the galaxy's stars. That slight difference from NGC 891 is a feature for which one should look. NGC 1055 is located in Cetus at a distance of approximately 15 Mpcs. Given that the surface brightness of an extended object is constant with distance, and given that this galaxy is approximately five times more distant than NGC 891, yet is smaller in its greatest apparent linear dimension by less than a factor of two, it follows that NGC 1055 is the intrinsically larger of the two. NGC 1055 is one of approximately six galaxies that form a cluster of which M77, a face-on spiral, is the dominant member. NGC 1055 forms an attractive equilateral triangle with a star of apparent magnitude 6.7 and another of magnitude 7.6.

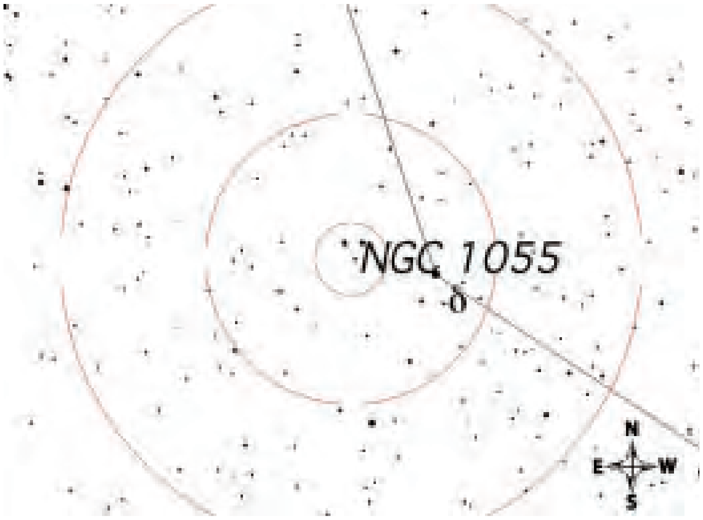


Figure 2a — Finder chart for NGC 1055 shown with Delta Cetus and 0.5°, 2°, and 4° Telrad circles.

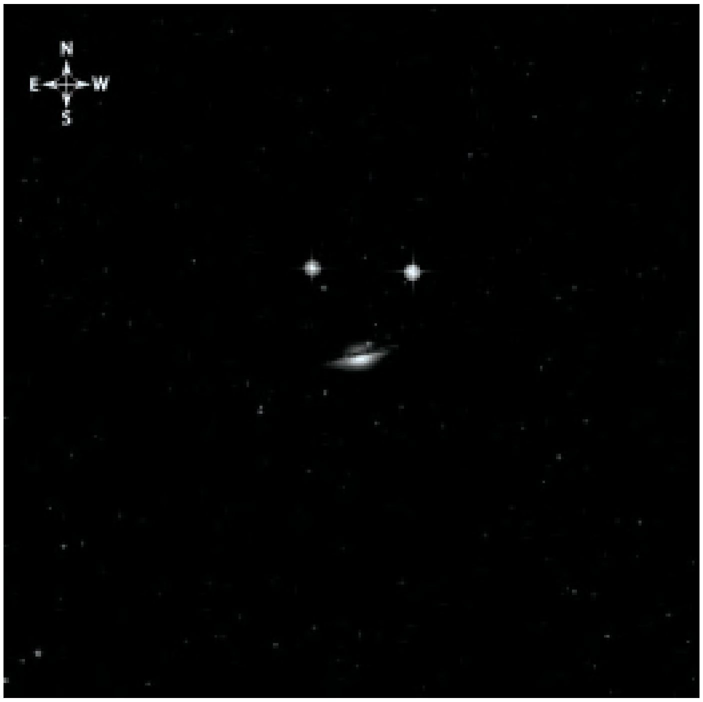


Figure 2b — 50´ × 50´ image from the POSS centred on NGC 1055.

Because we are observers external to NGC 891 and NGC 1055, the dust within those two galaxies prevents us — even using the best available optical telescopes — from observing a star located within them in a position equivalent to that of the Sun within the Milky Way. Reversing the argument, from our position within the Milky Way we cannot observe external galaxies located in directions that coincide with the dusty band of our galaxy. That region was known in the past — with reference to spiral nebulae — as the *zone of avoidance*, a term that has all but disappeared from the astronomer's lexicon.

Doug Hube is a professional astronomer actively retired from the University of Alberta, and Associate Editor of this Journal. *Warren Finlay is the author of "Concise Catalog of Deep-Sky Objects: Astrophysical Information for 500 Galaxies, Clusters and Nebulae" (Springer, 2003), and is a professor of engineering at the University of Alberta.*

Starting Out – Great Expectations

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

Your brand-new telescope arrived today, and you put all the pieces together. What are you going to look at tonight?

Most new-telescope owners have a set of expectations in mind as they prepare for their first night under the stars, but often those expectations are quite wrong. Frequently, the expectations are too high, based on pictures they have seen in books — even the pictures on the box in which the telescope arrived — but they can also be way too low, based on what others have told them about light pollution.

Low Expectations

I sometimes hear people say that there is no point in buying a telescope, since it won't show you anything in your typical city sky because the light pollution is so severe. Nothing could be further from the truth. Though light pollution hampers certain areas of observation that depend on dark skies, there are many things to see from under even the most blighted urban sky. First and foremost, the Sun, Moon, and planets are just as beautiful in the city as anywhere else. In winter, nearby chimneys may cause unstable or blurred images, known as "poor seeing," but those affect only a few spots within the whole sky, and cease to be a problem in milder weather when furnaces are turned off.

What can you see of our Solar System in a typical amateur telescope? Lots! With the help of a solar filter that fits over the front of the telescope, you can safely view the surface of our local star. Most noticeable are sunspots: ink-black cool regions (called umbra) on the Sun's surface that typically are surrounded by medium-grey halos (called penumbra). Sunspots are often found in groups, and over daily intervals, change their shapes and orientations as they drift across the solar surface with the Sun's slow rotation. With good resolution, you can also see granulation — the actual convective cells on the surface of the Sun, bringing up heat and energy from the depths. Granulation is in constant motion, like water bubbling in a pot, except that it takes place over a period of several minutes.

The Moon is a spectacular object in *every* telescope. Where else can you study the details of an alien, airless world, watching the changing pattern of bright light and dark shadows across a fantastic landscape of mountains, valleys, and craters? Craters, a topographic form only rarely seen on Earth, come in a multitude of sizes and shapes. Watching the sunrise shadows as they cross a 200-kilometre-diameter crater is an awesome spectacle, yet one available almost any night to a telescope owner. Use as high a magnification as your telescope can handle; the Moon can usually reveal detail at any level. High magnifications also dilute the Moon's bright light, making the view easier on the eye and more satisfying than the view through a greenish "Moon filter."

All of the planets are visible in any telescope. Mercury and Mars will usually disappoint in a small telescope, as they only reveal fine detail in larger amateur instruments. Even so, when Mars is close, you should be able to make out a tiny polar cap and some darker markings on its peach-coloured surface. You may not see this at first, but take your time, relax your eye, and let the detail come to you. Making a simple sketch often helps bring out the detail; no artwork needed here: just draw a circle and try to add shading where you see it.

Saturn is the opposite of Mars: a spectacle in just about any telescope. Don't even think about trying to make a drawing of it — it's a challenge for even the most accomplished astronomical artist. Again, spend some time, relax your eye, and see if you can tease out the subtle interplay of light and shadow between the globe and the rings. Can you spot Cassini's Division, a thin black line about two-thirds of the way out? Currently Saturn's rings are getting narrower as they tilt in line with our view from Earth, so they, and Cassini's Division, are getting harder to see. Look for Saturn's moons surrounding the planet. Titan is easy in even the smallest scope; Rhea requires a bit more aperture. With an 8-inch aperture, you should be able to see at least five moons: Titan, Rhea, Tethys, Dione, and Iapetus. Use a planetarium program to plot the current positions of the moons. Iapetus is particularly interesting: its orbit is large and at an odd angle to those of the other Moons; it also has one black side and one white, so it visibly changes brightness from one side of its orbit to the other. Our *Observer's Handbook* (page 190) will tell you when it is brightest and dimmest.

I have saved the best planet for last: mighty Jupiter. Even the smallest telescope will show its four bright moons, in constant motion. Their positions change from night to night and from hour to hour. Here is a simple "research project": make a drawing of their position every night for a week. That is exactly what Galileo did when he first observed them in 1609. Some nights, one or two will be missing because they're either behind or in front of the planet. Your *Handbook* will tell you where they are and when they'll reappear (pages 183 to 189). The times are in Universal Time, so you'll have to subtract some hours, depending on where you're located (pages 39 to 40). If you are very lucky, one of the moons may be casting its ink-spot shadow on Jupiter's cloud tops. Most scopes will show two or more dusky bands on Jupiter. A good scope and a well-trained eye will show lots of detail: see my article in the last issue of this *Journal*.

Some other excellent targets for light-polluted skies are double and variable stars. Many stars come in pairs, and amateur astronomers a century ago used to devote a lot of observing time to them, but this fell off because of rising interest in planetary and deep-sky observations. Doubles are becoming popular again, both because of their inherent beauty, and because they are unaffected by light pollution. I started observing variables a few years ago with Rick Huziak's encouragement, and found that I could have fun and make a scientific contribution even from my back yard in downtown Toronto. Thanks, Rick!

High Expectations

You've seen all those gorgeous colour images made with the *Hubble Telescope* or those backgrounds in Star Trek, and you can't wait to view them through your new telescope? Well, be prepared to adjust your expectations.

The human eye loses its sensitivity to colour at low levels of illumination. Your colour sensors stop functioning, and you start to perceive the world in shades of grey or, more accurately, pale green. That is just how the human eye works. It doesn't matter whether you're looking at a nebula through a telescope or from the command deck of the Starship Enterprise: all nebulae are faint, and, with a few exceptions, your eye won't see any colour in them.

When I first started into astronomy, all astrophotographs were made in black and white, so there was not as big a disconnect between pictures and what could be seen through a telescope. I still remember when the first colour pictures from Palomar were released and the excitement they caused. Nowadays, you hardly ever see anything else, so beginners often expect their telescopes to show the Universe in living colour.

So, forget about colour. Also, forget about deep-sky objects being bright through the telescope: most are faint, and the rest are even fainter. However, there *are* compensations. I've yet to see a photograph of a star cluster, either galactic or globular, that comes close to the view through a medium-sized telescope. No imaging technique can capture the full brightness range of the human eye. In long-exposure images, stars that are sparkling points of light of varying brightness to the eye become boring blobs of varying size on film or CCD.

Nebulae and galaxies are far less impressive at first glance, yet their faint inward glow is really quite magical. Most magical of all is what your brain adds to the image: the knowledge that the photons that are falling on your retina have been travelling for thousands or millions of years, just to hit the light receptors in *your* eye. No one else will ever see those same photons: they are yours alone. Anybody can look at a photograph, but with a telescope, you are actually *participating* in the Universe. That *always* takes my breath away!

Geoff Gaherty is currently celebrating his 50th anniversary as an amateur astronomer. Despite cold in the winter and mosquitoes in the summer, he still manages to pursue a variety of observations, particularly of Jupiter and variable stars. Though technically retired as a computer consultant, he's now getting paid to do astronomy, providing content and technical support for Starry Night Software.

Precise Measurements for Earth-Crossing Asteroid 2006 VV2

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

One by-product of being set up to measure variable stars with CCD cameras is the ability to pick up new and varied opportunities when they present themselves. One such opportunity was to do photometry on a newly discovered Earth-crossing asteroid, 2006 VV2, when it recently was near closest approach to the Earth. With good photometry, the rotation period of the asteroid could be found, and irregularities on the surface might be detected, adding to the pool of knowledge about this object. 2006 VV2 was discovered on 2006 November 11, by the Lincoln Near Earth Asteroid Research program (LINEAR) from the cameras located on the White Sands Missile Base in New Mexico, USA.

Asteroid 2006 VV2 comes close enough to the Earth to be classified as a PHA, or Potentially Hazardous Asteroid. On this inaugural approach, the asteroid was to pass the Earth at a distance of only 3.4 million kilometres, or about 9 times the distance of the Moon. Only a small change in its orbit could cause it to come crashing onto the Earth at some future date, and with a size of about two kilometres, it could wreak havoc around the world.

Although fairly small as asteroids go, its close approach meant that it would become brighter than 14th magnitude for about two weeks, so photometry could be easily done with the 12-inch scopes on the roof of the University of Saskatchewan Physics department. On the downside, the close approach also meant that it would be moving very rapidly against the stars, — so close that the asteroid could be seen moving in real time in the eyepiece. Although this makes for a very exciting visual observation, it becomes an imaging issue in that even short exposures would show trailed images.

This complication made me think about the best time and way to image this asteroid, so that I'd get an exposure long enough to get reliable data, but short enough that the trail would not present data-reduction problems. To solve all these problems, I decided to wait until the asteroid was above 12th magnitude, which would allow good statistical saturation (*i.e.* enough photons captured) with short exposures. In previous articles, I've mentioned that it is not particularly important for the star images to be well-focused for good photometry, so a trailed asteroid fitted into this allowance by looking like a poorly focused star. In effect, all of the light is still there; it's just spread over a larger area. When doing aperture photometry, a trailed image measures the same as a round image, provided that the entire image is within your measuring aperture. So, if I kept the streaks sort, I knew I could get good data.

The first clear night that allowed good photometry came on 2007 March 28/29. I decided to image the asteroid using 15-second exposures with a V-filter, electing to do a continuous time-series run for as long as I could follow the asteroid that night. I used the ephemeris from the Lowell Observatory ASTEPH utility, and the first slew of the telescope found the correct field. The movement of VV2 was so rapid that it took only two sequential exposures to identify unequivocally which of the stellar images was the asteroid.

On this night, the asteroid was moving at a rate of almost 16 degrees per day! Due to the quick motion, I could only get about 40 exposures at one setting (over 10 minutes) before I had to shift the 18′ field of view. During each 15-second exposure, the asteroid would move a whopping 10 arcseconds, creating a small dashed image!

Unlike comet photography, where you would likely want to track on the moving object, I decided that tracking on the asteroid would cause data-reduction problems. Instead, I placed the asteroid at the top of each field and allowed it to move southward until it would almost leave the frame. In the 10 minutes I had as waiting time while the camera was automatically

Figure 1 — Over 260 images were used to measure the changing brightness of Earth-crossing asteroid 2006 VV2, assembled here as a montage of 5 frames. Slight changes in seeing and glare from the nearby bright Moon during the run are reflected by the difference in contrast shown between frames in the image. The asteroid was moving from the top toward the bottom. The compound image is about 1.5 degrees high.

exposing the next 40 images, I researched what stars I needed to keep in the field when I shifted the camera. Those stars had to be bright enough to be useable as standard stars for image reduction.

To get enough good measurements over a few hours, I would have to have the asteroid drift over many adjoining fields. The precise magnitudes of stars that I could use as references had to be transferred from frame to frame from a single standard star on the first exposure. The reason for this is that I would be required to know a precise magnitude for a reference star on every frame, and each frame had to have the same zero-point.[1] Otherwise, the data processed on each successive frame might not line up very well. In reality, catalogue magnitudes of the stars in the 10th to 12th magnitude range that I use for standards might have accuracies of just +/-0.3 magnitudes; I would need accuracies of better than 0.05 magnitude to see fine surface features instead of just the gross shape of the curve. Thus it became a critical issue to keep as many bright stars as possible on the frame each time the camera moved. I generally chose six to eight stars at the top and bottom of each frame. In the end, I averaged the values of each of these stars over about 40 frames each and managed to keep the overall magnitude transfer error down to 0.03 magnitudes. Due to other imaging commitments, the run on 2006 VV2 ended up lasting 0.091 days (2 hours, 11 minutes), over which I took about 260 images and moved the camera 7 times. A montage of five of these images appears as Figure 1.

Cool Data

Once the data were collected, I analyzed the frames using standard-aperture photometry with *MaximDL* software. Unlike the photometry of variable stars, moving objects have nasty habits of crossing near bright stars, or sometimes the image is hit by a cosmic ray that adds many unwanted photons. Each image needs to be critiqued to assure that changes in light are not really just reflections of stellar appulses or cosmic noise.

What emerged was a double-humped curve with unequal humps and an amplitude of about 0.5 magnitudes, ranging from 11.1V to 11.6V (Figure 2). With only a short portion of the curve, I could not determine an accurate period of rotation using my data alone, but luckily, others were also studying this asteroid, and had determined that the primary period is approximately 2.43 hours. (Hergenrother 2007). This means that my curve represented almost one complete cycle.

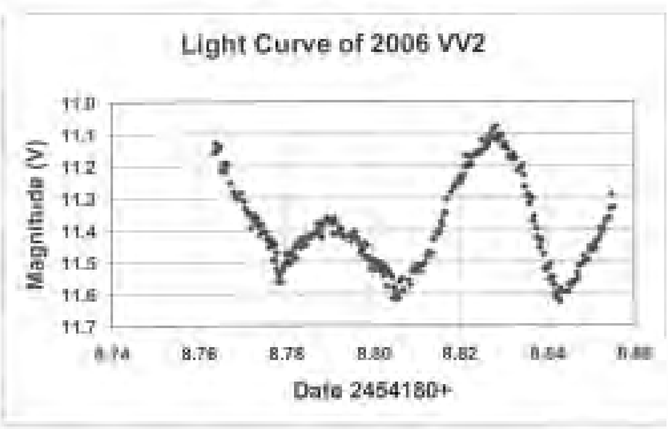


Figure 2 — The light curve of 2006 VV2 for a period of just over two hours, or just less than one rotation period. The irregular light curve indicates an irregular, non-round surface. The curve doesn't repeat exactly on every revolution due to a complex rotation about more than one axis.

Close scrutiny of the curve shows some interesting features. One is that the curve does not repeat precisely after one revolution. This is not unusual for asteroids; most rotate in more than one axis, a relic of their collisional past. The shape of the light curve changes from rotation to rotation as different faces are presented to the observer. Had I imaged the asteroid for an extended period, eventually I would have been able to determine all of the rotation periods, but that was not possible with the limited one-night sample presented here.

Also visible are small bumps and humps along the curve, indicating that the asteroid is irregular, and that varying surfaces and shadows are being presented to the camera. One surprise is the sharpness of the minimae of the curve. The quick transition in brightness may indicate that the asteroid has at least some sharp angular or wedge-like edges, though there could be other reasons for the light-curve's shape. To sort all this out, however, would take dozens of hours of imaging. And, as it turns out, the asteroid has a binary companion. Some of the smallest features on the curve might be attributed to a contribution from the companion, though a photometric sensitivity of <0.02 magnitudes is required to separate the effect of this object (Pravec 2007). An Internet search revealed that the asteroid was also pinged with radar by the Jet Propulsion Laboratory (JPL) on the night before my observation, so exact details will come out of that work.

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[1] All-sky surveys have determined the approximate magnitudes of stars as faint as 17th or 18th magnitude, but even so, errors are large because the magnitudes are obtained from scans of film or from digital media where the accuracy is determined by the background noise. The most accurate method to determine magnitudes within a star field is to do *all-sky photometry,* where your chosen star field is compared repeatedly with standard fields in the sky (called Landoldt fields). However, this method is time-consuming and requires much skill and practice. For seven fields required, this process may take several nights. Because I did not need an absolutely accurate magnitude for each star, I decided to arbitrarily assign the first star the catalogue magnitude as it was given, do photometry across each field, then use stars at the opposite end of the frame as new standard for the next overlapping image. This process was repeated six times for the run.

But I'm Not an Asteroid Expert

Asteroids vary in brightness because of sunlight reflecting off their ever-changing faces. When observing an asteroid over long periods, the sunlit phase or illuminated percentage needs to be taken into account. This is especially true of Earth-crossers, which may change from being fully illuminated to being backlit within a few hours of passing the Earth. These effects sometimes have to be removed before the light curve can be fully understood. However, the effect is lessened, and can basically be ignored, if distant asteroid-belt objects are measured, and especially if the measurements occur near opposition. With the short duration of my run, the effect also can be ignored, even though this is an Earth-crosser. Future studies of other asteroids should keep this in mind however.

Although this project is interesting and it would be fun to measure the rotation periods of asteroids and do more analysis, I'm no expert. However, because the data I collected might be useful to researchers, I contacted David Dunham of the International Occultation Timing Association (IOTA), instead of putting it on the shelf. David, in turn, sent me to the Association of Lunar and Planetary Observers (ALPO) and other asteroid observers around the globe. All seemed quite excited about receiving more data to complement their own. Who knows, maybe it will reach publication one day in *The Minor Planet Bulletin?* I certainly encourage readers to consider doing work on asteroid periods, something that is a fairly straightforward task with a good telescope and a CCD camera or photometer. ◆

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Richard Huziak would love to observe everything all the time, like variable stars and asteroids, but simply has less time as time goes on. However, he still loves to hold up his hand and volunteer for even more stuff that requires even more time of which he simply has none. Even this article was submitted late because of lack to time. He will likely get back to variable stars very soon.

Gizmos

X-Y to the Sky

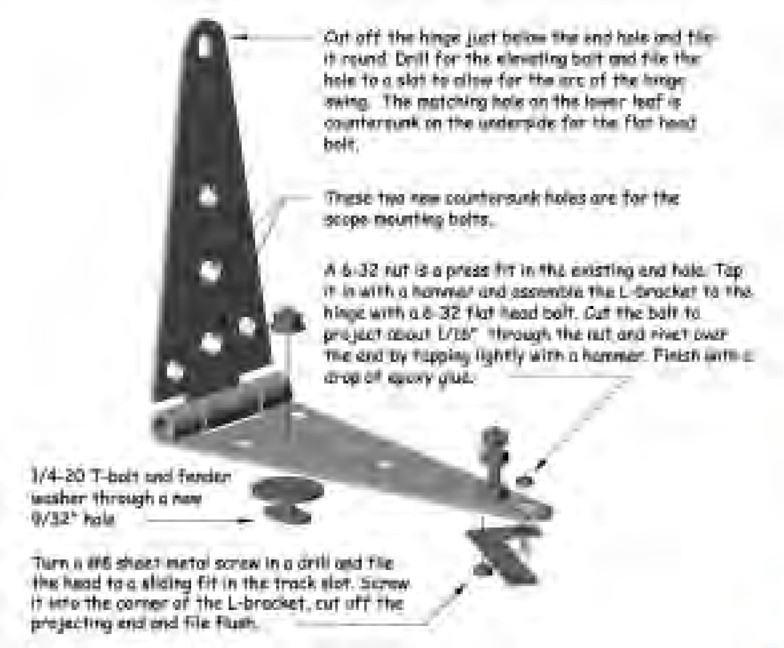
by Don Van Akker, Victoria Centre (don@knappett.com)

One of the frustrations of imaging is that guide stars are not equitably distributed. To find one, the guide scope often needs to point in a somewhat different direction than the main tube, an awkward and time-consuming process accomplished by adjusting three screws in the mounting rings. What you see in the pictures here is an attempt at something better: an x-y mount intended for use with small guide scopes that are equipped with a tripod shoe. For the most part it consists of an 8″ gate hinge drilled to fit the scope and mounted on a 1/4″ T-Slot track. It rides a bolt for altitude, and an L-bracket with eccentric pivots for azimuth.

I bought my first hinge at Home Depot and, after getting the holes wrong, bought the second one there too. It's made of steel and has enough slop to work well as a gate hinge even after it's good and rusty. Unfortunately, that's rather more slop than is needed to aim telescopes, so the first step is to tighten the hinge up by squeezing it in a vise.

After that, drill it like shown in the pictures: holes for the tripod shoe, a hole and a slot for the altitude bolt, and a hole for the T-bolt that holds it to the track. By itself, the track is too insubstantial to hold even a small scope, but, let into a wooden rail, it is as solid as any dovetail bar. The radius blocks are easy. Measure the circumference (not diameter) of your scope and do the math. Make sure the bolt holes are on the radius lines for mounting to an SCT or, if your scope doesn't have mounting holes, consider some sort of hose-clamp arrangement. Hose clamps are available in almost any size and will not mar if lined with tape or felt. Give the whole thing a coat of paint, some stain on the wooden parts, and it will look better than it really has a right to.

The instructions are intentionally vague this time out because the idea isn't so much to have you build my design (although you are welcome to it), but to kick-start your own ideas. Somewhere, amid all that stuff that was too good to throw



out, you probably have just what it takes to make this a really classy project. Let me know how it works out.

The hinge is by Stanley; use that specific one because it has a plastic bushing to prevent side-to-side slop. The L-bracket started as a standard 3″ × 3″ × $^1/_2$″ corner brace from any hardware store. The T-Slot track is Lee Valley part 12K79.22. The scope is an ETX90 like the one in the back of your closet.

The idea is from Jay Anderson. Thanks Jay.

Help is available from don@knappett.com.

Don Van Akker and his wife Elizabeth are members of RASC Victoria. They have begun an in-depth study of clouds because if they could get really enthusiastic about clouds they would probably stop coming over quite so often.

After all...it worked with stars.

Orbital Oddities

Saros Subtleties I

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

All that is now
All that is gone
All that's to come
And everything under the Sun is in tune
But the Sun is eclipsed by the Moon

Pink Floyd, *"Eclipse"*

Another eclipse season is almost upon us. The one of late summer 2007 is fairly typical, consisting of one lunar and one solar eclipse, one total (the lunar), and one partial. The lunar eclipse will be visible from the western part of the country during the wee hours of August 28. Unlike the four total eclipses of the tetrad of 2003-04 (McCurdy 2003), which stuck to one hemisphere of Earth's shadow, this one is considered a "central" eclipse, in that at mid-eclipse part of the Moon — near its north pole on this occasion — will be immersed in the very centre of Earth's shadow. This eclipse therefore is longer-lived than any of the eclipses in the tetrad, with a totality lasting just over 90 minutes.

It seems an oddity that in the present era there are many total lunar eclipses yet relatively few of them are central. But, there is in fact an anti-phase relationship between them. Meeus (1997) did a statistical breakdown of lunar eclipses, including penumbral, partial, total, and "deep-total" (defined as having an umbral magnitude of 1.5 or greater, slightly more exacting than the standard for central eclipses), finding, that in the 20 centuries 1000 to 2999, the current one has the most total lunar eclipses (86) yet the *fewest* "deep-total" eclipses (just 11). In just two centuries, in 2200-2299, there will be just 59 total lunar eclipses, but 42 of those will be deep-totals. It's a fascinating pattern with an ebb and flow of some 5.5 to 6 centuries, a periodicity that is manifest in all sorts of eclipse cycles.

For now central eclipses are rare: the last central lunar eclipse occurred on 2000 July 16, (an exceptionally deep eclipse, with a totality of about 107 minutes), the next on 2011 June 15, and then not again until 2018 July 27, one full Saros period after that of 2000.

The Saros is perhaps the most fascinating periodicity in classical astronomy. After 6585 days + ~8 hours, the Earth, Sun, and Moon return to a very similar configuration. In this time the Moon undergoes almost an integer number of three important periods: 223 lunations (new to new), 239 anomalistic months (perigee to perigee), and 242 draconic months (node to node). It also is very nearly an integer number of years, about 18.03, so that eclipses in the same Saros series occur progressively later on the calendar by some 10 or 11 days. Over the full life of a Saros family of some 70 to 80 eclipses, eclipse dates progress through 2 full calendar rotations, with some interesting consequences that will bear study in a future column.

The other most important eclipse cycle is the Inex, 29 years less ~20 days, which consists of 358 lunations and 388.5 draconic months. Very long series of eclipses occur at this interval, flipping from one node to the other (due to that .5), although they tend to vary in type because the number of anomalistic months is not an integer and the Moon therefore varies in distance from one to the next. Van den Bergh (1955) established that the interval between any two eclipses can be stated by the formula $[aI + bS]$. The relationship between Saros (S) and Inex (I) reasonably approximates the Golden Ratio (McCurdy 2004). As a general rule, the smaller the coefficients, the more likely there will be further repetitions at the same interval.

The Saros also subdivides into shorter periods of lower accuracy. The first division is into the complementary periods known as Tritos (10.9 years, or the difference between the Inex and Saros; in van den Bergh's terms, $I - S$) and Tzolkinex (7.1 years, or $2S - I$), which together add up to one Saros. Next best is the Octon, 3.8 years, which is $2I - 3S$, or the difference between Tritos and Tzolkinex (van Gent 2007). All of these periods can be seen in the consecutive dates of central lunar eclipses mentioned above: 2000 July, 2007 August, 2011 June, and 2018 July.

Less-good periods can be found, such as Hepton (3.3 years, $5S - 3I$), the Semester (0.48 years, $5I - 8S$), and the Lunation ($38I - 61S$). The latter period can be found in eclipse duos - two eclipses of the same type during the same eclipse season, separated by one lunation. In such eclipse seasons, therefore, there are three eclipses altogether, a marginal pair of one type on either side of the node and seen in opposing hemispheres, sandwiching a central eclipse of the other type (Meeus 2002).

Currently, eclipse duos are relatively rare. Over the course of 18 years there are 242 - 223 = 19 eclipse years, or, since there are two nodes, 38 eclipse seasons. Presently, there are 41 active lunar Saros families, resulting in three active duos, with recent paired eclipses in 1973, 1980, 1984, 1991, 1998, 2002.... The periods Inex, Saros, Tritos, Tzolkinex, and Octon are all in evidence in that short list.

Solar eclipse duos are currently at an historic low. At the moment there are just 39 active solar Saros, numbered 117 through 155, resulting in exactly one eclipse in every eclipse season but one. The exception involves the oldest Saros family (#117) and the newest (#155). It is instructive to consider the sequence of events of this series of duos:

Table 1

Saros 117	**Mag**	**Saros 155**	**Mag**	**Σ**
1910 May 9	1.060	No eclipse		
1928 May 19	*1.014*	*1928 Jun 17*	*0.038*	*1.052*
1946 May 30	0.887	1946 Jun 29	0.180	1.067
1964 Jun 10	0.755	1964 Jul 09	0.322	1.077
1982 Jun 21	0.617	1982 Jul 20	0.464	1.081
2000 Jul 01	0.477	2000 Jul 31	0.603	1.079
2018 Jul 13	0.337	2018 Aug 11	0.737	1.073
2036 Jul 23	0.199	2036 Aug 21	0.862	1.061
2054 Aug 3	0.066	2054 Sep 02	0.979	1.045
No eclipse		2072 Sep 12	1.056	

This is how one Saros cycle replaces another within the same eclipse season. Because the window is wider than one month, for a time there will be two eclipses in the window, but never zero. Usually both eclipses in a duo are partial.

The one active duo is a deep one. The sum of the magnitudes (Σ) is greater than 1 in all cases, following a smooth curve that peaks at 1.081 in 1982, very close to the maximum value of 1.100 found by Meeus (2004). (The minimum sum found was <0.15.) Because the two eclipses add up to magnitude >1, it is rare but just possible for a duo to occur where one of them is a total eclipse, as happened here in 1928. Such a "special duo" must be the first or last duo in a series, as the magnitudes change too rapidly for a repetition.

Duos always follow the Saros numbering sequence $n, n+38$. This is consistent with van den Bergh's formula for the lunation, $38I - 61S$. (This seems backwards, but consecutive Saros numbers are always at intervals one Inex.) It is instructive to note that 38 Inex cycles equals 13,604 lunations, and 61 Saros equals 13,603. These two great cycles are incommensurate by one lunation after 1100 years. That is intriguingly close to double our great periodicity of <6 centuries.

So what happens at the midway point? $n+19$ is Saros 136, currently the central active Saros that is producing total eclipses of extremely long duration — at the opposite node. Perhaps this is the mechanism that splits the ~1100-year cycle in half.

The eclipses of Saros 136 listed on Table 2 overleaf are the only total eclipses greater than six minutes during that entire period. While it didn't quite measure up to the eclipse of 1955 for duration, the eclipse of 1991 was exceptionally central ($\gamma = -0.004$), the total eclipse that was closest to the zenith in many centuries (Meeus 1997).

Table 2

Saros 136	**γ**	**Duration**
1919 May 29	-0.296	6m51s
1937 Jun 08	-0.225	7m04s
1955 Jun 20	-0.153	7m08s
1973 Jun 30	-0.079	7m04s
1991 Jul 11	-0.004	6m53s
2009 Jul 22	+0.070	6m39s
2027 Aug 02	+0.142	6m23s
2045 Aug 12	+0.212	6m06s

Note how the eclipses of Saros 136 are offset to the duos of Saros 117-155 by almost exactly 9 years, with all currently happening in July. The duo occurs at 111 and 112 lunations respectively after one major central eclipse and the same intervals before the next. The first period, identified by Wm. Hibbard in this publication some 50 years ago (Hibbard 1956), and subsequently dubbed by van den Bergh as the Hibbardina, is 31*S* – 19*I*. The complementary, unnamed period, is 19*I* – 30*S*. The sum of the two is S, one Saros period; the difference 38*I* – 61*S*, one lunation.

Of course, all lunations are not created equal. Those periods are also approximately 119 and 120 anomalistic months respectively, so since the Moon was at perigee for the long total eclipse in 1991, it was also near perigee for the duo in 2000. From the *Observer's Handbook* of that year (Bishop 1999):

July 1 19h20m	**New Moon, Partial Eclipse**
July 1 22h	Moon at perigee (357 362 km)
July 4 00h	Earth at aphelion (152 102 Mm)
July 15 16h	Moon at apogee
July 16 13h55m	**Full Moon, Total Eclipse**
July 30 08h	Moon at perigee (358 375 km)
July 31 02h25m	**New Moon, Partial Eclipse**

These conditions — Moon near perigee at beginning and end of the lunation, Earth near aphelion — satisfy the conditions for a "short" lunation (McCurdy 2001). The consecutive New Moons of July 2000 occurred just 29d 7h 5m apart, within half an hour or so of the shortest lunation possible. With the Moon speeding from one syzygy to the next, it moved almost as little as possible relative to the node over the course of that lunation; thus each eclipse of the duo is a relatively deep partial, and Σ approaches the maximum value possible.

The duo is effectively a double data point that hints at the high peak between them. That peak is much more than an imaginary one; the solar duo brackets a major central *lunar* eclipse, as occurred on 2000 July 16. The two major eclipses of opposing type occur at interval one Sar (half Saros), 111.5 lunations or 9 years ~5 days. The long solar eclipse occurred at perigee with the Moon at its largest angular size and the Sun at its smallest; the long lunar eclipse at apogee with the small Moon dawdling through Earth's shadow, whose angular size was somewhat broadened near aphelion. The conditions seem opposite, but both are ideal for producing a series of exceptionally long central eclipses a Sar apart.

How central was that 1991 eclipse? The wonderful new *Five Millennium Canon of Solar Eclipses* (Espenak & Meeus 2006) gives start and end dates for over 200 Saros periods active between -1999 and +3000. Focussing on just the first, central, and last Saros families currently active:

Table 3

Saros	**#**	**First**	**Middle**	**Last**
117	71	792 Jun 24	1423 Jul 08	2054 Aug 03
136	71	1360 Jun 14	*1991 Jul 11*	2622 Jul 30
155	71	1928 Jun 17	2559 Jul 06	3190 Jul 24

One can select any two diametrically opposed dates, and (adjusting for Julian calendar dates) the average of the two is always 1991 July 11. In fact, the average of all nine dates shown is 1991 July 11. The same statements also apply to Table 1, which details the overlapping ends of Saros 117 and 155 yet isolates the centre of Saros 136. Other than Saros 117-155 there have been no other duos active since Saros 116 (the former companion to this September's still-young Saros 154) ended on 1971 July 22; the next duo will begin with the birth of Saros 156 on 2011 July 01. Again, the midpoint between those two dates is 1991 July 11!

Note also the consistent difference of 568 years between the analogous events of the consecutive Saros in Table 3. This is again pleasingly close to our long-term periodicity. That we have Saros families old, young, and mature, all occurring near perigee at the same time of year is perhaps evidence of clumping, which causes the phase/antiphase relationship among various types of eclipses.

By no means do all Saros fall into such an orderly pattern as suggested by Table 3, but the regularity of this sequence offers some enticing clues that will prompt further research.

My one lifetime totality, a spectacular black hole in the sky that punctured the zenith as seen from Mazatlan on the Tropic of Cancer, was truly the Eclipse of the Century. Turns out I chose the ultimate central eclipse in my lifetime.

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Bruce McCurdy is an "Ancient Past" President of the RASC Edmonton Centre. He has long been fascinated with the dynamics of the Solar System; everything under the Sun that's attuned to the "Music of the Spheres." He particularly enjoys pondering the complex weave of solar and lunar eclipses.

Carpe Umbram

Asteroid "Caught" near Edmonton!

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

Are you ready?
Are you ready for this?...
Yes I'm ready! I'm ready for this!
I'm standing on my own two feet!
...and another one bites the dust!
— "Another One Bites the Dust," by Queen
© 1980 Queen/EMI

The path of an occultation by the asteroid (19) Fortuna on the night of 2007 April 12/13 lay squarely across central Alberta. Noting this, RASC Edmonton Centre members Mike Hoskinson, Alister Ling, and Mike Noble decided to observe the event and, they hoped, time it to an accuracy that the International Occultation Timing Association would accept. So they...well, I'll let Mike Hoskinson tell the tale [with occasional interjections from me]:

> [The large asteroid] (19) Fortuna was responsible for two occultations that went across Edmonton [in early April], so I was keenly watching the weather. It would have been very cool to record the same asteroid [but different occulted stars] from the same location, but alas, the first event was clouded out. Watching the Clear Sky Clock the morning of the second event, I noticed that a patch of cloud was predicted to cover the city and both my regular observing sites, but it looked like a large clear patch would develop west of Edmonton a couple of hours before the event. What does anyone in Edmonton do who wants to know the possibility of clear sky? Why, call our local meteorologist and "asteroidologist," Alister Ling. Alister said that it looked good to him, so we hatched a plan over a couple of lunchtime phone calls and an email to the third member of our occultation group, Mike Noble. [Coordinating with IOTA, so we wouldn't duplicate others' chords], we chose sites 80, 100, and 120 kilometres south of the path centreline. [The path would be nearly 300 km wide, so they would be well within the shadow.] "Noble Mike" is an expert on regional observing sites and he told me about a spot at ~123 km that was at the dead end of a road.
>
> I was on call at a couple of hospitals and, wouldn't you know it, there were two late cases at the University Hospital to which I had to attend before I went out. I considered calling Noble Mike to take my site, but thankfully the cases were done and results called by 8:00 p.m., so I was able to scramble, get my gear packed, and get on the road before 9:00. The event was due at 11:06 and would happen whether I was ready or not, but I was pretty confident that, with my manual-pointing 8-inch f/4.25 and its video finder scope, I'd be OK. I had printed out good charts and rehearsed the short star hop from Denebola on my laptop, so I was as ready as could be after a long stretch of cloudy sky.
>
> As all occultation observers know, Edward Murphy is always riding shotgun and the possibility of getting nasoned looms large on every occultation attempt.
>
> [Columnist's note: The verb "nason," usually used in the sense "I have been nasoned," means that the occultation attempt is thwarted because of poor weather: clouds, wind, cold, etc. It was coined by IOTA's Derek Breit after I reported no fewer than a dozen consecutive cloud-outs during the consistently cloudy winter of 2005-2006. Now, back to Mike.]

I arrived at the site just before 10:00 p.m. and what a beautiful site it was: at the end of a wide gravel road; with a gurgling brook just beyond; at least a kilometre from the nearest habitation. The sky was as dark as I have ever seen it. Often I have trouble picking out the Little Dipper because the stars that define it are relatively faint, but here the difficulty was picking out the asterism from a sea of bright stars. "Holy Cow!" I said to myself.

I quickly set up the equipment: Poncet tilting platform; followed by the base of the 8-inch "Aluminator" that I had made a few years ago; the scope itself, which was already assembled; then the cameras. I had brought my little video finder, made from an old 50-mm camera lens and a PC164C ["Surveillance"] camera. It is quite the convenience aid, with its 4-degree field of view and a steady image on a 5-inch monitor that can be compared side-by-side with a star chart. The only problem was that it had been haphazardly put back together in its rings after being taken apart for camera testing the previous weekend. Oh-Oh. The camera fell out, the whole contraption slipped out of the rings, and here I was with a flashlight in my mouth and the clock ticking (literally, because my KIWI-OSD [GPS-driven on-screen timing device] has been modified for audio output and it clicks every second). OK, OK, lots of time. I put it all back together — tightly — and set about aligning on Saturn. This would have gone much quicker if I had had the presence of mind to put an eyepiece into the scope, but, oh no, wouldn't think of that, would we? Just find Saturn in a half-degree field of view, no problem.

Anyway, with that done, the target found, and the Poncet tracking, there were ten minutes to go. With the maze of wires sorted out and hooked up, it was time to get the camera out. My camcorder has been acting up lately, eating tapes, and denying the presence of pre-recorded material. I had tried it a few times and it seemed to be OK if I did not try to replace the tape. So here I was, at crunch time. I started up the camcorder.

At this point, you are probably cringing in you seats, ready for the inevitable triumph of Mr. Murphy. However, what I have not disclosed until now is that a couple of days prior to this event I had come across my long-lost LUCKY OBSERVING HAT and had dutifully worn it for this trip. So, HA!

The Poncet was not level, so there was some drift. The target would last about ten minutes in the field before I had to edge it back down. I knelt on the ground with the camcorder on the chair, peering into the tiny screen. I had no idea what to expect. The star and asteroid were both about 11th magnitude, and I had arrived too late to see them as separate objects in my camera image. (Use the eyepiece, Luke.) There was supposed to be a one-magnitude drop. Even the combined light of the asteroid and star were pretty dim in my image, so I upped the ante a bit by adding some integration in the camera — 2-field integration, to be precise, for which my experiments the previous weekend had prepared me.

The target was scintillating, coming and going to some extent because of some thin cloud that was drifting through the field, but a minute before the event it settled down. A nearby field star of the same magnitude was also steady. So, stop breathing, count with the ticks, one, two, three, four, five, SIX! Gone! Just a hint of a photon or two where previously there had been an easily visible target. YAY! Seven, eight...twenty-three, twenty-four, twenty-five, TWENTY-SIX!

It's in the bag! I called Alister on the cell phone, which he answered with a scream. Two positives! Alister's first, my second.

The euphoria of that, plus a much-needed infusion of galactic photons into my photon-deprived brain, lasted me through the next day. But Murphy, having been held at bay for the night, made the next day's work a Friday from hell — 12 hours at the computer, tons of complicated cases to report. No matter. I had my positive occultation.

And, another one bites the dust! Well done, guys!!

Here is a list of possible occultations over populated parts of Canada in August, September, and early October. For more information on events in your area, visit the IOTA Web site, www.asteroidoccultation.com. Please let me know (email address above) the events in which you plan to participate, so we can coordinate all observers in the most efficient fashion.

DATE(UT)	ASTEROID		STAR	Δ-MAG	MAX	PATH
2007	#	Name	MAG		DUR	
Aug 07	1356	Nyanza	9.8	5.4	6.9	AB-BC
Aug 08	85	Io	11.9	0.6	25.4	nwON-MB
Aug 13	391	Ingeborg	9.9	2.4	7.8	sON
Aug 18	4838	Billmclaughlin	10.3	5.6	2.8	SK
Aug 21	146	Lucina	8.2	5.8	4.4	cON
Aug 22	176	Iduna	10.8	1.6	10.8	nMB-seAB
Aug 22	1284	Latvia	10.6	4.4	1.1	nMB-seAB
Aug 22	2126	Gerasimavich	10.4	5.5	1.9	SK
Aug 27	1269	Rollandia	11.9	2.9	7.0	NL-PE-NB-NS
Aug 30	602	Marianna	11.2	1.6	9.2	nwON
Aug 31	2303	Retsina	10.1	5.8	1.4	NL-NS
Aug 31	1939	Loretta	8.2	6.9	2.3	cON-nQC
Aug 31	1783	Albitskij	7.5	9.5	1.2	sAB-sMB
Sep 01	1116	Catriona	8.6	5.9	1.4	nAB-swBC
Sep 06	3642	Freiden	10.4	4.8	6.7	SK-MB
Sep 18	4460	Bihoro	9.7	5.2	4.0	BC
Sep 19	2920	Automedon	11.6	4.6	10.2	BC-nSK
Sep 20	4672	Takuboku	11.3	4.6	3.2	nwON-seMB

DATE(UT) 2007	ASTEROID #	 Name	STAR MAG	Δ-MAG	MAX DUR	PATH
Sep 21	1522	Kokkola	9.8	5.9	1.9	nMB-sBC
Sep 24	198	Ampella	11.9	0.6	11.7	nwON
Sep 26	925	Alphonsina	10.1	2.9	5.5	sNL-sAB
Sep 26	905	Universitas	11.5	2.1	4.3	NL-sSK
Oct 03	663	Gerlinde	10.6	4.3	8.5	sMB-NS
Oct 06	3227	Hasegawa	9.6	7.2	1.6	sON-NS
Oct 08	201	Penelope	11.9	1.7	6.2	sAB-NL

Figure 1: A preliminary sky-plane plot of asteroid (19) Fortuna derived from observations made on 2007 April 13 (UT). The chords and their observers are: 1. J. Sedlak, Ashland, VA; 2. D. Oesper, Dodgeville, WI; 3. S. Messner, Northfield, MN; 5. A. Ling, Spruce Grove, AB; 6. M. Hoskinson, Edmonton, AB. (Mike Noble's data were not available at press time, so his chord, #4, is absent.)

Great Images

The Toronto Centre's Stef Cancelli captured this marvelous view of the Flame Nebula using a 200-mm f/6.4 Vixen VC200LDG telescope. The image was collected with an SBIG ST2000XM camera using exposures of 180 minutes in H-alpha and 45 minutes in each of R, G, and B. The Flame lies next to Alnitak, the easternmost star in Orion's belt, seen here on the right. It is usually encountered while searching for the nearby Horsehead Nebula, but is a bright and easy-to-observe nebula that deserves a reputation of its own.

Society News/Nouvelles de la société

Across the RASC
du nouveau dans les Centres

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

It came about mostly by accident, but here I am, writing a column that used to be a regular by my recent predecessors, Kim Hay and Stan Runge. I praise those two for the work they put into the position, because it has made my task much easier, especially Kim's invaluable *RASC Secretary Manual* - Thank You!

As I write this, the National Council Meeting of June 2 is fresh in my mind. It promises to be a meeting of far-reaching implications, since Council voted to spend nearly $60,000 to upgrade our computer systems and MPA software at National Office. This will position the Society for the first half of the 21st century; it will streamline processes in the eStore, membership renewals, and publications sales, making the office much more efficient.

Also, National Council voted to begin an experiment that will see a Board Pilot Committee (BPC) operate as an expanded Executive Committee, in preparation for a change in our governance model. This one-year committee, at the end of its term, should have laid the groundwork for new and revised By-Laws, a long-term strategic plan, and positioned the Society to operate with a permanent Board, responsible to National Council.

This is an exciting time to be in on the action!

By the time this gets to print, the GA will be a fond memory in attendees' minds, and the organizing committee members will wonder why they took on such an enormous job, vowing never to do it again! However, it's volunteers like those in Calgary Centre who make this Society what it is and who deserve the greatest praise. The next time you feel like getting involved, follow your inclination — it is rewarding and satisfying, and ultimately makes the Society a better place in which to belong.

……

We note the passage of several old and some not-so-old friends. We received a note from the family of recently deceased Honorary Member, Dr. Frank Maine Bateson, O.B.E. This is copied from the card returned to me in response to a sympathy card sent on behalf of the Society: "All of Frank's family thank you most sincerely for your kind words and expressions of sympathy following my Dad's death. He will be sadly missed by us all but we are so thankful for his long and fruitful life. We appreciate your thoughtfulness at this time.
- Audrey and Jim and all of his Australian and Canadian families"

Then, in a hand-written note to the side was this: *"Our many thanks to all members of the Royal Astronomical Society of Canada. My Dad really enjoyed his visits to your country when he met with many members of your Society. Audrey"*

Bruce Pippy, a long-time member of the Winnipeg Centre, passed away earlier this year at the age of 74. Astronomy and contract bridge were his favourite pastimes, but music was his true passion: he was the organist for two of Winnipeg's churches for 49 years. Bruce was a quiet but regular participant in Centre meetings; his wry sense of humour will be missed.

ARE YOU MOVING? IS YOUR ADDRESS INCORRECT?

If you are planning to move, or your address is incorrect on the label of your *Journal*, please contact the National Office immediately:

(888) 924-7272 (in Canada)
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By changing your address in advance, you will continue to receive all issues of *SkyNews* and the *Observer's Handbook*.

Great Images

This image of M45, the Pleiades cluster, comes from Charles Banville of the Victoria Centre.   He captured the scene on 2007 January 11 from the parking lot of the Dominion Astrophysical Observatory using an f/4.5 TeleVue NP-101 and a Canon 20Da camera. The image is a compilation of 75 frames at ISO 800, each 60 seconds in duration. The blue colour in the nebulosity around the Pleiades stars identifies it as a reflection nebula, but a more reddish tone, signifying emission processes, is evident in the lower part of the photo.

Astrocryptic

by Curt Nason, Moncton Centre

We present the solution to last issue's puzzle:

R	U	B	I	N		B	A	R	T	B	O	K
O		A		U		L		E		R		A
M	I	R	A	N	D	A		S	C	A	R	P
E		E		K		Z		E		N		E
R	A	N	D	I		H	A	R	V	E	S	T
		T				K		V				Y
M	U	S	C	A		O		E	D	W	I	N
A				D		E				H		
T	U	R	N	O	F	F		F	A	I	N	T
A		E		R		F		O		P		R
D	I	A	N	A		E	C	L	I	P	S	E
O		L		M		C		I		L		V
R	E	M	N	A	N	T		C	A	E	L	I

Great Images

This stunning photo is from the August pages of the RASC 2007 *Observer's Calendar*.
The 2008 *Calendar* is now in preparation — it will feature another great collection of top-notch astrophotography and astronomical information and lore.

Sparkling Fossils
M92 is a brilliant swarm of a few hundred thousand stars discovered in 1777 by J.E. Bode and rediscovered in 1781 by Charles Messier. The globular cluster has a visual magnitude of 6.4 so it is just barely visible to the unaided eye. It lies 26,000 light years away and its age, 12-14 billion years, approaches that of the Universe itself.

Photo by Paul Mortfield and Stef Cancelli — from *Observer's Calendar 2007*

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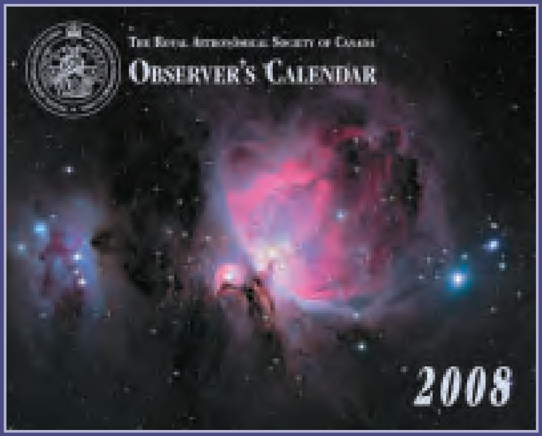

Observer's Calendar — 2008

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Created by the Royal Astronomical Society of Canada and richly illustrated by photographs from leading amateur astronomers, the calendar pages are packed with detailed information including major lunar and planetary conjunctions, meteor showers, eclipses, lunar phases, and daily Moonrise and Moonset times. Canadian and U.S. holidays are highlighted. Perfect for home, office, or observatory.

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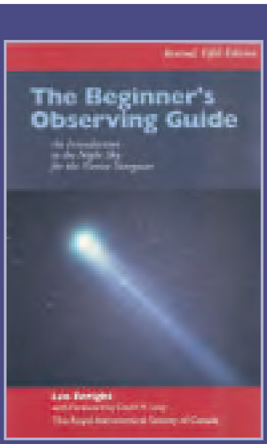

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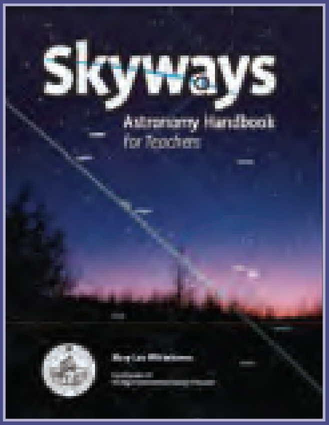

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