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Journal

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Journal

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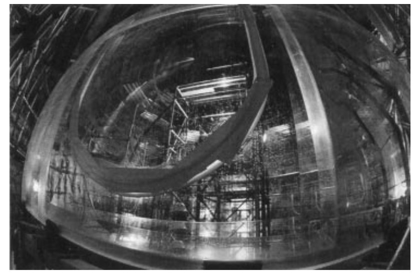

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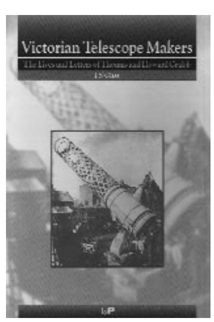

Victorian Telescope Makers: The Lives and Letters of Thomas and Howard Grubb,
by I. S. Glass p. 218

Cover Photo:

The attendees of the 1998 General Assembly held at Pearson College of the Pacific, near Victoria, B. C.

See page 207

(Photo by David Lee)

From the Associate Editor

by Patrick Kelly

Is it just me, or do most people find that time moves more quickly the older you get? I would have sworn that I just wrote one of these columns, but there is the e-mail message from Dave Lane reminding me that 90% of the August issue is ready to go and my column is needed ASAP, yesterday if possible. What to write… what to write? Usually I have no trouble thinking of a subject, but today — nothing. My gaze casts about. There is this morning's *Daily News*, still lying on the chesterfield with the headline proclaiming "Red Wings Keep Cup" blazoned across the front page. Hockey and astronomy… now there are two subjects that you seldom find together.

As I expect is the case for many amateur astronomers, the lure of the nighttime sky must often compete not only with work and family obligations, but with other personal interests as well. In my case, Saturday nights are usually reserved for *Hockey Night in Canada*. When I was young, our family used to watch *Hockey Night in Canada* on Saturday night without fail. In fact, at that time there was also a game on most Wednesday nights. In those distant days I used to play hockey (somewhat below average) and now one of my sons also plays the game (well above average). We also carry on my family's tradition of watching the game on Saturday nights. Out here in the Maritimes, the first game starts at 8:30 p.m. and the second one starts three hours later (past the children's bedtimes), so by the time both are over you cannot do a great amount of observing if you want to turn in at a reasonable hour. (You may not be in the best condition for observing either, depending on how many "pops" you had while watching the games!)

You should keep in mind that the Moon will cause some Saturday nights to be unusable, and the weather, especially in Nova Scotia, will take care of a lot of the rest, so normally I do not suffer from guilt pangs about missing a dark clear night while waiting for "Coach's Corner" to come on. In fact, whenever there is a call for an observing session on Saturday night, it is usually assumed that I will not be there, but once in a while the call of a dark sky will prevail — especially if the Leafs are down by five goals heading into the second period — and I will head out to the backyard to put in some eyepiece time. Once I even went to the St. Croix Observatory and put in a very unexpected appearance. You would have thought it was the Second Coming!

So, readers, whatever other interests you have that keep you from your telescope, once in a while I hope that the siren song of the sky becomes too irresistible to fight and you find yourself once again under that dark canopy of stars observing some aspect or another of the universe that we call home. Trust me, it truly is invigorating. When the hockey season resumes this fall, if it is a nice clear Saturday night, and you go around to the back of my house, you just may find me outside with my telescope — unless, of course, the Canadiens are playing that night!

Journal

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

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President's Corner

by Randy Attwood, (attwood@istar.ca)

At the General Assembly in Victoria in June, there was a changing of the guard. As a result, this is my first address to the Society as National President.

First, on behalf of the entire Society, I wish to thank the Past President, Doug George. Doug took over as President at a time when the Society was implementing many changes and improvements. It was a challenge and, although there is still work to do, the Society owes a great deal to Doug for his leadership during his term as National President.

I also wish to thank Bonnie Bird. When Bonnie took over the operations at National Office as Executive Secretary two years ago, everything was in disarray. Bonnie worked through difficulties associated with the handling of memberships through outsourcing, the introduction of a new computer, a new financial reporting system, the introduction of e-mail and the Internet to the National Office, a change in tenancy, and the introduction of merchant credit cards to handle telephone sales of Society publications, and she is presently redesigning the National Office workspace. We are very fortunate to have found Bonnie.

The new executive consists of Dr. Robert Garrison, Raymond Auclair, Dr. Rajiv Gupta, and Michael Watson. I welcome Michael to the executive as Treasurer and wish Robert and Rajiv success as Vice - Presidents. I consider myself very fortunate to have an executive composed of individuals with many years of experience in the RASC at both National and Centre levels. I intend to keep them busy; the Executive has much work to do.

In order for me to state two years from now that we have accomplished something during my term of office, it is necessary to have some type of plan. For the first year I hope to concentrate on two items. First, we need to ensure that we run the Society like a small business. The Society has an annual income of $250,000, and we would be irresponsible to do otherwise. Second, before we begin any new projects we must ensure our base business is operating smoothly and efficiently. That consists of membership handling, finances and publications.

Our membership handling has not been going very smoothly over the past few years since we outsourced the function to the Journals Department at the University of Toronto Press. Over the next year we will be looking at alternatives, most likely bringing the job back in-house to the National Office. Fortunately, our finances have been handled very well under our Treasurer, Dr. Rajiv Gupta, and the computer system we use to track our revenue and expenses works very effectively. Our publications are in very good shape. *The Observer's Handbook* is consistently first rate and sells well around the world. The new look of the *Journal* has received many favourable comments from members. The current edition of the *Beginner's Observing Guide* continues to sell well and the *1999 Observer's Calendar* is already printed and looks fantastic. If we get all three areas (membership handling, finances, and publications) operating smoothly within the first year, I would like to spend the second year on other improvements to the Society.

It is not surprising that many people consider the National Society a "bureaucratic black hole." I want to change that image. Meetings of National Council are where we do our business; recall the $250,000 of revenue that we must handle. Each Centre has at least one representative who has the right to recommend how Society funds are spent. If we can streamline the process at our three meetings a year, we can spend more time on what we are all here for — astronomy.

I want to remind members that most of what we do depends upon people who volunteer their time. It may seem that "things take forever to get done" in the RASC, but eventually they do get done, thanks to the many members who help to make the RASC a successful astronomy organization.

Over the next two years I hope we can continue to promote the Society to Canadians through our publications, the Internet, and communications with schools and with the dozens of teachers and students who contact the National Office yearly looking for astronomical information. I am especially excited about the recent discussions on the RASCLIST regarding setting up RASC Youth Groups across the country.

I am very happy with the strength of our Society today. During the 1990s other organizations have disappeared because of the recession and the fact that people have less free time to spend on hobbies. At the same time we have grown financially and are recovering in membership numbers. The arrangement with *SkyNews/Ciel Info* is helping to draw people to astronomy and the RASC. In addition, one cannot help but be impressed by the skills of Society members who spend their free time producing the *Observer's Calendar*, the *Journal*, the *Observer's Handbook* and, at the Centre level, local newsletters.

During the term of the new executive we will see the year 2000. Whether or not you believe it is the beginning of the new millennium, one thing is certain; it will signal a fresh start. We will have the opportunity to look back to see where the RASC has been and to look ahead to see where we are going. Over the next two years I hope we can look ahead and see where we would like to be as an organization. I strongly believe in our influence when it comes to introducing the night sky to Canadians, particularly young people.

Where do I see the Society two years from now? I see an increased, active membership with a membership handling system being run in the National Office, an active web site with astronomical information available for students and teachers, increased *Observer's Handbook* sales, our publications distributed across the country, a new observing program for beginners in place, and increased activities for our young members. If we can do all of that, I will be very happy. With your help I know we can achieve such goals. I invite input and feedback from all members. Please contact me or any of your executive via e-mail, snail mail or telephone. I look forward to visiting various Centres during my term, talking to members, and seeing first-hand what you are doing.

Clear skies.

Correspondence
Correspondance

SUNDIAL DESIGNS

Dear Sir,

With regard to David Chapman's column on sundials in the April issue (JRASC, 92, 75, 1998), as a long-standing member of RASC who has designed accurate sundials in both hemispheres and who has written a very useful and highly accurate MS-DOS computer program to calculate the angles for every 5-minute division of any vertical or horizontal sundial, I have to disagree with the statement in David Chapman's article quoted below:

> "Interestingly, a sundial properly designed for a latitude other than your own is still perfectly usable, as long as you tilt the base north or south by the appropriate angle to align the gnomon edge with the polar axis. By doing that you are simulating installation at the design latitude."

This is perhaps the most frequent error regarding sundials. It has been copied from text to text, article to article, and used by salesmen *ad nauseum* to sell (inappropriately) their mass-produced "replica" sundials to unwitting clients who are located at latitudes different from that for which the sundial is calibrated. The fact of the matter is that the *formula* for calculating the angle (X) of any radial time-line marked on the surface of a horizontal sundial *inescapably "locks in"* the other two factors in the equation — the Sun's hour-angle h for that particular time of day and the angle L between the style of the gnomon and the flat horizontal dial plate. The well-known formula (Mayall & Mayall 1994) adequately expresses this *fixed* relationship,

$$\tan X = \sin L \tan h \ .$$

If the alignment of the gnomon's style were to be held constantly parallel to the Earth's polar axis, then altering the angle that the plate makes with the style (*i.e.* setting the plate off true horizontal) will inevitably alter the position of the shadow on that plate and will thus disagree with the previously-inscribed radial time-lines on that plate (if it had been designed for a different latitude from your current position).

As Rene Rohr states on page 49 of his book on *Sundials: History, Theory and Practice* (Rohr 1970),

> "...the hour-line of noon must be exactly oriented in the north-south direction when the dial is set in position and the table should, of course, be *strictly horizontal*."

Equally erroneous advice, often given by salesmen in order to sell useless "sundials," is to rotate the numerals in order to account for daylight saving time or even to compensate for a longitude different from that for which the sundial was designed. Mayall & Mayall (1994) are equally unequivocal about the same type of "malpractice."

The bottom line is that any effective, accurate, flat-surfaced, horizontal sundial has its time-lines carefully and irrevocably calibrated for a *specific* latitude, and its numerals are assigned to those lines with respect to a *specific* longitude, either in standard time or in daylight saving time, and the plate of the sundial *must* be mounted *strictly horizontal* with the style of the gnomon in true polar alignment.
I would be interested in receiving the names and addresses of any more Canadian designers and/or makers of accurate, functional sundials.

Roy Makepeace
RASC, Vancouver Centre

References

Mayall, R. N. & Mayall, M. W. 1994, Sundials:Their Construction and Use, 3rd Edition

Rohr, Rene R. J. 1970, Sundials: History, Theory and Practice (Univ. Toronto Press: Toronto) (Dover Edition 1996)

Chapman Replies: Roy Makepeace is absolutely correct about the geometry of horizontal sundials. His views are also consistent with my original statement, however. I should have explained more clearly that, in order to use a sundial designed for another latitude, one has to tilt the dial and gnomon together as a unit without altering their relative orientation.

The style of the gnomon (*i.e.* the shadow-casting edge) must always be parallel to the Earth's polar axis. If the Sun is at hour angle h, Mayall & Mayall's formula gives the angle X of the shadow cast on a plane inclined at an angle L from the style. The mathematical relationship holds for planes at all angles, including the local horizontal plane, for which the inclination angle is equal to the latitude of the sundial position. Once a dial is inscribed with hour lines for a given plane (horizontal or otherwise), the angle between the dial and the style cannot be altered, as Roy Makepeace says. I apologize if I my poor choice of words gave the wrong impression.

Consequently, a horizontal sundial correctly calibrated for a given latitude can be set up to keep correct time at a different latitude. If the entire sundial — gnomon and dial together — is tilted to align the style with the polar axis at the new latitude, correct calibration is restored, but the sundial will no longer be a "horizontal" sundial. For example, a horizontal sundial calibrated for installation at the North Pole consists of an upright gnomon perpendicular to the dial, with the hour lines spaced equally by 15 degrees. The same sundial can be installed at latitude *L* by tilting the base 90 – *L* degrees northwards from the local horizontal plane — that is the principle of the equatorial sundial.

The question of longitude calibration arises only if the sundial is designed to indicate standard time rather than local solar time. Although that might apply to some custom-designed modern sundials, it is not an issue for mass-produced sundials or any sundial constructed before the introduction of standard time zones. The procedure for correcting sundial readings for longitude and for the non-uniform apparent motion of the Sun is discussed on page 70 of the 1998 *Observer's Handbook.*

I thank Roy for "focusing" on this point.

David Chapman

News Notes
En Manchettes

ALL THE WORLD'S A STAGE

Two recently discovered moons of the planet Uranus are soon to receive their official names. In keeping with rules established by the International Astronomical Union's Working Group for Planetary System Nomenclature (WGPSN), it has been proposed that the two tiny worlds be named after Shakespearean characters. The discovery team has suggested that the moons be called Caliban and Sycorax, characters from *The Tempest.*

The two moons were discovered by an international team of astronomers led by Brett Gladman from the Canadian Institute for Theoretical Astrophysics (30 April issue of *Nature*). The team imaged the area around Uranus with a 2048 × 2048 CCD camera mounted at the prime focus of the 5-m Hale telescope on Mt. Palomar. The astronomers examined a series of images taken between September 6 and November 28, 1997, looking for the telltale motion of a new satellite.

Backyard astronomers will be hard-pressed to find the new worlds. The objects are extremely dim, with an estimated red magnitude of 20.4 for Sycorax and 21.9 for the dimmer Caliban. They translate into probable diameters of about 120 and 60 kilometres, respectively. They are both quite far from their parent planet, having estimated semi-major axes of 253 and 305 Uranian radii and orbital periods of 495 and 654 days, respectively. They are classified as irregular moons and possess orbits that are moderately elliptical, retrograde and highly inclined.

Asked why the group picked those particular names, Gladman replied, "Caliban is a magical character that sneaks around much of the play in the dark corners, which seems fitting." Gladman continued by saying, "Sycorax is his mother, although dead, and thus not a character in the play. There is a wonderful verse in Act II, scene ii, that particularly attracted me…"

> *Caliban: This island's mine, by Sycorax my mother,*
> *Which thou takest from me. When thou camest first,*
> *Thou strokedst me and madest much of me, wouldst give me*
> *Water with berries in't, and teach me how*
> *To name the bigger light, and how the less,*
> *That burn by day and night.*

Gladman and his team will be continuing their search for new moons of the outer planets. They have been granted additional time on the Hale telescope for 1998.

SOUNDING ROCKET TESTS MARTIAN ATMOSPHERE EXPERIMENT

A sounding rocket launch at Churchill, Manitoba, on April 27 tested new Canadian technologies, some of which will soon be part of a mission to Mars. The ACTIVE test carried instruments to measure the ozone layer, test the use of GPS (Global Positioning System) sensors in accurately determining the orientation of the wobbling sounding rocket, and a Thermal Plasma Analyser (TPA) to check the composition of the ionosphere. The latter test held no surprises, according to Dr. Andrew Yau of the University of Calgary, and that is a good thing. Dr. Yau is Principal Investigator for a second TPA experiment to be launched toward Mars in July, which will be the first Canadian instrument to head toward the Red Planet (or in fact any planet). The recent tests in the well-known ionosphere of the Earth proved that the instrument can function well and should be able to give new information about the upper atmosphere of Mars when it gets there, carried on Japan's *Planet-B* space probe. Although missions starting with *Mariner 4* in 1965 have studied the upper atmosphere and magnetosphere of Mars, most have done so briefly or at relatively large altitudes. *Planet-B* will come as close as 150 km to the Martian surface in its highly elliptical orbit, for the first time allowing repeated measurements at heights corresponding to those of Earth's important ionosphere. As part of a larger grouping of instruments, the Canadian TPA will help to answer questions about the Martian atmosphere, the magnetosphere generated by the interaction of Mars' weak magnetic field with the solar wind, and the relations between the two at the planet's boundary with space.

SNO OPENS

Over fifty physicists, including Stephen Hawking, who gave the keynote address, gathered at an INCO (International Nickel Company) mine outside Sudbury, Ontario, on April 29 for the official opening of the Sudbury Neutrino Observatory (SNO). Also present was the Honourable John Manley, federal Minister of Human Resources Development, who has been a strong ally of the observatory during its construction.

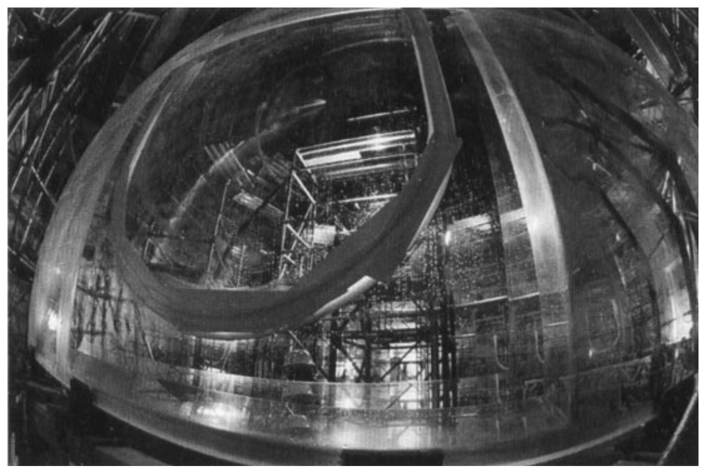
Neutrinos are particles associated with the nuclear weak force; there are three "flavours" (electron, tau and muon). They are produced at the Sun's centre as a consequence of the thermonuclear reactions that produce its energy. For over 30 years there has been a problem with "missing" solar neutrinos. By knowing the Sun's luminosity and the approximate conditions at its centre, astronomers can calculate how many neutrinos of each flavour should be produced. They found only about one half to two thirds as many as expected.

Neutrinos are very hard to detect, because they interact very weakly with matter. Moreover, until recently the neutrinos that could be observed were only of one flavour, and they came from a minor branch of the energy-producing cycle in the Sun. SNO is unique in being able to measure the flux of all three flavours.

The observatory, which is located two kilometres down a working nickel mine, consists of 9,500 light sensors surrounding a 12-m diameter acrylic flask that will hold 1,000 tonnes of heavy water. Interactions between neutrinos and the deuterium in the flask will produces flashes of light. Because the detector can make an independent measurement of all three types of neutrinos, it should be able to determine if neutrinos produced inside the Sun change type as they travel to the Earth. If they do change type, they must have mass, which would require revisions to the "standard model" of particles. Opinions about the nature of the revisions run from simply extending the model, to a major change.

As this is written, a competing experiment — Super-Kamiokande, located in the mountains of Japan — has claimed that they have found evidence for muon neutrinos changing type. Such neutrinos were created by cosmic rays colliding with atoms in the Earth's upper atmosphere, and there is deficit in the ones passing through the Earth relative to ones originating directly from the upper atmosphere. (There is no evidence for electron neutrinos changing type.) The general idea is that muon neutrinos passing through the Earth have had a longer time to change, which allows an estimate of their mass. The estimated mass is by far the smallest for any known particle. Although there have been assertions that the many neutrinos created just after the Big Bang might account for much of the mass of the universe, they do not seem to have the properties that would enable them to produce the observed large-scale structure of the universe — they would be spread too thinly to accumulate in clusters of galaxies because they travel very close to the speed of light.

That still leaves the solar neutrino problem, which is a deficit of electron neutrinos. Only SNO, with its ability to measure independently all three types, can hope to resolve the problem.



A view of the exterior of the 12-m diameter acrylic flask that holds 1,000 tonnes of heavy water. Interactions between neutrinos and the deuterium in the heavy water produce flashes of light which will be detected by 9,500 light sensors surrounding it.

ASTEROIDS WITH CANADIAN CONNECTIONS

(7886) REDMAN = 1993PE

Discovered 1993 Aug. 12 by D. D. Balam at Climenhaga Observatory, University of Victoria.

Named in memory of Roderick Oliver Redman (1905–1975), professor of astronomy and long-time director of the University of Cambridge Observatories, and in honor of Russell Ormond Redman (b. 1951), a radio astronomer on the staff of the Dominion Astrophysical Observatory. The senior Redman established a lifelong association with the DAO when he obtained the observational material for his doctoral thesis there; he became renowned for his superlative observational techniques and designs for astronomical instrumentation. The junior Redman, whose association with the DAO began as a summer student assistant in 1970, has pioneered the study of minor planets at submillimeter wavelengths and is an authority in using the thermal emission spectra to study their surfaces. Citation prepared by P. A. Feldman at the request of the discoverer.

ERRATUM

In the *Education Notes* article "The Composite Observational-Theoretical HR Diagram" by B. Cameron Reed, published in the February 1998 issue (JRASC, 92, 36–37, 1998), the terms in (log T) appearing in equation (5) should be replaced by terms in (log $T - 4$). Equation (5) does not generate correct values for the bolometric correction unless that change is made.

Astrophotography in the Digital Age

by Rajiv Gupta, Vancouver Centre (gupta@interchange.ubc.ca)

Among the many aspects of astronomy that amateurs enjoy, photography of the night sky is generally considered one of the most challenging. Deep-sky astrophotographers, in particular, have long been attempting to coax imperfect films into producing pleasing and accurate renderings of faint nebulae and galaxies. Such attempts necessarily involve long, guided exposures, and are often thwarted by an inaccurate telescope drive, poor polar alignment, imprecise focus, or mechanical flexure. One respected fellow astrophotographer, after hearing of my multiple failed attempts to produce an acceptable, manually guided, 3-hour exposure of a particular faint emission nebula, inferred (incorrectly) that I must be someone who enjoys sleeping on a bed of nails.

Many amateur astrophotographers have embraced digital technology as a means of achieving higher success rates. CCD autoguiders have largely eliminated the tedium of manual guiding. In addition, CCD cameras are now widely used in place of film cameras. Electronic cameras are much more efficient at collecting light than film and consequently require shorter exposures. They produce digital images that can be conveniently viewed and archived on a computer system. They are generally useful only for smaller night-sky objects, however, since their detection area is much smaller than that of film.

Digital techniques are also being applied to photographs originally taken on film. Joining their CCD colleagues, many film astrophotographers are now manipulating their images on computers by first converting them into digital form. The application of computer technology to film-based astronomical photography has tremendous untapped potential. One exciting possibility is the digital combination of two or more photos into a single image that is superior to the individual ones. A major practical obstacle, however, is the difficulty, or even impossibility, of precisely aligning the different component images with each other.

Here I provide an overview of the emerging art of film-based digital astrophotography, describing in particular some techniques I have employed. A *Windows* program, recently developed jointly with David Hare, plays a key role in my procedure. Our novel computer application completely automates the otherwise tedious process of aligning individual images with each other.

What is a Digital Image?

In a computer's eye, an image is a long sequence of numbers. The image is broken down into a large number of tiny elements called pixels, often several million in number. The number of pixels per inch is called the resolution of the image, and typically ranges between 72 and 600. The resolution of the image, together with its physical size, can be used to determine how many pixels an image has. For example, an image that measures 8 by 10 inches with a resolution of 300 pixels per inch has pixel dimensions of 2400 by 3000, giving a total of 7.2 million pixels.

Each pixel is assigned a descriptive number or series of numbers. The numbers usually range between 0 and 255. In the case of a black-and-white image, a single number determines the brightness of the pixel, with 0 representing the darkest black and 255 the brightest white. In the case of a colour image, a series of numbers is needed to describe not only the brightness but also the colour of the pixel. The RGB colour model is most commonly used — it assigns a triple of red (R), green (G), and blue (B) values to each pixel. For example, a pixel that measures (255, 0, 0) is pure red, while one that measures (200, 100, 50) is pale orange.

A computer image is, then, just a sequence of numbers giving the characteristics of each pixel, one by one. In the RGB model, since 3 numbers are needed for each pixel, the size of the image (in 8-bit bytes) is three times the number of pixels. Black-and-white images are correspondingly smaller, and images

Fig. 1R

Fig. 1G

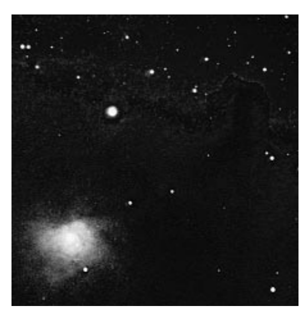


Fig. 1B

Fig. 1 A computer's view of the Horsehead Nebula. Note how colour information can be inferred from these red (R), green (G), and blue (B) images.

that use a greater range of values for the pixels, for example 16-bit images that use the 2-byte values 0 to 65535, are correspondingly larger. Image files can be compressed using various schemes (for example JPEG compression is very effective), but ultimately in a computer's memory a digital image is a string of numbers that directly correspond to the pixels in that image.

It is important to note that, to a computer, a colour RGB image is equivalent to three separate black-and-white ones, formed by separating the image's red, green, and blue pixel-values (see figure 1 for the red, green, and blue components of an image of the Horsehead Nebula).

How to Digitize

Photographic images are converted to digital form using a scanner. The image is broken into its many, many constituent pixels, each of whose attributes are recorded in the image file. The negative or film can be scanned directly using a film or drum scanner, or an enlarged print can be scanned using a flatbed scanner. A photofinisher or digital service bureau can provide scans that can be brought home on a compact disk or *Zip* disk, or a personal film or flatbed scanner can be purchased. Photographic scans are much more readily available now than they were just a few years ago. The Kodak Photo CD format is widely available from photofinishers, and personal flatbed scanners are now just a few hundred dollars, as opposed to over a thousand.

To reverse the process, that is to convert a digital image to physical form, is still somewhat problematic. Colour printers are improving, but in my (perhaps minority) opinion only expensive continuous-tone printers do an acceptable job. Another option is the output of the image onto a negative, using a high-resolution film-recorder at a digital service provider. The negative can then be printed at any desired size in a traditional darkroom.

Adequate computer resources are absolutely essential for frustration-free image editing. In particular, a good rule of thumb is that a system should have 3 times as much memory as the maximum (uncompressed) size of an image that will be processed on it. Also, large hard-drive capacity, a fast processor, and a large monitor are desirable. Fortunately, memory has fallen in price by a factor of 30 over the last 3–4 years (much to the chagrin of those of us who bought large amounts of memory several years ago), and computer components in general continue to become cheaper and better.

Since I routinely process images greater than 150 megabytes in size, it means that my system currently has a respectable 512 megabytes of memory. Most systems do not need nearly that amount of memory, but 64–128 megabytes is a reasonable amount for serious digital image manipulation.

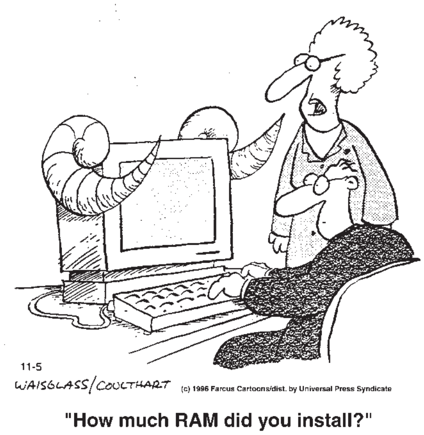


Fig. 2 *Don't* do this at home!

Why Digitize?

The advantages of digital images are many. Flaws such as scratches are very easily removed using image-editing software such as *Adobe Photoshop* (which, notwithstanding the manufacturer's claims to the effect, really *is* the premiere image editing software around). Also, colour, saturation, brightness, or contrast adjustment is all easily accomplished by adjusting the numerical values of the pixels. In order to make an RGB image redder, for example, the R-values have to be increased while the G- and B-values are lowered or remain the same. To make an image more colour saturated, the differences between the R-, G-, and B-values of a pixel need to be exaggerated.

Digital images are also easy to archive and catalogue, and are easily shared with others. When converted to JPEG form, the images routinely shrink in size by a factor of 20 or more, with good preservation of quality. The compact size and high quality of JPEG images explain why they have become the standard for Web pages.

Astronomical images in particular can uniquely benefit from digital processing using various software packages. Slightly out-of-focus stars can be sharpened using an image editing program's "sharpen" commands, and subtle details enhanced using various program-specific features. Among the more sophisticated techniques is maximum entropy deconvolution, used to correct the original *Hubble Space Telescope* images and now available to home enthusiasts (for example in the software package *MaxIm DL*).

Tricolour Photography

I believe the greatest potential for digital imaging as applied to astrophotography is in the combination of several photos of the same field into one. This, in principle, is not a new notion, but application of it has been quite limited to date. As mentioned earlier, a colour RGB image can be regarded as three separate black-and-white ones; while somewhat amusing, this observation is not particularly useful. On the other hand, what *is* significant is the converse: a colour image can be formed by combining three separate black-and-white ones that respectively represent the red, green, and blue intensities of the subject.

CCD-camera users are already routinely using the technique. By taking three separate red-, green-, and blue-filtered exposures on their electronic cameras, which directly record the images in digital form, and regarding the three images as the R, G, and B components of a single RGB image, they are able to produce colour images using what is in effect a black-and-white camera. Care must be taken to align the three separate B&W images with each other, but that is generally not very difficult because of the relatively small size of the images. While emulsion-based images can easily measure a few thousand pixels across, CCD images typically are several hundred, and consequently are readily aligned or "registered."

The technique has been extensively used by veteran Canadian astrophotographer Jack Newton. For example, he has formed a stunning image of a small portion of the Veil Nebula. The individual red, green, and blue exposures are given in figure 3, and a colour combination in figure 1C.

CCD "tricolour" photography, while capable of producing deep and accurate colour images of small objects, is not well suited to larger targets. Small images representing pieces of a large field can be "stitched" together, but typical CCD cameras would require dozens of stitchings to equal the coverage of a 35-mm film frame. About 100 separate exposures would be needed to match the coverage of medium-format film.

Fig. 3R

Fig. 3G

Fig. 3B

Fig. 3 The Veil Nebula as recorded through a 16-inch Meade SCT telescope by Jack Newton in three separate red (3R), green (3G), and blue (3B) exposures on a Meade 1616XT CCD camera. The blue and green exposures record glowing oxygen ([O III]) whereas the red exposure records excited hydrogen (H II).

Film-based Tricolour Photography — the Legacy of David Malin

The tricolour method also has a strong tradition in emulsion-based imaging. David Malin, now living in Australia and unquestionably the world's leading astrophotographer, refined the technique of taking separate red, green, and blue exposures on large B&W film plates and then combining them in a darkroom to produce the most spectacular astrophotos of our generation. The alignment of the individual B&W images to produce a colour image was made feasible by Malin's use of rigid photographic plates and professional telescopes that could be precisely positioned from one exposure to the next. While it is a painstaking method of producing images, the results are certainly worthwhile.

Amateur emulsion-astrophotographers have also dabbled in tricolour imaging to a limited extent. Unlike professionals, amateurs use elastic film that can stretch slightly from one exposure to the next. Also, it is difficult for an amateur to precisely centre the various exposures relative to each other at the telescope, especially if they are taken on several nights. If the exposures are significantly off-centred, then lens distortions, together with possible film stretch, may mean that the negatives cannot be subsequently aligned in the darkroom, no matter how painstakingly they are adjusted in the enlarger.

If the individual exposures *can* be aligned, a tricolour photographer can produce a colour image superior to any image obtainable through use of the same instrument with colour film. Colour films generally have coarse grain and inferior resolution as compared with black-and-white ones. In particular, Kodak's Technical Pan B&W film is a mainstay of serious astrophotographers because of its sharpness and sensitivity. Compare, in figure 4, the image of a portion of the North America Nebula taken on this wonder film with one taken on Kodak's Pro PPF colour film (one of the better colour emulsions available).

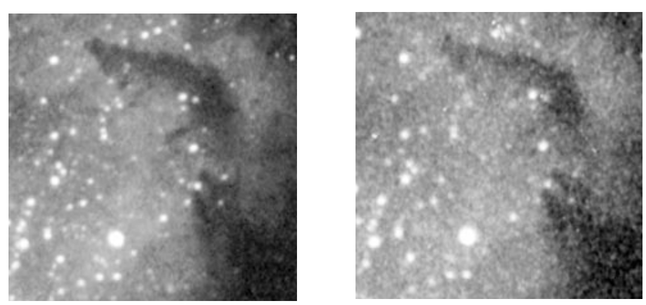


Fig. 4 Compare the resolving power of Kodak Technical Pan film (left) with that of Kodak PPF (right). Both exposures were taken using the same instrument.

The tricolour method, if successfully implemented, is also capable of more accurate renderings of nebulosity than colour films. Emission nebulae often produce forbidden emission lines of oxygen that shine at a wavelength of approximately 500 nanometres. A B&W film with an appropriate filter can record such blue-green light, whereas colour films tend to fall short

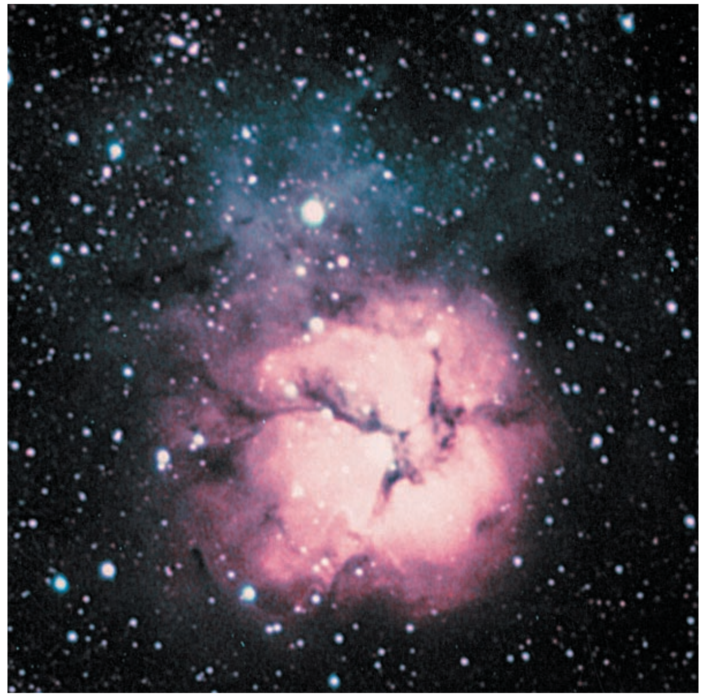


Fig. 1C (Above) The Veil Nebula in Tricolour, by Jack Newton. See the *1999 RASC Observer's Calendar* for a full-page reproduction.

Fig. 2C (Right) A bicolour image of the Trifid Nebula, formed by combining a yellow-filtered and a red-filtered exposure taken on Kodak Technical Pan film using a 5-inch Astro-Physics refractor. Note how the blue reflection nebulosity can be recorded even without a blue exposure.

Fig. 3C (Above) Compare the standard colour exposure of a portion of the Pelican Nebula on the left, taken using Kodak PPF film, with the composite image on the right, formed by combining the colour information in the PPF image with the sharpness of a red-filtered Technical Pan black-and-white exposure. Both images were taken with a 5-inch Astro-Physics refractor. A full page version of the composite image appears overleaf.

Fig. 4C (Above) An image of the Pelican Nebula, formed using the composite *Lab* technique described in the text.

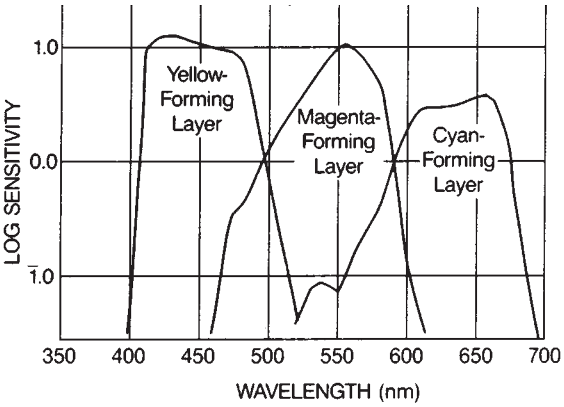


Fig. 5 The spectral response of a typical colour film. Note the "[O III] gap" around 500 nanometres. Taken from Kodak Technical Information Manual.

in this part of the visible spectrum. This inadequacy of colour films is the reason why film-based colour images of the Veil Nebula, for example, are usually a monotone red as opposed to the wide range of hues present in Jack Newton's CCD image (figure 1C). See figure 5 for the typical spectral response of a colour film.

Digital Image Registration – the Program *RegiStar*

The computer can come to the assistance of the frustrated aspiring Malin-ite. Instead of attempting, perhaps unsuccessfully, to align the B&W exposures in the traditional manner at the enlarger, one can employ a digital darkroom. The separate images can be digitized and then carefully shifted, scaled, and rotated using appropriate software. Once registered, they can be combined into a colour image just as for colour CCD images.

The procedure of digital registration, as described above, is tedious, time-consuming, and has uncertain results, and so may effectively only transfer the photographer's frustration from his enlarger to his computer. No matter how precisely the images are rescaled and rotated, parts of the images may not be aligned because of lens distortions and film stretch. Even if successful registration is possible, it may take a great deal of time and patience.

A software package that registers images to each other has recently been developed by David Hare and the author. Our program, *RegiStar*, is slated for release this fall. Employing a sophisticated automatic star-identification and matching algorithm, the program is able, with a single click, to register images with each other to fractional-pixel accuracy.
The new software, I believe, opens the door to a new, digital age of astrophotography. The computer can now relieve the tedium and difficulty inherent in the combination of several exposures into one, and make previously impossible images possible.

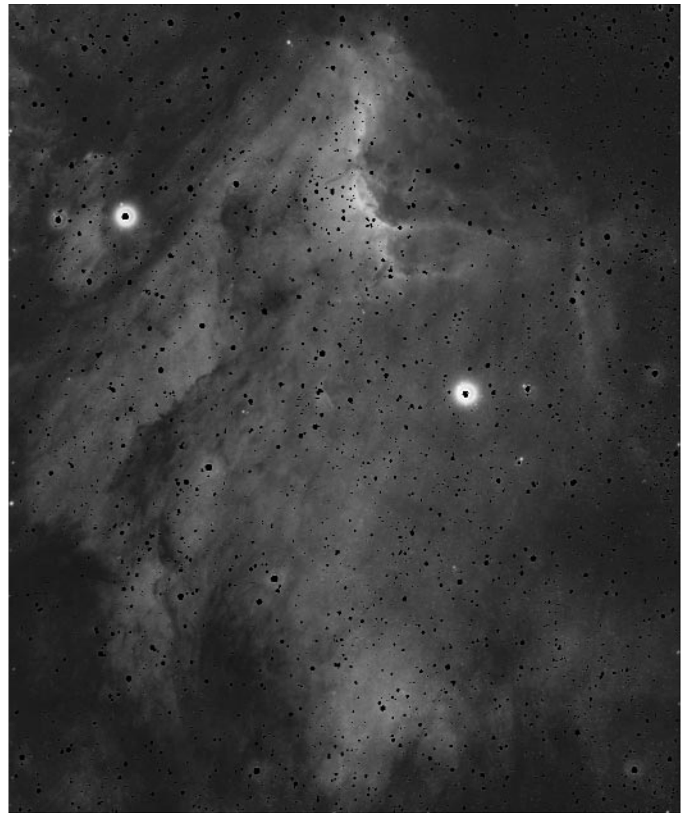


Fig. 6 A different view of the Pelican Nebula, with the 3309 stars identified by *RegiStar* removed.

The *RegiStar* Algorithm

The program works by first identifying stars, which it subsequently uses as landmarks to determine how one image must be deformed in order to align it with another. Several matching pairs of stars are found and their positions are used to compute the translations required to align them. Various local shifts are then used to deform the entire image. Since the deformation is determined using information that is localized rather than globally averaged, *RegiStar* can achieve a "rubber sheet" effect, compensating for differential warping and stretching in the two (or more) images being registered.

An incidental feature of this approach is that the program is able to separate the stars in an image from background information and can provide an accurate count of the stars in an image. See, for example, figure 6 for the "background-only" version of an image of the Pelican Nebula. The ability to separate stars might prove useful in other applications, for example stellar population studies. Also, the program's auto-registration capabilities may prove useful for supernova searching or other tasks that require repetitive comparison of pairs of images.

The program provides "single-click" operation for images that are at roughly the same resolution and that do not require a large deformation (*e.g.* if the maximum shift is less than 100 pixels). It is also capable of registering more grossly misaligned images and ones at different resolutions, if a small amount of assistance is provided by the user.

Variations on the Theme

Tricolour astrophotography has its limitations, even with digital techniques employed and the problem of image registration now completely solved. A major drawback is that three exposures on relatively slow B&W film are needed. Typical tricolour filters, especially the green and blue ones, tend to have low transmission and hence require long exposure times. Thus, an entire night, or significant portions of several nights, may be spent acquiring a single colour image.

One modification with which I have experimented is to replace the usual green and blue filters with higher-transmission yellow filters. A yellow filter simply blocks blue light below a certain wavelength, and transmits close to 100% of the green and red light above the cutoff. In spite of the fact that no blue exposure is taken, blue light is recorded as being slightly brighter in a yellow exposure than in a red exposure, and it can be extracted to produce blue out of yellow and red. It is not necessary to take three exposures; a "bicolour" RGB image can be formed by interpolating the red and yellow pixel values provided by just two exposures. (It would be preferable to replace the yellow exposure with an unfiltered one, but residual chromatic aberration in my refractor has thus far precluded such exposures.) See figure 2C for an example.

Another technique I have employed quite recently is to combine a single black-and-white Technical Pan photo with a single colour photo. The Tech Pan image provides good definition and detail, while the colour image renders the colour information in the subject. The RGB model for digital images cannot be directly used for such a combination; instead one must use the *Lab* model (available for example in *Adobe Photoshop*). Like the RGB model, *Lab* uses three numbers to represent each pixel: the "L" value gives the overall brightness of the pixel, and the "a" and "b" values its colour tinting.

With the *Lab* model available, the method of combining a B&W image and a colour image, once they have been registered relative to each other, becomes obvious. The colour image is converted to *Lab* mode, and the "L" pixel values in the colour image are replaced with the brightness values of the corresponding pixels in the B&W image. The resulting image retains the colour information of the original colour photo but is enhanced by the fine detail and sharpness present in the B&W image. The contrast or colour saturation of the original image can be increased before the L channel is replaced with its B&W counterpart. The saturation boost may make the grain of the colour image more evident, but that can be overcome by blurring the a and b channels prior to replacing the L channel.

An illustration of the improvement possible using this new composite technique, as applied to the Pelican Nebula, is given in figure 3C. A full-page version of the *Lab*-formed composite image is given as figure 4C. Note the marked reduction in grain and enhancement of detail in the composite image.

Two more examples of the composite colour-plus-black-and-white technique can be found in the *1999 RASC Observer's Calendar*. It is worth noting that the constituent exposures in both of the images were taken using different instruments: colour exposures were taken by Peter Ceravolo using custom-made Maksutov instruments, and B&W exposures by the author using an Astro-Physics refractor. Exposures taken through different telescopes cannot be registered using a darkroom enlarger or rigid digital scaling/rotation, but *RegiStar* is able to deform one image to match the other. As far as I know, it marks the first time that composite images have been formed using exposures from more than one instrument.

A final variation on the tricolour theme is the stacking of two or more images taken using the same film. Physical stacking of negatives using a darkroom enlarger has become a common method of increasing contrast and reducing grain of colour images. Now, using *RegiStar*, this is more readily accomplished digitally.

A Retrospective Perspective

Astrophotography is one of the most difficult branches of amateur astronomy and one of the most technically challenging types of photography. It has a long tradition of incorporating emerging technologies, with the goal of producing the most faithful renderings possible of its elusive targets. The list of sophisticated techniques and aids that have been widely employed by practitioners of this hundred-year-old science in their incessant struggle is long and impressive: long guided exposures, high-contrast films, special developer formulas, tri-colour photography, unsharp masking, gas hypersensitization, cold cameras, negative stacking, and CCD autoguiders.

Digital manipulation of film-based images provides us with significant new capabilities, and is now ready to occupy a front-line position in the arsenal of the happily struggling, patient and persistent, amateur astrophotographer.

Rajiv Gupta is a mathematics professor at the University of British Columbia, and a longtime astrophotographer specializing in wide-field, long-exposure imaging on medium-format film. He is the editor of the RASC Observer's Calendar, *and is currently 2nd Vice-President of the RASC.*

FROM THE PAST AU FILS DES ANS

MEETING OF THE SOCIETY IN TORONTO ON NOVEMBER 30, 1920

The Society met in the Physics Building of the University at 8 p.m., the President, Mr. J. R. Collins, in the chair.

The paper for the evening was given by Prof. G. R. Anderson, of the University of Toronto, on the subject "Landmarks in Photography." The lecturer traced the development of the art of photography from the Middle Ages to its present state of perfection. The alchemists, searching for the philosopher's stone and the elixir of life, discovered the germ of photography when they found that light affected the salts of silver. The Italian Porta, in the 16th century, invented the camera obscura, or pinhole camera. Later he replaced the pinhole by a lens, and using a mirror produced erect pictures on a screen. In 1802 an Englishman, Wedgworth, experimenting with silver salts, formed an image on paper, but could not fix it. He searched for years for a fixer but failed to get a solution. Niepce, a French scientist, was the first to get a process of photography that gave pictures subsequently unaffected by light. He coated the surface of a metallic plate with a solution of asphaltum in oil of lavender, and exposed it. After an exposure of twelve hours, the parts unaffected by light were dissolved away by immersing the plate in a solution of oil of lavender and white petroleum. This is the first landmark. In 1834 Fox-Talbot obtained images of objects on paper by placing the object, such as a fern leaf, upon a sensitive paper and exposing it to the light. He fixed his picture by means of a salt solution. By his process he obtained a photograph in one hour. In 1841, by using more sensitive paper, he obtained pictures with the camera.

In 1839 Daguerre announced his discovery. Exposing a highly polished surface of metal such as copper to the vapours of iodine he obtained a sensitive surface. To develop his plate he exposed it to the vapour of mercury that condensed on the surface acted upon by the light and formed an amalgam. Daguerreotypes were very popular in the middle of the 19th century, but they were not always complimentary, as the subject was forced to sit for 15 minutes in the sunlight, and consequently often closed his eyes. In 1855, Daguerre, not satisfied with his method, tried to develop a sensitive glass plate instead of paper. Archer produced the wet plate process using a solution of collodion and silver. The process had the disadvantage that the plate was not sensitive when dry. Thus a new problem presented itself — to make a sensitive dry plate. Dr. Maddox, in 1875, using gelatine, succeeded in obtaining the dry plate, and this step may be regarded as the second landmark in the development of the science.

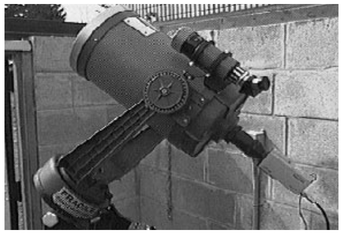
Orthochromatic and panchromatic plates were produced in the seventies. In 1890 when the celluloid film replaced glass plate, we have the advent of the Kodak, which has popularized photography. Muybridge in California in 1877 using a number of cameras in a row obtained a series of photographs of a horse in action. The idea was developed by Marey in Paris, who invented the first moving picture machine in 1893. Since then moving pictures have been brought to a high degree of perfection. A large number of slides were shown illustrating every phase of the art mentioned by the lecturer. Daguerreotypes and pictures obtained by the various processes were passed and examined by the members.

by J. A. Pearce, Recorder,
from *Journal*, Vol. 15, pp. 35-36, January, 1921.

Capturing the Surface of the Moon on Video

by Roger Hill, Hamilton Centre

Last fall, I captured the occultation of Saturn on a small 8-mm camcorder. Since then the Hamilton Centre has acquired a black and white video camera with a removable lens. This exquisitely sensitive device has proven to be a lot of fun to use, and I am looking forward to doing some more work with it in the future. Before going into future plans, however, let me bring you up to date on what has been done so far.



Ian Stuart's C-8 telescope in the Chilton Building at the Hamilton Centre's Observatory in Flamborough, Ontario. The television camera is a Sony monochrome security device. Its sensor is a CCD chip.

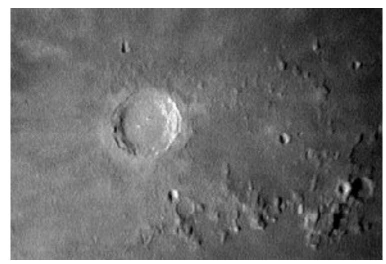
The first time we used the camera was last year when I brought it to the Leslie V. Powis Observatory. Using a hose clamp to attach its removable lens to an eyepiece, I was able to get an image of the Sun's disk that clearly showed sunspots. More importantly, it was immediately obvious that there were "waves" of seeing passing across the surface of the Sun. If we could capture images of the Sun during brief periods of good seeing, we had a chance to do some very high resolution work.

Mark Kaye, when he heard about the camera, offered the loan of his T-C adapter, which allowed us to connect the camera to any telescope that had a T adapter. With such a setup, along with the telecompressor, Les Nagy and I successfully imaged the occultation of Aldebaran and the Hyades last fall. It was during that time, while Les and I were waiting for stars to appear from behind the dark limb of the Moon, that we began to appreciate what the camera-telescope-combination could do. That was because we not only viewed the occultation on a monitor, but videotaped it as well. Viewing the tape after the event, Les picked out several re-appearances that were not predicted, since the target stars were too faint to observe normally. Les estimated that stars of around 9th magnitude were readily visible on the videotape.

Copernicus and area, as viewed with the camera.

Since Saturn was up and visible during the occultation, we pointed the camera at it, but were presented with a rather poor view. After playing around with the Automatic Gain Control (AGC), we obtained a very fine view of the ringed planet. Jupiter was also imaged on the same night, and we found that we could view either its satellites, or detail on the planet itself, but not both.

The results were most encouraging. It was a straightforward matter to capture black and white images of stars or bright, extended objects on videotape. The next step was to set up a system so that the images could be stored in a computer. The company for which I work no longer had a use for an old video capture card — a Creative Labs *VideoBlaster* (model CT6000). That model was the same one used by Colin Haig, and his help was invaluable in getting my system to work. The video card turned out to be so old that *Windows 95* does not support it. Furthermore, it could not be used in a computer with more that 15 megabytes of RAM. A long and involved search on the Internet turned up a few drivers that were developed by Creative Labs but no longer supported by them. I could also try to use the real-mode *Windows 3.1* drivers with the card running under *Windows 95*. It took a lot of fiddling, but I was finally able to get all the bits of hardware and software working. Next I captured my first image.

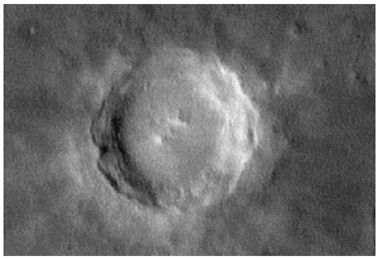


Copernicus as seen using 30–mm eyepiece projection.

The next celestial event for testing was the partial eclipse of the Sun in February (for Hamilton—it was total in the Caribbean, of course). Assisted by Jessica Reese, I tried to videotape all of the partial phases of the eclipse. It was discovered, however, that the Sun's brightness washes out the small glowing indicators on the VCR we were using. We discovered that we had not recorded what the camera was showing, only displaying it. Fortunately, I had my camcorder with me, and was able to get a reasonable shot of the eclipse by using it with my telescope eyepiece. It was certainly a learning experience. I am happy that I had not made the same mistake after travelling thousand of miles to view the eclipse!

I was corresponding via e-mail with Mark Kaye the day before the Centre's May meeting, and we decided that, if it was clear, we would go to the observatory and use the video camera to image the Moon. Although the weather was rather "iffy" most of the day, it cleared up in the evening and shortly after 9:00 p.m. Mark and I began to observe. I carried the big TV and the VCR from the Marsh building to the Chilton building, hooked up the camera to Ian Stuart's old orange C-8, and began to tape the session. We tried to use the camera at prime focus, as well as with the telecompressor. We placed a mask in front of the corrector plate and were so surprised with the detail in the images that we set up another telescope to see which provided greater detail — the camera or the eye. The eye proved better, but only by a small margin. From time to time the seeing improved and the view was tremendous. The video camera had certain advantages over viewing through an eyepiece. For example, we could use two eyes to view the TV screen instead of just one used at the telescope eyepiece, and more than one person could view at a time.

Mark and I looked for the Centre's eyepiece projection unit, but could not find it. We made a few calls to other Centre members in an attempt to determine its whereabouts, and managed to convince Les to join us at the observatory with his unit. When Les arrived he was as fascinated by the detail as Mark and I. We switched to a fairly long focal length eyepiece, but the continued sharpness of the images convinced us that we were not yet close to the limit of resolution. At that point we tried using a 9-mm eyepiece, and decided to observe the lunar crater Copernicus as a test. The section of the Moon that we were viewing was so small that we had extreme difficulty finding the crater, and it took us some time to locate it. Once located, the crater filled the screen. Since Copernicus is 90 km across, we would have needed a focal length of around 40 metres (40,000 mm, or 2,000 inches!) to photograph it at that scale with a regular 35-mm camera. The view on the screen was somewhat fuzzy, however, and proved to be too close to the limit of resolution. As a compromise we switched to a 15-mm eyepiece. After a good evening of "viewing," it was time to pack up. I showed our results to the Hamilton Centre the next night.



Copernicus as seen using 15–mm eyepiece projection.

I later transferred to my computer a few of the better frames that we had taped that night. Using a copy of *The Hamlyn Atlas of the Moon* (by Antonin Rukl), I was able to determine exactly how much detail was detectable. One crater, that was very distinct in the better frames, is only 5 km in diameter. A few other smaller craters can also be distinguished. An angle of 1 arcsecond corresponds to a resolution of 2 km at the distance of the Moon. Since that night was not a very good one with regard to seeing (6 or 6.5 out of 10), it seems that we should be able to do better on a good night.

What is next? Clearly, more lunar observing is being planned. Yet there are a few other possibilities. The planets would make ideal viewing with such a setup, for example. Twenty minutes taping of Jupiter, for instance, should allow us to obtain very good, clear, images. Obtaining images of Jupiter in three different coloured filters could get us started in tri-colour photography, by combining the images to get a true colour image. If we had only discovered the setup prior to the impacts with Jupiter of the fragments of Comet Shoemaker-Levy 9! Of course, we should be able to do similar observing for Saturn and Mars, and there is also the possibility of using the setup for deep sky objects. I suspect that we may be able to co-add our images for deep sky objects, just as is done with CCD cameras. We will see.

Roger Hill is a recent recipient of the Society's Service Award (see JRASC, 92, 97, 1998). He has been using telescopes since 1965, and has been a member of the Hamilton Centre since 1970. A self-professed computer geek, he is employed by a software development company in Milton, where he lives in a house that contains its own computer network — one that will also include the new observatory he is building in his backyard. A long time manager of the Hamilton Centre's web site, Roger has been on three solar eclipse expeditions since 1972.

140 Years of Comet Photography

by David M. F. Chapman (dave.chapman@ns.sympatico.ca)

The first person to photograph a comet was not an astronomer but a professional photographer — an Englishman named Usherwood. Using a portrait camera with a f/2.4 objective lens, he made a seven-second exposure of Donati's Comet (1858 VI) on 1858 September 27, just about 140 years ago. The first astronomer to snap a comet photo was George P. Bond, Director of Harvard College Observatory, who used a f/15 refracting telescope to form an image of the very same comet only one night later. Perhaps "snap" is not the right verb to describe Bond's photo, as he needed to expose the image for six minutes to register the faint image with his "slow" lens. Bond was only able to register the bright inner coma of the comet, while Usherwood actually captured parts of the tail.

In 1858 photography was still a young science in its teen-age years, having been invented by the Frenchman Louis Daguerre in 1839. Daguerre's process was relatively insensitive, however, and for suitable subjects astrodaguerrotypers had to content themselves with the more brilliant celestial objects such as the Sun and the Moon. Also, there were no 1-hour daguerro-finishers back then; astronomers had to process the plates themselves. Because of the narrow range of subjects available, the considerable inconvenience of the daguerrotype did not win it many fans among astronomers. In the words of David Malin and Paul Murdin, in *Colours of the Stars* (Cambridge University Press, 1984), "...the daguerrotype process was slow, inconvenient, unpleasant, and often downright hazardous to use."

> "The great comet of 1882 caused quite a sensation. At its brightest it was magnitude –14, making the Full Moon seem dim by comparison. The comet was an astrophotographer's dream."

The last comment probably refers to the necessity to immerse the exposed plate in the vapours from a heated tray of mercury...yech! The poisonous fumes, however, did not stop William Draper from imaging the Moon in 1840. Soon after, in 1845, Fizeau and Foucault captured some sunspots, and in 1850 William Bond (George's father) exposed the first quality image of the Moon. Those early images were unique, in the sense that they could not be reproduced or enlarged, and they did not last.

The delicate wisps of a comet's coma and tail were too faint for the daguerrotype; a more sensitive recording medium was needed. Fortunately, the science of photography advanced quickly, producing first the wet collodion process and then the dry gelatin emulsion. Both produced transparent negatives, but the collodion process still required the photographer to fuss with the plates just before use and to deal with them promptly after exposure. It is likely that Usherwood used the wet collodion process for the first comet photo. In 1889 George Eastman introduced the first "modern" photographic medium: mass-produced emulsion on rolls of flexible film. Although the same type of film is convenient to use with lenses of short focal length, professional astronomers have long preferred large glass plates to support the emulsions needed to capture a reasonable chunk of sky with their longer astronomical lenses.

The Great Comet of 1882 caused quite a sensation. At its brightest it was magnitude –14, making the Full Moon seem dim by comparison. The comet was an astrophotographer's dream (and would have been within the grasp of the daguerrotype, I wager). Working from the Cape of Good Hope in South Africa, David Gill took many photographs of the comet, piggybacking a f/4 portrait camera on a 6-inch refracting telescope. Gill was instrumental in developing improved drives for telescopes, which were needed to prevent long exposures from being blurred by poor tracking. His photos of star fields proved that astrophotos were more than a curiosity — the plates were beginning to show faint stars that were beyond the ability of the human eye to register, even with the aid of a telescope.

With the increasing interest in astrophotography, it was only a matter of time before someone would discover a comet in such fashion. The honour went to the American astronomer Edward Emerson Barnard. On the cool autumn night of 1892 October 12, Barnard made a 4 hour, 20 minute photographic exposure of the Milky Way in the region of the bright star Altair, using a 6-inch telescope at Lick Observatory in California. When the plate was developed, a fuzzy streak betrayed the presence of the new periodic comet that came to be called Barnard 3 (1892 V). That accidental photographic discovery was the last of a lifetime total of sixteen comets discovered by Barnard.

Nowadays most comets are discovered photographically (or through electronic imaging), usually by imposing themselves on a photographic exposure intended to record some entirely different celestial scene. On the other hand, determined comet-seekers (who are almost always amateur astronomers) typically conduct visual searches through their telescope or large binoculars. Occasionally a comet is discovered not by a human observer but by an orbiting observatory conducting survey work. IRAS, the *InfraRed Astronomical Satellite*, is credited with 2 co-discoveries in 1983 alone. More recently, the instruments aboard the *Solar and Heliospheric Observatory* (SOHO) spacecraft have discovered the amazing number of 49 comets, the latest being C/1998 J1.

The human masters of the photographic discovery of comets, however, must be the team of Carolyn and Eugene Shoemaker, joined for a time by David Levy. Their photographic search for potential Earth-bound asteroids served up a feast of comets as a side dish to the main course. (Thirteen comets bear the Shoemaker-Levy moniker.) Their technique was an enhancement of that used by Clyde Tombaugh to discover the planet Pluto: expose two plates of the same region of the sky at different times, then place them in a stereoscopic viewer and register the images of the "fixed" objects. If an object has moved during the interval of time between the exposures, the eyes and brain interpret the images as views of an object much closer than the background; the moving object appears to float above the background. In March 1993 the Shoemaker-Levy team used this photographic method to discover one of the most remarkable comets of all time: D/1993 F2, or Shoemaker-Levy 9 (because it was the ninth periodic comet the team had discovered). That comet, also known as the string-of-pearls comet, achieved notoriety the following July when its twenty-odd nuclei smashed into the planet Jupiter over a period of several days while the world watched. (Hence the designation "D," for "disappeared.") The full story of the comet can be found in David Levy's book *Impact Jupiter* (Plenum Press, New York, 1995).

The 1990s have turned out to be a good decade for comets, not only with the appearance of S-L 9, but also Comet Hyakutake (C/1996 B2) in 1996 and then Comet Hale-Bopp (C/1995 O1) in 1997. Although Hyakutake made a big impression on amateur astronomers, its appearance was too fleeting for casual sky-gazers, especially if they did not take the trouble to search out dark skies on the one superb night of 1996 March 24/25. Many excellent photographs of Hyakutake were published in astronomy magazines. The next year, however, Comet Hale-Bopp put on a much longer display and was situated better in the evening sky for city-bound observers. Many saw the comet and even more photographs were published. Comet Hale-Bopp must hold the record for the most widely observed and most-photographed comet of all time. With today's fast camera lenses and high-speed colour film, even beginning astrophotographers are able to capture excellent views of bright comets like Hale-Bopp.

David M. F. Chapman became interested in astronomy at the age of 8, and studied physics at the University of Ottawa (B.Sc. 1975) and the University of British Columbia (M.Sc. 1977). Since then he has performed research in ocean acoustics at the Defence Research Establishment Atlantic. He occasionally writes astronomy scripts for the StarDate *and* Earth&Sky *radio broadcasts.*

Astrocryptic

by Curt Nason, Halifax Centre

Here are the answers to last issue's Astrocryptic Puzzle:

1 R	E	2 D	G	3 I	A	4 N	T		5 N	6 O	V	7 A
O		A		A		O		8 A		R		N
C		9 C	A	P	A	C	I	T	O	R		N
H		T		E		T		O		E		U
10 E	G	Y	P	T		11 I	M	M	O	R	A	L
		L		U		L				Y		A
12 M			13 E	S	T	U	A	14 R	Y			R
O		15 A				S		E		16 D		
17 O	R	G	A	18 N	I	C		19 G	H	O	S	20 T
N		A		E		E		U		R		I
S		21 T	R	I	A	N	G	L	E	S		R
E		E		L		C		U		A		O
22 T	E	S	T		23 P	E	R	S	E	I	D	S

Second Light

Breaking Up Asteroids

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

This summer seems an appropriate time to look at how we might deal with an asteroid (or comet) that is on a collision course with the Earth, given that two movies on the topic have been released. Although plans to protect the Earth are in their infancy, some people have high hopes that such protection might ultimately be possible. The *Spaceguard* program in the United States, which would attempt to deflect or destroy incoming bodies by shooting many missiles tipped with nuclear weapons at them, is one such project. Erik Asphaug of the University of California at Santa Cruz and his collaborators have some cautionary news for the backers of projects like *Spaceguard*, as reported in the 4 June issue of *Nature*. They find that some (perhaps many) of the small asteroids that threaten the Earth may be more difficult to break up than previously thought.

At the present time, astronomers estimate that they have catalogued and calculated the orbits of fewer than ten percent of the asteroids whose orbits cross that of the Earth and therefore potentially could hit us. (That does not include comets coming into the inner solar system for the first time in recorded history.) The *Spacewatch* project will find and track bodies that might threaten the Earth with the hope of identifying threats many orbits in advance of the impact. If we can accomplish it, then perhaps we can break up the asteroid or nudge it out of the way, at least for a while. But that might be harder than expected.

> "At the present time, astronomers estimate that they have catalogued and calculated the orbits of fewer than ten percent of the asteroids whose orbits cross that of the Earth and therefore potentially could hit us."

A revolution in our understanding of asteroids has occurred over the last few years. Up until recently it was believed that asteroids smaller than about 5 kilometres in diameter had to be held together by mechanical strength, because their self-gravity was so small. Such bodies would be "solid," meaning that they were held together by "chemical" forces — the same kinds of bonds that hold molecules together. While this might seem like a trivial point, "chemical" forces are, in fact, electrical which means that, per unit mass, they are about 40 orders of magnitude stronger than gravity. The practical effect of such forces is that many small asteroids, which are much more common than larger ones (the number of asteroids in a given size range scales approximately as the inverse cube of the diameter), turn out to be "rubble piles" rather than big boulders. While that might seem like an academic distinction, of interest only to a few asteroid astronomers, it might affect our future quite profoundly.

Asphaug points out that the effects of depositing large amounts of energy locally on a rubble-pile asteroid are substantially different than depositing it on a solid asteroid. The bottom line is that rubble-pile asteroids are very effective at absorbing blasts of energy, either from nuclear weapons or from impacts of smaller bodies, without widespread damage to their overall structure. The asteroids simply rearrange their internal structure rather than blowing apart. To anyone who practices karate, the effect is like the difference between hitting a brick (which is solid, and will break in two) and a pile of sand; the pile of sand will simply reorganize its shape, thereby absorbing the energy of impact. Asphaug also shows that the distribution of cracks and fissures in solid-body asteroids will have a large effect on the propagation of shock waves through the rock (it is the shock waves that "shake apart" the asteroid). "Contact-binary" asteroids — bodies that are essentially two smaller asteroids butted against each other —are also difficult to disrupt. A shock wave might break apart one but leave the second intact, because the shock cannot travel across the interface between the two components. That is a problem for us if we are in the way of the asteroid.

Where does it leave us? Collisions between the Earth and other bodies are inevitable — anyone who has seen the streaks of meteors across the sky should appreciate this. Every year the Earth is hit by many small bodies that hardly ever do any damage to humans or their property. Clark Chapman (of the Southwest Research Institute in Boulder, Colorado) estimates that about once every ten thousand years an asteroid with a diameter of 250 metres and an average velocity of 20 kilometres per second will strike the surface with an energy equivalent of 1,000 megatons of TNT (see the 6 January 1994 issue of *Nature*). Although such an impact would wipe out a large city, the chances of the asteroid hitting a city are actually quite small, because cities cover a negligible fraction of the Earth's surface. Most of the Earth's population would be unaffected. We have actually had a smaller event (over Tunguska, in Siberia) during this century; the effective energy of that blast has been estimated to be in the 10-40 megaton range.

Strikes by larger bodies occur much more rarely, but are also much more catastrophic. It is now widely accepted that 65 million years ago the dinosaurs were killed off when an asteroid roughly 10 kilometres in diameter struck near the Yucatan peninsula. It has been estimated that as much as ninety percent of life on the Earth was wiped out by this event, but on the other hand it may well have been the most energetic impact of the last few hundred million years.

Threats from comets are more difficult to deal with, in several regards. The average impact speed will be much greater than that of an asteroid; because the energy scales as the square of the speed, comets therefore have greater energies for the same sized body (even though their average densities are less than those of asteroids). There is also the problem of advance warning. In the movie "Deep Impact" it was about two years, which is quite realistic. Would that be sufficient time in which to respond to the threat?

Not all is doom and gloom. Asphaug's simulated impacts had an equivalent energy of only 17 kilotons; much larger energies might be enough to demolish totally the kinds of bodies that pose much of the threat. His main message, though, is that the outcome of such events is very hard to predict without a detailed understanding of the asteroid. He also urges caution that, until we actually send a probe to an asteroid to understand its nature, the underlying assumptions that went into his model should be regarded as tentative.

Finally, in the light of recent test nuclear explosions in India and Pakistan, there is the wider question of whether we want to develop the capability to launch large weapons out of Earth's gravity well. Perhaps we should try to understand asteroids before attempting to blow them up.

Dr. Leslie J. Sage is Assistant 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.*

STAR QUOTES

"That one body may act upon another at a distance through a vacuum without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that, I believe, no man who has in philosophic matters a competent faculty of thinking could ever fall into it."

Sir Isaac Newton
English physicist/mathematician (1642–1727)

• • •

"I remember discussions with Bohr which went through many hours till very late at night and ended almost in despair; and when at the end of the discussion I went alone for a walk in the neighbouring park I repeated to myself again and again the question: Can nature be as absurd as it seemed to us in these atomic experiments?"

Werner Heisenberg
German physicist (1901–1976)

Research Papers
Articles de recherche

OBSERVATIONS OF MARS DURING ITS 1996-97 OPPOSITION

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Abstract. Intensive visual and photometric observations of Mars were carried out during the 1996-97 opposition. The Hellas basin appeared very bright while Mars passed through areocentric longitudes 90° < L_S < 120°, a feature that could be attributed to either ground frost or low lying clouds. The north polar cap (NPC) had an uneven spatial intensity during 1997, which may have been caused by dust activity in September 1996. There is evidence for orographic cloud activity occurring in the area of Ortygia, and bright clouds were observed in Tempe, Tharsis, Elysium and near Syrtis Major. A total of 221 *B, V, R* and *I* photoelectric measurements of Mars resulted in normalized magnitudes of *B*(1,0) = −0.26 ±0.02, *V*(1,0) = −1.58 ±0.02, *R*(1,0) = −2.72 ±0.02 and *I*(1,0) = −3.16 ±0.03. The opposition surge of Mars was largest in the *B* and *V* bandpasses, but was less pronounced in 1997 than in 1995.

Résumé. Les observations visuelles intensives et photométriques de Mars ont été effectuées durant l'opposition de 1996-1997. Le bassin de Hellas paraissait très vif lorsque Mars a passé à travers les longitudes aréocentriques de 90° < L_S < 120°, un trait qui pourrait être attribué soit à la givre au sol ou à des nuages à basse altitude. Le cap polaire du nord avait une intensité visuelle irrégulière durant 1997, causée selon toute possibilité par le mouvement de poussière atmosphérique en Septembre 1996. Des signes de mouvements de nuages orographiques ont été aperçus dans la région d'Ortygia et de nuages clairs dans celles de Tempe, Tharsis, Elysium et près de Syrtis Major. Un total de 221 mesures *B, V, R* et *I* photoélectriques de Mars a produit des magnitudes normalisées de *B*(1,0) = −0.26 ±0.02, *V*(1,0) = −1.58 ±0.02, *R*(1,0) = −2.72 ±0.02, et *I*(1,0) = −3.16 ± 0.03. La montée de brillance durant l'opposition de Mars était la plus forte dans les bandes *B* et *V*, mais moins prononcée en 1997 qu'en 1996. SEM

1. Introduction

Mars reached opposition on March 17, 1997, during which its diameter was 14.2 arcseconds and its declination +4°.5. At opposition its sub-Earth latitude was 23°.2 N and the planet had travelled 92° from the ascending node of its orbit (*i.e.* the areocentric longitude L_S of the Sun was 92°). The areocentric longitude of Mars was 45°, 59°, 72°, 85°, 98°, 112° and 126° on the first of each month starting on December 1, 1996 — the values are given so that the reader can estimate those applying on the various dates given in this paper. On July 4 the *Pathfinder* spacecraft landed on Mars and its mobile vehicle *Sojourner* began to carry out chemical tests of the Martian soil (Peterson 1997). Two months later *Mars Global Surveyor* entered orbit around Mars. Observations by the *Hubble Space Telescope* (HST) suggest that the climate on Mars has changed over the last twenty years (Fischer & Duerbeck 1996).

As part of an ongoing study of Mars, the author carried out an intensive photometric study of Mars during its 1996-97 opposition. A preliminary abstract was published elsewhere (Schmude 1997) and a 20-minute talk on the photometric results was given at the 1997 General Assembly of the RASC in Kingston, Ontario. The photometric results, along with the visual observations, are summarized here. The visual studies are described in three sections that concentrate on observations of Hellas, the north polar region, and the clouds and surface features. All of the observations and photoelectric work were carried out at the Charles Barber observatory located just north of Villa Rica, Georgia. The observatory has an elevation of 323 m and is located at 84°.935 W, 33°.791 N.

Visual observations were carried out for two reasons: to assist in the interpretation of photometric measurements, and to facilitate comparison of visual and electronic images of Mars. Surface features, including polar caps, affect the brightness of Mars. During the 1992–93 and 1994–95 oppositions, for example, photoelectric observations indicated that Mars was brightest when longitude 160° W was directed towards Earth. A Mars map produced in 1992–93 is consistent with the photometric data since it contains few dark areas located near 160° W. The north polar cap can also increase the brightness of Mars by 0.2 magnitude or more, depending upon its size and orientation. The size of the polar cap is therefore important to monitor.

Visual work also has some value as a means of confirming observations made with electronic cameras and computer enhancement techniques (broadly referred to as "CCD imaging"). Although CCD imaging has proven value, CCDs have a different response than the human eye to different wavelengths of light. Inconsistencies in imaging techniques and uncertainties associated with image processing may also be important. The author is therefore of the opinion that a transition period is needed for comparison of visual work with CCD imaging.

The three types of visual measurements carried out during the 1996–97 campaign were drawings, intensity measurements, and size estimates for the shrinking polar cap. Drawings were made to help interpret photometric measurements. The names for the various Martian features referred to here are those on the Mars map compiled by Dr. S. Ebisawa (McKim 1986; Beish & Capen 1988). The clouds/surface features section of this reference is organized in the same way as recent British Astronomical Association Mars Reports (McKim 1997). My intensity measurements were made on the European scale in which 0 = white, 10 = black, and values between the two refer to intermediate shades. Intensity estimates help to monitor seasonal changes in the Hellas basin as well as spatial changes in the north polar cap.

2. Hellas

The Hellas basin underwent substantial changes during 1997, much like it did during 1994-95. The author made several intensity estimates for Hellas between February 16-23, 1997, the average intensity measuring 1.2. The estimated value during the period March 23-27 was brighter, namely 0.3. Such a brightening trend was confirmed by HST images; Hellas was moderately bright on March 10 (O'Meara 1997) and very bright on March 30 (Dyer 1997). A general trend during 1997 was for the region to reach peak brightness between orbital phases L_S = 90°–120°, following which it gradually became less bright at larger areocentric longitudes (Minami 1996, 1997b, d, e, f, g, h, i, j, k, l; McKim 1997). A similar trend occurred during 1995 (Schmude 1996).

The brightening of Hellas was probably caused by either ground frost or by low-lying clouds or fog. Hellas was reported to be dull in a red light CCD image taken by J. Dijon on March 22/23 when the central meridian was 289° W. That rules out dust clouds as an agent for the brightening since they are bright in red light (Beish & Capen 1988). High altitude clouds are also unlikely to be the cause of the brightening because Hellas was faint in an ultraviolet filter photograph taken by F. J. Melillo on April 3 when the central meridian was 260° W; high altitude clouds appear bright in ultraviolet light (Parker *et al.* 1986).

3. North Polar Region

A total of 103 estimates of the size of the north polar cap (NPC) were made during the 1996-97 opposition, in the same manner described previously (Schmude 1996). The average measures for the cap radius are summarized in Table I. They are consistent with a polar cap extent in 1996-97 covering about the same amount — or perhaps slightly less — of the Martian surface as in 1994-95.

Troiani *et al.* (1996) conclude that the use of red filters is preferable for estimating the size of the polar caps because observations through filters in other colours do not allow one to distinguish between the true cap and thin hazes. I therefore reanalyzed my 1994-95 polar cap data in order to obtain information on the perceived size of the NPC through filters of different colour. The average perceived sizes for the NPC through each filter divided by the perceived sizes in integrated light are: 0.95 ±0.03 Red (#25), 0.96 ±0.06 Orange (#23), 1.00 ±0.04 Yellow (#15), 0.98 ±0.03 Green (#58), and 1.00 ±0.04 Blue (#82A). The NPC during 1994-95 therefore appeared in red light to be 95% of its apparent size in integrated light. Similar results were obtained during the 1996-97 opposition; different filters were used, however, and there was a possibility of bias that was not present in 1995. The results generally support the concept that observations through red filters are relatively unaffected by the presence of extra bright areas that are not part of the polar cap. But the difference between NPC size as established by observations in integrated light and that established through red light filters amounts here to only 5%. Since an average over observations in all filters was adopted in my 1994-95 study as well as here, the cap radii should be about 3% (±3%) larger than those cited in the Association of Lunar and Planetary Observers (ALPO) studies of 1995 and 1997. One concern that the author has about using only red filters for making polar cap size measurements is that red filters may not distinguish between the polar cap and a dust cloud.

Table I

Estimated Radii for the North Polar Cap of Mars during 1996-97 Opposition

Longitude Interval L_S	Cap Radius
20°–25°	22°.1
45°–50°	19°.1
50°–55°	21°.1
65°–70°	18°.1
70°–75°	13°.4
75°–80°	12°.6
80°–85°	8°.9
85°–90°	6°.9
90°–95°	6°.3
95°–100°	8°.0
100°–105°	6°.9

The HST imaged a dust storm over the north polar cap on September 18, 1996; the dust storm was located at 160°–200° W and 55°–70° N (O'Meara 1997). What appeared to be a second dust storm located in the Tempe area was imaged by D. C. Parker on September 18, 1996 (O'Meara 1997). The storm imaged by the HST undoubtedly deposited large quantities of dust on the NPC. Such dust could have lowered the albedo of the NPC, *i.e.* produced a larger value on the European intensity scale. There is some visual evidence to support such a possibility. H. Ishadoh, for example, noticed that the NPC was slightly dull during November and the first part of December (Minami 1997a). On February 10, 1997, M. Minami noticed that a quarter of the NPC on the following side was yellowish and less bright than the rest of the cap; the observation was confirmed by CCD images made two days earlier (Minami 1997c). The author also noticed that the NPC had an orange-white colour on December 20, 1996, when the longitude of the central meridian (CM) was 231° W. It appeared to be dull on February 1, 1997 (CM = 185° W). At other times, however, the cap was bright white.

The asymmetry in brightness is evident in HST images (Dyer 1997), which suggests that the north polar cap was darker in some areas because of the deposited dust from the September 1996 dust storms. The HST images for September 18 and October 15 imply that the NPC dust storm shifted about 30° westward (James & Lee 1997). My intensity estimates for the NPC during the 1990-91, 1992-93, 1994-95 and 1996-97 oppositions are listed in Table II, where each observation was given equal weight in the determination of the average intensity at opposition. Two trends are evident. First, the average intensity in 1996-97 had a larger value on the European scale, which means that the cap was darker than at previous oppositions.

Table II
Estimated Intensity of the North Polar Cap During the Last Four Oppositions

Longitude Interval	North Polar Cap Intensity 1996-97	1994-95	1992-93	1991
250°–310° W	0.5	0.4	0.0	0.3
310°–10° W	0.6	0.5	0.5	..
10°–70° W	..	0.2	0.3	1.0
70°–130° W	0.8	0.4	0.5	..
130°–190° W	0.3	0.3	0.2	..
190°–250° W	0.7	0.7	0.5	..
Average	0.60 ±0.21	0.37 ±0.11	0.38 ±0.15	(0.5)
No. Observations	12[a]	50[b]	18[c]	3[a]
Range in L_S	54°–107°	1°–113°	29°–82°	29°–34°

Notes: [a] Instrument used was a 25-cm Newtonian.
[b] Instrument used was a 9-cm Rich Field Refractor.
[c] Instrument used was a 36-cm SC.

Second, the area lying between 190°–250° W was darker than the surrounding portions of the cap in 1996-97.

A bright, isolated area in the region Ortygia was detected on February 18 (figure 1) and on March 27. The estimated ground coverage was 30,000 km^2 on February 18 and 400,000 km^2 on March 27. A similar feature was noticed by ALPO observers during oppositions in 1994-95 (Troiani *et al.* 1996), 1982 (Parker *et al.* 1983) and 1984 (Beish & Parker 1988); it also appears as an extension of the NPC in a drawing from February 3, 1963 (Both 1963). The feature, however, was not mentioned in the BAA reports for the 1980, 1982 or 1984 oppositions (McKim 1984, 1985, 1987), but was apparently observed as a bright "cloud" on June 13, 1969 (Collinson 1970). The Martian co-ordinates for the feature are 353° ±4° W and 73° ±4° N, in which the co-ordinates reported by Beish & Parker (1988) received double weight in forming the averages because they were based on several observations. The bright areas fall in the general vicinity of two volcanoes, Kison Tholus at 358° W, 74° N, and Ortygia Tholus at 8° W, 70° N (Batson *et al.* 1979). The observations from February 18 and March 27, 1997, indicate that the bright Ortygia feature grew by more than a factor of 10 between those dates, consistent with the formation of an orographic cloud.

The author observed the north polar collar on August 14, 1997, and observed the feature frequently until early March 1997. There seems to be no correlation between the collar and albedo features listed elsewhere (Batson *et al.* 1979). The feature was not observed after Mars reached orbital longitude L_S = 85°.

4. Clouds and Surface Features

A map of Mars prepared from the present study is shown in figure 2. Observations employed to construct the map were obtained mainly using a 25-cm f/6 Newtonian telescope with a 4.0-mm orthoscopic eyepiece (380×), although a 51-cm f/4.5 Newtonian telescope was also used at times. The nomenclature is identical to that adopted by Ebisawa (McKim 1986).

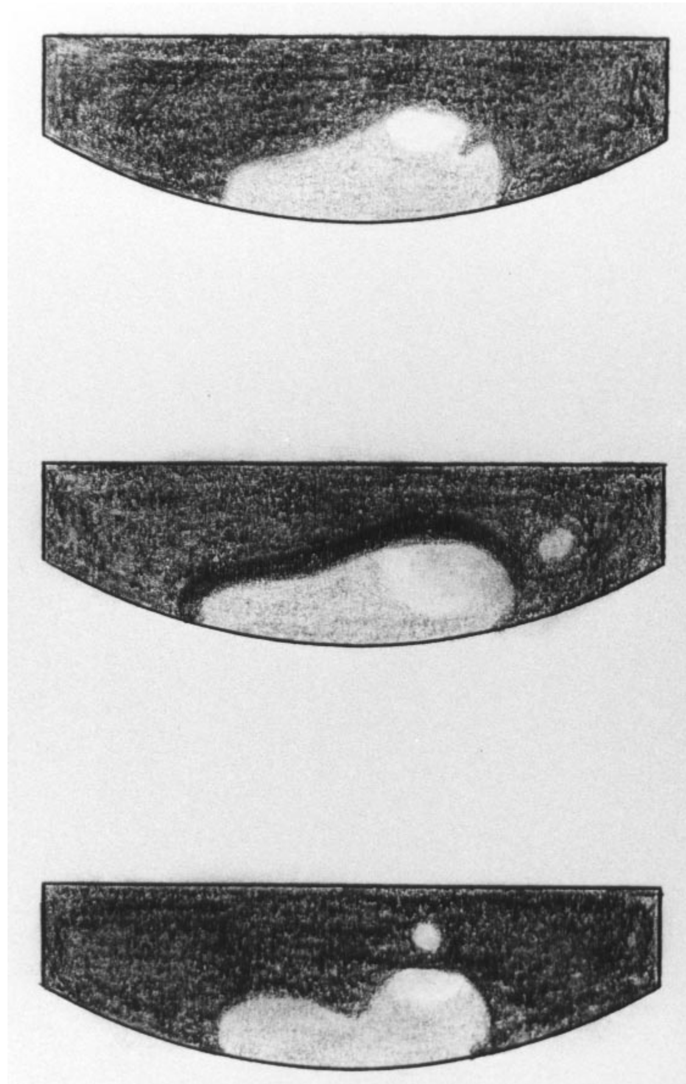

Fig. 1 — Drawings of the north polar cap made on February 18, 1997. All 3 drawings were made at 380× . The top drawing was made at 6:06 UT (CM = 301° W), the middle drawing at 7:02 UT (CM = 315° W), and the bottom drawing at 8:43 UT (CM = 339° W).

Region I: 250° W–10° W. Syrtis Major appeared about the same in 1997 as it did in 1993 and 1995. Timings for the central meridian transits of Syrtis Major on February 18, 1997, correspond to longitudes of 281° W, 289° W and 296° W for its preceding edge, centre and following edge, respectively. The northern end of the feature was blunt with a small westward extension, while the northern third was lighter than the southern portion on February 16, 1997 (CM = 297° W). The northern portion was darker one week later (CM = 272° W). Such a rapid change implies the existence of thin cloud cover over Syrtis Major on February 16. The Syrtis Major blue cloud was observed twice on the following limb, once on January 26 (CM = 240° W) and again on February 16 (CM = 297° W). On February 16 the cloud appeared faint through a red filter (#25), but bright through orange (#23) and green (#58) filters. Aeria and Libya were both bright on several occasions in 1997, and that did not seem to depend on the longitude of the central meridian. The brightness of Libya blended in gradually with the areas to the north. Moeds Lacus was barely visible as a tiny, faintly dark area in 1997; the feature seems to have

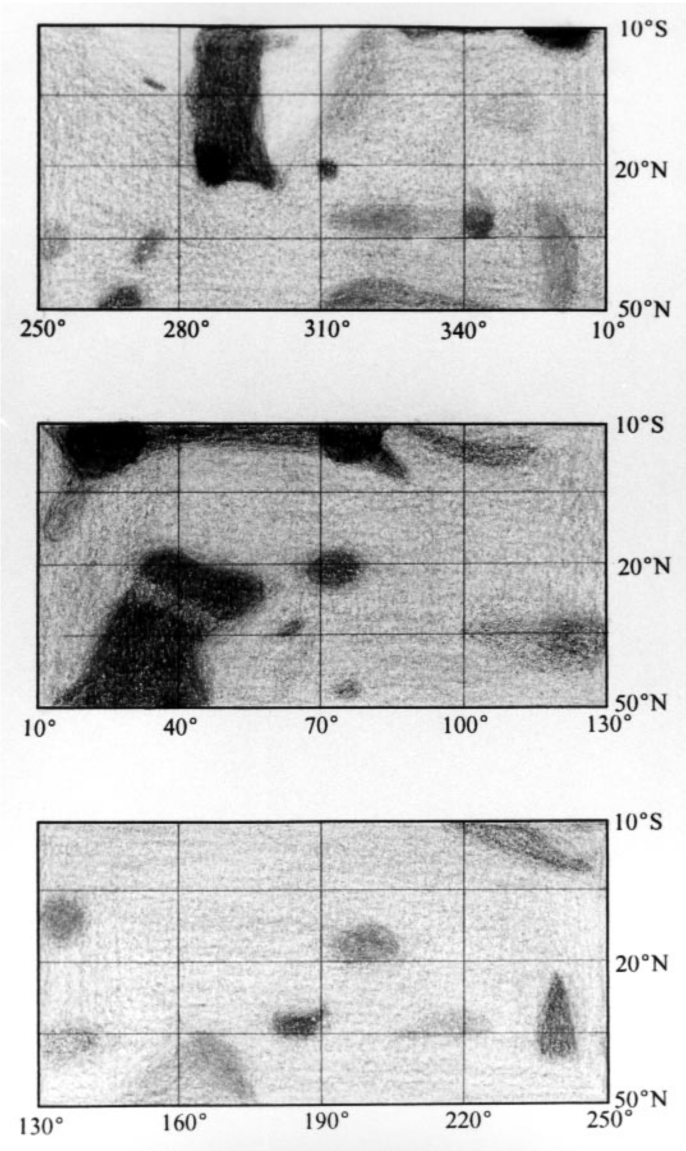

Fig. 2 — Map of Mars made during the 1997 opposition.

become smaller or fainter at each successive opposition since 1988. Sinus Meridiani did not have its usual two northward pointing spikes, but instead appeared as one pseudo-circular dark area. The time for the central meridian transit on March 23 corresponds to a longitude of 8° W for the western edge of Sinus Meridiani.

Region II: 10° W–130° W. Mare Acidalium was the most prominent surface feature during the 1996-97 opposition. Its brightness was uneven and darkest near its centre. Achillis Pons was visible and separated Mare Acidalium from Niliacus Lacus, while Tempe was darker than Chryse and contained several small dark spots. On March 23 Chryse appeared quite bright through a red filter (#25). Solis Lacus was faintly visible near the southern edge of the disk, but Aurorae Sinus appeared very dark. A spectacular group of morning clouds was visible over Tempe on March 23 (CM = 9° W). The clouds were very bright through a blue filter (#80A), moderately bright through a green filter (#58), but dull through a red filter (#25). They had largely dissipated two hours later (CM = 40° W). A similar group of bright clouds was seen in the same location on both March 21 (CM = 24° W) and March 27 (CM = 330° W). It was not seen on March 12 (CM = 82° W) or March 8 (CM = 330° W). In 1978 Rogers observed a similarly bright cloud during the period February 1–4 at L_S = 42° (Collinson 1980), and Ebisawa & Dollfus (1993) reported a strong negative polarization event over the Tempe-Arcadia area at the same instant (L_S = 43° in 1978). Strong negative polarization events were also observed over Tempe later in 1978 and in 1982 (Ebisawa & Dollfus 1993). The bright cloud in Tempe was not intense in 1995 (Pepin 1995).

Region III: 130° W–250° W. Propontus I appeared quite dark and distinct; it was centred at about 183° W, 34° N. A small extension to the southwest was visible. Olympus Mons appeared as a slightly dark circular area centred at about 135° W, 11° N, while Trivium Charontis was visible but not very dark. Mare Sirenum, Mare Cimmerium and Mare Tyrrhenium were dark but difficult to study because of foreshortening. Orographic clouds were detected in the Elysium region on February 23 (CM = 272° W) and near Olympus Mons on March 2 (CM = 170° W). Both Elysium (April 9; CM = 208° W) and Olympus Mons (April 18; CM = 124° W) appeared dull near the central meridian, consistent with the behaviour of orographic clouds.

5. Visual Photometry

Twenty-two eye estimates for the magnitude of Mars were made between September 14, 1996, and May 28, 1997. Comparison stars included γ Gem, β Gem, α CMi, α CMa, α Boo and η UMa, and all reference magnitudes were taken from the AAVSO atlas (Scovil 1990). An average normalized magnitude (see §6) of $V_{vis}(1,0) = -1.4 \pm 0.1$ was derived for Mars in 1996-97.

6. Photoelectric Photometry

The 51-cm Newtonian telescope of the Charles Barber Observatory was used to obtain 221 photoelectric measurements for Mars using the same photometer and filters employed in 1995 (Schmude 1996); the instrument is described elsewhere (Schmude 1992). Because of the brightness of Mars, the telescope aperture was reduced to 12 cm during December 1996 and to 7 cm during 1997. The comparison star for the last two *BVRI* observational sets on December 20 and the fourth set on March 4, 1997 was α Boo, while γ Leo served as the comparison star for all other measurements. Adopted magnitudes for γ Leo are B = 3.13, V = 1.98, R = 1.12 and I = 0.50, and the corresponding values for α Boo are B = 1.18, V = –0.06, R = –1.04 and I = –1.70 (Iriarte *et al.* 1965). On eight occasions α Boo was used as a check star; its average measured magnitudes at those times were $B = 1.18 \pm 0.02$, $V = -0.08 \pm 0.02$, $R = -1.03 \pm 0.02$ and $I = -1.71 \pm 0.01$, where the uncertainties equal $\sigma/N^{1/2}$, σ being the standard deviation and N (the number of observations) = 8. The good agreement between the measured magnitudes and literature values for α Boo suggests that the average measured magnitudes for Mars are accurate to within the stated uncertainties.

Transformation coefficients were determined by measuring the magnitudes of a blue and red star — the two-star method discussed by Hall & Genet (1988). The two stars employed were γ Peg and χ Peg, both of which are standards listed in the *Astronomical Almanac*. The transformation coefficient for the V filter was calculated using:

Table III
Photoelectric Observations of Mars in 1996-97

Date (UT) 1996-97	Magnitudes B	V	R	I	CM (W)	Phase Angle	Date (UT) 1996-97	Magnitudes B	V	R	I	CM (W)	Phase Angle
Dec. 8.390	2.23	0.80	−0.39	−0.87	300°	36°.5	Mar. 21.143	-0.04	−1.40	−2.39	−2.90	350°	3°.9
Dec. 8.418	2.20	0.79	−0.36	−0.87	310°	36°.5	Mar. 21.180	-0.06	−1.34	−2.41	−2.89	3°	3°.9
Dec. 20.308	2.01	0.51	−0.66	−1.17	156°	36°.3	Mar. 21.270	-0.11	−1.37	−2.41	−2.89	35°	4°.0
Dec. 20.335	2.01	0.50	−0.65	−1.19	166°	36°.3	Mar. 21.296	-0.14	−1.34	−2.44	−2.86	44°	4°.0
Dec. 20.378	2.02	0.55	−0.62	−1.16	181°	36°.3	Mar. 23.075	0.03	−1.31	−2.41	−2.86	309°	5°.3
Dec. 20.438	2.09	0.67	−0.55	−1.07	202°	36°.3	Mar. 23.102	0.06	−1.30	−2.41	−2.86	319°	5°.3
Dec. 20.500	2.09	0.68	−0.54	−1.04	223°	36°.3	Mar. 23.158	0.01	−1.31	−2.38	−2.82	338°	5°.3
Feb. 23.149	0.63	−0.79	−2.03	−2.55	220°	17°.1	Mar. 23.186	0.03	−1.30	−2.42	−2.82	348°	5°.3
Feb. 23.181	0.59	−0.75	...	...	231°	17°.1	Mar. 23.217	0.06	−1.29	−2.38	−2.80	359°	5°.4
Mar. 4.155	0.21	−1.21	−2.37	−2.89	143°	10°.8	Mar. 23.270	-0.04	−1.24	−2.40	−2.81	18°	5°.4
Mar. 4.204	0.19	−1.15	−2.39	−2.85	160°	10°.8	Mar. 23.365	-0.06	−1.31	−2.37	−2.85	51°	5°.5
Mar. 4.237	0.20	−1.18	−2.35	−2.82	172°	10°.7	Mar. 23.375	-0.10	−1.33	−2.36	−2.88	55°	5°.5
Mar. 4.272	0.24	−1.14	−2.36	−2.82	184°	10°.7	Mar. 27.081	0.10	−1.21	−2.35	−2.80	277°	8°.3
Mar. 4.353	0.23	−1.16	−2.40	−2.77	212°	10°.7	Mar. 27.153	0.07	−1.25	−2.36	−2.82	302°	8°.3
Mar. 4.406	0.25	−1.16	−2.29	−2.69	231°	10°.6	Apr. 8.126	0.37	−1.06	−2.29	−2.78	187°	17°.3
Mar. 9.104	0.08	−1.37	−2.50	−2.99	81°	7°.1	Apr. 8.180	0.29	−1.08	−2.27	−2.75	206°	17°.3
Mar. 9.133	0.02	−1.36	−2.47	−2.99	91°	7°.1	Apr. 8.252	0.36	−1.03	−2.19	−2.65	231°	17°.4
Mar. 9.193	0.06	−1.34	−2.48	−3.00	112°	7°.1	Apr. 18.044	0.47	−0.79	−1.92	−2.40	69°	23°.5
Mar. 9.227	0.05	−1.23	−2.51	−3.03	124°	7°.0	Apr. 18.086	0.48	−0.84	−1.96	−2.50	84°	23°.5
Mar. 16.064	0.05	−1.36	−2.44	−2.87	6°	2°.4	Apr. 18.210	0.51	−0.92	−2.16	−2.65	128°	23°.6
Mar. 16.088	-0.04	−1.40	−2.43	−2.92	15°	2°.4	Apr. 18.241	0.54	−0.92	−2.16	−2.65	139°	23°.6
Mar. 16.098	-0.06	−1.40	−2.42	−2.92	18°	2°.4	May 1.123	0.97	−0.46	−1.67	−2.24	339°	30°.1
Mar. 16.229	-0.20	−1.43	−2.52	−2.97	64°	2°.4	May 1.162	0.93	−0.42	−1.64	−2.17	353°	30°.2
Mar. 16.241	-0.20	−1.43	−2.53	−2.98	68°	2°.4	May 1.209	1.04	−0.37	−1.54	−2.02	9°	30°.2
Mar. 16.298	-0.22	−1.48	−2.57	−3.04	88°	2°.4	May 1.230	0.95	−0.37	−1.62	−2.17	17°	30°.2
Mar. 16.326	-0.20	−1.50	−2.60	−3.10	98°	2°.3	May 8.116	1.05	−0.31	−1.47	−1.96	272°	32°.7
Mar. 16.370	-0.20	−1.49	−2.64	−3.09	114°	2°.3	May 8.137	1.02	−0.35	−1.47	−1.95	279°	32°.8
Mar. 21.109	0.00	−1.40	−2.42	−2.88	339°	3°.9	May 8.157	0.99	−0.30	−1.48	...	286°	32°.8

$$\varepsilon_v = [\Delta V - \Delta \upsilon + k'_v \Delta X + k''_v X_{avg} \Delta(B - V)]/\Delta(B - V) \ , \quad (1)$$

where ΔV is the difference between the literature V magnitudes for the two comparison stars (1.96 here), $\Delta \upsilon$ is the difference between the instrumental V-filter magnitudes for the stars (not corrected for extinction or transformation), k'_v and k''_v are the first and second order extinction coefficients in V, ΔX is the difference in air mass between the objects, X_{avg} is the average air mass for the γ Peg and ξ Peg measurements, and $\Delta(B - V)$ is the difference between the literature values of B–V for the two stars (1.80 here). Values for k', in magnitudes air-mass^{-1}, were 0.292, 0.161, 0.096 and 0.059 for the B, V, R and I filters, respectively, on the night used to measure the transformation coefficients. A value of $k''_B = -0.03$ was adopted, while k''_v, k''_R and and k''_I were assumed to be vanishingly small. Five sets of measurements were made for each filter. The average values for the transformation coefficients were ε_B = 0.039 ±0.005, ε_V = 0.008 ±0.003, ε_R = 0.013 ±0.004 and ε_I = 0.065 ±0.005. In all cases the transformation corrections were less than 0.01 magnitude and were not applied to the results, although extinction corrections were applied to all measurements.

The individual magnitudes are listed in Table III. Since the brightness of Mars depends directly on the distances between Mars and Earth and Mars and the Sun, the measured magnitudes for Mars on different dates are affected by the changes in those distances that take place as Mars and Earth orbit the Sun. Corrections for such effects are incorporated into the normalized magnitude for a planet, which represents in magnitude units the brightness of a planet if it were 1.0 astronomical unit (1.496×10^8 km) from both the Earth and the Sun. Normalized magnitudes are represented using the symbol $X(1,\alpha)$, where X represents the filter system employed (*i.e.* B, V, R or I) and α represents the solar phase angle of Mars (*i.e.* the angle at Mars between the Earth and the Sun). The normalized magnitude for a planet is related to the measured magnitude, X_{mag}, by the following relationship:

$$X(1,\alpha) = X_{mag} - 5 \log(rd) \ , \quad (2)$$

where r is the distance between Mars and Earth and d is the distance between Mars and the Sun. In many cases the normalized magnitude is adjusted to the value it would have for a phase angle α = 0°. It is then designated as $X(1,0)$. $V(1,0)$, for example, represents the photoelectric visual magnitude for an object if it were located a standard distance of 1.0 A.U. from both the Earth and the Sun and viewed at a solar phase angle of α = 0°.

The $X(1,\alpha)$ values for each filter X were plotted for all of the 12 longitude regions as a function of the solar phase angle of Mars (see Schmude & Bruton 1994; Schmude 1996), and the resulting values of $X(1,0)$, magnitudes normalized to zero phase angle, are listed in Table IV. The corresponding slopes and solar phase angle coefficients are listed in Table V for all filters and longitude regions. Table VI lists the average values for the normalized magnitudes, solar phase angle coefficients and geometric albedos for Mars during the 1996-97 opposition. The geometric albedo was calculated as in Schmude & Bruton (1994).

7. Discussion of Photometric Results

The sub-Earth latitude of Mars during the period when photometric data were obtained ranged from 22°.6 N to 25°.1 N. The northern hemisphere, including the north polar cap, therefore faced Earth during 1997. Three factors likely influenced the photometric results, namely the presence of few dark areas in the northern hemisphere of Mars, the shrinking north polar cap, and the formation of seasonal clouds. Mars would be brighter than normal according to the first and last factors, as evidenced by the results in Table VI. A shrinking north polar cap would make Mars dimmer, possibly offsetting the increased brightness caused by the seasonal increase in clouds. A combination of CCD images through Johnson *B, V, R* and *I* filters, along with photometric measurements, should reveal the influences of each factor on the brightness of Mars.

Table IV
Normalized Magnitudes for Twelve Longitude Intervals

Longitude Interval	$B(1,0)$	$V(1,0)$	$R(1,0)$	$I(1,0)$
250°–280° W	–0.22	–1.50	–2.65	–3.08
280°–310° W	–0.27	–1.58	–2.67	–3.12
310°–340° W	–0.25	–1.57	–2.64	–3.05
340°–10° W	–0.24	–1.58	–2.66	–3.05
10°–40° W	–0.34	–1.52	–2.66	–3.04
40°–70° W	–0.35	–1.59	–2.61	–3.12
70°–100° W	–0.29	–1.74	–2.86	–3.35
100°–130° W	–0.29	–1.59	–2.78	–3.32
130°–160° W	–0.26	–1.59	–2.81	–3.28
160°–190° W	–0.22	–1.55	–2.78	–3.22
190°–220° W	–0.21	–1.58	–2.81	–3.20
220°–250° W	–0.18	–1.55	–2.72	–3.10
Average	–0.26	–1.58	–2.72	–3.16

8. Opposition Surge

Table VI records the average opposition surges measured at two solar phase angles. As in 1995, the opposition surges were largest for observations through the *B* and *V* filters. However, the same opposition surges were smaller than in 1995. The change may be related to the seasonal increase in clouds combined with the shrinkage of the north polar cap. CCD images along with photometric measurements should yield further information.

Table V
Phase Angle Coefficients for Twelve Longitude Intervals

Longitude Interval	c_B	c_V	c_R	c_I
250°–280° W	0.014	0.011	0.012	0.010
280°–310° W	0.018	0.015	0.013	0.013
310°–340° W	0.018	0.014	0.010	0.004
340°–10° W	0.018	0.017	0.013	0.009
10°–40° W	0.020	0.015	0.012	0.006
40°–70° W	0.016	0.014	0.010	0.011
70°–100° W	0.013	0.019	0.019	0.017
100°–130° W	0.015	0.009	0.007	0.009
130°–160° W	0.015	0.010	0.011	0.010
160°–190° W	0.014	0.010	0.011	0.009
190°–220° W	0.016	0.015	0.015	0.011
220°–250° W	0.015	0.014	0.012	0.009
Average	0.016	0.014	0.012	0.010

9. Summary

The NPC had an irregular spatial intensity during early 1997 and was not as bright as in previous years; both trends might be caused by dust. Observations through a red filter make the north polar cap appear slightly smaller than it does in integrated light, which can be attributed to the ability of red wavelengths to penetrate haze. Hellas appeared very bright when Mars was at areocentric longitudes of L_S = 90° to 120°, much like it did in 1995. The average value for the normalized eye-estimated magnitude of Mars in 1997 was –1.4 ±0.1. The selected photoelectric magnitudes for 1997 were $B(1,0)$ = –0.26 ±0.02, $V(1,0)$ = –1.58 ±0.02, $R(1,0)$ = –2.72 ±0.02 and $I(1,0)$ = –3.16 ±0.03. The solar phase coefficients and geometric albedos were similar to those measured in 1995. The opposition surge in 1997 was smaller than in 1995.

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Table VI
Selected Photometric Constants for Mars
During the 1996-97 Opposition

Parameter	B	V	R	I
$X(1,0)$	−0.26 ±0.02	−1.58 ±0.02	−2.72 ±0.02	−3.166±0.03
c_X	0.016 ±0.001	0.014 ±0.001	0.012 ±0.001	0.010 ±0.001
p	0.083 ±0.002	0.158 ±0.003	0.297 ±0.006	0.342 ±0.009
Opposition Surge (α = 2°.4)[a]	0.06	0.07	0.03	0.03
Opposition Surge (α = 3°.9)[b]	0.05	0.05	0.00	0.05

Notes: [a] Includes regions I-D, II-A, II-B, II-C and II-D.
[b] Includes regions I-C, I-D, II-A and II-B.

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Research Note

A POSSIBLE INCREASE IN MID-LATITUDE SIGHTINGS OF NOCTILUCENT CLOUDS?

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Abstract. The mesospheric phenomenon of noctilucent clouds (NLCs) has increasingly been observed from latitudes considered to be on the southern fringe of NLC visibility in North America. The increase in sightings and range, though partly attributable to heightened interest and knowledge of NLCs, may indeed be tied to an actual migration of NLCs to more southerly latitudes as a result of global climate changes.

Résumé. Le phénomène mésosphérique de nuages noctiluques (NLCs) est de plus en plus observé dans les latitudes considérées à la marge sud des latitudes habituelles de visibilité de ces nuages en Amérique du nord. La croissance de ces observations et du rayon d'action, même si attribuable en partie à l'intérêt et les connaissances grandissants dans ce phénomène de nuages noctiluques, pourrait toutefois bien être lié à un mouvement réel vers les latitudes sud, à la suite des changements du climat global. SEM

Noctilucent clouds (NLCs) are mesospheric ice clouds that form over high latitudes in the months of May through August in the northern hemisphere as well as in the corresponding austral latitudes during their summer months. They are believed to be the product of a complex process involving the nucleation of water vapour upon meteoric dust and ions in the upper mesosphere under the typically cold conditions experienced there in the summer (Turco *et al.* 1982). Over the poles the clouds exist as a large, probably continuous veneer, and are known as polar mesospheric clouds, or PMCs (Olivero & Thomas 1986). When PMCs form in subarctic areas, at latitudes of 50°–65° N in the northern hemisphere, they are visible from the ground and are known by the more common term of NLCs. Usually NLCs can be seen between 3°–5° south of their area of evolution (Thomas 1996), but only in twilight through a combination of their optical thickness (typically much less than 0.001) and their great height (82–83 km), which allows them to remain sunlit long after sunset at ground level (Fogle 1966). Since the ice clouds scatter light from the below-horizon Sun, they appear as cirrus-like arrays of silvery-white strands, often tinged with blue because of absorption by stratospheric ozone.

In recent years there has been much speculation about why NLCs exist, why sightings of them appear to be increasing (Gadsden 1997), and whether or not such changes are signals of global climate change. Thomas *et al.* (1989) presented evidence indicating that about half of the water vapour existing in the mesosphere results from the transformation of methane, one of the so-called greenhouse gases, emitted from Earth's surface. Sources of methane are numerous and include bogs, rice paddies, cattle, and mining and petroleum production. Increased agricultural and industrial activity in the past two centuries has freed up large amounts of methane; the gas is transported into the upper atmosphere, and, in the stratosphere, breaks down into water vapour among other products. The attendant increase in water vapour has led to increases in both the number and size of ice particles; previously sub-visible clouds would then become visible, increasing the overall frequency of NLC sightings (Thomas 1996). The increase in sightings has, for the most part, taken place in the aforementioned latitudes where NLCs are now commonly seen. Thomas (1996) predicts that farther-reaching changes in the mesospheric environment will result in an encroachment of the evolved NLCs into more southerly areas where the phenomenon is now only very rarely observed.

The historical southern limit for NLC visibility in the northern hemisphere has been the 45° N parallel, although McConnell (1987) extended that limit somewhat, claiming that NLCs had been reported previously in the state of New York at a latitude of around 42° N. In a summary made ten years earlier, Bronshten & Grishin (1976) compared three different results: a Soviet study covering the period 1885–1956 that reported a most southerly NLC sighting at 46°.4 N, another Soviet study surveying the period 1957–59 that gave a similar value of 45°.0 N, and a North American survey conducted by Fogle & Haurwitz (1966) covering the years 1964–65 that reported a value of 45°.5 N. Fogle (1966) compared the percentage of clear nights during which NLCs could be seen at different latitudes and found that, during the height of NLC season in June and July, fully 10% of clear nights were NLC-active at a latitude of 45° N. Fogle also stated, however, that no reliable sightings of NLCs had been reported from immediately south of the 45^{th} parallel.

A contour map derived from observations over the period 1988–92 by members of the North American surveillance network NLC CAN AM indicated, on the basis of lines of equal average seasonal NLC incidence, that there was a probability of seeing NLCs only once per year along the 49^{th} parallel in the western half of the continent (Zalcik 1993). Ironically, also in 1993, aurora observer Jay Brausch from Glen Ullin, North Dakota (latitude 46°.8 N) reported an NLC in the pre-dawn sky on July 1 (Zalcik 1994). Photographs taken of the event (*e.g.* figure 1) show that the phenomenon was unmistakably a NLC. Until Brausch's sighting, the farthest south from which an NLC CAN AM report originated was Victoria, British Columbia (June 18, 1991; observer C. Spratt) at latitude 48°.4 N, nearly two degrees of latitude north of Brausch's location. In subsequent years, during

Fig. 1 — Photograph of a NLC (white patch near horizon) with auroral arc above in the morning sky at 09:10 UT (03:10 local time) on July 1, 1993. The Sun was 13°.2 below the horizon at the time the photograph was taken by Jay Brausch at Glen Ullin, North Dakota (latitude 46°.8 N).

which he maintained an earnest watch for NLCs, Brausch has seen them at least once per year; the 1995 season was remarkable with seven active nights from Glen Ullin (and another from Minnesota), a number similar to the average seasonal occurrence of NLCs from the high incidence zone (55°–60° N) a full ten degrees of latitude to his north.

On the morning of June 23, 1997, the author observed and photographed a display (figure 2) at Beaverhead National Forest in Montana (latitude 44°.7 N, longitude 113°.0 W). The site appears to be the farthest point south in North America from which NLCs have been photographed to date. Unfortunately, there were no sightings from other observers to corroborate the observation, although the recorded photographs appear to show a typical array of NLCs consisting of band-type clouds similar to those in instructional images in a recently-published NLC observing manual by Gadsden & Parvainen (1995).

Fig. 2 — Photograph of NLCs from Beaverhead National Forest, Montana (latitude 44°.7 N) at 10:30 UT (04:30 local time) on June 23, 1997. The Sun was 10°.5 below the horizon when the photograph was taken by Mark Zalcik.

The observed azimuths and altitudes of the NLCs seen by Zalcik can be used to establish the downrange position of the clouds. The NLCs were seen to cover a span of 25° in azimuth (at bearings ranging from 5° to 30°) at elevation angles of <5° to 10° above the horizon. Reference to graphs provided by Fogle (1966) yields downrange distances of 400 km for the southern or upper edges of the observed NLCs located 10° above the horizon. The clouds were, therefore, well south of the U.S. border, sitting over the area of Great Falls, Montana, near the 48th parallel. From how much farther south could the display have been seen? Reference to Fogle's graphs suggests that an observer located 200 km farther southwest on the Zalcik–NLC line of sight, near the Utah-Nevada border around the 43rd parallel, would have seen the same clouds ~5° above the local horizon. In general, if one observer sees NLCs, it is possible that observers farther south can see the same display. Such a possibility takes on new significance here, where we are examining the equator-ward edge of the range of NLC visibility.

The locations of Beaverhead National Forest and Glen Ullin, the site of Jay Brausch's observations, are shown in figure 3, which is a contour map of NLC sightings that updates the information in the earlier map by Zalcik (1993) and covers the eight-year period 1988–95 (climatological data are listed in Table I). Glen Ullin appears as an anomalous island of high NLC activity on the basis of Brausch's 1994 and 1995 observations, and it is difficult to explain why NLC frequency in the American mid-west should be so high. There is clearly a need for more NLC-watching at such latitudes to determine if the Glen Ullin anomaly is real or if instead it is likely that NLCs may be more commonly seen in the 45°–50° N latitude range than was previously believed.

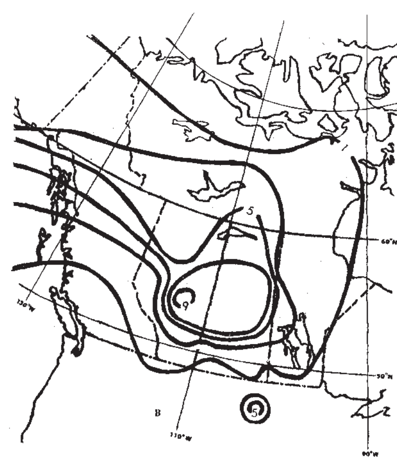

Fig. 3 — A contour map showing lines of equal average seasonal NLC incidence in western North America during the period 1988–95. The five-display iso-line in the U.S. south of the Saskatchewan-Manitoba border denotes Glen Ullin, North Dakota, observing site of Jay Brausch. The letter "B" denotes Beaverhead National Forest, where the author observed NLCs on June 23, 1997. NLC detections decrease to the south as a consequence of their southern limits of evolution, to the north as a result of the shorter lengths of polar nights in summer (and hence the intervals during which NLCs may be seen), and to the east, possibly because of tropospheric cloudiness over Hudson Bay.

Another sighting of a NLC from NLC CAN AM records (Lohvinenko & Zalcik 1991) stands out, namely that by amateur observer Steve McKinnon in Oakville, Ontario (latitude 43°.3 N) on the evening of July 15, 1988. As with the author's June 23, 1997, observation referred to above, there were no corroborative sightings. Since 1988 there have been a few other reports of mid-latitude NLC CAN AM observers who may have seen NLCs but were unable to make a definitive designation and, moreover, were not supported by confirming observations by others nearby. Conversely, some southerly observers, notably Michael Boschat in Halifax, Nova Scotia (latitude 44°.6 N), have not seen any NLCs since 1988.

Recent mid-latitude sightings of NLCs have not been confined to North America. At Alma-Ata (latitude 43°.2 N) in Kazakhstan, Victor G. Tejfel of the Fessenkov Astrophysical Institute reported the detection of NLCs on June 17 and June 24, 1996, and on June 6, 1997 (note the lack of a corrrelation with the June 23, 1997, sighting from Beaverhead), after never seeing NLCs from that location in the preceding four decades (Tom McEwan, personal communication, 1997).

Could these mid-latitude NLCs have been mistaken for something else? Positive detection of NLCs can be a challenge, especially for someone who has never seen them; other types of clouds, such as cirrus clouds illuminated by moonlight or distant low clouds illuminated by artificial lighting, can mimic NLCs.

It is nonetheless apparent that it has indeed been possible to see NLCs from the upper to mid forties of north latitude over the past decade, if not before then. What is unclear is whether or not the clouds are truly evolving with increasing frequency at the southern edge of their range, or if their range is extending equator-ward. With the latter comes the potential for NLCs to be a new feature of the summer twilights in the lower forties of latitude. The situation is analogous to that at the end of the last century, prior to which NLCs had *never been seen*. Only in 1885 was the existence of the phenomenon confirmed; exhaustive efforts by, for example, Gadsden (1985) have found no older sightings. Only in 1933, nearly half a century later, were they first reported in North America (Vestine 1934). Did the clouds merely evade detection or did they simply not exist prior to 1885? Thomas *et al.* (1989) suggest that the very debut of NLCs is explained by the gradual increase in NLC brightness past the threshold of naked eye visibility as historical methane levels, and hence mesospheric water vapour concentrations, have climbed.

One must wonder, over a century later, though the phenomenon is now a regular sight in the twilight skies of the southern subarctic, why there is now a steadily increasing tally of NLC reports from those areas farther south where NLCs have rarely, if ever, been seen before. Perhaps the clouds are indeed on the equator-ward march as a consequence of global increases in the greenhouse gases: methane, which in turn increases water vapour concentrations in the mesosphere, and carbon dioxide, which lowers mid-latitude mesospheric temperatures, or perhaps we simply have a more enlightened global regiment of skywatchers.

Table I

Summary of North American Sightings of Noctilucent Clouds, 1988–1995

Site	N Lat.	W Long.	Type[a]	Number of Sightings								Years	Displays	Displays
				1988	1989	1990	1991	1992	1993	1994	1995			Per Year
Baker Lake	64°.3	96°.1	F	..	..	..	..	..	1	0	3	3	4	1.33
Winnipeg	49°.9	97°.2	I	..	2	1	1	0	..	..	..	4	4	1.00
Lynn Lake	56°.9	101°.1	F/W	..	..	..	..	..	2	4	2	3	8	2.67
The Pas	54°.0	101°.1	F	1	8	3	3	..	1	4	6	7	26	3.71
Glen Ullin	46°.8	101°.8	I	..	..	..	..	..	..	4	7	2	11	5.50
Broadview	50°.4	102°.7	W	2	3	1	0	0	..	..	..	5	6	1.20
Estevan	49°.2	103°.0	W	..	..	2	0	1	..	..	..	3	3	1.00
Wynyard	51°.8	104°.2	W	6	8	..	..	..	..	..	..	2	14	7.00
Cambridge Bay	69°.1	105°.1	W	..	0	0	0	0	0	..	..	5	0	0.00
La Ronge	55°.2	105°.3	F	..	..	10	9	7	7	8	8	6	49	8.17
Swift Current	50°.3	107°.7	F	1	2	..	..	..	..	..	..	2	3	1.50
Ft. Reliance	62°.2	109°.2	W	1	9	2	..	..	..	..	..	3	12	4.00
Lethbridge	49°.6	112°.8	W	7	3	0	1	0	..	..	..	5	11	2.20
Edmonton	53°.7	113°.5	I	12	8	8	12	3	9	16	..	7	68	9.71
Slave Lake	55°.3	114°.8	W	7	8	5	1	..	..	..	..	4	21	5.25
Whitecourt	54°.1	115°.8	F	..	..	..	..	..	4	3	4	3	11	3.67
Vancouver	49°.2	123°.2	W	..	..	1	0	0	0	0	..	5	1	0.20
Cape Parry	70°.2	124°.7	W	1	0	..	..	..	..	..	..	2	1	0.50
Watson Lake	60°.1	128°.8	F	4	6	5	4	..	..	..	..	4	19	4.75
Cape St. James	51°.9	131°.0	W	..	..	..	2	0	..	..	..	2	2	1.00

Notes:[a] Notation for Types: W = Atmospheric Environment Service Weather Station, F = Transport Canada Flight Service Station, I = Individual Observer: Todd Lohvinenko (Winnipeg), Brausch (Glen Ullin), Zalcik (Edmonton).

The sites are listed in order of increasing longitude. Missing entries indicate years in which no observing was conducted or that data for the year were not used in the analysis. Criteria for site selection included observing for at least two years during the survey period, observing through most of the three month season from May through August, and completeness of the written reports. The paucity of sightings in 1992 is believed to be the result of mesospheric changes brought about by the Mount Pinatubo eruption a year earlier (Gadsden 1997).

Acknowledgments: I thank G. E. Thomas and E. P. Lozowski for providing preliminary reviews of this paper. Todd Lohvinenko provided technical assistance with the NLC CAN AM data reductions. I also thank the amateur observers mentioned here for their diligence in watching for NLCs despite the sometimes daunting odds against seeing a display, and all other NLC CAN AM observers, including voluntary contributors from Canadian weather and flight service stations as well as several other individuals, who have contributed observational data for the past ten summers. The observers are listed in Appendix I.

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APPENDIX I.

NLC CAN AM participants during the years 1988–1997.

Amateur observers: Michael Boschat, Halifax, NS; Jay Brausch, Glen Ullin, ND; Peter Brown, Sheila Callan, Michael Gabriel, Helen Hawes, Robert Howell, Brian Tkachyk, Ft. McMurray, AB; Bill Burton, Reston, VA; Gaetan Chevalier, Ste.-Foy, PQ; Martin Connors, Alister Ling, Bruce McCurdy, Murray Paulson, Don Thacker, Larry Wood, Mark Zalcik, Edmonton, AB; David Dawson, Broad Brook, CT; Bob Fischer, Fairbanks, AK; Susan French, Scotia, NY; L. Geelan, Cochrane, AB; Gary Hargreaves, Vancouver, BC; Richard Huziak, Gord Sarty, Saskatoon, SK; Randall Janssen, West Lafayette, IN; Dale Johnson, Muskegon, MI; Lucian Kemble, Lumsden, SK; Glen LeDrew, Cape Parry, NT; Todd and Stan Lohvinenko, Winnipeg, MB; Wayne Madea, Mapleton, ME; Larry Manuel, Calgary, AB; Cheryl Matsugi, Raymond, AB; Steve McKinnon, Oakville, ON; Adrienne Morris, Buffalo, NY; Dave Parkhurst, Anchorage, AK; John Rousom, Arva, ON; Art and Joan Seabury, Jr., Norris Point, NF; Chris Spratt, Victoria, BC; G. E. Thomas, Boulder, CO; Ron Thompson, Wynyard, SK; Oscar Van Dongen, Vermilion, AB; Allen Walker, Plato, SK; Karren Webb, Freeport, MI.

Airline pilots: Stuart Beresford, Bob Fearn, and Frank Kosalla.

Canadian weather and flight service stations: Alert, NT; Baker Lake, NT; Broadview, SK; Cambridge Bay, NT; Cape Parry, NT; Cape St. James, BC; Churchill, MB; Cold Lake, AB, Cree Lake, SK; Edson, AB; Estevan, SK; Ft. McMurray, AB; Ft. Reliance, NT; Gander, NF; Goose Bay, NF; La Ronge, SK; Lethbridge, AB; Lynn Lake, MB; Meadow Lake, SK; Montreal, PQ; Moose Jaw, SK; Moosonee, ON; Peace River, AB; Pickle Lake, ON; Red Lake, ON; Schefferville, PQ; Sept-Îles, PQ; Sioux Lookout, ON; Slave Lake, AB; Swift Current, SK; The Pas, MB; Thompson, MB; Vancouver, BC; Wabush, NF; Watson Lake, YT; Whitecourt, AB; Whitehorse, YT; Wynyard, SK; Yellowknife, NT.

U.S. weather station: Fairbanks, AK.

MARK S. ZALCIK is the amateur astronomer who founded the Noctilucent Cloud Canadian-American (NLC CAN AM) surveillance network in 1987 and who has served as its co-ordinator since then. He holds diplomas in chemical technology from the Northern Alberta Institute of Technology and in mineral resources/prospecting from the Saskatchewan Institute of Applied Science and Technology. He has been a participant in a variety of meteorite search efforts (see JRASC, *91, 248-249, 1997). His interests include astronomy, meteorites and impact craters, and backpacking.*

A "CLASS" EXPERIENCE IN ASTRONOMY EDUCATION

by Winston Stairs

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Abstract. Recent changes to Ontario's school curriculum have benefited amateur and professional astronomers by opening the door for more direct involvement in astronomy education in the primary grades. This paper summarizes the author's recent experience in introducing astronomy to one grade 4/5 classroom in southern Ontario.

Résumé. Les astronomes amateurs et professionnels sont avantagés par les changements récents au curriculum des écoles ontariennes, en se trouvant plus directement impliqués dans l'enseignement de l'astronomie dans les classes primaires. Cet article fait le sommaire des expériences de l'auteur lorsqu'il a présenté une causerie d'astronomie à une classe de 4/5 année dans la région sud de l'Ontario.
SEM

Early in my daughter's school year at one of the "meet the teacher" nights, I noticed a poster with an astronomical theme hanging on one of the walls of the classroom. I made some comment about it in passing that the teacher overheard, and she inquired if I had an interest in astronomy or worked in the field. I acknowledged my interest and involvement in astronomy since early youth. She then mentioned that they would be doing a unit in astronomy later in the year and suggested that I might "come in to speak to the class." I supported the idea enthusiastically, thinking little would come of it, until I was approached again in April with a query as to whether I would be willing to appear "some time next month to speak about astronomy." It took me only an instant to say yes. In a recent article in the *Journal*, Percy (1998) suggested that there would be increased opportunities for amateurs and professionals to play a greater role in bringing astronomy to the classroom. I was pleasantly surprised at how quickly the opportunity presented itself.

In preparation for my visit I corresponded with the teacher in order to determine to what extent the students had already been exposed to astronomy. Since it was a grade 4/5 split class, the students who were in grade 5 had already studied astronomy in grade 4. The grade 4s, however, had no previous exposure. The teacher suggested that I could discuss how I got started in astronomy and came to know "all that I know" (the latter of which should only take about two minutes!). In addition, she suggested that I talk about something other than the planets, since the grade 5s had studied them last year and information could easily be obtained from a book or the Internet. Armed with that information and keeping in mind that "less is more" (Percy 1998), I set about preparing what I felt would be a simple, straightforward, easy to understand introduction to astronomy for grades 4 and 5.

The presentation began with the teacher's explanation that, "Mr. Stairs is here to talk to us about the solar system." That was followed by my opening of, "Well… actually I was prepared to speak about something other than the solar system, if that is okay with you?" Puzzled and confused faces descended over half the class. Great, I was off to a stellar beginning!

I opened with the questions "what is astronomy" and "what is meant by studying astronomy?" The answers I received were fairly accurate and reasonably well informed, I thought. Next I asked if anyone could tell me the difference between astronomy and astrology, in order to dispel a few myths and to direct them along the path of knowledge. Many seemed to have some grasp or understanding of the difference and had heard of the signs of the zodiac *et cetera*. But when asked which was based on science and which was not — for which there was a 50/50 chance of getting it right — the student picked to answer the question… well, anyway, it was clear that there was a little more work ahead of me.

I tried to move quickly into the who, what, when, where and why of who does astronomy, namely when they do it and where they do it, but less than five minutes into the presentation I could see the heads beginning to nod. One small boy was already asking the teacher if he could go to the washroom. It seemed time for a change of direction, so to spice things up I decided to bring the subject of *money* into the discussion. "Does anyone know that if you find a piece of meteorite and turn it over to the government (Geological Survey of Canada — GSC), you could get $500 for it?" Instantaneously heads popped up and necks began to straighten as their eyes glazed over with visions of *Nintendo* and *Spice Girls* videos. "Has anyone ever seen a meteor?" "Do you know what a meteor is?" Quite a bit of discussion developed over the next few minutes about meteors and meteorites and how to identify them. I left the subject with the presentation of a poster on meteorites to the teacher (compliments of the GSC).

We next moved into a discussion on Mars and the recent *Pathfinder* mission, and then to the *International Space Station* (ISS) and Canada's role in the building of it. I quickly discovered that "less is more" also means "less time spent on any one topic means more interest and attention being shown towards a number of astronomical themes" — at that age anyway.

Inevitably the questions turned to the subject of UFOs and alien visitation of Earth — too much *X-Files*? I tried to debunk the stories of UFO landings and crop circle "discoveries" with simple explanations and questions about "hard evidence" that was lacking. When asked whether I "believed" a UFO had ever landed on Earth, I responded with a simple "No." The questioner countered with, "But what about Roswell?" I was astonished by the degree of knowledge and understanding of the class about such pseudo-scientific subjects as UFOs and alien abductions, but how little they knew about real science.

It is always dangerous (and a clear indication of one's advancing years) to compare the present with the "way back when…" of our youth. Since I had grown up during the Apollo era when men walked on the Moon, however, I cannot help but recall how keenly interested and knowledgeable many of us were in what was happening in the skies above us. That was, of course, before the era of VCRs, video games, personal computers and all the other technological "gee-whiz" items of the nineties that vie for our kids' attentions. The natural wonders of the heavens seem to have been forsaken for the artificial wonders of the electron. I am not suggesting that all technology is harmful to our kids, particularly in the case of personal computers and information readily available off the Internet, but I sense a lack of balance between the old and the new and feel a more complementary relationship could be formed between them.

Another feature that surprised me was the speed with which $1^1/_4$ hours could go by, even when the lesson plan was not followed. I tried not to leave with a defeated attitude, even though I felt that I had fallen short of my goal of convincing the children to take up astronomy and explore the world around them. There were a few who seemed keenly interested and who asked very sharp questions, but for many the sound of the lunch bell was a genuine relief.

Perhaps my expectations were too high or I had approached the subject and audience with the impression that they had the same sense of awe and fascination for the subject as I did. The latter was clearly not the case. If I had to do it again (and I hope I have the chance), there are a few things I would do differently that can be pointed out to others. For example, do not bother assembling a detailed or elaborate lesson plan since you will not stick to it long enough to make it worth your time and effort (I refer specifically to children in grades 4 & 5 and those younger). Be prepared to be flexible in what you present or discuss with the class since your lesson plan may change dramatically. Bring a variety of materials (pictures, charts, etc.) to support your presentation, and be prepared for the unexpected. Start by discussing topics familiar to the class and in which they are interested (in my case UFOs and aliens), before moving on to more everyday topics such as meteors and comets. (I also received very good feedback on my explanation of the difference between a refractor and a reflector.) Be certain to approach the class with a positive but realistic attitude; you are not going to convert the entire group to astronomy and away from skateboards in a single session. Finally, enjoy yourself!

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Reference

Percy, J. 1998, "Astronomy in the Pan-Canadian Science Project," JRASC, 92, 38-39

A member of the RASC since 1979, with a one-year hiatus in 1986, Winston Stairs has had two previous articles published in the National Newsletter *(1989, 1990). His interests, besides astronomy, include the triathlon and duathlon (for which he recently qualified as a member of the Canadian Team competing at the World Duathlon Championships in Germany), scuba diving, reading (mainly physics), writing and his family. He is employed full time by Bell Advanced Communications as a network consultant, and part time by Rural Metro Ontario (Lindsay) Ambulance Service as a Paramedic.*

Across the RASC
Du nouveau dans les centres

Scenic Vistas: Clusters on a String

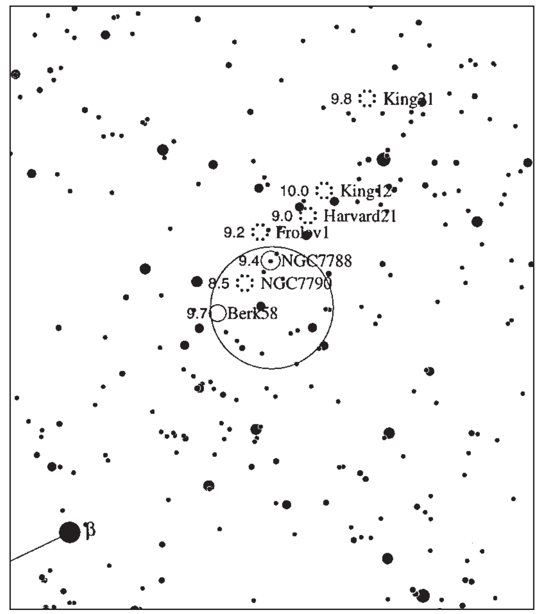
by Mark Bratton, Montreal Centre (mbratton@generation.net)

The constellation of Cassiopeia has always been one of my very favourite regions of the night sky. Although I fancy myself a hunter of galaxies and derive a great deal of pleasure ferreting out faint patches of light at the threshold of visibility, it is refreshing to sometimes turn one's attention back to our home Galaxy and the many treasures it has to offer. Although Cassiopeia is well-populated with diffuse and planetary nebulae, as well as the odd galaxy, it is a region best known for its abundance of open star clusters both bright and faint.

About two degrees north and west of β Cassiopeiae is an intriguing patch of sky, unique in the northern hemisphere, for here lie six open star clusters arranged in a straight line spanning about two degrees. A seventh, designated Frolov 1, lies just off the line. Only three of the clusters are plotted on *Sky Atlas 2000.0*; they are NGC 7788, NGC 7790 and Harvard 21. The first time I visited the area, in September of 1992, I was equipped with my old 8-inch Schmidt-Cassegrain and I concentrated on these three clusters, ignorant of the existence of the others. The minor members of the assemblage are not necessarily invisible in small telescopes, but more later.

My observing notes for the evening of September 19/20, 1992, indicate that it was a clear night with average seeing and transparency slightly above average. I observed the pair of NGC 7788 and 7790 first, those clusters being the brightest of the group. NGC 7788 is a small cluster of bright and faint stars, near the core of which is a small, faint, unresolved haze of light. The brightest cluster member, a star of about magnitude 10, sits atop this faint haze. Possible outlying members of the cluster are scattered to the east, south and west. Fifteen arcminutes to the south and east is NGC 7790, a faint, compressed arrowhead shaped haze pointing towards the southeast. Suspended over the haze is a faint, barely resolvable semi-circle of stars. To the west of the haze is a small grouping of four or five brighter stars.

Next in line, about 20 arcminutes to the northwest, is a third, fainter cluster. This is Harvard 21, but it was invisible in my 8-inch Schmidt-Cassegrain on that occasion. Instead I looked beyond, northward past a pair of eighth magnitude field stars to a cluster designated King 12. I had hand-plotted it on my copy of *Sky Atlas 2000.0*. The cluster was elongated almost due east-west and too faint to resolve, though two faint stars, one about magnitude 11 and the other about magnitude 12, were suspended over the tenuous haze of light.



This 4.4° × 5° chart shows stars as faint as about magnitude 9. North is up and β Cassiopeia located at the lower left. The circle in the middle is one degree in diameter (*Chart prepared by Dave Lane*).

What of the other clusters in the area? King 21 is well-detached from the others, located about one degree northwest of King 12. The sixth cluster of the string, Berkeley 58, lies just southeast of NGC 7790 and is thus the starting point for this curious group of objects. The *Deep Sky Field Guide to Uranometria 2000.0* indicates that these clusters, as well as Frolov 1, are unquestionably faint, difficult objects, but are they beyond the abilities of the amateur with a small telescope? Not necessarily. Certainly, observer experience as well as sky conditions play important roles in the visibility of faint, challenging objects, but determination and concentration are equally important and can very likely make the difference between success and failure.

On the evening of September 19/20, 1996, coincidentally four years to the day after I originally observed the field, I once again turned a telescope to the clusters in question. This time, though, I used my 15-inch Newtonian in an attempt to view all seven of the clusters. Despite early evening interference from a seven-day-old Moon, which made the naked-eye limit about magnitude 5.0–5.2, I was able to view each object over a period of about an hour and a half. My results are below.

Berkeley 58: This is the first cluster in the string and a rather difficult object. The field is dominated by a faint, coarse asterism numbering eight stars with a magnitude 12 star at the centre. A magnitude 13 pair is visible in the east. A secondary chain of stars, made up mostly of magnitude 14 stars, is located south of the asterism and elongated east-west. A faint pair is visible here also. About sixteen cluster members are visible in all and Berkeley 58 is about six arcminutes in diameter.

NGC 7790: This is a very pretty cluster; a curving asterism made up of magnitude 11 and fainter stars precedes the cluster to the west. The main body is made up of magnitude 13 and fainter stars, fairly well-resolved though there are persistent hints of a faint unresolved glow surrounding these stars, particularly at 146×.

NGC 7788: This cluster is smaller than the preceding, dominated by two magnitude 10 stars bordering the cluster to the southwest and a third, marginally fainter, to the north. About a dozen faint stars are resolved on a faint nebulous background. The cluster is about four arcminutes in diameter, well defined and quite round.

Harvard 21: This is a faint group that was overlooked in 1992. The group is little more than an asterism, comprising five magnitude 13 stars and three stars slightly fainter, all in a star-poor field. The cluster lies about halfway between two magnitude 7 field stars that are plotted in *Uranometria 2000.0*.

Frolov 1: This is a pleasant surprise! It is a distinct grouping of stars, moderately bright and dominated by four magnitude 11–12 stars. About a dozen, other, significantly fainter stars can be counted as cluster members. A magnitude 9 star precedes the group to the west-northwest. The cluster is fairly coarse and displays little compression. It measures about 9×4 arcminutes in size, elongated northwest-southeast.

King 12: This is another nice cluster and much more interesting in a large aperture telescope. It is a very beautiful, minor cluster dominated at the centre by a close, equal magnitude 11 pair. The cluster is well resolved and elongated east-west with most of the members around magnitude 14. At least two dozen members are visible, distinct and well separated from the sky background. There is no evidence of an unresolved background.

King 21: This cluster is the last of the seven and quite isolated from the rest. It is a rather poor cluster, dominated by four magnitude 12 stars, two of which form a close pair oriented east-west. The balance of the cluster is made up of magnitude 14 stars scattered amongst the four dominant members — size about five arcminutes in diameter. About seventeen stars are visible in all.

I would be interested to hear from other members who observe this remarkable area of the sky. Clear skies!

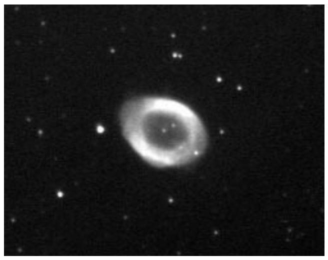
Mark Bratton has had a life-long interest in astronomy and first became acquainted with the RASC in November of 1966 at the age of eleven. He did not become a member until twenty-five years later. He is currently the editor of the Montreal Centre's newsletter Skyward *and was recently elected as president of the Centre. He is the single parent of an eleven year old boy, Kristopher, and his greatest joy, besides his son of course, is slowly exploring the skies with a 375-mm reflector from the deck of his small country cottage near Sutton, Québec.*

At the Eyepiece

Five Planetaries, from Small-scope-easy to Alberta-tough

by Alan Whitman, Okanagan Centre (awhitman@vip.net)

The Ring Nebula, M57, repays careful study. The disk of the famous planetary nebula was easily visible in my old 60-mm refractor and Edmontonian Larry Wood reports seeing the disc with his 80-mm finder. Wood has even star-hopped to the magnitude 9.0 object with 7×50 binoculars, although, of course, it appeared stellar at 7×. While the famous "smoke ring" appearance may be hinted at in smaller telescopes, a 15-cm telescope is usually required to see the darker centre plainly and enjoy an aesthetically satisfying view. My 20-cm Newtonian at 116× shows M57 to be fainter at the ends of the oval and brighter inside of the 80″ by 60″ gray annulus than outside of it. The 13th magnitude star that follows it is usually visible.



A CCD image of M57 taken at Saint Mary's University's Burke-Gaffney Observatory (*Image by Dave Lane*).

Using Allegheny Observatory's 33-cm Fitz refractor at 600×, James Mullaney and Wallace McCall glimpsed the 15th magnitude central star. Walter Scott Houston accomplished this with Stellafane's 30-cm f/17 Porter telescope, but he did not state what power he used. While I have suspected that I detected the central star with smaller apertures myself, my 40-cm f/4.5 Dobsonian at 392× is the smallest telescope with which I have made a definite sighting. On the night that I saw it, I rated the seeing as excellent and the transparency as superb. There is a 15th magnitude star preceding M57 by about 7″. When that star was visible at 392×, the central star usually was as well, although the preceding star is a little easier. Even much larger telescopes need about 400× to dim the nebulosity enough to reveal the central star, so very good to excellent seeing is always required for success. If the four stars of the nearby double-double, Epsilon Lyrae, are crisp and well-separated, then you may have a night that will grudgingly give up the Ring Nebula's central white dwarf.

At 261× the 40-cm Newtonian showed a bright rim in M57 near to but south of the following star. Surprisingly, in tests with the Prince George Observatory's 0.6-metre Cassegrain, neither an ultrahigh contrast (UHC) filter nor an [O III] filter showed any more details in the planetary nebula than were visible without a filter.

Year after year I viewed the Ring Nebula with John Casino's 0.9-metre Dobsonian at the Mount Kobau Star Party. On August 26, 1990, at 420× the giant Dobsonian showed me the central star, the other star inside the ring, and one foreground star superimposed on the ring. Then, in a moment of superior seeing, I saw broad parallel banding in the gauzy nebulosity inside the annulus, as can be seen in photos taken with the 5-metre telescope at Mt. Palomar[1]. I was not looking for the banding — it just flashed out. I have never again been favoured with such a view despite many subsequent observations with the 0.9-metre; owner John Casino has never been so fortunate, either. It is interesting to note that *Burnham's Celestial Handbook* says: "Faint streaks traversing the ring were seen visually by Lord Rosse as early as 1844, and were first photographed with the Crossley reflector at Lick Observatory in 1899." (The 0.9-metre Dobsonian was a fixture at the Mount Kobau and Table Mountain star parties for a decade. The telescope technician was no less than John Dobson himself — many afternoons Dobson could be seen, Teflon pieces in hand, tweaking the great bearings. The telescope's loss in a flood several winters ago was a loss not only for the Casinos, but for all star party attendees.)

The pretty Albireo-like double Otto Struve 525 (OΣ 525) lies in the same low power field of view as M57, about a degree to the NNE. Its magnitude 6 and 7.5 components are a wide 45″ apart. Compare OΣ 525 to the real thing; no night of late summer observing is complete without a low power view of Albireo, that matchless pair of topaz and sapphire gems.

One of the more interesting objects in the sky is the Blinking Planetary, NGC 6826 in Cygnus. With direct vision the central star almost overpowers the 25″ wide nebula; with averted vision the magnitude 9.8 planetary nebula becomes so bright that it completely hides the magnitude 10.4 central star. Alternate quickly from direct vision to averted vision and the central star blinks on and off. The effect can be seen to some degree in quite a few planetaries, but it works best in NGC 6826, perhaps because the disk is of equal luminosity all the way across its diameter.

[1] The Palomar 200-inch photo on page 1168 of *Burnham's Celestial Handbook* shows the parallel banding inside the Ring Nebula that I momentarily saw with John Casino's 36-inch Dobsonian. Such an observatory photo is probably required to show the banding since even in the *Meade* ads that display Jack Newton's CCD image with his 25-inch Newtonian do not show the banding. The Palomar photo also shows the five stars that I mention in the article (two inside the ring, one on the ring, one preceding, and one following).

The dimensions of objects are from *Burnham's Celestial Handbook* when available, since Burnham gives the apparent visual size, which is much more useful to the visual observer than are the much larger sizes measured on astrophotos. Except for some double stars and the Pere-Kohoutek planetaries, the magnitudes and celestial co-ordinates are from the 1998 *Observer's Handbook*:

	R.A.(2000.0)	Dec.(2000.0)	Comments
M57 (NGC 6720)	$18^h\ 53.6^m$	+33° 02′	Ring Nebula
Beta Cygnii	$19^h\ 30.6^m$	+27° 57′	Albireo
NGC 6826	$19^h\ 44.8^m$	+50° 31′	Blinking Planetary
PK71-2.1	$20^h\ 21^m\ 04.8^s$	+32° 29′ 36″	
PK65-27.1 (Pease 1)	$21^h\ 29^m\ 59.4^s$	+12° 10′ 27″	
PK103+0.1	$22^h\ 16^m\ 04.5^s$	+57° 28′ 34″	

To me this planetary appeared white even with the 62-cm Cassegrain of the Goldendale Observatory in Washington state, but some observers saw a greenish tinge with that telescope. It "blinks" equally well whether using a 20-cm or a 62-cm telescope.

The wide double 16 Cygni (two 5th magnitude stars separated by 39″) is in the Blinking Planetary's low power field, just to its west. Three other fainter pairs are in the field as well — all have about the same separation that 16 Cygni's stars do, while two pairs also sport components of equal brightness.

Here are some reports of Alberta-style "observing at the edge" from Edmontonians Larry Wood and Denis Boucher, and Father Lucian Kemble (of Cochrane, Alberta, when the observations were made, but currently observing in Lumsden, Saskatchewan). These observers hunt tiny 14th and 15th magnitude glows from the *Catalog of Galactic Planetary Nebulæ* by L.Perek and L. Kohoutek. [Their quarries are even fainter than Comet Kohoutek!]

Observing at the 1997 Alberta Star Party (ASP), Wood found PK71-2.1 (in Cygnus, near the Veil Nebula) in his 32-cm Newtonian at 274× only after 10 minutes under a dark cloth and using averted vision. The object is magnitude 14.5 and only 5″ in diameter! He confirmed his find in Boucher's 40-cm Newtonian a few minutes later. Father Kemble reports observing PK71-2.1 with his C11 at 166× with a UHC filter. It was seen as a very faint flicker by using averted vision and movement in declination.

Wood and Boucher also spent about three hours at the ASP on PK65-27.1 (Pease 1)[2], a magnitude 14.9 planetary nebula, 1″ in diameter, located in the northeastern part of the wonderful globular cluster M15, and apparently a true member of the cluster. Their report: "We both sorted out the field and got a glimpse of it in both scopes (32-cm and 40-cm Newtonians) at about 275× to 350×. We blinked the field with the [O III] filter with limited success, then screwed the filter right into an eyepiece, viewed with it, then switched to another similar eyepiece sans filter and could pick it out quite nicely."

Wood also located PK 103+00.1 in Cepheus: "...a neat, faint (magnitude 13.5) PN (planetary nebula) about 25 or 30 arcseconds in diameter... and a bright region on the SW edge of the PN. It is slightly elongated SW-NE. I could get a hint of slightly larger fainter nebulosity out to 45 arcseconds."

Father Kemble's sources state that the planetary's central star is magnitude 20.4, so that would not be what he called a "star-like" centre in his 1989 observation from Cochrane with his C11 at 166×: "Star-like, with surrounding glow on averted vision; in a field of nice chains of stars; seems slightly fan-shaped to N. OC (open cluster) NGC 7235 ~ 30′ to the SW."

Here is some observing advice on hunting near-stellar planetary nebulae from Father Kemble: "I'd like to mention my great success with Diffraction Grating eyepieces and, more recently, Barry Arnold's superb diffraction prism eyepiece. Hardly any source (other than a brief note in the Webb Society volume) mentions this piece of equipment for such a purpose, talking of it mainly as a way of seeing spectral lines — an application that is next to useless except for very bright stars and a very steady sky. With the diffraction grating or prism eyepieces, when one finds the field of a stellar, small, faint PN that will not yield even with use of an [O III] or UHC filter, the stars in the field yield their characteristic elongated spectrum, but the PN, with its emission spectrum dominated by lines at only a couple of specific frequencies, will stand out like a sore thumb, a simple dot."

The massive high pressure areas of late summer frequently offer the best conditions of the year. Good observing!

Retired weatherman Alan Whitman is now a full-time amateur astronomer. His other interests include windsurfing on the Okanagan Valley's lakes, hiking and skiing on its mountains, and travel. He invites detailed observing reports from experienced amateurs who have largely completed their Messier list, for use in this column.

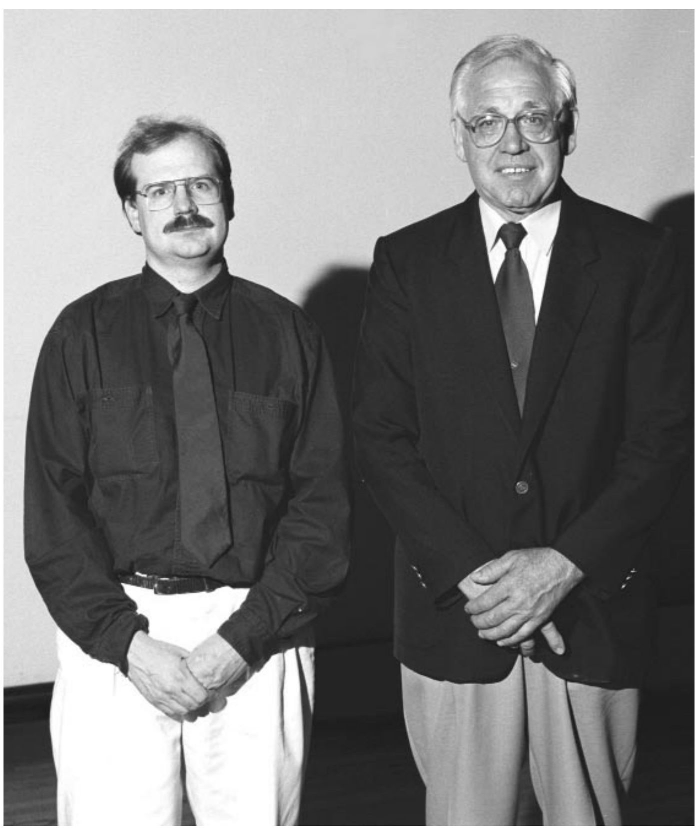
[2] Larry Wood offered a guide to finding Pease 1 in M15 as follows: "Pease 1 is imbedded in M15. I have a bitmap Hubble photo of the globular cluster with the appropriate bright stars marked so that it is easier to locate the planetary nebula. The file is 258K if you want it."

Photo Gallery

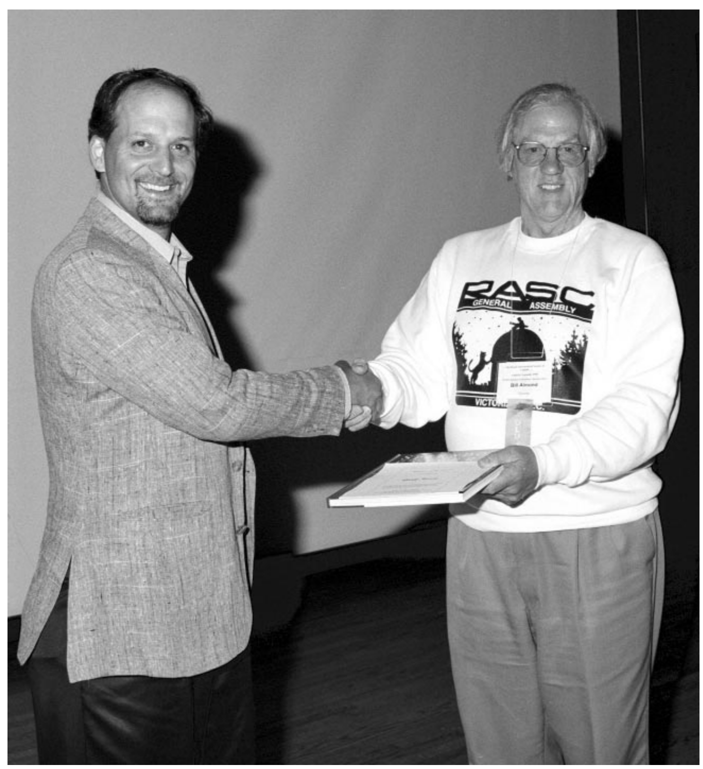
1998 Victoria General Assembly Held at Lester B. Pearson College of the Pacific

All photos are by David Lee, Victoria Centre, unless otherwise noted — captions written by Dave Lane, Halifax Centre.

Our hosts from Pearson College, Heline and Jean Godin with Julie Payette (centre), one of Canada's astronauts, who was a pleasant last minute addition to the programme. Ms. Payette spoke energetically about the space program from the very beginnings to the present day.



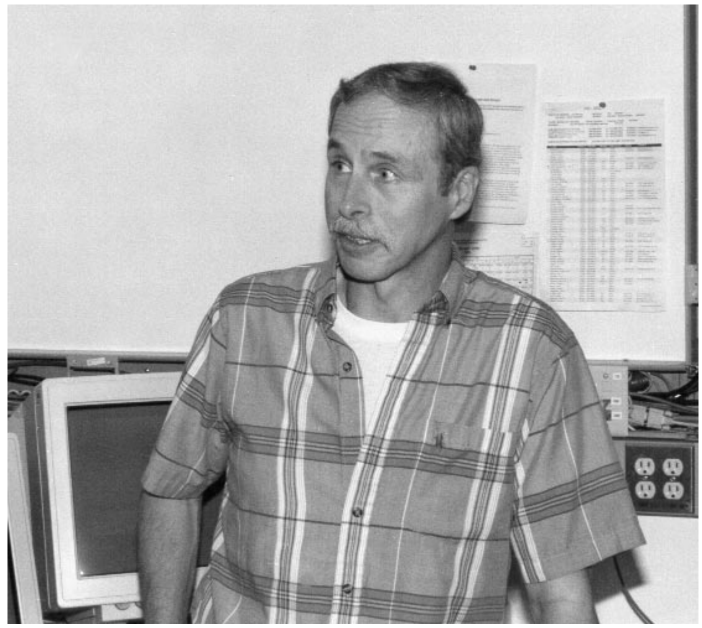
The two national award winners present at the GA: David Lane (Halifax Centre, at left) received the Service Award and Bert Rhebergen received the Chant Medal.



Bill Almond, Centre President and GA Co-ordinator, presents a gift to Dr. Geoff Marcy, one of the excellent invited speakers on the programme. Dr. Marcy spoke about his successful efforts in searching for extra-solar planets. GA attendees were also the first to hear of a newly discovered planet orbiting the star *Gliese 876*.

Those in attendance who received their Finest NGC Observing Certificates from outgoing National President, Doug George were Alan Whitman (Okanagan Centre, at left) and Glenn Hawley (Calgary Centre, at centre).

The sole entry in the song contest this year was Phil McClausland (St. John's Centre), now pursuing graduate studies at the University of Western Ontario, in London.



Well-known minor planet researcher David Balam of the University of Victoria explains his near-Earth asteroid work in the telescope's control room.

(*Photo by Dave Lane*)

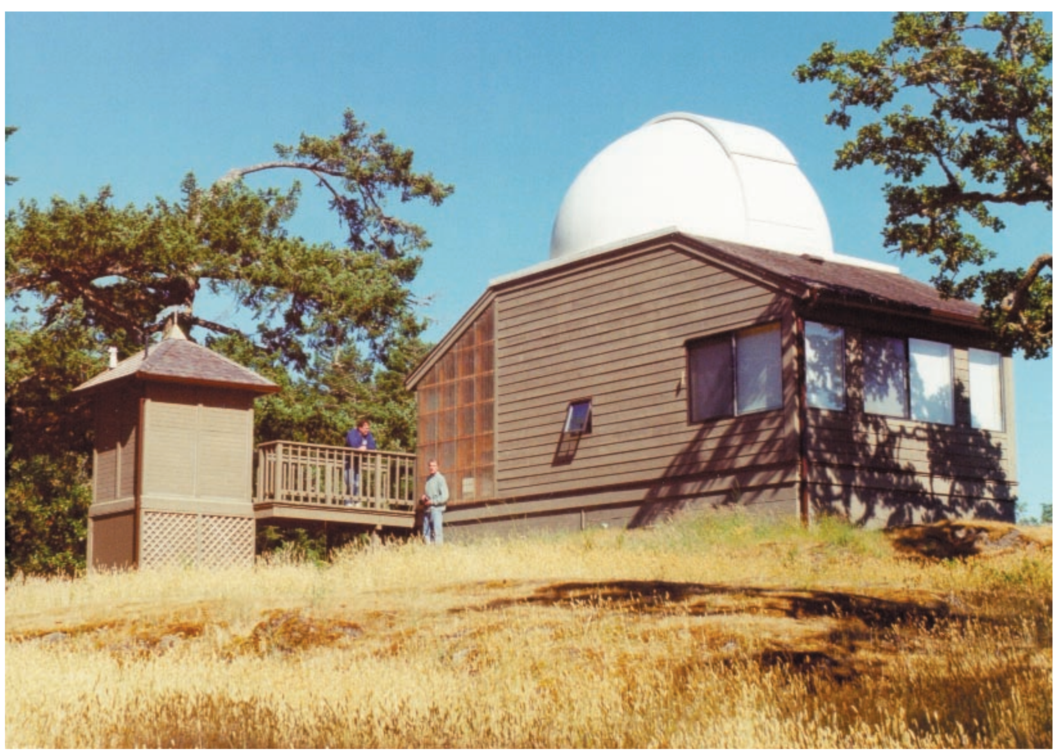
Richard Wagner (Ottawa Centre) and Sid Sidhu (Victoria Centre) are discussing the finer points of astrophysics at the Wine and Cheese Party.

Above: Alice Newton (Victoria Centre) presents Dave McCarter (London Centre) with "the big door-prize," a 3.5-inch ETX Maksutov telescope donated by Meade Instruments Corporation.

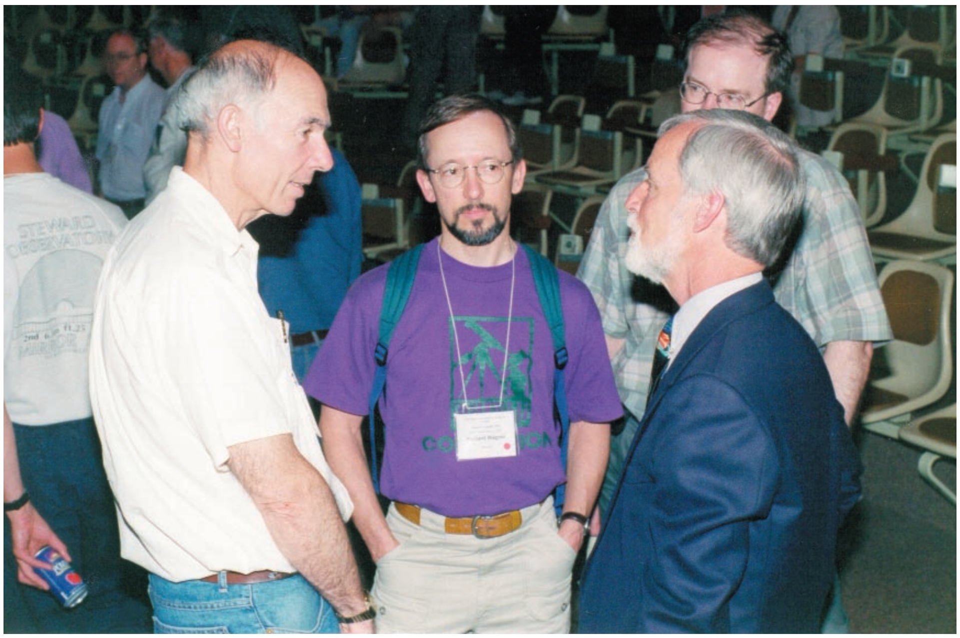
Left: Dr. Roy Bishop stands beneath the "business" end of the 72-inch Plaskett telescope while on a tour of the Dominion Astrophysical Observatory. (*Photo by Dave Lane*)

Overlooking the campus is the Pearson College Observatory, which houses a 25-inch Newtonian telescope. On all three nights of the assembly, the telescope was open for observing, a unique feature of this GA! Standing in front of the observatory are Randy Attwood and Bob May, both of the Toronto Centre.

(*Photo by Dave Lane*)



Right: Most of the society's National Council, which is comprised of the elected and appointed officers, editors, and Centre Representatives, posed for a photo on the stairs leading up to Max Bell Hall, the site of most of the assembly's events.



Left: Jack Newton (Victoria Centre, at left) and Richard Wagner (Ottawa Centre, at centre) speaking with Dr. David Crampton following his lecture on the Adaptive Optics work undertaken at the Canada-France-Hawaii Telescope and soon the Gemini Telescopes which are currently under construction.

(*Photo by Dave Lane*)

Right: Members from across the country gather for an informal chat between events in the busy program. From left to right are: Christopher Spratt (Victoria), Mark Kaye (Hamilton), Jack Newton (Victoria), Colin Haig (Hamilton), Leo Brodeur (Kingston), and Tim Bennett (Windsor).

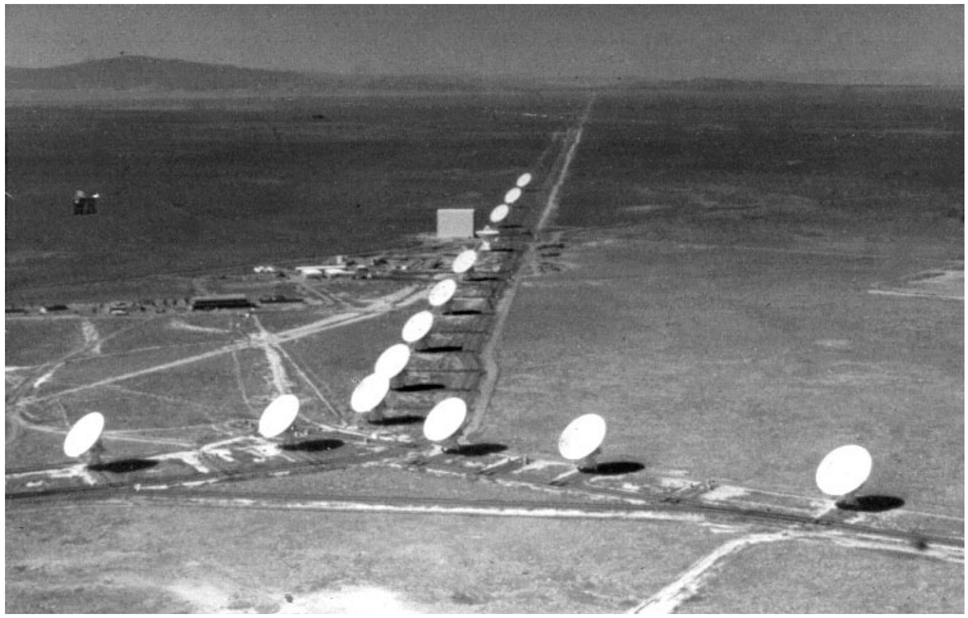
(*Photo by Dave Lane*)

The Light Side of Research

Terminal Astronomy

by Orla Aaquist, Keyano College, Fort McMurray
(Orla.Aaquist@keyanoc.ab.ca)

At the end of February, during reading break, I took a trip to the University of Calgary to set up an experiment for a VLA observing run (see column in last issue). As always, when I visit a university, I drop by the campus bookstore to browse through their science and mathematics selections, and, as always, I bought a book beyond the scope of my understanding. For some reason that I do not care to disclose here, I sometimes feel the need to study complex equations and contemplate abstract concepts, review quantum mechanics, or try once again to understand general relativity. Those topics are not subjects I teach, and they are not useful for my current research project. They are just subjects that I did not grasp with the same clarity as the process of long division. I have a modest collection of such books and they are extremely useful. I always keep one on my night table and study it after getting into bed at night, and within five minutes I am sound asleep. I recommend it to anyone who suffers from insomnia.



14 of the 27 dishes comprising the Very Large Array (VLA) radio telescope in New Mexico.

After a long absence from the U. of C., before any work can be done it is important to catch up on the department gossip. For some reason it is difficult to get down to business without such information. It is same reason why I cannot start working in the morning before I read my e-mail. So, after visiting the bookstore, I dropped by the department office to spend a few minutes with the secretaries. Whereas scientists search for God, the secretaries speak directly to Him; consequently they know more about the goings-on than anyone else in the department. All you have to do is bring them a box of chocolates. That is one of the greatest skills I learned as a graduate student.

So, by 10 o'clock on Monday morning, I was completely settled in front of my terminal. That was a new record for me. The task at hand was to set up an observing file for a VLA run on March 12. I had applied for 24 hours of observing time, but was granted only 8; hence, my source list had to shrink by a factor of three. When I wrote my proposal back in August 1997, I took great care deciding what source should be observed and every one of them had become one of my children. Now I had to tell eight of them that they could not go to the VLA. It was going to be painful. So, being a typical parent, I put it off to avoid having to listen to their endless protests: *"You said we could all go! Why does Hb12 get to go when I'm just as compact and bright as SHE is? You lied! It's not fair! Well, I don't want to go anyway! … "* Can you imagine trying to work with such endless complaining?

I had five days to cut the roster down to four, plan the observing sequence, create the observing file, do trial observing runs to eliminate potential problems — like observing too close to a planet or the Moon, observing the zenith (which is hard to do with an alt-azimuth mount), and making sure that the cables did not wrap around the axis. I felt like I was planning a space mission. As you can see, it does not take much to excite someone who has been teaching first-year physics for the last six months. I estimated that it would take me only three days to finish my task. That would leave two days to… Who was I kidding?

The most critical part of my mission was to refamiliarize myself with the observing program, appropriately called OBSERVE. I had run the program ten years ago on the VLA's old DEC-10, so I was not expecting too much trouble. Like riding a bicycle. The first problem, however, occurred as soon as I sat down at the terminal and looked at the monitor. I remembered that UNIX is distinctly different from Windows 95.

By 1:00 p.m. and with a little help from the local UNIX guru, I had managed to download OBSERVE along with a manuscript that was to guide me through the software. I figured that I actually did not need the manuscript. How hard could it be to run a new piece of software? They must have upgraded it by now. It probably had a menu bar with logically named menu items, a tutorial and a help icon.

Well, no. Apparently, research software has not progressed beyond text screens and keyboard commands. The latest version of OBSERVE looked like a macro program written in Version 2 of Lotus 1-2-3. Apparently professional astronomers have better things to do than write user-friendly software. By 3:00 p.m. I was ready to give up on the trial and error approach and print the User's Guide and go for coffee. Come to think of it, I never did have lunch that day.

How to print a document from UNIX: **print observ.txt.** Right? The printer to my left produced nothing. Now I have to tell you that I am not one of those people who, when a command does not work, follows the adage, *"try, try again."* No sir. When, 30 minutes later, I finally located the printer, I only found three copies of my file in the print tray. Of course, not one of the printouts was any good because the document contained tables that were too wide for portrait mode and the default font. Another 30 minutes went by before I discovered the necessary print command.

> "A bit of a learning curve" and "apparent with experience" were two very disturbing phrases.

```
genscript observ.txt -hBr - P lj -f courier8
```

God! I should have known! I felt like a million monkeys typing random phrases for hours.

It was now 4:00 p.m. and time to quit. Please don't do the math. It only seemed like an hour, but it was really 4:00 p.m. I have no idea how it took me three hours to print a document. Time flies when you are having fun? I grabbed my printout and headed for supper.

Over supper, my spirits lifted and energy returned as I sipped a glass of wine with an old friend and talked about the good old days when we unravelled the mysteries of the universe over coffee. Later, when I crawled into bed, I felt confident that tomorrow I would make progress. I made the mistake of taking the OBSERVE User's Guide to bed with me. I read the first paragraph and a vague feeling of discomfort swept over me as I read,

> *"A VLA observing file creation and editing program, OBSERVE, is now available for VAXs, SUN Workstations, IBM R6000s and PCs. The user interface has changed quite drastically from the line editor approach that was used in OBSERVE on the VLA DEC-10 to a menu-driven spreadsheet approach. While the result has a bit of a learning curve, it provides increased capabilities and flexibility that become apparent with experience."*

"A bit of a learning curve" and *"apparent with experience"* were two very disturbing phrases. I didn't sleep as well as I had planned. Fortunately, my observing run was very simple and I was pretty sure that all I had to do was follow the example in the User's Guide and merely substitute my sources for theirs.

You will notice my blind optimism. Here I was, one day after spending three hours printing a simple *how-hard-can-it-be* text file, declaring that something else was very simple. But, how can we ever admit to ourselves that printing a text file is going to cause problems? If I admitted to myself at any point of my career as a scientist, teacher, or cab driver (yes, I drove cabs — but before I got my Ph.D.) that every step is hard, I would still be … driving cabs. Although, in defence of cab drivers, driving a cab is not an easy job. You really do have to learn the location of every business and back alley in town in order to survive, and unless you live in Fort McMurray, it is a pretty daunting task, comparable to obtaining a Ph.D. in… Well, perhaps I should stifle that thought before I get into trouble with the editor.

In any case, needless to say the OBSERVE User's Guide was just a little more complicated than printing a text file. You can take that any way you like, but I had that program purring like a well tuned Volkswagen by late Wednesday afternoon. On Thursday morning I chopped seven screaming little heads from the body of the observing list and by Friday afternoon, I was out-of-there with two hours to spare, thinking "God, I'm good!"

Orla Aaquist is the physics instructor at Keyano College in Fort McMurray. His rather varied career has included periods as an undergraduate at the University of Alberta (B.Sc.) and Queen's University (B.Ed.), a graduate student at the University of Calgary (M.Sc., Ph.D.), a high school teacher of physics and mathematics in Toronto, and "telescope instructor" at the Calgary Centennial Planetarium.

An "Insider's" Look at the Binocular Industry

by Joseph O'Neil, London Centre

Being on the business side of things is certainly an education. That, along with rapid changes in the optics industry and the collapse of the Asian markets, has changed many circumstances in the binocular industry over the past four to five years. Presented here is a brief description of some of the changes.

As a rough guess, worldwide only ten to twenty factories supply 90% of the world's binoculars. Ten years ago most of the factories were German or Japanese, but many of them are now located in mainland China. The quality of binoculars produced ranges from poor to excellent, regardless of the brand name, since almost all major binocular brands are producing optics in China. With the exception of Russian optics, any pair of binoculars that retails for under $100 has been made in China, and almost all of those between $100 and $200 have been also. Japanese-made binoculars are like Japanese-made VCRs — only the high-end items are still made there.

> "Ten years ago most of the factories were German or Japanese, but many of them are now located in mainland China. … The old adage of "try before you buy" is more valid now than in the past."

Some German brand-name optics (camera lenses for example) are also being made in China. It is a bit bewildering, but you can get an extreme range of optics coming off the same assembly line depending on who the buyer is. A major brand name, for example, will have quality control representatives watching the production. Even then, for some low end lines quality can be poor.

The old adage of "try before you buy" is more valid now than in the past. Manufacturers have done a good job of educating the public that Bak 7 prisms are not as good as Bak 4 prisms, but have not gone further by explaining the importance of the lens, coatings, *etc*. It is possible to have good prisms but mediocre coatings and lenses in a binocular. Indeed, I have seen binoculars with Bak 7 prisms outperform similar sized binoculars with Bak 4 prisms.

What produces such a difference? A few things do, of which coatings are probably the most important. In a totally uncoated binocular, only about 50% of the total light entering the binocular is transmitted through the eyepiece; much of it is lost in internal reflections that also lower contrast and sharpness. With the very best advanced coatings, such as top-of-the-line Fujinons or Nikons, about 95% of the light is transmitted.

The next item is that of eyepieces. Almost all binoculars sold for under $200 will only have three-element Kellner eyepiece lenses (or variations thereof). You should understand that there is a wide variation in the quality of such eyepieces, but it is rare to find Plössl or Erfle designs until you break the $200 price barrier — unless the items are on sale.

The third item is lens quality throughout the entire binocular, including the eyepieces. If you search the web, you will find Plössl eyepieces for telescopes ranging from $75 to $150. Anyone who is an experienced observer will very quickly spot the difference between two 32-mm Plössls of varying price and quality. The same is true for binoculars. That is why, in some circumstances, binoculars with Bak 7 prisms may outperform a similarly-priced pair with Bak 4 prisms.

The collapse of the Asian markets has had weird effects on the price of Japanese optics. Overall prices are dropping, but the rate and timing of the drops is extremely erratic and unpredictable. For example, a brand-name 4-inch refractor that sold last year in Toronto for about $1,700 can now be found, on a slightly smaller mount, for $900 – $1,000. Another person that I talked with spoke of buying a large Japanese refractor last year, and now fourteen months later it is retailing for $1,400 less. By comparison, a top-of-the-line pair of nitrogen-filled waterproof binoculars is only $25 less than the price a year ago. In some cases it seem the higher the quality, the less the price difference.

What has caused such a drop? Two factors are at work. One is the strength of the Canadian dollar against the Japanese yen. While our dollar has been weak relative to the American dollar, it has done very well against all Asian currencies, something that has not been well noticed. The second factor is that, in some cases, Asian manufacturers have been desperately trying to move products in order to shore up their cash reserves. What it means to the average consumer is that, at the present point in time for top-of-the-line binoculars, the Japanese products are a far better value than their German counterparts. If you took two 7×50 binoculars side by side, one German and one Japanese, and determined that they were identical in performance, the German pair would probably sell for 50% to 100% more than the Japanese model.

While such a drop in price might, at first glance, sound good for the consumer, it might ultimately be harmful. Some background is helpful. In retail sales of any product, the lower the price, the higher is its markup. That is not the fault of the retailer; it is how the product is supplied. For example, a retailer will make perhaps twice as much selling six pairs of binoculars at $100 each as he does selling one pair at $600. Since the $100 pair is more likely to sell and the $600 pair may only sell a couple times a year, that is why for any product you see less and less choice for more expensive items. Retailers simply cannot afford to keep such items in stock. Or they may do as some of the less reputable mail-order house do — simply never stock an item, just order it as orders are received.

Imagine now, for argument's sake, that you are the retailer who last year was trying to sell that 4-inch refractor for $1,700. All of a sudden you find the same telescope selling for $800 less, and you are stuck with a telescope that you can only sell at a great loss. You may think there was a large markup for your purchase, but the truth is that the average markup on big ticket items may be as low as 10%. In the retail trade you need an average markup of 30% to 40% just to pay basic bills such as rent, insurance, telephones, *etc*. If one item is marked down 10%, then another item will be marked up by up to 90% just to balance out. It should also be remembered that every time you use plastic to buy something, be it a credit or debit card, the bank is getting a percentage of the sale, sometimes as high as 5%. As a result, all prices across North America are marked up enough to cover that margin. As such, if you were the merchant stuck with the very expensive telescope and looking at the prospect of losing a few hundred dollars, it would be a very long time before you ordered another one. Merchant confidence, while not often talked about in financial reports, is often just as important as consumer confidence.

> "In the retail trade you need an average markup of 30% to 40% just to pay basic bills such as rent, insurance, telephones, etc. If one item is marked down 10%, then another item will be marked up by up to 90% just to balance out."

One last factor in the changing of the binocular industry is the use of "plastic" or, more accurately, polycarbonate resins. It started a few years ago with the development of the police and military issue Glock handgun, which is mostly "plastic." From first-hand experience, I can tell you that the Glock is a hundred times more durable and dependable than the old all-steel .38 revolvers or .45 pistols. You can literally drop a Glock in water, run it over with an eighteen-wheeler truck, and the thing will still fire more often than not.

The impressive durability of the new resins has not been lost on other manufacturers, but there is a public resistance to their use because of how they feel. With respect to the Glock, the first time I picked one up it felt like a child's toy. When I fired it for the first time on the police range, even with single shots, it was terrifyingly easy to pump out fifteen shells in under five seconds and literally blow the cardboard target into little shreds of paper. At that point, the seriousness of both the gun and the design hits home very hard.

That is easy for me to say, but convincing the public is another matter. There are not too many models of binoculars using resin bodies as yet; however, the manufacturing costs are much lower in form-injecting a resin body as opposed to machining a high-grade aluminum body. Fujinon's Mariners, which have an all-resin body, are in my humble estimation optically equivalent to their Nautilus Series, which have aluminum bodies. Even though they both have similar optics, the resin body binocular sells for about 60% the price of the aluminum body binoculars. Still, the lightweight model feels like a child's toy, so it will take some time for the public to get used to the new resins. When they become more commonplace, you will find a binocular that is not only more durable, but also costs a lot less.

As for advice to which is the best brand, even I cannot tell from my side of things. Just keep trying them out, and buy the best you can afford. Good luck.

A member of the London Centre, Joe O'Neil has been interested in astronomy since grade school. Joe recently founded O'Neil Photo & Optical Inc. based in London, Ontario. In his spare time he enjoys planetary and lunar observing from the light polluted skies of London, and black and white astrophotography from the family farm near Granton, Ontario, about 5 kilometres due north of Western's Elginfield Observatory.

Reviews of Publications
Critiques d'ouvrages

Prisons of Light: Black Holes, by Kitty Ferguson, pages 214, 15.75 cm × 23.5 cm, Cambridge University Press, 1996. Price US$24.95 hardcover (ISBN 0-521-49518-0), US$14.95 paperback (ISBN 0-521-62571-8).

With so many good books about black holes on the shelves, whenever I see a new one I have to wonder: what particular aspect sets this book apart? Kitty Ferguson's first book on the topic, *Black Holes in Spacetime*, already succeeds admirably as an introduction for beginners. With *Prisons of Light* I was intrigued to see what she might have to offer in a return to the subject. Unfortunately, the book does not live up to the standard set by its predecessor.

Ferguson races through the first half of *Prisons of Light*, bringing the reader from basic concepts to full-blown theory in a little over 100 pages. The process goes far too quickly. For example, Ferguson introduces electron degeneracy only two pages after defining mass. After covering the entire life cycles of stars in Chapter One, she turns her attention to an equally rushed treatment of gravity and light.

Once Ferguson dives into the topic of black holes proper, she takes the reader from tidal forces through to Hawking radiation and then, suddenly, she stops. Instead of moving on to theoretical developments during the past twenty years, she begins a section on the observational side of black hole astronomy. In her acknowledgements Ferguson thanks almost two dozen researchers for "keeping her up-to-the-minute," but her theoretical references are invariably out of date. The reader is left wondering if the field has been static for a quarter of a century.

Ferguson's theoretical arguments are mainly assertions, for the most part lacking in authority and relying on vague wording. The book is further hampered by a number of factual and logical flubs. Most are minor, but a few are jarring. By her explanation of time dilation, we should expect time to go faster on a ship approaching us and slower on a ship speeding away. (It does not.) After introducing the idea of redshifted gravity waves, she launches into an extended (for this book — three pages) discussion of redshifted light waves, returning to gravity waves by writing, "What about gravity waves? The expectation is that they also will be redshifted."

At the beginning of the fourth chapter, Ferguson imagines the reader is a volunteer on an expedition to study a black hole. When she refers back to the first three chapters as "previous briefings," the structure of the book begins to make sense, but the expedition soon fades away. Later Ferguson advises the readers "to adopt… the attitude of the White Queen in *Alice Through the Looking Glass*, for whom it was routine to believe 'as many as six impossible things before breakfast'," but only points out the first impossibility before the White Queen disappears as well. The expedition occasionally makes return appearances, but is never fully realized as an explanatory tool. Throughout the book Ferguson passes by many opportunities for an enlightening quote, anecdote or metaphor. The occasional good passage shines in comparison.

When Ferguson finally warms up in the sixth chapter, the contrast is marked. Further improvements continue sporadically in the observational section of the book. Often Ferguson succeeds in humanizing the scientists, but sometimes she seems to be merely summarizing their journal articles. Proceeding now at a more relaxed pace, she accords black holes in binary systems, quasars, and the centres of active galaxies each a separate chapter. Together the three chapters contain enough stories of discovery, colourful examples and metaphors to keep the reader involved. The reader never gets a feel for how many of each sort of black hole there may be, how many astronomers are working on the problems, or even if the examples are typical.

Although Ferguson does deal with some recent observations, most of her discussion continues to be outdated. The quasar chapter culminates with four theories of how jets are formed — all proposed in the mid-1970s. The best chapter in the book comes when Ferguson returns to theory to discuss wormholes. With only a few stumbles, she explains zero point energy, virtual particles and pocket universes clearly, accurately and engagingly. Finally, Ferguson seems to be enjoying herself and at ease with her topic.

It is unclear what audience Ferguson was aiming at with *Prisons of Light*. Beginners may be confused, experts disturbed by her errors, those in between bored by the lack of anything they have not read before. The few interesting ideas that are presented here can mainly be found in the last two chapters. We can only hope Ferguson can salvage them for use in a better book.

William Jacobs

William Jacobs is a science writer and a graduate student at Boston University.

Calendrical Calculations, by Nachum Dershowitz and Edward M. Reingold, pages xxi + 307, 15 cm × 23 cm, Cambridge University Press, 1997. Price US$64.95 hardcover (ISBN 0-521-56413-1), US$22.95 paperback (ISBN 0-521-56474-3).

This book presents, in a unified form, the descriptions of 14 different calendar systems and the computational algorithms needed to convert dates in one into dates in another. It is intended for the computer programmer who has a particular need for accurate calendar conversions, but the book should also interest the general reader wanting to learn more about calendar systems. In effect the book is reference documentation for a suite of computer programs available from the authors over the internet (http://emr.cs.uiuc.edu/home/reingold/calendar-book/index.html). The motivation for the work was to create Emacs-Lisp code for calendar and diary functions in the GNU Emacs editor used on many computers, but the project expanded from there and the resulting publication represents effort spread over ten years. Although the authors have included much historical, cultural, religious, and astronomical information, the primary focus of the book is the efficient and accurate computation of calendars. The copious references at the end of each chapter point readers to sources of complementary information.

In case anyone thinks that such calculations are trivial, consider the following calendar-related calculations computers need to handle: the issue of pay cheques (usually biweekly) and bills (monthly), switching operating systems to and from daylight savings time, the scheduling of activities around secular and religious holidays, automatic control of systems whose functions depend on the day of the week, and so on.

Some of the calendars considered are: the Gregorian calendar (*i.e.* our current civil calendar), the ISO calendar, the Julian calendar, the Islamic calendar, the Hebrew calendar, the Mayan calendar, the ancient and modern Hindu calendars, the French Revolutionary calendar, and the Chinese calendar. The treatment of the Gregorian calendar shows the authors' U.S. bias, as they have coded functions for special days such as Memorial Day and (U.S.) Election Day, but have not offered any for other countries, for example, Canada's Victoria Day. (If the Americans want to do business with us under NAFTA, perhaps they should put our statutory holidays on their calendars, eh?) To their credit, the authors have provided enough information for programmers to create their own special functions of this type.

An aside on Victoria Day: the official formula for the date of Victoria Day is the first Monday preceding May 25. That is the same as the second-last Monday in May, but the official version expresses the link to Queen Victoria's actual date of birth, 1819 May 24, which happens to be a Monday. In any given year Victoria Day could be the fourth of five Mondays in May or the third of four Mondays in May, falling anywhere from May 18 to May 24. Calendar makers sometimes get confused, which is why having a validated suite of calendrical algorithms is so important.

One topic that could have been covered in a little more depth is the confusion that was — and still is — created by the transition from the Julian (Old Style) calendar to the Gregorian (New Style) calendar. Although the changes introduced by Pope Gregory XIII in 1582 were necessary and progressive, the non-Catholic world did not immediately agree. Many countries delayed the transition for centuries, the most significant change (for us) being the Calendar Reform Bill of George II of England, which officially installed the Gregorian calendar in September 1752, removing 12 days from that month. It applied to England and all its colonies, including what became Canada and the United States. A little-known fact is that the same calendar reform moved New Year's Day from March 25 to January 1, so that the year 1752 started on March 25 and ended on December 31, spanning only 271 days. Before the reform, January and February were the last two complete months of the year (which is why February contains a 29th day, when necessary.) Also before the change, September, October, November, and December were the seventh, eighth, ninth, and tenth months of the year, as the Latin roots of their names suggest. Ivan Smith (rustfrog@han.auracom.com), of Canning, Nova Scotia, tells of one gravestone in Annapolis Royal that marks the grave of an infant who was born in September 1750 and who died in March 1750. Perhaps a proper treatment of this anomaly lies beyond the scope of *Calendrical Calculations*, but at least mention of it would have been welcome.

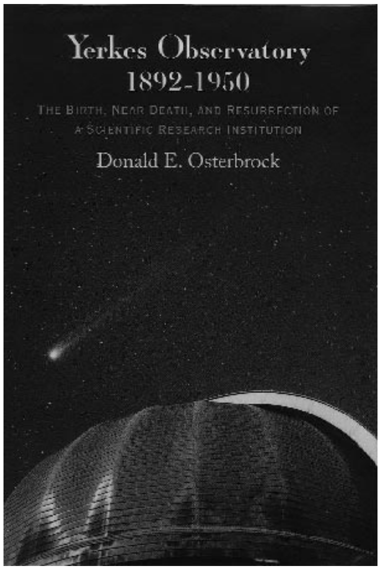
The treatment of the less-familiar calendars is detailed and rigorous. I particularly enjoyed the chapter on the Chinese calendar. It turns out to be much more complex than I imagined. For example, the Chinese New Year is not always the second New Moon following the Winter Solstice, a common misconception (and one that I have promulgated myself, I am ashamed to say).

The book is attractively typeset and each chapter starts with a relevant illustration and a literary citation. Such features add some life to what could have been a dry read. Even so, the book is much closer to being a reference work than a casual read for those interested in calendars and time systems. The latter book has yet to be written, although I recommend Isaac Asimov's *The Clock We Live On* (Collier, New York, 1963) as a good introduction, if you can find a copy! Anyone interested in chronology should acquire *Calendrical Calculations.*

David M. F. Chapman

David Chapman writes the regular JRASC *column "Reflections," in which he frequently discusses calendrical topics.*

Yerkes Observatory, 1892-1950: The Birth, Near Death, and Resurrection of a Scientific Research Institution, by Donald E. Osterbrock, pages x + 384, 16 cm × 17.5 cm, University of Chicago Press, Chicago, 1997. Price US$40.00 clothbound. (ISBN 0–226–63945–2)



Yerkes Observatory is a magical place located on the shores of beautiful Lake Geneva in southeastern Wisconsin. When it was built in 1897, and for nearly a decade, the forty-inch refractor was the largest telescope in the world; it still has the world's largest lens. Upgraded with automated cameras, the century-old telescope is still used on clear nights for parallax and proper motion studies, as well as for other projects. The observatory building now also serves as a centre for other projects as far away as New Mexico and Antarctica.

I remember my first view of the grand old refractor. It was a clear night in June of 1960, and I had just arrived with my wife and two-year-old child. I couldn't wait until morning to see the telescope, so I wandered into the dome. The largest telescope I had seen was a six-inch Clarke refractor, which was about ten feet long, so the appearance of the sixty-two-foot Yerkes telescope was overwhelming. The ninety-foot diameter dome seemed huge and the rising floor was awe-inspiring. George van Biesbroeck, then in his eighties and master observer of visual double stars, was working. He would wait patiently for those few seconds of good seeing and quickly adjust the micrometer to make a measurement. He offered me a look. I waited and waited, but couldn't distinguish what his trained eye could see easily.

During the first half of the twentieth century, Yerkes Observatory played a key role in the development of astronomy. If you enjoy astronomy and history, and would like a perceptive look at some of the people who had an impact on both, read this book. It is well researched and well written, resulting in a thoroughly engaging tale. The history of Yerkes is directly related to the biographies of the three directors during the period 1892–1950: Hale, Frost, and Struve. We are introduced to them, not as gods on a pedestal or evil demons, but as extraordinary people with weaknesses and strengths. Osterbrock provides a good balance.

History fascinates me. I don't write history, I don't teach history, nor do I carry out historical research, but I thoroughly enjoy reading histories, especially of people, places and disciplines with which I have some connection. This book has all these elements.

As a graduate student at Yerkes in the early 1960s, I observed on half the clear nights for three years with the grand old telescope. I used a reducing camera (f/20 to f/1.5) designed by Hiltner that allowed me to take narrow-band filter photographs of all the Shapley-Ames galaxies and all the Sharpless H II regions, as well as many of the Abell clusters. Some of the galaxy photographs were used in Morgan's 1962 Russell lecture.

I knew many of the people mentioned: Morgan, Chandrasekhar, Hiltner, van Biesbroeck, Crump, and others. I had also met Struve and Kuiper. It was fascinating to read of their origins and early interactions. Even if I had not known them personally, I certainly would have heard of them and would have been attracted to Osterbrock's book to learn more. Many of the stories are familiar to me, but I learned new details and Osterbrock has contributed new insights into the reasons for some of the successes, failures, and conflicts of that period of Yerkes history.

Don Osterbrock brings to the story a unique perspective of experience. He was a graduate student at Yerkes from 1948 to 1952 and former Director of the Lick Observatory (1972–1981). In addition, he has held staff positions at several of the best-known American astronomical research institutions, including Princeton, the University of Wisconsin, California Institute of Technology, Mt. Wilson Observatory, and the University of California at Santa Cruz. His books on the subject of interstellar matter are classics in the field, and he has written several monographs and articles on astronomical biography and history. A winner of several awards, he was also President of the American Astronomical Society from 1988-1990.

Osterbrock divides the history of Yerkes into three eras, corresponding to the tenures of its first three directors: George Ellery Hale, Edwin B. Frost, and Otto Struve. Hale's interest in Yerkes Observatory was soon displaced by the attraction of the clear skies of the American Southwest. Frost was not a good leader, so the observatory nearly died under his directorship. Under Struve's tyrannical reign, Yerkes Observatory, with its guardianship of the eighty-two inch reflector at McDonald Observatory in the mountains of West Texas, became the centre of astronomical research. Struve gathered an incredibly talented staff and gave them a good balance of direction and freedom. During that time, most of the world's best-known astronomers passed through Yerkes, as faculty, students, postdoctoral fellows or visitors, either long-term or short term.

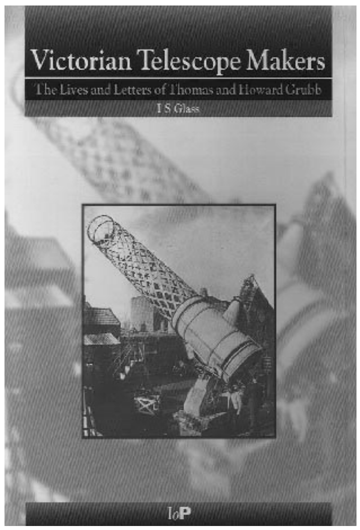
The only error I found in the book was a reference to the "Dominion Observatory in Toronto" (p. 201). Canadians know that the Dominion Observatory is in Ottawa and it is the David Dunlap Observatory that is located near Toronto. The University of Chicago Press has produced a high-quality book, with excellent illustrations.

This fascinating history contains valuable insights and hints on how to run a successful observatory as well as how not to run one. While not everyone will agree with Osterbrock's judgements in detail, his assessment of the trials and successes of Yerkes Observatory provides wisdom from an insider who has done an impressive amount of research into his subject. I thoroughly enjoyed the book, and predict that anyone who has read this far into the review will also find it an excellent read.

Robert F. Garrison

Bob Garrison, Associate Director of the University of Toronto's David Dunlap Observatory, is the Society's new First Vice-President.

Victorian Telescope Makers: The Lives and Letters of Thomas and Howard Grubb, by I. S. Glass, pages xiii + 279, 16 cm × 24 cm, Institute of Physics Publishing, 1997. Price US$50 hardcover, US$30 paperback (ISBN 0-7503-0454-5).



History is best told in the words of those who made it, for there is a peculiar fascination in reading the letters and diaries of those who were involved in the hurly-burly of their times that a historian's account, however fair and accurate, inevitably lacks. Ian Glass has done well to tell this story largely through the letters of its characters.

Thomas and Howard Grubb (father and son) were Irish telescope makers who largely dominated British telescope making in the second half of the nineteenth and early twentieth centuries. Their efforts were not limited to astronomical telescopes, but it is this for which they are best known. They interacted with many leading astronomers of their day, both in Britain and abroad, whose arguments over what kind of telescopes should be built are illuminating indeed. On the one hand there were the "professional" astronomers, typified by Sir George Airy (the Astronomer Royal) and university professors, who were firmly in favour of refractors. On the other hand, "amateurs" like John Herschel and Lord Rosse championed the use of reflectors. They were interested in exploring new fields like nebulae (particularly spiral ones), and even applying spectroscopy to "astro physics" in the case of William Huggins, all of which required more light-gathering power than refractors could provide. Airy *et al.* thought this a frivolous waste of time, when clearly astronomy's future lay in getting better parallaxes and proper motions, a task that required the stability of refractors. Even among the reflector proponents, however, there were arguments as to whether mirrors should be made of speculum (a copper-tin alloy) or silvered glass, with speculum winning out more often than not.

There are pages, such as those devoted to long quotations about the detailed working of various mechanical parts, where I must admit one hurries on, but there are marvellous sections where you laugh out loud. There is Howard Grubb's recollections of casting the speculum mirror for the Great (40-inch) Melbourne Telescope, a process involving three tons of metal. They built a bigger furnace than ever before, and stoked the fires furiously. After a day or so of this, Howard was soundly asleep in bed when "At 12.30 a messenger rushed into the house with the cheerful news that the works were in flames; the almost red-hot chimney had set fire to the roof. I rose quicker than usual…" And then there was the hilarious visit of the Emperor of Brazil to Dublin, with the Emperor sending for Dublin's mayor late one Saturday night and announcing that his principal interest in Dublin was to meet the great telescope-maker "of world-wide celebrity. I cannot remember exactly [his] name, but, of course, you know whom I mean." Neither the mayor nor his assistants had the foggiest idea, and a fearful scurrying about ensued before it was established that it must be Grubb. The result was an early Sunday morning visit to the Grubb Works, ending with the Emperor "accidentally" setting out to leave with Grubb's new hat. The error was tactfully corrected by the Emperor's secretary.

Finally, I cannot resist a personal note. One of the Grubb telescopes dating from the 1890s was a 24-inch refractor known as the McClean Telescope, a gift from Frank McClean, a wealthy English engineer, to what was then the Royal Observatory at the Cape of Good Hope. When I was starting out on a master's degree at the University of Cape Town I was assigned to do the photometry I needed with the McClean refractor. This 23-foot long telescope was not the most convenient, and in particular the drive from the motor to the polar axis was via a sector rather than a full 360 degree gear wheel. Thus, every couple of hours or so everything would have to stop while the sector was rewound with a crank. It seemed that this always happened just as I had laboriously set the telescope on some difficult-to-find star, and I would curse the wretch who had designed the drive with this limitation. What could the man have been thinking? Now, more than forty years later, I finally learn from Glass's book that Sir David Gill, the Observatory's director in the 1890s, had also complained about it to Howard Grubb. The answer was simple: Grubb did not trust his machinists to cut the gear teeth to the requisite precision over a full 360 degrees, so he limited the range to something much less than that.

In summary, the main appeal of this book lies in the letters, putting the reader right among the arguing, demanding, apologizing, cajoling, complaining, explaining, and at times indifference of the protagonists until we feel as though we had known them personally. Ian Glass must be thanked for putting it all into the public record with his book.

Don Fernie

Don Fernie is Professor Emeritus of Astronomy in the University of Toronto. He was formerly Chairman of that department and Director of its David Dunlap Observatory, and is also a former National President of the RASC.

Historical Eclipses and Earth's Rotation, by F. Richard Stephenson, pages xvi + 557, 25 cm × 18 cm, Cambridge University Press, 1997. Price US$160 hardback. (ISBN 0-521-46194-4)

Ah, the marvels of history! 2,300 years ago, a Babylonian astrologer or his scribe used a pointed reed to press strange cuneiform symbols into moist clay. They had no idea that the Earth spins on its axis, and yet their record of the Sun setting in eclipse on the 28th day of month VI of year 2 of King Philip is evidence that one rotation took about 1/30 second less in their time than it does now. The intervening work of scholars is no less amazing — the museum employee who fit pieces of the smashed tablet together, the translators who deciphered it, the historians who interpreted it, and a long list of astronomers and mathematicians who have refined the understanding of time and the Moon's motion to the point where such a conclusion can be reached. The techniques used to analyze the hundreds of relatively crude, ancient observations to yield long term trends in the length of the mean solar day is the subject of Chapter 3.

Halley and Dunthorne, in the mid-1700s, were unwittingly the first astronomers to find evidence for the lengthening day through the acceleration of the Moon by a mere 10 arcseconds per century. It turned out that some of the acceleration was only apparent, arising from the lengthening day that they had assumed was constant. But conservation of momentum dictates that if the Earth slows down, the Moon will actually speed up. The gradual untangling of the various causes of the real and apparent lunar acceleration is a stimulating, though rather bewildering, story outlined in Chapters 1 and 2.

Most of the book, Chapters 4–13, is concerned with the actual eclipse observations and the analysis of each one. Original records of 161 solar and 137 lunar eclipses are given (in English translation) from Assyria in 763 BC to France in 1605 AD. The Far East, Middle East and Europe are represented in this survey, but Stephenson tells us that no useful observations are known from ancient Egypt (other than the Greek city of Alexandria), India or Central America.

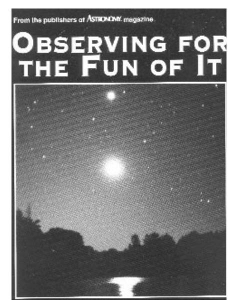
In the final chapter, different values of ΔT (the change in Earth's period of rotation) deduced from individual eclipses are grouped into two categories depending on whether the observations were timed (*e.g.* "at sunset") or untimed (*e.g.* "half the Sun was eclipsed"). Curves representing the trends in the length of day are fitted, and the results from the two categories and from many early civilizations are shown to agree remarkably well. The results suggest that the steady increase in the length of the day of 2.3 ms century^{-1} resulting from tidal friction is opposed by a decrease of 0.6 ms century^{-1}, probably resulting from the post-glacial rebound of the Earth's polar regions. Fluctuations in the length of day and their possible causes are also discussed briefly.

This large and expensive tome is destined to be a valuable reference work in astronomical libraries. Researchers will consult it, as they used to turn to R. R. Newton's books on the same subject, primarily to see what eclipses were actually observed or to find out what value of ΔT is needed to convert Terrestrial Time (the uniform standard used to generate ephemerides) to Universal Time. Nonetheless, Stephenson intersperses a lot of fascinating history with useful information on ancient calendars, units and prediction methods. There is much food for thought in this book, even on an elementary level. Here is a nice question for Astronomy 101, for instance: "Which central solar eclipse has the longer duration (from first to fourth contact), an annular or a total eclipse? Explain." (The answer is in Chapter 3.)

Ah, the mysteries of progress! 2,300 years from now will anyone know that this Canadian scribe pressed strange-looking keys to imprint magnetic dots on a disk? We really do not have any archival medium to equal clay tablets, do we?

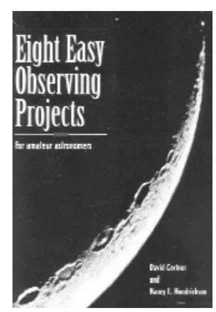
Peter Broughton

Peter Broughton is a Past-President of the Society and author of "Looking Up: A History of the RASC." As a keen amateur historian, he has had to compare computed positions with ancient observations and has experienced some of the calendrical and time-keeping problems dealt with by Stephenson.



Observing For The Fun Of It, by Melanie Melton, pages 104, 19 cm × 25 cm, Kalmbach Books, 1996. Price US$14.95 paperback. (ISBN 0-913135-26-7)

Eight Easy Observing Projects, by David Cortner and Nancy L. Hendrickson, pages 160, 19 cm × 25 cm, Kalmbach Books, 1996. Price US$21.95 paperback. (ISBN 0-913135-27-5)



There will always be a great need for books aimed at beginning amateur astronomers. I do not believe that one book will serve for all time, nor that one book can serve all the various interests and levels of expertise that novices bring to their new hobby. Can we ever have enough introductory astronomy books? Kalmbach Books, the same folks who publish *Astronomy* magazine, are well-placed in the market to provide such books, and here are two more.

Melton's book is the more basic of the two Kalmbach offerings. There are eleven short chapters focused on topics like "Constellations," "Meteor Showers," and "Binoculars vs. Telescopes." Diagrams (like the solar eclipse viewer on page 51) are uncluttered and uncomplicated, and that is good. Explanations are so elementary that they can only be intended for children, such as this treatment of comet tails: "Have you ever tried walking against the wind while holding a stack of papers? No matter how tightly you hold them, the wind always seems to grab one or two pieces." Melton recognizes that her readers have a way to go before they are ready to tackle the tools used by intermediate astronomers. For instance, she writes, "It's a good idea to put the Barlow lens aside until you've observed with your telescope and are comfortable with the way it works." Most chapters contain single-page "activities" that might have appealed to me when I was eleven or twelve years old. These activities, such as the "meteor-counting contest" on page 40, are nicely laid out for young readers. The only hint that the book is intended for pre-teens, however, is the phrase "Family fun inside" on the back cover.

Cortner and Hendrickson have aimed their work at folks who want to take the step from beginner to intermediate amateur astronomer. The eight projects to which the title refers are not particular projects but general skills that a person might wish to develop, like chapter 5, "The Astro Log: Recording the Sky," or categories of activities that might be appealing, like chapter 7, "Rainy Night Astronomy." Chapter 2, "Your First Telescope," for instance, touches on upgrading the mount of a typical 60-mm refractor, has a few paragraphs about the Moon, the Sun and Jupiter, and then serves up almost six pages on double star observing! There are some nice touches, such as the outline of a hand in the star field photographs in chapter 3 to indicate angular scale. The photographs, a fraction of which are in colour, are agreeable and the quality of the paper is quite good. However, the title *Eight Easy Observing Projects* seems inappropriate, if not quite misleading, given the overall thrust of the book.

Somewhere out there in the wide world of new amateur astronomers there are doubtless certain persons who would find these books helpful — although I doubt they would find them inspiring. Neither book displays any particular passion for amateur astronomy, and occasional attempts at a jocular or even self deprecating humour were lost on me. My criticisms of the two books could be summed up by a sentence in Hendrickson and Cortner's introduction: "The difference between disappointment and wonder is often just a matter of knowing what to expect to see." It would be a great help if writers, editors and publishers would be more forthright about who their intended readers are, instead of using sentences like, "This is a book for all amateur astronomers," which appears on Hendrickson and Cortner's back cover. I should not have to read the book before I can figure out who the book is aimed at, and you should not have to take my word for it. If the back cover of Melton's book advertised, "Here's a book for a young person who would like some simple activities in astronomy," and if the back cover of Hendrickson and Cortner's volume said, "This book will help a beginning amateur astronomer develop their interest," then at least no one would be fooled. But in their rush to make these books appeal to as many amateur astronomers as possible, the promoters have cast their products adrift.

Peter Jedicke

Peter Jedicke is the Society's recorder and a long-time active member of the London Centre. He has spent much of his life enthusing young people and old about the wonders of astronomy, both via one-on-one interactions as well as through public education programs.

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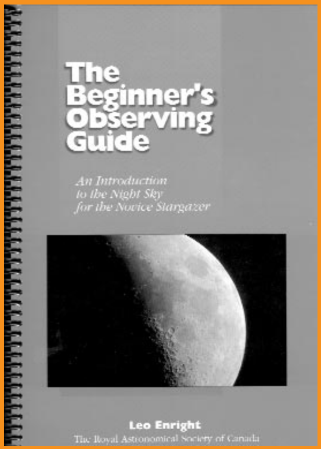
Publications from
The Royal Astronomical Society of Canada

Observers Calendar — 1999

This calendar was created by members of the RASC. All photographs were taken by amateur astronomers using ordinary camera lenses and small telescopes and represent a wide spectrum of objects. An informative caption accompanies every photograph. This year all of the photos are in full colour.

It is designed with the observer in mind and contains comprehensive astronomical data such as daily Moon rise and set times, significant lunar and planetary conjunctions, eclipses, and meteor showers. (designed and produced by Rajiv Gupta)

Price: $16 (includes taxes, postage and handling)



The Beginner's Observing Guide

This guide is for anyone with little or no experience in observing the night sky. Large, easy to read star maps are provided to acquaint the reader with the constellations and bright stars. Basic information on observing the moon, planets and eclipses through the year 2000 is provided. There is also a special section to help Scouts, Cubs, Guides and Brownies achieve their respective astronomy badges.

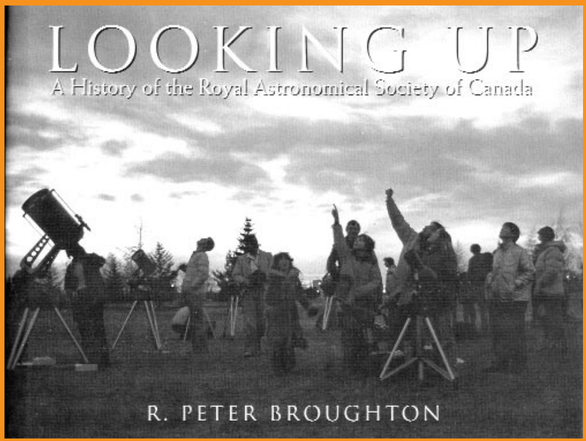
Written by Leo Enright (160 pages of information in a soft-cover book with a spiral binding which allows the book to lie flat).

Price: $12 (includes taxes, postage and handling)

Looking Up:
A History of the Royal Astronomical Society of Canada

Published to commemorate the 125th anniversary of the first meeting of the Toronto Astronomical Club, "Looking Up — A History of the RASC" is an excellent overall history of Canada's national astronomy organization. The book was written by R. Peter Broughton, a Past President and expert on the history of astronomy in Canada. Histories on each of the centres across the country are included as well as dozens of biographical sketches of the many people who have volunteered their time and skills to the Society. (hard cover with cloth binding, 300 pages with 150 b&w illustrations)

Price: $43 (includes taxes, postage and handling)



*** Special Discount — Looking Up and the BOG — $50 — All three publications — $60 ***

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