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Journal

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Journal

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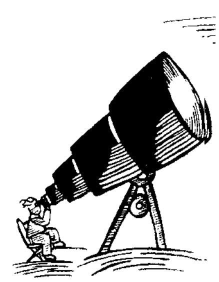

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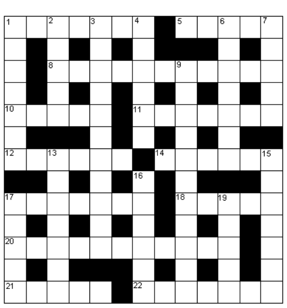

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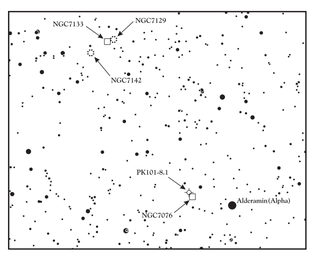

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President's Corner

by Robert Garrison (garrison@astro.utoronto.ca)

Those of us who are fascinated by the wonders of the sky are lucky to be alive during this golden age of astronomy. Who could have predicted that by mid-year 2000, we would be celebrating the discovery of the 50th extrasolar planet? Yet that is just what we have been doing the past few days at the triennial meeting of the International Astronomical Union (IAU) in Manchester, UK, where I am spending most of the month of August. Six years ago, there were no positive results to be discussed, though it was Canadian astronomer Bruce Campbell, using the Canada-France-Hawaii Telescope in the 1980's, who developed the technique and paved the way for today's discoveries.

As your new President, it pleases me to be part of the RASC, an organization whose members are devoted to sharing the excitement of astronomy with the public as well as with each other. Most of us who are lucky enough to get paid for doing astronomy as professionals also feel the wonder of it all and many of us want to communicate that excitement. As stated by the science advisor to the British Prime Minister a few days ago at the opening ceremonies for the IAU: "...astronomy is responsible for stimulating more fundamental discoveries than any other discipline." I might add that dinosaurs, stars, and planets are the first scientific subjects to impress young children. They may not all go into astronomy as a career, but they are the major part of the pool from which future scientists and engineers are drawn.

Since the baton has been passed to me to carry for the next two years, it is encouraging to find that the RASC is in very good condition, thanks to the efforts of Randy Attwood and his Executive team during the past two years. The membership numbers are high and are increasing at a rapid rate. Two new centres have been added, and we now have a centre in every province. Among most of the members of Council and the Executive, there is a feeling of having set up a good, new structure and an atmosphere of anticipation of good things to come. In the spirit of keeping communications between the centres and the National Office open, I hope to continue the tradition of having the President visit each centre at least once during the two-year term of office.

Early in Randy's term, the decision was made to modernize the National Office and bring the out-sourced services, such as membership tracking and invoicing, back home. It was the right decision. With relatively few glitches, the National Office is now operating at a higher level of efficiency than ever before, thanks to a number of people including Randy, Rajiv Gupta, Colin Haig, Peter Hollings (software design), Dave Lane, Michael Watson, and of course the real hero, Bonnie Bird, who patiently guided and co-ordinated everyone else and was the guinea pig for

Journal

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

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testing the new system. Most of the problems have now been sorted out and fixed, so we can look forward to several years of good service to members.

Other major changes have been implemented. This term begins with new editors for the *Observer's Handbook* and the *Journal*, our two flagship publications. The editorial structure has also been changed to ease some of the load on individuals. Details can be found elsewhere in this issue; however, I don't want to leave the topic without again personally acknowledging my gratitude to Roy Bishop and Dave Turner for their dedication and skill in producing very professional publications.

In contrast to the past five or so years, which have been characterized by major changes, the next two years will be characterized (I hope) as a time of consolidation and good works within the new structure. In these times of rapid technological change, it is too easy to become totally immersed in change for its own sake, never stopping long enough to actually use the system to produce new results. From all indications, it should be a good two years. I'm looking forward to meeting you all at some time during the next few years.

GREAT ASTROPHOTOS WANTED

A new feature coming to the *Journal* is a regular gallery where we will feature members' astrophotography. As well we always have a use for photos that can be used to illustrate articles in the *Journal*.

For many of our members astrophotography is a passion. The search for the perfect shot of some faint fuzzy can consume countless frigid nights and buggy evenings — as long as the sky is clear and dark, some RASC member is out there shooting the stars and planets and other related phenomena such as aurorae and other atmospheric events.

We invite you to send us your best shots. We can handle prints, transparencies (from 35mm to 8×10 inches), and high resolution digital or scanned images in most popular formats. Your image will most likely be printed in black and white, but if you have a great color shot, send it along as we try to print at least one color section per year.

Contact the editors (addresses can be found on the masthead at the beginning of this magazine).

Editorial

by Wayne A. Barkhouse, Editor-in-Chief

My fascination with astronomy began at a very young age. Growing up in rural Nova Scotia allowed that fascination to evolve into a passion as the heavens, in all their glory, were visible for all to see. Since kindergarten I had always wanted to be an astronaut or an astronomer, even if that meant spending many years in school. As I near the completion of my Ph.D. in Astronomy at the University of Toronto, that dream will soon become reality.

With the recent resignation of David Turner as the editor of the *Journal*, I decided to offer my services as the new editor-in-chief. David, as well as those who preceded him, has done an outstanding job in making the *Journal* a reputable publication for the Canadian astronomical community. The RASC is very fortunate to have had such highly qualified editors throughout the *Journal's* history.

The job of *Journal* editor requires a huge investment of time and effort, and it was for that reason that the RASC National Council recently decided to make changes to the editorial structure. The new framework consists of an editor-in-chief, associate editor for research papers, associate editor for popular material, a production manager, and a number of assistant editors, columnists, and proofreaders (see the masthead for a complete listing). The objective is to spread the work among a team of volunteers so that no one individual is being overworked.

The August and October issues of the *Journal* have been combined in an effort to bring the production schedule in phase with the publication of *Sky News*. This has given me the necessary time to implement the new editorial changes, which will help to ensure that the *Journal* will be published in a timely fashion. I hope that the reader will understand the need for this action.

In the future, I hope to make some changes to the *Journal* in an effort to increase our visibility within the international astronomical community. These changes will include the publication of review papers from expert Canadian astronomers, invited papers, and a complete redesign of the *Journal's* web page.

I encourage all of you to send us your comments about the *Journal* and to include any ideas that you have for improvement. Please don't forget to send us your papers and articles since this is your journal and together we can explore the exciting world of astronomy in the 21st century.

FROM THE PAST | **AU FIL DES ANS**

EDITORIAL

Two hundred and fifty years ago Frederick the Great of Prussia discovered that the most absurd statement repeated often enough would eventually be accepted as the truth by an initially skeptical population. Jeremy Tatum clearly learned this lesson well, since his oft-repeated suggestions that I should become the next Editor of the JRASC (as it is now known) have clearly had their desired effect. According to Jeremy, my fate was sealed the moment I handed to him a fully edited set of abstracts for the 1992 meeting of CASCA (the Canadian Astronomical Society – Société Canadienne d'Astronomie) at Saint Mary's University. In a sense, I have no one to blame but myself.

As the new editor I hope to initiate a few changes to the *Journal*, but it may take some time for these to appear. Possible additions that I would like to see are a "Letters to the Editor" section and an expanded version of the "Notes" section, although much of the material for the latter may overlap with the mandate of the *Bulletin*. I hope that any modifications will be considered as positive changes. The *Journal* has always served as its own unique outlet for the publication of astronomical research and ideas on a wide range of topics, as well as a means of highlighting the work of Canadian astronomers, both professional and amateur. As the distinctions between professional and amateur astronomy gradually disappear in this electronic era, changes to the *Journal* are certain to keep pace.

by David G. Turner,
from *Journal*, Vol. 88, p. 91, April, 1994.

Correspondence
Correspondance

ON MESSIER MARATHONS

Dear Sir,

When I received the April issue of the *Journal*, I was very dismayed by a comment in the "Congratulations To..." portion of *Society News*. In particular, "March has traditionally been the best month to make a one-night attempt at the Messier Certificate, since it is possible to observe all 110 objects of the RASC Messier list on one good clear night. Perhaps those Centres or individual observers who had successful Messier Marathons will be evident through applications for the RASC's prestigious Messier certificates."

Surely the point of the Messier Certificate is to encourage the development of observing skills at the eyepiece. All serious deep-sky observers that I know typically spend anywhere from 15 minutes to an hour studying each object, trying to discern subtle low-contrast detail. A detailed description or sketch is then made.

A Messier Marathon is the antithesis of careful observing — an object is merely identified in a glance lasting only seconds. The successfully found object is ticked off and the star hop to the next begins immediately. I greatly enjoy Messier Marathons; in fact, I did five marathons this spring! But a Messier Marathon is a hunting game that only teaches efficient star hopping. It has absolutely nothing to do with the development of other important visual observing skills.

A few of the far southern Messiers like M69 and M70 are difficult to find from many Canadian observing sites, and seldom show much detail at the eyepiece because of their low altitudes — when I completed my Messier list 19 years ago my only observations of those two objects were through gaps in a hedge in my then Kelowna backyard. It would be reasonable for an observer to count a *few* such far southern fuzzies if their only view of them had been during a marathon. But the suggestion that a Messier Marathon is an appropriate approach to doing a significant part of the observations necessary for "the RASC's prestigious Messier certificates" is appalling. Nothing could devalue Messier Certificates faster than that misguided suggestion.

Alan Whitman, awhitman@vip.net
Okanagan Centre

OBSERVING VARIABLE STARS

Dear Sir,

In his review of *Observing Variable Stars* (April 2000 issue, pages 74–76), David Turner wrote that the book's star charts "appear to have been taken from a photographic atlas of the sky but without attribution." May I set the record straight?

The charts for *Observing Variable Stars* were created especially for the book, not from any photographic atlas, and they are credited on page xix at the front of the book "to James V. Scotti, for his expert and original creation of the finder charts and some of the detail charts." The process of creating the charts was an interesting one. In my own experience observing variable stars, I find the biggest problem is to find the variable. I conceived the set of finder charts so that beginners to the field (and I!) would have an easier time getting started. Back in 1987, Jim carefully produced the charts on a computer plotter, but then he and I went through every one by hand to try to make the magnitudes as close to visual as we could; *i.e.* the magnitudes should reflect what observers see in the sky rather than what appears on a photograph, since stars on a photograph have different magnitudes from their visual ones. I also added the variables by hand.

Thanks for this opportunity to solve the mystery of those charts.

David H. Levy, david@jarnac.org
Tucson, Arizona

JAN H. OORT

Dear Sir:

No one can expect a one-and-a-half page column to provide comprehensive insight into the work of such an influential astronomer as J. H. Oort. Nonetheless, I think readers of April's *Reflections* would have been pleased to see Oort's honorary RASC membership mentioned (*JRASC*, 87, 67 and 73) and would have appreciated some discussion of the influence his pioneering research on the rotation of the galaxy had on the outstanding work of Canadian astronomers Plaskett and Pearce (*JRASC*, 30, 153 and 82, 318).

Peter Broughton, peterb@torfree.net
Toronto, Ontario

News Notes
En Manchettes

THE FUTURE OF ASTRONOMY IN CANADA

Rest assured, there is a future for Canadian astronomy; but for Canadian astronomers to compete on the future world stage will require an investment in personnel and, of course, money. So concludes a report by the Long-Range Planning Panel of the Canadian Astronomical Society. Released during the Society's 31st Annual meeting held at the University of British Columbia in May, the Report set out to identify those areas of critical importance to the future of astronomy in Canada. The Panel consulted with the astronomical community both nationally and internationally, and set about identifying some of the research fields in which Canadian astronomers presently play a leading and prominent role. Key to future developments, the Panel concluded, is the involvement of Canadian astronomers in several multinational, "big science," projects. Singled out for particular attention were the Next Generation Space Telescope and the Atacama Large Millimetre Array. The Report also calls for the establishment of new university laboratories for experimental astrophysics, increased training opportunities for new astronomers, improved computing facilities for data reduction and interpretation, and an enhanced public outreach program.

The Report also recommends that over the next decade Canada invest $100 million in space-based programs through the Canadian Space Agency (CSA). In addition, some $147 million should be invested in the facilities run by the National Research Council (NRC), and an additional $17 million should be made available by the Natural Sciences and Engineering Research Council (NSERC) to support the university-based research effort.

FUZZY AND SPIKY LEONIDS

The spectacular Leonid meteor displays of the past two years have enabled the collection of an impressive database of observations. Now, as the data are carefully sifted, researchers are beginning to find some oddities. Among the more exotic finds are the "fuzzy" and "spiky" Leonids reported by Andrew LeBlanc, formerly of Mount Allison University but now at Saint Mary's University in Halifax. Writing in the *Monthly Notices of the Royal Astronomical Society* for 21 March, 2000, LeBlanc and nine co-workers present a study of two most unusual Leonid meteors, both of which were captured on videotape during the 1998 shower. The first meteor is notable in that it shows light emission from a region extending over a perpendicular spread of a kilometre or so. The second meteor is remarkable for sporting an array of spikes, or jet-like features. The jets appear to range in size from several hundred metres to possibly several kilometres, and they persist for about 1/30th of a second.

Neither of the observed Leonid meteor features can be explained easily. The light emission from the fuzzy or extended-width Leonid is derived from an area some 50 to 100 times larger than that expected for a typical meteor. Visual observers have occasionally reported so-called nebulous-looking meteors in the past, but the images presented by LeBlanc and co-workers are the first to show clearly a large transverse displacement of meteoritic material. The jet-like features are unprecedented and have never been reported on before. Perhaps the simplest explanation for the extended or fuzzy Leonid is that a large, originally compact meteoroid separated into its constituent grains while in space and before it encountered the Earth. In that case the many fragments encountered the Earth's atmosphere as a form of grapeshot. As to whether the original meteoroid broke apart because of a collision with another object or through rotational bursting is unknown. The jet-like features are probably not the result of material or grain ejection and transport, but may possibly be associated with poorly understood (at present anyway) electrostatic and meteoroid charging effects.

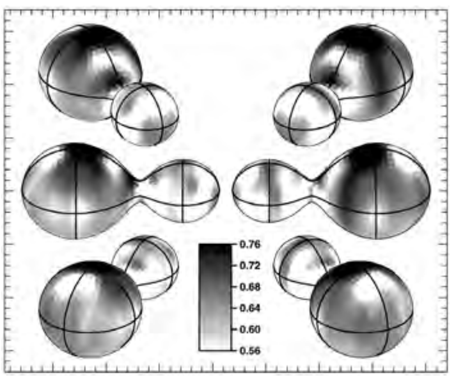
STARSPOTS ON VW CEPHEI

As the Sun approaches solar maximum, one cannot help but wonder if other stars have spots. A team of Canadian astronomers has addressed that question using an ingenious technique to create images of starspots on the bright contact eclipsing binary VW Cephei (RA $20^h\ 37^m.4$, Dec. $+75°36'$). Contact binaries are two stars that orbit so closely that they actually touch each other, and gravitational attraction distorts the pair into a bizarre dumbbell shape (see figure). Paul Hendry and Stefan Mochnacki of the David Dunlap Observatory (DDO) constructed the images by combining computer models with photometric and Doppler shift measurements of the two stars as they rotated around each other (March 1, 2000 issue of the *Astrophysical Journal*).

Doppler imaging techniques were first used to detect starspots in eclipsing binary stars by Vogt & Penrod (PASP, 95, 565, 1983). So-called "classical" techniques required the two stars to be detached and spherical. To tackle the thorny problem of contact binaries, Hendry and Mochnacki devised a technique in which the method of maximum entropy could be used to image such systems. Maximum entropy attempts to minimize extraneous information in an image, and is commonly used in Doppler imaging research.

It took 48 nights or partial nights of observing. The team used the David Dunlap Observatory's 0.5-m and 0.6-m telescopes to obtain photometric data. At the same time CCD spectrograms of the sodium D line were obtained with the DDO 1.88-m reflector. The photometric instruments recorded the changes in brightness as the two stars eclipsed each other. The spectrograph recorded the blue and red shift of the light of the two stars as they approached and receded from the Earth. The combined observational data were then used to set limits on the computer model, which ultimately produced the image. The spectrum and brightness of a more distant third companion star were included in the model in order to prevent contamination of the final image.

The images suggest that there may be large polar spots on both stars in the VW Cephei system (see figure). Such large, high-latitude starspots are still somewhat controversial. The results of Hendry and Mochnacki lend some much-needed credibility to their existence, however. The polar spot on the primary star may be 50° in diameter, while that on the secondary is about 30° across. The spots on the primary were seen to migrate around the star in the same direction as the orbital motion. Both stars had extremely high starspot coverage, 66% of the surface area of the primary and 55% of the secondary, making our star look rather dull by comparison.



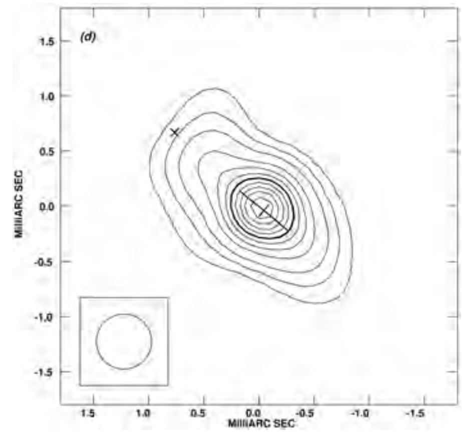
Doppler image of VW Cephei, March 1991. Gray-scale legend indicates fractional spot coverage. (Image courtesy of Paul D. Hendry, Stefan W. Mochnacki, and the *Astrophysical Journal*.)

THE NUCLEUS OF M81

Sometimes the best way to learn about our own galaxy is to look at another. Since the Earth is embedded within the Milky Way, the intervening gas has prevented astronomers from getting a clear radio view of its central source — Sgr A*. Fortunately, the nearby galaxy M81 resembles our own in type, size and mass. It also affords astronomers a clearer radio view of its core. At a distance of 3.63 Mpc (11.8 million light years) M81 is also the closest spiral galaxy with a central compact radio source and an Active Galactic Nucleus (AGN). An AGN is a central region of a galaxy that emits much more energy than what the stars alone could produce. The most reasonable explanation for this extraordinary behavior is the presence of a supermassive black hole.

Using Very Long Baseline Interferometry (VLBI) Michael Bietenholz and Norbert Bartel, both of York University, and Michael Rupen of the National Radio Astronomical Observatory (NRAO) have peered into the heart of M81 (April 1st, 2000 issue of *The Astrophysical Journal*). VLBI is a technique pioneered by Canadian radio astronomers that combines the signal from many distant radio telescopes to achieve an angular resolution equal to a single dish the diameter of the telescopes' separation. With radio telescopes in Spain, Germany, Italy, the U.S. and Canada (the Algonquin Radio Observatory) the combined aperture was close to the diameter of the Earth. At this aperture and at a frequency of 8.3 GHz, the instrument achieves a resolution of 0.57 mas (milliarcseconds or thousandths of an arcsecond), equivalent to a distance of 2000 AU at M81. Between 1993 and 1997 the team had 20 observing runs, each lasting 12 to 18 hours. Considering that each run needed the dedicated and simultaneous use of between 11 and 18 major radio telescopes it is easy to see how complex such a VLBI operation becomes.

The team of astronomers found what they believe to be a short, occasionally bent, one-sided jet directed towards the northeast (see figure). For the first time,



VLBI images of the core of M81. The boxed circle is the width of the radio 'beam' and represents the resolution of the instrument at 8.3 GHz.

changes were observed in the shape of the jet. Strangely, the jet's motion appeared to be rather slow — about 8 percent the speed of light (0.08*c*). However, on a number of occasions rapid flux changes over the entire area were observed. Since these changes were not accompanied by structural changes, the team determined the flow speed of the jet to be at least 0.25*c*. Bietenholz and his group surmise this may be caused by clumps of plasma ejected from the central black hole.

The size of the central source was estimated to be only 700 by 300 AU — about ten to twenty times the diameter of our Solar System. The actual core where the supposed supermassive black hole resides was found by comparing the changing VLBI images with the position of the radio supernova SN1993J in M81 (see figure). It is assumed that the supermassive black hole would be the stationary centre of the galaxy and all objects in the galaxy would orbit around it. From a careful analysis of all the images, the core was found to be about 0.6 mas to the southwest of the maximum brightness in the image. The team concluded that no more than 25% of the total radio intensity came from the core – the remainder was from the jet.

The legacy of this work is far reaching. The accurate astrometric position of the core establishes a useful stationary reference. This reference can be used to study the expansion rate of SN1993J by locating its explosive centre (Bartel *et al*, January 7th,

A 50 GHz VLA Radio map of SN1993J superimposed on an optical image of M81 taken from the *Hubble Atlas of Galaxies*. North is up and east is to the left (Both images courtesy of Michael Bietenholz and Norbert Bartel).

2000 issue of *Science*). It can also help determine the proper motion of the galaxy itself. So far, the proper motion of a galaxy has never been measured. The team estimates that within 20 years the core will have moved far enough for the first such measurement to be achieved. Finally, the core of M81 may represent a scaled-up version of the centre of the Milky Way; maybe telling us a little about the galaxy in which we live.

CFHT SPLITS ZETA CANCRI C

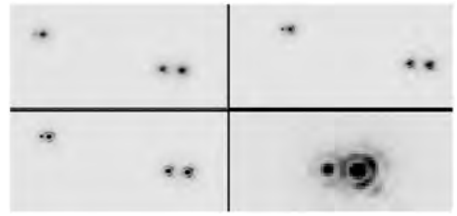
Many double star enthusiasts are familiar with the beautiful triple star ζ Cnc (RA $08^h\ 12^m.2$, Dec. +17° 39′). Also known as Tegmine, this system is comprised of a tight stellar pair: ζ Cnc A and B, and an apparently solitary outlier, ζ Cnc C. The visual magnitude of the close pair is 4.7 for ζ Cnc A, (spectral class F8), and 6.0 for the B star (G0). The A and B components are currently separated by about 0″.9, at a position angle of about 86°. This pair has a relatively short orbital period of 58.9 years. The more distant member is a 6.2-magnitude white star (F9), located 6″ to the northeast of the brighter pair. ζ Cnc C has an orbital period of approximately 1100 years.

This stellar trio has been studied for more than 200 years. For much of that time, a fourth member has been suspected to orbit closely around ζ Cnc C. In 1831, John Herschel reported slight irregularities in the star's proper motion. In 1874, Otto Wilhelm Struve used these observations to infer the existence of a fourth star taking about 20 years to orbit around ζ Cnc C. Recent spectroscopic observations by Roger Griffin of Cambridge University also support these early findings (February 2000 issue of *The Observatory*).

The existence of a fourth star seemed assured yet its properties were unknown. Griffin's observations suggested that it was comparable in mass to the C star, yet must be considerably fainter. To fit these assumptions, some speculated that the unseen star might be a white dwarf or an extremely close pair of faint red dwarfs. To find out, the star had to be observed separately from its companion.

A team of astronomers led by John Hutchings of the Herzberg Institute of Astrophysics in Victoria has now successfully split ζ Cnc C (June 2000 issue of the *Publications of the Astronomical Society of the Pacific*). The pair was an easy target for the adaptive optics (AO) system of the Canada-France-Hawaii Telescope. Using a tiny computer-controlled 'rubber' mirror, the AO system helps reduce the distorting effects of the turbulent atmosphere – essentially taking the twinkle out of the stars. Each near-infrared image clearly shows two stars separated by 0″.32 (see figure).

Hutchings, along with Roger Griffin and François Ménard (CFHT Corp.), coupled the adaptive optics system to the observatory's near-infrared camera (KIR). The experiment rode piggyback on other projects, taking advantage of gaps in their observing schedules due to twilight and clouds. Since the stars were bright, the total observing time was less than a minute. A series of observations using narrow-bandpass infrared filters showed that ζ Cnc D has an M2 class spectrum. Combined with its brightness and mass estimates, it seems almost certain that ζ Cnc D is actually a pair of red dwarfs. Yet further evidence will have to wait until it can be split or observed spectroscopically. According to Hutchings,



Near-Infrared images of ζ Cnc taken with the CFHT adaptive optics system coupled with the KIR camera. North is 2°.8 left of vertical and east to the left. ζ Cnc A and B are the left and right stars located in the lower right of the wider angle images. Top left image was taken with a *J* filter (1.2 μm), top right image with an Fe II continuum filter (1.7 μm), and lower left with a Br γ filter (2.2 μm). The lower right image is a close-up of the CD pair taken with the Fe II continuum filter. (Images courtesy of John Hutchings, Herzberg Institute of Astrophysics)

"Splitting ζ Cnc D is currently beyond any available instruments I know about, but it may well be possible with interferometers of the future."

UNUSUAL METEORITE FOUND IN SASKATCHEWAN

It sat in Melvin Christensen's farmyard gazebo for two decades. The strange, dense rock was just a local conversation piece until Andrew Bird rolled into Kyle, Saskatchewan on July 3rd. "The first thing that struck me was the perfect fusion crust and the dished surface typical of meteorites; however, this meteorite had a hole through it the size of a quarter," recalled Bird, a third-year geology student from the University of Calgary.

Bird is a member of the Prairie Meteorite Search project organized by the Meteorites and Impacts Advisory Committee of the Canadian Space Agency. Their goal is to educate prairie farmers on the identification of meteorites, and in the process, discover new specimens. Bird organized a "show and tell" at the Kyle museum where local farmers were asked to bring in their weird rocks and compare them to actual meteorites. Harvey Nininger, an American pioneer in the study and collection of meteorites, introduced this method to western Canada in 1931 when he found four new specimens.

Christensen found the seven-kilogram

specimen while cultivating his fields. "It was in the back of your mind that it just didn't look like a rock that should be here," Christensen says. Grain farms are a great source of meteorites since rocks must be removed from the fields in order to keep them from damaging farm machinery.

Alan Hildebrand of the University of Calgary and John Wacker of the Pacific Northwest Laboratory in Washington examined the meteorite and realized it was an unusual specimen. Its interior is a mixture of coarse fragments in a fine grain melted matrix. "This texture may represent a mixture of melt and broken fragments produced by a large impact on the meteorite's parent asteroid," says Hildebrand. "This odd-ball texture will make the meteorite an interesting study, and will provide one more clue about what the rest of our solar system is like."

For more information go to the Prairie Meteorite Search web page at `www.geo.ucalgary.ca/PMSearch/`.

Melvin Christensen and the Kyle meteorite.

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Observer's Report: The November 15, 1999 Transit of Mercury

by J. Randy Attwood, Toronto Centre (attwood@istar.ca)

Mercury is perhaps the most elusive of all the naked-eye planets. Because it is invariably veiled in twilight skies, you have to know exactly when and where to look for tiny Mercury. If only a few people can be said to have ever caught a glimpse of the "winged" planet, it is safe to say that even fewer have ever seen it in transit. Fleeting passages of Mercury across the disk of the Sun do not occur very often, but they can be seen at intervals ranging from three to thirteen years. Closing out the second millennium, the most recent transit of Mercury took place on November 15th, 1999. While it was a rare enough sight for Canadian observers, in Australia and New Zealand the event was an even rarer grazing transit. In the latter case only part of the mercurian disk is seen against the Sun's disk. The last grazing transit took place in 1937; the next is not due for another 600 years.

To see a mercurian transit, it has first to take place during your daytime. If you cannot see the Sun, then you cannot see the transit. In addition, to see the transit the weather has to be clear and you have to have the correct equipment to look safely at the Sun. While in transit, Mercury appears as a small black dot (in size some 1/150th of the Sun's diameter) slowly moving across the Sun's disk.

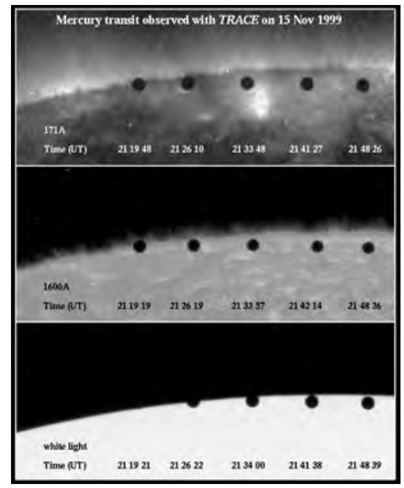
Transits of Mercury can take place only during the months of May and November when Mercury is at one or the other of its nodal points. Since the orbit of Mercury is tilted by seven degrees to the Earth's orbit, it crosses the Earth's orbital plane twice per orbit. The crossing points are called the nodes. For a transit to take place, Mercury must be at one of its nodal points and between the Earth and the Sun.

The predicted conditions for the transit were not particularly promising for Canadian observers. Not only was the transit taking place in November, it was not scheduled to start until 21^h UT. The Sun would have set for observers east of Ontario at the onset of the transit, and for observers to the west of Ontario the Sun would still be low in the afternoon sky. With such poor weather prospects and low Sun conditions, not many observers, myself included, had much hope of seeing the transit. The following is a sample of the experiences logged onto the RASC list after the transit. (The RASC list is a way for members to share their observations over the Internet. All members can join and are encouraged to send in their observing experiences.)

Like many observers who sent in their transit observations, Dan Taylor of the Windsor Centre had trouble simply seeing Mercury, and he comments:

"I followed the ingress event from the first scallop of the solar profile to final release to the Sun's disk. Very turbulent seeing made black drop sighting questionable. Mercury would erratically jump out onto the disk and alternately retreat to the edge in quick time fashion. During that time a flock of birds, then a jet airliner, successfully transited the solar disk!"

Frank Dempsey of Pickering, Ontario, along with his wife Jennifer, viewing from the Lake Ontario shoreline at Ajax, record that they were lucky to see the event at all:



The November 15th, 1999 transit of Mercury was the first to be observed from space. The Transition Region and Coronal Explorer (TRACE), a solar research spacecraft in Earth orbit, had a unique view of the transit as seen in this photograph. (Photograph reproduced by permission.)

"The sky was overcast all day until a few breaks in the clouds uncovered the Sun (with Mercury) during the last 15 minutes before sunset. Fragments of Mercury and the Sun were seen for several minutes at a time, and Mercury was cruising surprisingly quickly (relative to some sunspots) across the short path close to the limb."

Dave Clark of the London Centre caught just a short glimpse of the transit, and writes:

"The skies have been totally cloudy all day in London, but right on cue, small openings began to clear on the western horizon. At 4:15 p.m., I set up my Tasco 4.5-inch on the back deck with a Thousand

Oaks filter, and began incantations to the weather gods. At 4:27 p.m., one of the cloud openings drifted in front of Sun. I aligned the scope using the scope's shadow on the wall behind me, and there it was, Mercury prominently placed at the Sun's lower rim. Clouds still covered 4/5^{ths} of the Sun's disk, but the transit rim was absolutely clear. One sunspot group peeked briefly out of the cloud. I was able to observe Mercury for about one minute before the clouds drifted back in."

Mark Kaye of the Kingston Centre records that he too barely saw the transit:

"I set up a small reflector in hopes of the clouds parting. They did move out of the way, but the Sun was now flirting with tree branches in poor seeing. There were magnificent groups of spots, and one tiny little black dot that I almost saw on the limb on several occasions. I saw it, but only just."

Toronto Centre member Ron MacNaughton also had clouds to deal with:

"For a while a cloud perversely covered the top half of the Sun. We could see lots of sunspots, but no elusive planet. The clouds had very sharp edges through the solar filter. Several flocks and one airplane flew past the eyepiece. Then the top of the Sun became visible and we could see a tiny dot at the edge of the Sun's disk."

Geoff Gaherty of the Toronto Centre headed westward to view the transit and explains:

"As planned, I drove from Toronto to Goderich, where I determined that I would have the best western horizon within reasonable driving distance. All the way there, the Sun peeked in and out of the clouds. I got to the far-western end of Highway 8, overlooking Lake Huron, only three minutes before the transit was scheduled to begin (04:11 pm EST), but by then the Sun was behind a massive cloud bank. There did look like clear space underneath the main cloudbank, however, so I set up my 80-mm f/5 refractor with solar filter and waited. Finally, at 04:50 pm the Sun crept out from under the cloudbank, and I had a five-second glimpse of Mercury's tiny disk with the 6-mm Radian eyepiece (67×). Then it ducked into a lower cloudbank. By the time the Sun emerged, it was touching the water, and the disk was distorted in a mass of ripples. I watched it until it dropped below the horizon at 05:02. It was the first time I have ever watched the Sun set over a truly distant horizon with a telescope (45× at that point). There was no green flash. The final treat was the sunken Sun lighting up all the layers of clouds in spectacular colours."

Likewise, refusing to let the local viewing conditions ruin the day, Dave McCarter and Glen Spooner of the London Centre headed out of town to "find" the transit, and in the process were rewarded with a glorious sunset over Lake Erie:

"Monday afternoon was cloudy with snow and rain in London, yet the satellite image at 3:00 p.m. showed some clearing down near Windsor. I called Glen Spooner in Chatham, and he reported the clouds were thin with some breaks. Operating on the principle that you have to at least try to be in the right place at the right time, I drove to Chatham, and together Glen and I went to the Lake Erie shore. I set up my ETX, solar filter, and Nikon camera, while Glen set up his 6-inch f/4 travel scope, also equipped with a solar filter. The clouds parted much like I imagine the waters of the Red Sea did for Moses, and we were able to enjoy the first half of the transit.

"Mercury was not as big as most of the sunspots, which were impressive in their own right, but it was perfectly round and black. Sunspots are ragged, often gray, and surrounded with speckles. I made many photographs starting at first contact, and almost continuously until the Sun slid behind a low bank of cloud that encircled our location. We saw the Sun again as it emerged between low cloud and the waters of western Lake Erie.

"As the Sun approached the lake surface, a duplicate Sun image was created at the water's edge. Both images merged to make a gigantic red mushroom, which then sank slowly out of sight. We strained for a green flash, but instead were rewarded with a shimmering deep red horizontal band that hung above the horizon like a sprite. Totally beautiful!"

Disaster strikes as Franklin Loehde's (Edmonton Centre) solar filter is destroyed while setting up to catch a glimpse of the transit of Mercury.

Sid Lee in Calgary shared the transit with over 100 members of the public, and comments:

"It was pretty marginal, but those with sufficient patience got to see at least part of it. I opened up and got the [Science Centre] deck scopes aimed about 10:30 a.m. I enjoyed the many sunspots until lunch. I also had Venus in the C-8 for a while, but it disappeared behind the wall before the public began arriving. A very nice 'quarter' phase. About 13:00 the public was allowed in, and those who came early got to see the sunspots too. About 13:30 it started to cloud over, and by the start of the transit it was very poor indeed. We played hide and seek in the clouds through most of the transit, with the clouds occasionally lightening up enough to see Mercury."

To the north of Calgary, Franklin Loehde of Edmonton Centre had one of those observing experiences that we all live in dread of and hope are few and far between. He explains:

"In the days immediately prior to the rare occurrence, Edmonton, and indeed much of Alberta, experienced thick fog under an otherwise clear sky. As the 'moment of truth' approached, it became apparent that Edmonton would remain enveloped in the shroud of gray. After I checked the satellite photos on the internet, however, it seemed that a 'small window' of opportunity presented itself some 160 km south of Edmonton near Red Deer. With only two hours remaining before the transit, I quickly dismantled the telescope from my deck and headed south only to find the fog getting thicker and thicker! Undaunted, I sliced through one fog bank and another until, in the vicinity of Red Deer, I reached a rise that hid a bright shimmering slice of blue sky. Eureka! Pulling off a side road, I quickly, too quickly as it turned out, set up my telescope just as Mercury was creeping over the disk of the Sun. Wanting to photograph the event, I left the camera with adapter rings attached to the telescope to reduce 'set-up' time. Hah! To shorten the painful story, after I jostled the rig the camera detached from the formerly well-balanced telescope and the front end 'keeled over,' sending the glass filter hurtling to the roadway lip. It did not survive!"

And what of the next mercurian transit? Michael Watson offers the following information:

"The next transit will be on May 7th, 2003, between 05:14 UT and 10:33 UT. The transit across the northern half of the Sun will be mainly an Asian and European event, although the final stages of the transit will be visible from eastern Canada. From Toronto, for example, the Sun will rise at 10:03 UT, just 30 minutes before the end of the 5.3-hour transit.

"On November 8th, 2006, Mercury will transit the southern half of the Sun, in a more central event. The transit will last four hours and 58 minutes. All of Canada (except the far north) will see a part of the transit, although the Sun will set before the transit is even half over for eastern Canadian observers. The transit will just be ending at sunset as seen from Calgary.

"The next truly great Mercury transit for Canadians takes place on May 9th, 2016. It will be a seven hour, 31 minute event across the Sun's southern hemisphere. As seen from Halifax, the transit will start at 07:06, with the Sun 22 degrees up in the eastern sky. Further west, the Sun will be lower at the start of the event; from Winnipeg, the transit starts just at sunrise. From Winnipeg east, therefore, the entire transit will be visible; west of Winnipeg, the transit will be underway at sunrise, but even from Vancouver, almost six hours of the event will be visible."

Michael also points out that a rare transit of Venus will take place in just four year's time. The viewing conditions for that transit, however, will not, unfortunately, be particularly good for Canadian observers, and the event will be best viewed from Europe, the Middle East, and Asia.

As for me, I did not set up any equipment, and was surprised to see the clouds open for a few short minutes during the transit. There is a moral somewhere in that experience.

J. Randy Attwood has been a member of the Royal Astronomical Society of Canada since 1971. His interests include astrophotography, solar eclipse chasing, and public education. He is currently co-writing a book on the Apollo Lunar Module intended for publication sometime in the near future. Over the past two years most of his spare time has been consumed by his duties as National President of the RASC.

The Observing Logbook

(this article first appeared in Scope*, the newsletter of the Toronto Centre)*

By Paul Markov, Toronto Centre (pmarkov@ica.net)

Unlike astrophotography and CCD imaging, visual observing produces no tangible results that can be shown to other amateurs. All that you see, observe, and enjoy will only be retained in your mind as a memory, unless you take the next logical step and record your observations with pen and paper.

> **"The best way to record what you see through your telescope is to write your observations in an observing logbook. If you do not record your observations on paper, you will never be able to recall everything that you have observed…"**

The best way to record what you see through your telescope is to write your observations in an observing logbook. If you do not record your observations on paper, you will never be able to recall everything that you have observed, especially as time goes by and as you view more and more objects. An observing logbook can be used for recalling the details of previous observations, and for comparing past observations with current ones. Also, having to write something about an object forces you to look for more details, thus sharpening your observing skills. Lastly, a logbook will help you to keep your observing organized and methodical. If you are planning to apply for the RASC's Messier Certificate, Finest NGC Certificate, or the Astronomical League's Herschel 400 Club Certificate, then you should definitely keep a logbook of your observations.

By maintaining your own observing logbook, not only will you be able to share observations with other amateurs, but you will also have something to show for after many years of observing. Simply keeping a list of objects with tick marks next to the observed ones surely does not make for a useful logbook. Instead, think of your logbook as an "observing diary," where you enter dates, times, object descriptions, observing conditions, names of people that observed with you, and special circumstances. Your logbook should be as scientifically relevant as possible, but should also be used to bring back memories from past observing sessions; it should be something that you can read for enjoyment as well as for reference.

I have been observing since the fall of 1982 and every observing session is recorded in my logbook. Each session describes the observing location, who was observing with me (if I had company), what I saw, and what each object looked like. Now I can go back to my logbook and in an instant I can recall all my observing sessions and read about what I viewed. For example, here is my very first deep sky observation: October 4th, 1982, my backyard in Toronto, full moon, 4.25-inch reflector at 15× the Andromeda Galaxy (M31) – "faint glow, oval shape, disappointing." This type of "observation" is typical of a beginning amateur observer, especially because I was observing with a small telescope, from the city, with a full moon, and even though I was looking at the Andromeda Galaxy, I was still disappointed with the view. As you can imagine I was expecting to see something similar to the many pictures I had seen in astronomy books and magazines! To me this logbook entry is a prized possession as it reminds me of my "first steps" in this great hobby.

Format

The format of a logbook is a personal preference. As long as the relevant information is included, you can use any format you want for a logbook. Try to experiment with the various methods and formats suggested below, make your own improvements, then choose the one you like best and the one that is most suited to your observing style. Chances are that over time you will make changes to the format of your logbook, but try to adhere to a similar layout in order to make the logbook more consistent over the years.

The first choice you have to make is whether you want to maintain a chronological or sectional logbook. In a chronological logbook all observations are entered sequentially by date. In a sectional logbook observations are entered according to their type. For example, all globular cluster observations go in one section and all galaxy observations go into another section. My choice is that of a chronological logbook as I am interested in the whole of an observing session.

Next you have to decide what kind of "book" you want to use to record your observations. Typical choices are a simple three-ring binder with standard 8.5 × 11-inch lined paper, spiral bound notebooks, or the more expensive hardcover record/accounting books. The most aesthetically pleasing is the hardcover book, but the most practical is the simpler three-ring binder. Using the latter allows you to add all sorts of materials to your logbook with the help of a three-hole punch, and entering observations out of sequence is never an issue because you can easily rearrange the sheets. Also, should you wish to make a copy of your logbook for safekeeping, it's much easier with the loose sheets. Initially I started using a hardcover book, but once that was filled I moved to a three-ring binder with lined paper and found it much more practical.

Now you have to decide how to actually record each observation. You can adopt the use of a preprinted observing form, either of your own design or as found in some observing books, or from the Internet (such as the one found at `http://www.davidpaulgreen.com/TUMOL.html`). There are several benefits of the preprinted forms: the "fill in the blank" fields remind you to record the relevant data, they give your book a neat and organized look, they typically encourage observers to make a sketch of the object in the space provided, and they make your book easy to read. You will only be able to use preprinted forms if you choose a three-ring binder as your "book."

Alternatively, you can use plain lined paper. The benefits of plain paper are also several: you never have to worry about running out of forms, you record only the required details thus using less paper, you are not restricted to any preset format, and you will not need different forms for different types of objects (*e.g.*, deep sky, planetary, and so on).

"Describing the objects you see in detail will make your observations much more relevant and rewarding."

Personally, I do not like preprinted logbook forms because many of the blank fields to be filled out are repetitive and do not need to be recorded more than once per observing session. For example, the observer's name, date, observing site, and telescope typically do not need to be recorded each time you observe an object. Also, many of these forms have a round circle drawn, to represent a field of view, where you can make a sketch of the object viewed, but I doubt many of us will sketch every observed object. Lastly, the use of preprinted forms is not very efficient as most forms allow you to record only one object per sheet.

Recording Observations

In the past I have seen only a few suggestions on how to keep a logbook. Some of these propose the use of some unbelievably cryptic code to record observations, in essence transforming your logbook into a book full of acronyms and abbreviations, for which you will need a secret decoder ring each time you want to read an observation.

My approach is completely the opposite. I use plain English to make entries in my logbook, such that anyone will be able to read my observations. Of course, you should use abbreviations and acronyms where there is lots of repetition or where these are well-known short forms, such as "mag." for magnitude or "OC" for open cluster. You can enter as much or as little data as you want in your logbook, but just make sure you enter enough to make it worthwhile. Here is the information I include in my logbook for each observing session: date, location, time of arrival and departure (if I have traveled somewhere to observe), names of other people at the observing site, a couple of sentences describing the environmental conditions, such as temperature, dew, wind, sources of light pollution, snow cover, mosquitoes, and sky conditions such as transparency and seeing. You can also number each observing session sequentially as this is helpful for referring to other observing sessions within your logbook. You should also note if the Moon is in the sky and its phase, although if you are a deep sky observer, you really should not be observing when the Moon is in the sky!

To simplify your logbook and to make it consistent, you should standardize on a format for recording the time and date right from the start. For the time, choose either military time or the AM/PM format. If you are accustomed to it, use military time, otherwise using AM/PM should be fine because even if you forget the AM/PM designation, it is impossible to confuse a deep sky observation made at 2 AM for 2 PM. For recording observations of static targets, such as deep sky objects, I suggest the use of local time, not Universal Time (UT). UT is more useful for timing dynamic events, such as occultations or eclipses, or for meteor shower counts. Lastly, do not forget to record whether the time is Daylight Savings Time or Standard Time. To avoid confusion when recording the date, I prefer using alpha characters to specify the month rather than numeric characters. My suggestion, for example, would be to use August 5th, 2000, instead of 8/5/2000. This format ensures that anyone reading your logbook, including yourself, will have no trouble reading the date.

For each object I observe, I record the following information, keeping in mind that I am a deep sky observer: time of observation, object designation (*e.g.*, M, NGC, IC), type (*e.g.*, OC, G, PN), constellation, magnification used, type of filter (if any), and visual description. The visual description is typically where some amateurs like to use acronyms and abbreviations, but I prefer using full sentences. The drawback to that method is that it will take a little longer to write your observations while you are at the eyepiece, so you will need a comfortable setup for writing. Alternatively, you can use acronyms and abbreviations while in the field, but make sure to rewrite these as full sentences in your final logbook if you want to make your logbook easy to read.

Additional entries should be made if an aurora appears, if you see impressive meteors, if the sky conditions change, and so on. You can also draw the objects you observe; even a quick, simple sketch is better than none and adds a lot to your logbook. If you are artistically inclined you can try detailed drawings using a variety of pencils and papers to add reality to your sketches.

Describing Deep Sky Objects

Describing the objects you see in detail will make your observations much more relevant and rewarding. Below are some basic suggestions on what to look for in each of the main deep sky object categories.

Open Cluster: What is its shape? Is there more star concentration in a specific part of the cluster? Is it fully resolved into its component stars, or are there any unresolved stars causing the cluster to appear nebulous? How many stars can you see (only if it is reasonable to count them)? Are there any bright stars within the cluster? What is your estimated size of the cluster (based on the field of view of your particular eyepiece)?

Globular Cluster: What is the degree of the cluster star concentration (high, medium, low)? How much of it can be resolved into its component stars (none, outer edges, middle, down to the core)? What is your estimated size of the cluster (based on the field of view of your particular eyepiece)?

Galaxy: What is the shape of the galaxy? Does it have a bright nucleus? Is the galaxy uniform in brightness? It is diffuse or stellar? Can any details or mottling be seen? Can it be seen with direct vision or is averted vision required?

Emission or Reflection Nebula: What is the shape of the nebula? Is its brightness even or are there brighter/darker areas? Are the edges of the nebula well defined? Are there any stars within the nebula?

Planetary Nebula: What is the shape of the nebula? Can you see any colour? Is it stellar in appearance or can a disk be seen? Are the edges well defined or diffuse? Are there any brighter/darker areas? Can a central star be seen?

If you are well beyond the Messier Catalogue and well into the New General Catalogue you will soon reach a point where most objects you view are at the limit of your telescope's ability to gather light, and just about every deep sky object will look like a "very faint fuzz with little detail." When you reach this point you may think recording your observations is pointless due to the lack of detail, however, as your observing skills improve, you will be able to write something about even the faintest object.

Hard or Soft Copy

With the advent of computers and deep sky databases many years ago, it became possible to use a computer to record, log, and track your observations. I have partially adopted the use of a computer database to track my observations; however, my paper logbook is still my main tool.

The primary reason I still use a paper logbook is that when I am at the eyepiece, it is much easier to write what I see on paper, rather than type it into a computer. Besides, you can only draw a deep sky object on paper! If you are really keen on maintaining your observations in "soft" format, you can transcribe your paper observations into your database, however, that takes additional time which most of us do not have. So, what I write on paper at the eyepiece remains on paper and becomes part of my permanent logbook. This also lessens the chances of transcription errors.

Several years ago I started using a computer database to track deep sky objects I have observed. I use the Saguaro Astronomy Club database (it can be downloaded for free at `www.saguaroastro.org`) and I simply added four fields to it: Seen (Y/N), Date, Telescope, and Location. Now in a matter of seconds I can find out which objects I have observed, and if I need to read my own observations for an object, the "Date" field directs me to the correct page on my paper logbook. My database is also extremely useful for generating up-to-date observing lists in a matter of minutes. You can also determine interesting facts, albeit trivial, such as at which observing location you observed the most objects, which telescope produced the most observations, or the magnitude of the faintest object you have ever seen.

Recently I have taken my logbook a step further: it is now available for everyone to see on-line at `http://home.ica.net/~pmarkov/astro.htm`. This huge effort (18 years of observations) is certainly mostly for my benefit as I doubt too many people will be interested in reading my logbook. The purpose of recreating my logbook in HTML format is to gain the ability to combine text with actual photos, thus giving it the look and feel of a magazine layout. I can then print the on-line logbook on a colour printer and have a beautiful and useful logbook complete with pictures. The other useful aspect of the on-line logbook is that my astronomy friends and acquaintances will be able to read and see what I have been up to on a regular basis. My on-line logbook lists only some of the observing details mentioned earlier. I chose to list only the objects' designation numbers for each session, rather than

> **"My logbook now spans over 18 years. By leafing through it I can see how my observing skills have improved over the years, I can read how the same objects appeared through the different telescopes I have owned..."**

include the detailed observations for each object. It would have taken me much too long to enter observations for each of the nearly 800 deep sky objects I have seen, and also it would have made for pretty "dry" reading material. Instead, I chose to include only details on the observing site, other observers at the site, and any special circumstances (aurora, meteors, unusual observations), as well as adding some relevant photographs. Take a look at it as I think you will enjoy it and may like the concept.

Remember that visual observations are quite abstract, so if you decide to maintain your logbook primarily in soft format, make sure to print out a paper version so as to make your efforts as tangible as possible, and remember to backup your data files often!

Long Term Benefits

My logbook now spans over 18 years. By leafing through it I can see how my observing skills have improved over the years, I can read how the same objects appeared through the different telescopes I have owned, and I can see how various observing sites have become increasingly light polluted. In the next few decades I may notice how my observing acuity will diminish as my eyesight deteriorates with age, and hopefully I will be able to include my son, now just two years old, in my logbook as one of my observing buddies.

I strongly urge you to start, or to continue updating, your own observing logbook. For visual observers it is the only way to show others, and remind yourself, what this hobby is all about.

Paul Markov is a program manager with ATI Technologies Inc., a computer graphics card manufacturer. He joined the Toronto Centre in 1982 at age 15 and immediately became interested in deep sky observing. Paul would like to hear from you at pmarkov@ica.net if you have your own tips and hints on maintaining a logbook.

RASC INTERNET RESOURCES

Visit the RASC Website
`www.rasc.ca`

Contact the National Office
`rasc@rasc.ca`

Join the RASC's E-mail Discussion List
The RASCals is a forum for discussion among members of the RASC. The forum encourages communication among members across the country and beyond. It began in November 1995 and currently has about 265 members.

To join the list, send an e-mail to listserv@ap.stmarys.ca with the words "subscribe rascals Your Name (Your Centre)" as the first line of the message. For further information see: `www.rasc.ca/computer/rasclist.htm`

GA 2000

A collection of images from the 2000 General Assembly in Winnipeg, Manitoba

The General Assembly group photo

New society President Robert Garrison, right, presents a plaque of thanks to retiring president Randy Attwood (Photo by Michael Watson).

GA 2000

Winnipeg, Manitoba

President Randy Attwood, left, presents a plaque of appreciation to David Turner. David recently retired as editor of the *Journal* after 6+ years of service (Photo by Robert May).

President Randy Attwood presents a plaque of appreciation to Roy Bishop. Roy recently retired as editor of the Observer's Handbook after 19 years of service (Photo by Michael Watson).

Executive Secretary Bonnie Bird with her husband and unattached member Andreas Gada (Photo by Michael Watson).

Featured speaker Steve Edberg (NASA/JPL), left, with Stan Runge of the Winnipeg Centre (Photo by Michael Watson).

General Assembly organizing committee chair Jay Anderson with President Randy Attwood at the banquet (Photo by Robert May).

Past President Doug George and his wife Mercedes Pelayo, both of the Ottawa Centre, at the banquet (Photo by Michael Watson).

Those present at the first National Council meeting (Photo by Michael Watson).

Bonnie Bird (Executive Secretary) and Roy Bishop (appointed scrutineer) count ballots for the election of 2nd Vice-president (Photo by Michael Watson)

The General Assembly organizing committee is congratulated for a job well done at the banquet (Photo by Robert May).

GA 2000

Winnipeg, Manitoba

Several members enjoy some after-dinner wine and conversation at the banquet.

Betty and Mel Rankin of the Edmonton Centre enjoy an outdoor barbecue meal (Photo by Michael Watson).

A group of members, mostly from the London Centre, enjoy some relaxation during the often busy schedule of a General Assembly (Photo by Michael Watson).

The *Truth* about Astroimaging

by Wil Milan (wmilan@airdigital.com)

Imaging of celestial sources using telescopes equipped with charge-coupled devices (CCDs) has become very popular in recent years. Most people who become involved with CCD astroimaging are motivated by the awesome images they have seen in magazines. What most do not realize, however, is what is required to obtain such images. From my own experiences, I can mention some of the disadvantages of using CCD cameras in preference to photographic emulsions.

> **"Perhaps (novices) do not realize that the production of top-quality (CCD) images requires a lot more effort than is evident from the basic exposure details."**

1. You inevitably end up with wires running all over your telescope and mount, and will need an extra ten or fifteen minutes each for setting up your equipment and shutting it down later. That is how long it takes get all of the electrical stuff set up and plugged together.

2. Cable management will become a significant part of your telescope set-up and operation.

3. Some of the larger CCD cameras require AC (alternating current) power in the field, so you should plan to take along a 300-watt AC inverter and a battery large enough to power it when you are in the field.

4. Some CCD cameras cannot be powered from the same DC supply as your computer because of ground-loop problems, so you will probably need to have separate batteries or power supplies for both. If you power everything from AC, which is what I do, that is usually not a problem. But in that case you need to take along a multi-outlet extension cord as well.

5. For the best results from a CCD camera, you need to take not only image frames but also dark frames, flat fields, and possibly bias frames, and not just one but at least three of each.

6. If you want to image in colour, you will need to take at least three separate images through the appropriate filters (for RGB) and perhaps four separate images.

7. Unlike the situation that applies with film, where you do not need to know much about how photographic emulsions work, with CCDs you need to learn a significant amount about things like quantum efficiency, well depth, differential spectral response, dark current, the difference between mean and median averaging, deconvolution, and other things that film photographers can safely ignore.

8. A laptop computer is an essential accessory, but less obvious is the fact that it also needs lots of free disk space. For my SBIG ST8E CCD camera, each finished colour image is the end result of perhaps 50 to 70 megabytes of original data frames, another 20 to 50 megabytes of calibration frames, and perhaps another 100 megabytes of intermediate processing frames. On a two-night imaging outing, I can easily consume a gigabyte of disk space by the time the processing is completed for three or four final images. While disk space is very inexpensive at the moment and, yes, film processing can also consume a lot of disk space, most beginning imagers do not realize that the best images obtained with large cameras can consume disk space at half a gigabyte per night. A CD burner is almost a necessity.

9. The software that comes with a camera (any camera) is fine for getting started, but for more advanced imaging (automated multi-frame RGB imaging, for instance), an after-market software package such as Maxim or Mira is also a necessity. For that add another $300 to $500 to your expenses.

10. Travelling with a computer, AC inverter, and a fragile but expensive CCD camera

requires the use of durable cases. You also need a place to set up the equipment in the field (an ST4 can operate lying on the ground, but you do not want to do that with a computer). It is necessary to consider the details of operating an "office in the field," in particular how to set up and operate everything in a way that is both convenient and also does not risk damage to the equipment.

11. For a good "field office" a comfortable chair is essential since you will be spending a lot of time in it. A metal chair tends to be rather cold, while a plastic chair creates static electricity, which can damage the camera and/or the computer. With a plastic chair, I have learned to ground myself to the telescope pier each time I stand up or sit down. On dark, dry nights it is rather entertaining to see how large a spark I can generate (okay, so there is a bit of boredom involved as well).

I could continue, but by now you should have a better idea of what is involved. I suspect that one of the leading causes of novice burnout is that people do not know what is involved with proper CCD imaging. Perhaps they do not realize that the production of top-quality images requires a lot more effort than is evident from the basic exposure details.

Neither is film photography exempt from such criticism. When film devotees tout the ease of film photography, there are several factors that they typically do not mention.

1. Most top-grade film photographers waste a significant portion of their sky time testing new films to replace the last stock of good film that was either discontinued or "improved" into uselessness. While many novices think that the trick is to find a good film and stick with it, they do not realize that manufacturers will not allow you to do that. It is amazing how much of the discussion on the Astro Photo Mailing List is about what film is being discontinued and what might be the next good film.

"It is rather ironic because, as John Gleason pointed out, film and CCD imaging are far more alike than different. In fact, 70% to 80% of it is exactly the same — telescope mounts, optics, alignment, guiding, *etc*."

2. The few good films that everyone talks about are often available only in specialty stores. Only after visiting fourteen different stores in your city will you discover that the film you want is not available where you live.

3. It is possible to order film by mail, but in the summer if you live somewhere hot you soon discover that mail order at that time of year is often a waste of time and dollars. Film should be refrigerated or at least kept cool to preserve its sensitivity, but in the summer that film will be in a courier truck at 65° C for several hours. Buy your film in the winter and keep it in your freezer.

4. To obtain the best results from film images, you need a film scanner. Once you have purchased your first scanner, you will then discover that you need a higher quality scanner. If you do most of your astrophotography with medium format, you will discover that the scanner you need costs more than your telescope gear, and perhaps more than your car.

5. If you cannot afford the proper scanner, you will probably spend a significant amount of money having Kodak PhotoCD scans made of your images. You will then discover that PhotoCD scans of astroimages are not usually very good. By then you may end up sending the images to a specialty house, such as Tony Hallas (which does a great job but charges US$10 per frame). The expense is reasonable for the work done, but the total cost per roll of 15 photos or so (typical for a weekend of 35-mm shooting) now approaches US$200 per outing. The cost to have Tony Hallas create stacks and inter-negatives for your best shots is probably US$300 or more for the processing cost of that weekend, which does not include prints.

6. You may discover that many places that do fine film processing for everyone else will botch the work for your astrophotos because they do not know what to do with them. They may cut frames in half, touch up "dust spots"

(which were stars — I had that happen once), or allow their processor rollers to put very fine scratches on your film (typically insignificant for daylight images, but can ruin astrophotos). That means that you need to find a top-grade pro lab with dip tanks, and such a lab may not exist where you live. You may have no choice but to return to mail order deliveries in 65° C courier trucks.

7. For many films you will learn the joys of film hypering, and also that what works for one person does not necessarily work for another. Inevitably that requires that you experiment to learn what works for you, *i.e.* wasting valuable sky time to find out if your hypering works as you thought.

8. Another hard-taught lesson is that your camera viewfinder does not actually work for focusing astrophotos. Inevitably that will lead you to purchase another camera with an expensive add-on focuser; either that or learn to use an arcane process such as knife-edge testing or Ronchi focusing.

9. With film you are likely to learn about film curl, dry nitrogen purge, static discharge on dry cold nights, frozen batteries, and the need for external batteries in some cameras.

10. Inevitably you discover drift alignment, which many CCD imagers can safely ignore, but which film imagers must do every time they set up in the field. That amounts to more sky time lost to non-photography.

11. You may learn that many telescopes that focus properly for a CCD array cannot properly focus or image over the full extent of a 35-mm frame, much less a 6 × 7 frame. Such problems result in brightness gradients and vignetting, which in turn means many hours spent at the computer trying to restore an image that the telescope could not deliver.

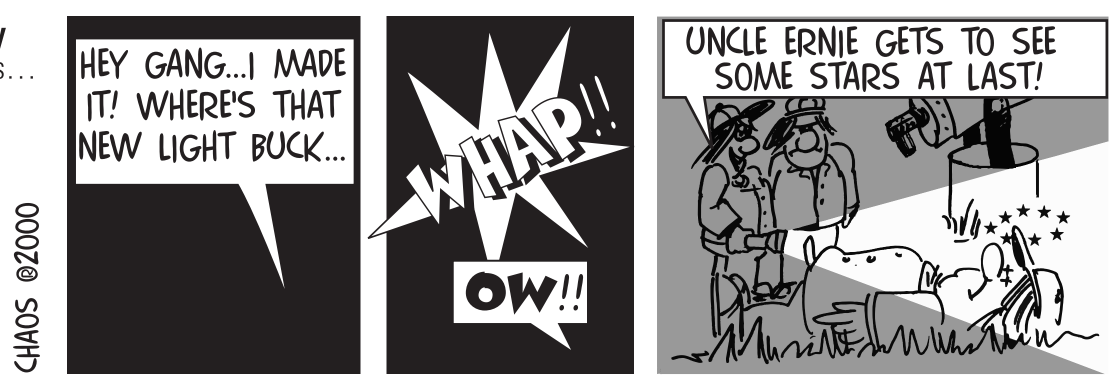
12. If you use a Schmidt-Cassegrain telescope (SCT), you will find that no one manufactures a good focal reducer to cover even a 35-mm frame. You may also discover that the focus of an SCT drifts rapidly with changes in temperature. That means that no matter how carefully you focus the telescope at the beginning of an exposure, if the exposure is long enough for the ambient temperature to change by even one or two degrees, most SCTs will be out of focus at the end of the exposure, resulting in less than optimum resolution. As well, you will learn there is no way to overcome the problem except to wait for the temperature to stabilize. In most places that means not starting exposures until after midnight — more lost sky time.

I could continue outlining additional problems in this area as well, but it should be clear that both types of imaging — CCD imaging and photography — have their drawbacks. Devotees of one medium recall in horror the difficulties of the other, overlooking all of the things they have come to take for granted for their own medium. That leads to a lot of misunderstanding between the two groups and even to what sometimes seems to be animosity. I find that to be unfortunate, because I think the two camps could learn a lot from each other if only there were more open dialogue between them. It is rather ironic because, as John Gleason pointed out, film and CCD imaging are far more alike than different. In fact, 70% to 80% of it is exactly the same — telescope mounts, optics, alignment, guiding, *etc.*

In conclusion, perhaps CCD imagers, when they tout their form of photography, should be more open about all of the difficulties involved in obtaining those great images. Perhaps film imagers should be equally open about their own complications and the difficulties they encounter when they tout the advantages of film over CCD. If nothing else, that would make it easier for others (particularly novices) to decide when to use one medium over the other.

Wil Milan is a professional photographer by day in Phoenix, Arizona, and a well-known astrophotographer by night. For those with internet access, Wil's excellent Web site can be found at: www.astrophotographer.com.

Another side of Relativity
Ernie finally sees some stars…



Gravity without Forces

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

I have been thinking a lot about gravity lately, partly because readers of a local Halifax paper have posed several gravity-related questions to the weekly science Q&A column called *ScienceQuest*. For about a year, I have been trying to answer some of the astronomy questions in simple language that a non-scientist could understand. This has turned out to be quite a challenge, especially when the subjects of relativity and black holes (a favorite of questioners) crop up. Gravity continues to perplex and confound scientists and non-scientists alike. The following essay was born when I made a casual remark to the *ScienceQuest* editor that one could treat classical motion under gravity without introducing forces. Judging by his surprise, and taking into consideration that he is a physicist himself, I began to wonder how many of us share this particular insight. My first exposure to this way of thinking occurred during my salad days at the University of British Columbia, studying under my graduate supervisor Professor Fred Kaempffer of the Department of Physics.

Prof. Kaempffer was a unique man and a natural teacher from whom I learned many things in my two-year stay at UBC. Above all, I admired his *style* in solving physics problems. He wrote a book entitled *The Elements of Physics*[1], intended for non-science undergraduates. One chapter of that book presents a classical physics (*i.e.* non-relativistic) treatment of motion under the influence of gravity and avoids the term "force" throughout. One might think this feat to be somewhat contrived, but I believe the good professor was simply trying to convey some sense of the modern view of gravity without cluttering the mind with non-Euclidean metrics, energy-momentum four-vectors, and such.

I did not think much more about forceless gravity until a new question came my way: "What causes gravity?" I did not feel up to answering this "deep" question, and tactically directed the editor to the best local mind on this subject that I knew of: the RASC's own Professor (retired) Roy Bishop of Acadia University and Editor (retired) of *The Observer's Handbook* (among other things). I was correct in thinking that Roy had some free time during his first *Handbook*-free summer in 20-odd years, and he readily agreed to tackle the question. His answer turned out to be a nice précis of his essay Orbital Motion that appeared for the first time in this year's *Handbook* (pages 22–23). Moreover, I was delighted to read the following words:

...no one has ever felt a "force" of gravity. It never did exist.

Finally, a fellow traveller!

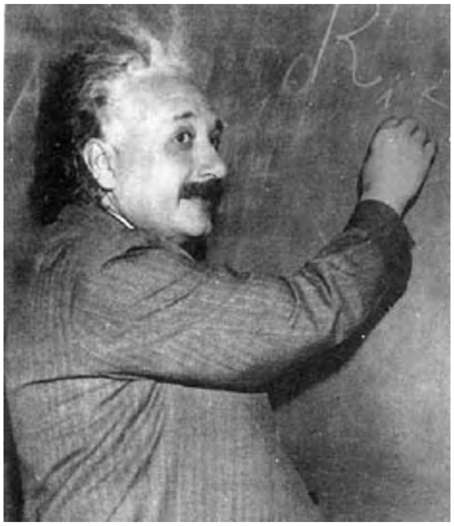
In what follows, I would like to explore this concept a little more from a strictly classical viewpoint. I must emphasize that I am not proposing anything new, nor cooking up some crackpot theory of gravitation to replace Newton and Einstein—nothing like that. I will simply take Newton's Second Law of Motion and his Universal Law of Gravitation and shake them down a little. However, I can think of no better way to start than by quoting (with permission) Roy's answer[2] to the question, "What causes gravity?"

> When not supported, apples, baseballs, and people fall. We label this phenomenon "gravity." What causes gravity? What causes unsupported objects to fall?
>
> In 1687 Isaac Newton proposed that all bodies attract one another with a force that depends upon both the masses of the bodies and the distance between them. According to Newton, an apple falls to the ground because the apple and the Earth attract each other with a gravitational force. With this idea Newton was able to explain the fall of an apple and the motions of the tides and planets and stars in terms of a single concept: a force of gravity.
>
> Despite the success of Newton's theory of gravity, eventually astronomers noticed that the motion of the fastest planet, Mercury, departs slightly, but measurably, from its predicted path. In 1915 Albert Einstein presented a new description of gravity which agreed with Mercury's motion. In science, a theory that disagrees with nature is wrong. A theory that agrees with nature might be right.
>
> A slight discrepancy in Mercury's motion may seem of no great consequence, but the description of gravity that Einstein presented,

Sir Isaac Newton (1642–1727). Gravitation is acceleration.

[1] F.A. Kaempffer, The Elements of Physics, A New Approach (Blaisdell Publishing Company, Waltham, Massachusetts, 1967).

[2] Roy Bishop, "What Causes Gravity?" The Halifax Chronicle-Herald, 2000 May 27.



Albert Einstein (1879–1955). Gravitation is geometry.

the General Theory of Relativity, is radically different from Newton's attractive force of gravity. According to Einstein, mass and energy curve the structure of space-time, and "falling" bodies follow the straightest possible, force-free paths through this warped space-time. In other words, gravity is not the attractive force invented by Newton. Gravity is the geometry of space-time, a dynamic geometry that is shaped by the mass and energy of matter.

This is why no one has ever felt a "force" of gravity. It never did exist. When you release a coin from your hand you see the coin "fall" because the force of the floor on your feet (the only force you feel) accelerates you the other way. An orbiting astronaut is not pushed by a floor, so he remains beside a released coin. Falling apples, golf balls, astronauts, the Moon, the planets, the stars and the galaxies drift silently along force-free paths in a curved space-time.

What causes gravity? Mass and energy cause gravity by shaping the geometry of space-time.

Whether this will be the final word concerning gravity is unknown. Someday Einstein's theory, like Newton's, may be found to disagree with nature. If this happens, we can only hope that someone will have sufficient insight to devise a more accurate description of gravity. Science advances by providing better and better descriptions of the physical world.

While I like Roy's answer, I think a case could be made that Einstein's approach to gravity has more in common with Newton's than Roy suggests. In particular, it is easy to show that classical gravity is also force-free, in effect, as my professor taught.

The mathematical kernel of Newtonian dynamics is Newton's Second Law of Motion, which says that the force required to accelerate an object is equal to the object's mass times the object's acceleration, that is,

$$\boldsymbol{F} = m\boldsymbol{a}\,. \qquad (1)$$

(Both force and acceleration[3] are vectors, which means they have both magnitude and direction; this is indicated by **boldface** type. In Equation (1), the direction of the force and the acceleration are the same.)

In Equation (1) the sense of m is "resistance to acceleration" or "inertia". This is more easily appreciated by re-arranging Equation (1) to read

$$\boldsymbol{a} = \boldsymbol{F} / m\,, \qquad (2)$$

which in plain English means "when a force is applied to an object, the resulting acceleration is equal to the force divided by the object's mass." For a given force, the larger the mass, the smaller the acceleration.

Once Newton established that forces cause accelerated motion, he was compelled to invent a gravitational force to explain the accelerated motion of one body under the gravitational influence of another. Newton's Universal[4] Law of Gravitation, found in almost all undergraduate physics textbooks on classical physics, is the well-known expression

$$\boldsymbol{F} = -\frac{GMm}{r^2}\hat{\boldsymbol{r}}\,, \qquad (3)$$

in which F is the force of M on m, is the distance between the centres of mass, G is a universal constant, and $\hat{\boldsymbol{r}}$ is just a unit vector pointing from M to m. The minus sign simply ensures that the force is attractive, given the definition of $\hat{\boldsymbol{r}}$. This force law is symmetrical, in that m impresses an equal force on M in the opposite direction.

Personally, I have never liked the symmetry of Newtonian gravitation, although generally I enjoy symmetry in Nature. I still do not feel comfortable with the idea that a speck of dust pulls on the Earth with the same force that the Earth pulls on a speck of dust. I know this is irrational, but read on....

In Equation (3), the sense of M and m is different from the sense of m in Equation (1). In Equation (3), mass is the source of gravity, not resistance to acceleration. However, Newton made the inspired assumption that gravitational mass and inertial mass are *identical*. Later, the Hungarian scientist Eötvös (1848–1919) and the American scientist Dicke (1916–1997) conducted experiments that proved this assumption to be true to a very high degree of accuracy, and Einstein made this Principle of Equivalence part of the foundation of the General Theory of Relativity.

Finally, we get to the last equation of this essay. The acceleration of the mass m due to the gravitational pull of mass M is obtained simply by substituting Equation (3) into Equation (2). Because inertial and gravitational mass are identical,

[3] Acceleration is the rate of change of velocity (a vector) with time, which in turn is the rate of change of position (also a vector) with time. Because acceleration and velocity are vectors, they can change in several ways: the magnitude can change, the direction can change, or both can change. When an apple drops from a tree, the velocity of the apple increases without changing direction; when a planet is in free-fall acceleration around a star in a perfectly circular orbit, the speed does not change, but the direction of velocity is constantly moving along with the changing direction of motion.

[4] "Universal" because it applies to all pairs of objects in the universe.

the m factors exactly cancel, leaving

$$\boldsymbol{a} = -\frac{GM}{r^2}\hat{\boldsymbol{r}}\,. \qquad (4)$$

After all this, the resulting gravitational effect of mass M is to accelerate objects towards itself by an amount proportional to its own mass and inversely proportional to the square of distance to the object. Nothing more, nothing less. What could be simpler? There are no forces explicitly involved, and the mass of the attracted object is totally irrelevant. A speck of dust, an apple, or the Moon—all are accelerated equally, at the same distance. Gravitation is acceleration, classically speaking.

Moreover, the apparent symmetry of the gravitational interaction has totally vanished, which is appropriate, in my opinion. If we imagine the acceleration induced on M (the Earth) by m (the speck of dust), we replace M by m in Equation (4), reverse the sign, and the result is minuscule, as it should be.

Newton could have made Equation (4) his starting point and not gone wrong. For systems of multiple bodies, each body moves according to the vector sum of the accelerations induced by all the other gravitating bodies. In general, one has dynamical chaos[5], but in many cases of interest (such as the Solar System) one can introduce significant mathematical simplifications, and temporary order is imposed. This is the basis of celestial mechanics. Occasionally, specific problems need to account for non-gravitational effects (the thrust of gas jets from comets nearing the Sun, for example) or for relativistic corrections (such as Roy Bishop's example of the precession of the orbit of Mercury). Forces cannot be dispensed with entirely in Newtonian mechanics, but they are needed only to account for non-gravitational effects.

Because Equation (4) does not make reference to any particular object, it is a good example of a *field*: a continuous function of space describing the magnitude and direction of the acceleration impressed by the gravitating body of mass M on any body introduced at any point in space. This acceleration field—or gravitational field—is in fact the departure point for Einstein's development of the General Theory of Relativity, in which gravity is indistinguishable from an accelerated frame of reference. In Einstein's introduction to his theory, he says,

> This view is made possible for us by the teaching of experience as to the existence of a field of force, namely, the gravitational field, which possesses the remarkable property of imparting the same acceleration to all bodies.[6]

To my way of thinking, this statement would not lose any meaning if the words "of force" were eliminated.

The radical part of Einstein's theory is the unification of space and time into an unconventional four-dimensional geometry, first introduced in his Special Theory of Relativity. He abandoned Newton's independent time and Euclidean space, and introduced a geometrical space-time that allowed the laws of physics to be formulated in a manner independent of the frame of reference: the Principle of Covariance. In this world view, gravitation is not even acceleration, as it can be removed mathematically at any point by a coordinate transform.

"Gravitation is geometry," relativistically speaking—these are the words of Roy Bishop in *Orbital Motion*. However superior this relativistic world view is, it is impractical for solving day-to-day mechanical and dynamical problems that take place at low speeds and in weak gravitational fields. In this limit, space and time become decoupled, and the mathematics of relativity simplify to those of the Newtonian world view, which has proved to be practical and correct (if you don't look too closely!). Both Einstein and Newton subscribed to the principle of equivalence of gravitational and inertial mass, and motion under gravity is force-free in both theories.

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[5] Newton is said to have written "...an exact solution for three bodies exceeds, if I am not mistaken, the force of any human mind," which suggests that he appreciated the complexity of many-body motion under gravity.

[6] A. Einstein, "The Foundation of the General Theory of Relativity," in *The Principle of Relativity*, translated by W. Perret and G.B. Jeffery (Dover Publications,

Henry Draper

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

Exactly 120 years ago, the American amateur astronomer Henry Draper became a pioneer of astrophotography by taking the first photograph of a nebula — the Orion Nebula. Draper was born in Virginia on March 7, 1837, to British parents, but almost immediately the family moved to New York City, where he lived the rest of his days. His father, John William Draper, was a Professor of Chemistry at New York University, and is credited with introducing the daguerreotype to America; in fact he created an image of the Moon using the process in 1840.

Henry Draper studied medicine and actually practised surgery with the U.S. (Union) Army. His one true passion was astronomy, however, whose study he undertook at his own expense, supported by his university dean's salary. Despite his medical training, he contracted a bad case of aperture fever from the Earl of Rosse during a visit to Ireland. (The eccentric and aristocratic Earl of Rosse is noted for his construction of a reflecting telescope with a 72-inch — 1.8 m — metal mirror, and for naming the Crab Nebula. His expensive, unwieldy, and rickety instrument is credited with revealing the spiral nature of some of the nebulae, and was the largest telescope in the world when it was dismantled.) The British astronomer John Herschel persuaded Draper that glass was superior to metal for telescope mirrors, and he eventually ground about a hundred of his own.

With his 28-inch (71 cm) reflector — large for an amateur telescope even by today's standards — Draper was able to photograph the spectrum of Vega in 1872, another first. That was accomplished with wet collodion emulsions, but Draper soon switched to the new-fangled dry plates, and collected scores of stellar spectra. In fact, his 1880 astrophoto of the Orion Nebula was a spectrum that indicated that the nebula was gas and dust lit by starlight.

Draper's life came to an untimely end. He succumbed to double pneumonia in 1882 at the age of 45, as a result of an unfortunate hunting trip in the mountains. His widow established the Henry Draper Memorial at the Harvard College Observatory to continue research on stellar spectra. That funded the compilation of the Henry Draper (HD) Catalogue of stars, which included spectral types designated by the familiar alphabetic sequence O, B, A, F, G, K, M. (Most of the work was done by three ladies, Williamina P. Fleming, Antonia C. Maury, and Annie Jump Cannon, but that is another story.) The sequence is known as the Harvard Classification System.

The (U.S.) National Academy of Sciences — with financial assistance from Mrs. Henry Draper — established the Henry Draper Medal in his honour, awarded every four years for contributions to astronomical physics. Indeed, the recipients of the medal read like a Who's Who of Astronomy and Physics: Hale, Michelson, Zeeman, Russell, Eddington, Shapley, Bethe, Ryle, Penzias and Wilson, and many more. In 1934, the recipient was John S. Plaskett, Canadian astronomer and one-time President of the RASC. The Draper Medal recognized Plaskett "for his able and consistent labours in stellar radial velocities and related studies energetically pursued for nearly 30 years." (See `http://www4.nas.edu/nas/nashome.nsf`).

The accomplished American amateur astronomer Henry Draper (1837–1882).

... ...

In April's column I neglected to mention that Jan Oort was Honorary Member of the Royal Astronomical Society of Canada in the years 1954–1992, and that Sidney van den Bergh wrote a fine appreciation of Oort's astronomical life in JRASC, 87, 73-76 (1993). Many thanks to several readers who noted the omission.

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Weighing the Universe

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

For a very long time, people have wondered about the nature of our universe. Some ancient Greeks believed that the stars were part of an invisible sphere located not far beyond the outer planets, and that comprised all there was. Since the time of Galileo astronomy has continually revealed new aspects of the universe, to the extent that we now know that we live in the outer reaches of an ordinary galaxy at no special point in space. But the underlying nature of the universe itself has puzzled cosmologists for most of a century. Now, Paolo de Bernardis of the University of Rome, and David Wittman of Bell Labs, along with their collaborators, have determined two of the most important properties of the universe: the total density of matter and energy, and the fraction of the total amount that is matter (see 27 April and 11 May issues of *Nature*). De Bernardis finds that the universe has the "critical density" that makes it "flat," and Wittman estimates that the contribution of matter — including dark matter — to the total is about thirty percent. The other seventy percent is energy.

"Now, Paolo de Bernardis of the University of Rome, and David Wittman of Bell Labs, along with their collaborators, have determined two of the most important properties of the universe: the total density of matter and energy, and the fraction of the total amount that is matter."

The universe has some interesting properties, starting with the observation that the sky is dark at night. You might think that has little to do with the rest of the universe, but in fact if it were infinitely old, the entire sky would shine with the brightness of the surface of an average star. That is because, in an infinitely old universe, every single line of sight would eventually end at the surface of a star. So, darkness has always been a strong indicator that the universe had a beginning. The discovery of the 3 K cosmic microwave background radiation by Penzias and Wilson settled the issue; that background is the remnant of the cooling expanding fireball in which space itself was created. The background is not completely uniform, though. The *COBE* satellite discovered tiny fluctuations in its temperature in 1992. Those fluctuations were so far apart on the sky, however, that they were physically unrelated to one another. One of the "holy grails" of cosmology has been to measure the fluctuations at sufficient resolution that the regions were physically connected when the universe was very young, and that is what de Bernardis has done. A second experiment (headed by Paul Richards of Berkeley) has since confirmed the results of de Bernardis (they will appear in an upcoming issue of the *Astrophysical Journal Letters*).

Before the universe had cooled sufficiently for electrons to combine with protons to form hydrogen, light could not travel very far before it was absorbed by an electron or proton. The universe at that time consisted of something like thick matter-light soup that had compression waves, which are like sound waves in air, sloshing around in it. Regions of higher density would contract under gravity until the pressure of photons pushed the gas back. The tiny fluctuations in the microwave background are the signatures of those waves. Where the gas was compressed, it was hotter, and when it expanded, it cooled, giving rise to the temperature variations in the background radiation. Just like waves in air and water have characteristics determined by properties such as the mass density of the medium in which the wave travels, so too were the compression waves influenced by the density of the matter-light soup. Therefore, the angular scale over which temperature variations are correlated with each other is a probe of the total mass-energy density of the universe. De Bernardis found that the fluctuations are essentially exactly as predicted for a universe with the critical mass-energy density, in other words, a "flat" universe.

The concept of a flat universe is both easy and complex to explain. Easy, in that flat means topologically flat, but difficult because it is hard for us to imagine what that really means. In physical terms, one consequence is that the sum of the interior angles of a triangle will always equal 180 degrees. Another consequence is that if a starship (say, the *Voyager*) flew in a straight line forever, it would never end up where it began. That is not necessarily true in a curved universe. Imagine a person walking over the surface of the Earth, which we will use as an example of positively curved space. While walking, the person sees flat land, and a flat horizon, and so could be forgiven for thinking that they are in a "flat universe." If the person walks long enough in a straight line, however, they will end up back where they started. Another person in orbit about the Earth would consider ending up in the same place simply as a consequence of the Earth being a sphere — there is nothing mysterious about it — but to the walker it would seem very strange. We have a hard time imagining what a curved universe would be like, because we cannot easily picture a four-dimensional space from which to look back on our three-dimensional universe and see the simplicity of the curved path we would follow. Fortunately, we do not have to worry about it, because we live in a flat universe.

The second part of the story is tracking down how much of the mass-energy density is actually in the form of mass. It has been well known for quite a long time that if you add up all of the mass observed in stars and galaxies, including very cold molecular gas, cool atomic hydrogen, and hot X-ray emitting plasma, then at best you get something like three percent of the critical density. That, along with problems involving how fast galaxies rotate and how they can remain bound in clusters, led to the theoretical proposal that most of the mass of the universe is in some exotic form, nebulously referred to as "dark matter." Over the last twenty years, a particular variant called "standard cold dark matter" has been elevated to the status of a religion among some theoretical cosmologists, despite ever-increasing amounts of evidence that it simply cannot explain the observations. Often, the tests were sufficiently imprecise, or the theoretical predictions sufficiently fraught with uncertainties, that the theoreticians had enough wiggle room to save their dark matter. As a result of measurements done by Wittman and three other groups whose results have not yet been published (led respectively by van Waerbeke, Bacon, and Kaiser), however, we know that is no longer true.

We tend to think of light moving in straight lines — indeed, lasers are used to dig straight tunnels — but light paths curve around very massive bodies. That is a straightforward prediction of general relativity, and was confirmed in 1919 by Eddington. It means that masses can act like lenses; a number of gravitationally-lensed quasars and distant galaxies have been discovered. The weak gravitational lensing observed by Wittman is a bit different. Instead of producing multiple images of galaxies, slight distortions are induced in their shapes. As the light from distant galaxies that lie close together in the sky, but are physically unrelated, travels past clusters of galaxies, the shapes of the distant galaxies are distorted in the same way. Measuring the amount of correlated distortion is a sensitive way to probe the mass density along the line of sight. Because dark matter does have mass, it will be detected in the same way. Although the project is easy to describe in principle, it is horribly difficult to accomplish in reality. Previous attempts failed. With four independent groups reaching essentially the same result, however, it seems that this time the result is dependable. There is only enough mass — even including the dark matter — to provide 30 percent of the critical density.

That means that the remaining 70 percent, which is needed to explain the result of de Bernardis, must be in the form of energy density: the name given to such energy density is the "cosmological constant." We do not understand this property of the Universe, but its observable effect is to accelerate expansion over time, acting like anti-gravity. Instead of the expansion of the universe slowing down with time, as a ball thrown in the air slows as it reaches its highest point, it is speeding up. That means that the Hubble constant — the rate of expansion at this time — is not a constant: it was lower in the past than it is today. One beneficial effect of the cosmological constant is to reduce the discrepancy between the age of the universe as inferred from the Hubble constant and the ages of the oldest stars in our Galaxy. The first hints of a cosmological constant were seen two years ago in systematic effects in the apparent brightness of supernovae in distant galaxies (see 1 January 1998 issue of *Nature*).

Not only does our universe contain lots of matter that we cannot see directly, now we know that some of its properties are dominated by an energy density that is even more mysterious.

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CONJUNCTIONS OF JUPITER AND SATURN

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Abstract. This year's Jupiter-Saturn conjunction is an astronomical event that has been noted in yearbooks, even though it occurred too close to the Sun to be readily visible. Astronomical conjunctions are often loosely defined. Four questions need to be answered: Which two astronomical bodies are involved? What co-ordinate system is used to define the conjunction? From what astronomical body is the event observed? Is the event described apparent or real? Jupiter-Saturn conjunctions are among the most impressive such events, occurring about every 20 years and involving the two outermost visible planets. The timing of apparent retrograde motion of the two planets can also produce an apparent triple conjunction, as happened in 1980-81. Triple conjunctions occur at irregular multiples of the conjunction interval. Occasionally a close grouping of Jupiter, Saturn, and Mars is also referred to as a triple conjunction. Successive Jupiter-Saturn conjunctions, slightly more than 240° apart, develop an interesting pattern as they step around the ecliptic, a rotating triangle with legs about 120° apart. In relation to the fixed stars, it takes about 854 or 913 years for the event to return to a point near the start of the sequence. Some scholars have given it as 960 years. Relative to a precessing co-ordinate system, it takes about 800 (794) years. Medieval scholars in Europe and the Near East were impressed by the above conjunction sequence, and tried to relate it to major events in world history. The earliest known attempts come from 8th century Baghdad, but their explanation may have originated in Iran (3rd to 7th centuries). It persisted in Europe into the 17th century.

Résumé. La conjonction de Jupiter et de Saturne cette année est un évènement astronomique qui a été signalé dans les annuaires, en dépis du fait qu'elle a eu lieu trop près du soleil pour pouvoir être facilement visible. Les conjonctions sont souvent définies qu'en grandes lignes. Pour ce faire, on doit répondre à quatre questions : Quels sont les deux objets célestes impliqués? Quel système de coordonnées utilise t-on? De quel objet observe t-on la conjonction? L'évènement est-il réel ou simplement apparent? La conjonction de Jupiter et de Saturne est parmi ces évènements les plus impressionnants, ayant lieu à peu près tous les 20 ans, et impliquant les deux planètes visibles les plus éloignées. La synchronisation du mouvement apparemment rétrograde des deux planètes peut à l'occasion produire une triple conjonction apparente, telle que s'est produite en 1980-1981. Les triples conjonctions ont lieu à des étapes multiples irrégulières de l'interval de la conjonction habituelle. De temps en temps, on parle de l'approche plutôt serrée de Jupiter, de Saturne et de Mars comme étant une triple conjonction. Les conjonctions successives de Jupiter et de Saturne, à un peu plus de 240° de séparation, présentent un aspect intéressant lors de leurs trajets le long de l'écliptic, soit un triangle tournant avec deux côtés faisant un angle de 120°. Par rapport aux étoiles fixes, environ 854 ou 913 années doivent s'écouler avant que la séquence reprenne plus ou moins au point de départ. Quelques savants maintiennent la durée du trajet aux 960 ans. Par rapport aux coordonnées avec calculs de précession, la durée est de quelques 800 (794) ans. Les savants médiévaux en Europe et au Moyen Orient avaient été très impressionnés par la séquence de cette conjonction et avaient essayé d'en faire le lien avec les évènements majeurs de l'histoire mondiale. Les plus anciennes tentatives de liens historiques connues remontent au 8e siècle à Baghdad, mais ces explications sont peut-être d'origine iranienne (3e au 7e siècle). Ces tentatives de liens persistèrent jusqu'au 17e siècle. SEM

1. Introduction

Among the astronomical events of the year 2000 was a conjunction of Jupiter and Saturn. It was highlighted in popular astronomy periodicals, and emphasized in the *Astronomical Almanac* and *Observer's Handbook*, even though it was too close to the Sun to be visible readily. It may be a good time to review planetary conjunctions in general, and Jupiter-Saturn conjunctions in particular. Several misunderstandings about such events are found in the current literature, and certain aspects of them are often overlooked. In addition, conjunctions of the outer visible planets were considered important omens by many people in medieval and early modern Europe and the Near East, and are therefore of interest to historians.

2. Conjunctions Defined

The *Explanatory Supplement* to the *Astronomical Almanac* (Seidelmann 1992) defines an astronomical conjunction simply and clearly: "...the phenomenon in which two bodies have the same apparent celestial longitude ...or right ascension as viewed from a third body." Variants of the definition are given in astronomical dictionaries and other reference works (Gribbin 1996; Ridpath & Woodruff 1996; Mitton 1993). Four important aspects of conjunctions are identified.

First, the two astronomical bodies in conjunction may be any such bodies: Sun, Moon, planets, or stars. Only two kinds of conjunction are usually discussed, however: those involving a planet and the Sun, and those involving two planets. Some sources give preference to the former, treating the latter almost as an afterthought.

Second, the two bodies may be considered in conjunction according to two different co-ordinate systems: one (right ascension) based upon the equator of the body from which they are observed, and the other based upon an alternative reference plane such as the orbital plane of that body (celestial longitude). Some sources mention only one co-ordinate system. Astronomical software packages used for calculating conjunctions usually calculate them only in celestial longitude. (They actually calculate minimum separations, which are not necessarily exact conjunctions in longitude.)

Third, the two bodies are considered to be in conjunction as viewed from a third body. The third body is usually assumed to be the Earth, the two co-ordinate systems being based on the Earth's equator and the ecliptic. As the *Explanatory Supplement* definition continues, "Conjunctions are usually tabulated as geocentric phenomena." But they can also be calculated as viewed from the Sun. The latter usually consider only the Earth's orbit — the ecliptic — as the reference plane, identifying conjunctions in heliocentric ecliptic co-ordinates. It would probably be more logical, truly heliocentric, to use the Sun's equator as the reference plane.

Fourth, the two bodies are considered to be in conjunction when they have the same apparent longitude or right ascension. Because light has a finite velocity, astronomical bodies are never where we "see" them. They are therefore not in conjunction when they appear to be so. Some astronomical software packages calculate apparent conjunctions (for example, *Dance of the Planets*™ and *RedShift3*™), and some true geometric conjunctions. (Tables kindly provided by E. Myles Standish of the Jet Propulsion Laboratory give geometric conjunctions, but the system could have provided apparent conjunctions just as easily.)

The two bodies in conjunction need not, and usually will not, overlap (Albers 1979). Some sources loosely define a conjunction as a gathering of two or more astronomical objects in a limited segment of the ecliptic (Ridpath & Woodruff 1996; Mitton 1993; Brau *et al* 1980). That is probably taken from pre-modern astronomy and astrology, which sometimes considered objects to be in conjunction if they were a few degrees apart, or even if they were in the same zodiacal sign (*i.e.* within 30° of ecliptic longitude). Such a configuration is often called a grouping or massing. One must decide how close together the objects must be to be considered a group.

3. Jupiter-Saturn Conjunctions

Among the most impressive planetary conjunctions have been those of Jupiter and Saturn. The two planets are the most majestic and slow-moving of those visible to the eye, and they are brighter than most stars. Their conjunctions occur with reasonable regularity, roughly every 20 years — the precise average is 19.86 years. This year's conjunction was preceded by one in 1980-81, and will be followed by one in 2020. That is often enough to be remembered, but not enough to be ordinary.

Jupiter and Saturn, as viewed from Earth, were in conjunction in geocentric ecliptic co-ordinates on May 28, 2000 (UT), and in geocentric equatorial co-ordinates on May 31. The ecliptic conjunction occurred when Jupiter and Saturn were in the constellation of Aries by modern constellation boundaries, specifically very close to the Aries-Taurus boundary. The equatorial conjunction occurred just on

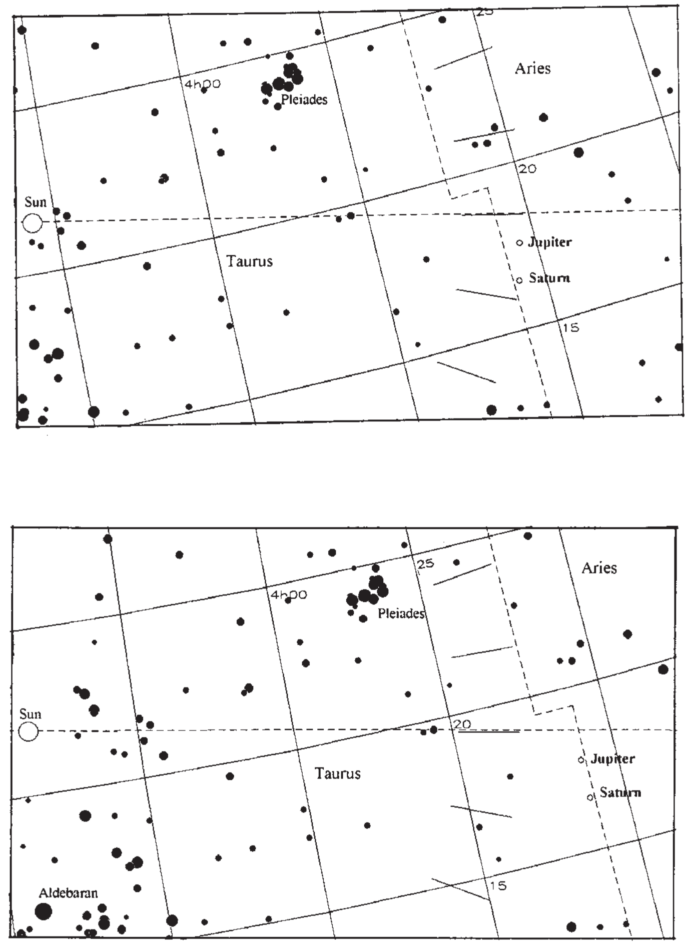

Fig. 1 — The Jupiter-Saturn conjunction of May 28, 2000 in geocentric ecliptic co-ordinates as viewed from Earth, showing the Taurus-Aries boundary (top), and the alternate conjunction of May 31, 2000 in geocentric equatorial co-ordinates (bottom). Fig. 1 was produced using *Dance of the Planets*™ 2.71.

the other side of the boundary, in Taurus (figure 1). As viewed from the Sun, Jupiter and Saturn were in conjunction in heliocentric ecliptic co-ordinates on June 22, and in heliocentric equatorial co-ordinates on June 21. Of the geocentric conjunctions, the *Astronomical Almanac* and the *Observer's Handbook* note only that of May 31. The *Observer's Handbook* also mentions the heliocentric conjunction of June 22.

Some geocentric conjunctions occur too close to the Sun for the planets to be visible readily at the moment of conjunction. That was true for the events of AD 2000, in both ecliptic and equatorial co-ordinates. By contrast, the conjunction of 2020, which occurs on the date of the winter solstice, December 21, will be a treat for some people. The planets will be more than 32° degrees east of the Sun, readily visible after sunset. According to *Dance of the Planets*™, Version 2.71, the equatorial conjunction will occur about 13:30 UT, and will be visible in south central Asia (*e.g.* Herat, Karachi, and Delhi). The ecliptic conjunction will occur about 18:20 UT, and will be visible in extreme western Europe and northwestern Africa (*e.g.* Madrid, Lisbon, and Rabat). Unfortunately, neither will be visible in the western hemisphere. Jupiter and Saturn will be closer together (about 6 arcminutes apart) than for any previous conjunction since 1623.

4. Retrograde Motion and Triple Conjunctions

When the Earth, which moves faster than an outer planet, passes such a planet in orbit, the planet appears to stop its eastward progress through the stars and to reverse direction for a while, then to resume its normal eastward motion. Such a reversal of direction is called retrograde motion.

If Jupiter and Saturn are near conjunction when Earth is passing them, we may witness a triple conjunction. Jupiter passes Saturn as both planets advance eastwards along the ecliptic, at which instant they appear to be in conjunction. Jupiter can again pass Saturn after both planets reverse their apparent direction of motion, during their retrograde phase, at which instant a second conjunction occurs. Jupiter passes Saturn one last time when both planets once again appear to reverse direction, moving eastward, producing a third conjunction. That last happened in 1980-81 during the last conjunction of the two planets (*e.g.* Meeus 1997).

Contrary to some sources, particularly those dealing with the Star of Bethlehem (Hughes 1979), triple conjunctions of the two planets do not occur regularly (Victor 1980; Robinson 1981). Triple conjunctions may occur as little as 40 years, or two conjunctions, apart, as they did in 1940-41 and 1980-81, with the single conjunction of 1961 between them. At the other extreme, they may occur as much as 380 years apart (specifically 377 years). The next triple conjunction is expected to occur in AD 2238-39, 258 years after that of 1980-81. Sometimes a conjunction can be a triple conjunction in one co-ordinate system but not in another. The conjunction of 1425 was triple in ecliptic co-ordinates, but not in equatorial co-ordinates. That of 1821 was triple in equatorial co-ordinates, but not in ecliptic co-ordinates.

Some authors refer to a close grouping of the three outer visible planets, or the three conjunctions that take place among them around that time, as a triple conjunction (Molnar 1999). There was such a grouping in the second week of April, 2000, with Jupiter and Saturn only about 5° apart with Mars between them. Their three ecliptic conjunctions took place on April 6 (Mars-Jupiter), April 15 (Mars-Saturn), and May 28 (Jupiter-Saturn). Some groupings are closer. On December 14, 1901, Mars was in conjunction with Saturn, with Jupiter only about 1½° away. Mars always joins the other two within roughly a year before or after a Jupiter-Saturn conjunction, so there can always be a grouping of the three, if the limits are large enough.

5. Constellations and Signs

Because equatorial and ecliptic conjunctions occur on different dates with the planets in different locations, they may occur in different constellations or zodiacal signs, as noted. As an alternative to the disparate widths and unstable boundaries of the ecliptic constellations, the ancient Babylonians standardized the system to twelve equal segments, or signs, each 30° wide and named for its principal constellation. That required a reference point, which the Babylonians established to be Pollux (β Gem), marking the eastern boundary of Gemini (Britton & Walker 1996). Most medieval astronomers set the western boundary of Leo at Regulus (α Leo). Copernicus used Mesarthim (γ Ari) as the western boundary of Aries (Neugebauer 1954).

By any such divisions of the signs, the conjunction of AD 2000, in both geocentric co-ordinate systems, occurred in Aries.

6. Stepping Through the Zodiac

Successive Jupiter-Saturn conjunctions develop an interesting pattern as they step around the ecliptic, as noted by Kepler (1981). The pattern is more regular if one uses zodiacal signs of equal length instead of constellation boundaries.

Saturn travels through about two-thirds of its orbit, about 240°, between conjunctions with Jupiter. If a conjunction occurs in the sign of Aries, the next will probably occur in Sagittarius, about 240° away, and the third in Leo, another 240° along the ecliptic. The fourth conjunction will likely also occur in Aries, since Saturn completes just over two orbital revolutions of the Sun during the 59½ years covered by three conjunction cycles. The sequence of conjunctions forms a rough triangle inside the zodiacal circle, every fourth sign (see figure 2). Astronomers and astrologers often call the group of three signs involved a triplicity, or trigon.

Conjunctions may vary from the normal pattern, sometimes occurring in neighbouring constellations or signs. The apparent positions of the planets are complicated by their relationship to Earth, by their positions in their elliptical orbits, and by variations in their semi-major axes and orbital periods. For example, the triple conjunction of 1940-1941 occurred in Aries, the conjunction of 1961 in Sagittarius, and that of 2000 on the border of Aries and Taurus (in the sign of Aries). But the triple conjunction of 1980-1981 occurred in Virgo, somewhat east of both the constellation and the sign of Leo.

Because the interval is roughly 2°–3° greater than 240°, the fourth conjunction does not return to the starting point, but to a location several degrees east of it. Similarly, the fifth is east of the second, and the sixth east of the third. Such eastwards stepwise rotation continues, the conjunctions advancing through the three zodiacal signs of the trigon into the three adjacent signs of the adjacent trigon, then into the next three, *etc.* Eventually each leg of the triangle steps through four zodiacal signs, and the second leg arrives at a location near the starting point of the sequence.

How long does it take? The answer depends upon whether one measures in relation to the fixed stars or the precessing vernal equinox. Relative to the fixed stars, it usually takes about 913 years (46 conjunction intervals), or about 854 years (43 conjunction intervals). For example, the conjunction of AD 2000, near the Aries-Taurus border, fell about halfway between the conjunction of 1087 (east of σ Ari) 913 years earlier, and that of 1146 (near 13 and 14 Tau) 854 years before.

With respect to precessing co-ordinates, the sequence usually takes about 794 years (40 conjunction intervals). The conjunction of AD 2000, with Saturn at a right ascension of about $3^h 23^m$, occurred close to that of AD 1206, when Saturn was at a right ascension of about $3^h 35^m$. In the literature on conjunctions, the number is often rounded up to 800 years.

Some authors, following Finegan (1964), cite a duration of 805 years for the sequence or for the associated groupings with Mars (Hughes 1979; Molnar 1999). Finegan apparently assumed that Kepler's conjunction of 1603 paralleled the conjunction of 7 BC, associated with the birth of Christ. Counting that as two successive sequences in 1609 years, he apparently divided by 2 to obtain 804.5 years, or 805 years per sequence. Since 40 conjunction intervals total 794 years, and 41 intervals total 814 years, Jupiter and Saturn would be near maximum separation in 805 years, making a conjunction or a grouping with Mars impossible.

Other authors, following Hellman (1944), cite the more precise

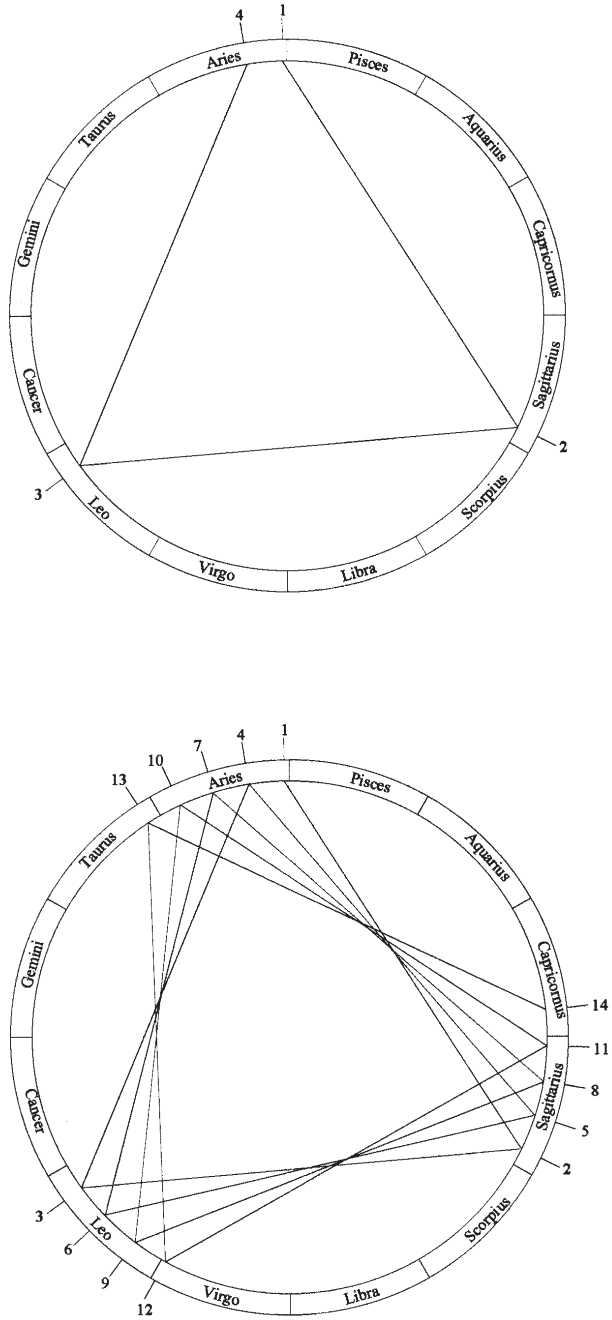

Fig. 2 — A conjunction triangle (trigon) for Jupiter-Saturn conjunctions (top), along with a partial conjunction sequence (bottom).

figure as 786.4 years (Aston 1970). Apparently Hellman misread the figure of 19.86 years per conjunction interval as 19.66 years, obtaining a duration for ten intervals of 196.6 years. That number, multiplied by four, gives 786.4 years.

7. The Conjunction Sequence in the Middle Ages

Interest in the conjunction sequence became prominent in the Near East in the early Middle Ages, and spread from there to western Europe. It was still fairly popular in Europe as late as the 17th century.

The earliest clear evidence for such interest comes from 8th century Baghdad. Scholars there, such as the Muslim astronomer/astrologer Abû Ma'shar (805?–886), known to medieval Europeans as Albumasar, related certain conjunctions to important events in world history (Pingree 1963). It was assumed that the first conjunction in each set of three (about 60 years), the first in each set of three zodiacal signs or trigons (about 200–240 years), and especially the first in each complete sequence through the zodiac (about 800–960 years), foretold such events. The main source of such ideas may have been Sassanid Iran (3rd–7th centuries).

Those scholars generally counted the sequence from the first conjunction in Aries, but some Jewish scholars, at least as early as the philosopher Abraham bar Hiyya (1065?–1136), counted from the first conjunction in Pisces (Silver 1927). Europeans such as Kepler became acquainted with the concept mainly through the works of a Portuguese Jewish scholar, Isaac Abrabanel (1437–1508).

Medieval scholars, including Abû Ma'shar and bar Hiyya, usually cited the duration for the complete sequence (in relation to the fixed stars) as 960 years. See, for example, the English Franciscan Roger Bacon (1214?–1294) (Bacon 1928). The origin of that number is not clear. The interval may be as long as 913 years, as noted previously, but 960 is not a rounding of that value. Perhaps medieval scholars had records of twelve conjunctions occurring within one trigon, for a total of about 240 years (238), and assumed that it was always the case. To cover the complete zodiacal circle, four trigons, would require about 960 years (953).

Use of the *Alphonsine Tables* in Europe apparently led to general use of precessing signs by the time of Tycho Brahe (16th century) (Woody 1977). European scholars therefore cited about 800 years (794 years) for the duration of a complete sequence (Kepler 1606). That figure is used by astronomers today, although the concept of conjunctions as omens has been abandoned.

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DONALD ETZ, who is a member of the RASC (though not a Canadian citizen), is an amateur astronomer with particular interest in the history of astronomy and the solar system. He gives occasional lectures on astronomy to local groups, and has published a few articles in his areas of interest. He presented a talk on the conjunctions of 2000 to the Miami Valley Astronomical Society, and reworked the talk material into the present manuscript.

ABSTRACTS OF PAPERS PRESENTED AT THE 2000 RASC GENERAL ASSEMBLY HELD IN WINNIPEG, JUNE 30 TO JULY 2, 2000

Featured Speakers:

Comets and Asteroids: Advances Since Halley's Comet, Steve Edberg, Jet Propulsion Laboratory (NASA), California Institute of Technology

The 1990s have been blessed with two bright comets, yielding new discoveries about such relics of solar system formation. The population of putative Kuiper Belt Objects continues to increase, and a population of Centaur asteroids is receiving recognition. Meanwhile, other objects that decrease the distinctions between comets and asteroids have been found. This presentation describes the considerable growth in the understanding of such objects seen in the last decade.

The Age and Size of the Universe, Wendy L. Freedman, Carnegie Observatories

In 1929, the astronomer Edwin Hubble made the fundamental discovery that the universe is expanding. His observations provided the first evidence for a Big Bang origin for the universe. The current rate at which the expansion is taking place, known today as the Hubble constant, is one of the key parameters that yields a measure of both the age and the size of the observable universe. Although Hubble made his discovery about seven decades ago, a reliable measure of the Hubble constant has continued to elude astronomers, and has led to much debate. Recently, observations with the *Hubble Space Telescope* have enabled astronomers to measure new and precise distances to the nearest galaxies, resulting in more accurate estimates of the size and the age of the universe. Those and other recent discoveries in cosmology are discussed within a historical context.

Don Parker, Association of Lunar and Planetary Observers

No abstract provided.

Contributed Papers:

Observational Astronomy without a Telescope, David Turner, RASC Halifax Centre

Tests reveal that the eye can distinguish brightness differences of as little as 0.1 magnitude when it is operating near one's limit of vision. By analogy that means that the light curves of bright variable stars can be constructed successfully without optical aid, provided only that the observer is working near the limit of stellar detection. Such expectations have been confirmed by the dedicated efforts of countless observers over the last few centuries, and were tested recently by the author through backyard observations of the bright Cepheids Delta Cephei, Zeta Geminorum, and Eta Aquilae. These observations were made during 1998–99 with the aid of newly generated reference charts tied to photoelectric *V* magnitudes rather than the usual "visual" magnitudes included on AAVSO charts. The derived light curves for the three variables exhibit surprisingly little scatter, and have direct scientific value for the study of period changes in the Cepheids.

Astronomy on Stamps, J. Randy Attwood, RASC Toronto Centre

Many countries around the world have issued postage stamps with an astronomical theme. Such stamps depict astronomical discoveries and events, observatories, individual objects (both solar system and deep sky), and astronomers (both professional and amateur). Canada has not chosen to produce any astronomy stamps. The RASC made an effort to convince Canada Post to issue an astronomy stamp in the 1980s. The effort was unsuccessful. Perhaps it is time to renew our efforts to support an issue.

High Level High School Mathematical Astronomy, David Orenstein, RASC Toronto Centre

The Ontario OAC algebra and geometry course is a very challenging pre-university mathematics program. Good students in the course are ready to delve into mathematical astronomy in a very serious way. To do that, each of my students chose a constellation using the data from the Bright Star tables of the *Observer's Handbook*. In carrying out the project, students reviewed trigonometry, applied and extended their knowledge of vector algebra in three-dimensional space, were introduced to vector calculus, and learned a considerable amount of stellar and deep space astronomy. The first step was to achieve familiarity with a wide range of astronomical concepts and terminology so that their data could make sense. Calculations started using the *Hipparcos* positional data, by verifying stellar distances using parallaxes. Celestial co-ordinates were transformed by a set of trigonometric equations into rectilinear co-ordinates in three-dimensional space. That allowed a simple calculation of the Euclidean distance to the stars using the Cosine Law. Further calculations established the rectilinear components in compatible dimensions for stellar position, radial velocity, whole space velocity, and especially transverse velocity vectors. The derivation extended over two 75-minute periods, and stretched the students to their intellectual limits. A large range of advanced mathematical topics were integrated and applied rigorously to actual scientific data. Brought together, the vectors generate linear equations of the stars' positions over time. Using a spreadsheet with which they were familiar, the students completed all calculations for the bright stars of their chosen constellations. In particular, they found the location of the stars in three-dimensional space for the current epoch, 10,000 years in the past, and a similar amount in the future. The final project steps produced a visual representation of the constellation in three dimensions, the astronomical and cultural background of the constellation, and a seminar presentation.

Full-Disk Wide Band Photoelectric Photometry of the Moon, Richard W. Schmude, Jr., Gordon College

Seventy *B* and *V* filter magnitude measurements were made of the lunar disk in 1999–2000, and from the measurements solar phase angle co-efficients and normalized magnitudes were determined. The major conclusions of the study are: (i) the *B–V* colour index of the Moon increases slightly with increasing solar phase angle, (ii) there is an almost linear relationship between the normalized magnitude and the solar phase angle for both the *B* and *V* filters, and (iii) the magnitude of the Moon changed by no more than 0.2 magnitude as a result of the Leonid meteor storm of Nov. 18, 1999, or the solar wind surge that occurred on Feb. 21, 2000.

Impact of a C-class Asteroid in Canada: The Fall of the Tagish Lake Meteorite, Phil McCausland and Peter Brown, University of Western Ontario, Ed Tagliaferri, and Alan Hildebrand, and the Tagish Lake field party, University of Calgary

A long-duration and exceptionally bright fireball was witnessed throughout the Yukon Territory, northern British Columbia, parts of Alaska, and the Northwest Territories on January 18, 2000. The fireball was also detected by infrared and optical sensors aboard U.S. Department of Defence satellites that timed the terminal flares to ~16:43 UT (08:43 PST) with a two-second duration for 1-micron radiation. The satellite observations provided information suggesting an entry velocity of ~16 km s^{-1}, an entry mass somewhat in excess of 200 tonnes, and an entry diameter in excess of 5 m. Satellite and ground observations both suggest that the fireball travelled towards the SSE with an elevation angle of ~16°. The largest burst happened at 33 km altitude over Mt. Patterson on the Yukon/BC border. The back-calculated orbit is of moderate eccentricity with aphelion in the outer asteroid belt. On January 25 near dusk, local resident Jim Brook found meteorites on the snow-covered ice of Taku Arm on Tagish Lake while driving home. He returned the next day, collecting several dozen pristine specimens in total. The meteorites represent a particularly fragile variety of carbonaceous chondrites, and were collected without skin contact and have subsequently been kept frozen. During the spring melt another ~500 meteorites were recovered from a strewn field ~16 km long and ~3 km wide oriented at ~150°. The meteorite represents a fantastic opportunity to study the earliest history of the solar system, and should spur the further development of planetary science in Canada.

Starlab *and Astronomy Education in Atlantic Canada Schools*, Mary Lou Whitehorne, RASC Halifax Centre

This paper provides a summary of astronomy education activities in Atlantic Canada's schools, in light of the new Pan-Canadian Curriculum and severe budget cuts, with an emphasis on the positive contribution of *Starlab* to learning outcomes.

Round and Round in Circles — Five Millennia of Eclipse Cycles, Jay Anderson, Winnipeg Centre

The analysis of eclipse cycles has entertained humans since early Babylon; the history of astronomy can be traced through five millennia of eclipse investigations. In the current age, digital archives of eclipse predictions and spreadsheets can be combined to give insights into the behaviour of the cycles and to extend the work of earlier investigators. The results are not only intriguing and scientifically interesting, but also reveal beautiful patterns which cross the centuries.

Techniques in Digital Photography, Rajiv Gupta, Vancouver Centre

We describe and illustrate various ways in which astronomical images can be manipulated and improved using modern digital techniques. Such methods include stacking of images, tricolour imagery, and the luminance transfer technique using the Lab colour model. The starting point for all processes is the registration of component images, which is accomplished using *RegiStar*, software that was recently co-developed by the speaker.

From the Small to the Large, Vesna Zdjelar, University of Manitoba

Is it possible to determine the age of the universe from a tiny glimpse of a star? Scanning the entire sky for small light amplifications of the stars caused by the gravitational lensing effect — microlensing — enables us to "see" what we can not see — dark matter. Searching for dark matter candidates in the halo of our Galaxy, the Milky Way, in, roughly speaking, the present moment in the history of the universe, makes it possible to determine several major cosmological parameters. This paper discusses the constraints on the baryonic mass-density parameter and the Hubble constant determined by such observations.

Hubble's Variable Nebula: The Movie, Chris Brown, Winnipeg Centre

Time-lapse imagery reveals changes that travel faster than the speed of light across the beautiful nebula, NGC 2261. What is going on and how the observations were made is discussed in this paper. For more details, including the animations, point your web browser to `www.umanitoba.ca/faculties/science/astronomy/cbrown/imaging/hvn`.

Enhancing CCD Images with MaxIm DL, Doug George, Cyanogen Productions

Images from CCD cameras naturally lend themselves to image processing because of their inherently digital nature and high dynamic range. Image processing can help elicit detail already present in the images but not readily visible. Various enhancement techniques are described and illustrated in a real-time demonstration using *MaxIm DL* software.

CCDs for Quantitative Observing, Gary Billings, Calgary Centre

Amateur astronomy has a long history of contributing to science. That has become more difficult as visual observations have become less accepted and observing conditions have worsened. CCD cameras, with their sensitivity, linearity, dynamic range, and their two-dimensional array of detectors, are a tremendous aid to "scientific" observing, even under sub-optimal conditions. Described here are the results of minor planet astrometry and differential photometry conducted using a CCD camera from my home in the city of Calgary. Also described is my observatory setup, followed by comments regarding equipment choices.

Poster Displays:

Pleione: A Spectroscopic Study of the Seventh Brightest Star in the Pleiades, R. F. Garrison, T. Karmo, Chris Capobianco, and Cristina Fayet, Dunlap Observatory, University of Toronto

Pleione, the seventh brightest star in the Pleiades, is rotating so rapidly that it occasionally releases a shell. The shell appears with an irregular characteristic time scale of 20–40 years. Shell phases have occurred in the 1940s and the 1970s. New spectra taken during the past few years show that a new shell phase is beginning. The poster illustrates past shell events as well as what happens to the spectrum during a shell phase and how astronomers interpret the results.

The South Saskatchewan Star Party, Ken Noesgaard, Saskatoon Centre

The Joint RASC/University of Saskatchewan Observatory Project, Ken Noesgaard, Saskatoon Centre

LUNA-TAC: An Electric Atlas of the Moon, Dan Collier, Vancouver Centre

Observatory Display, Bill Almond, Victoria Centre

The display consists of an illuminated multi-slide viewer containing slides of my observatory's construction as well as CCD images taken with its SBIG ST6 and Schmidt-Cassegrain telescope.

Photographic Report on the January 20–21 Total Lunar Eclipse, Leo Enright, Kingston Centre

The display contains a written report of the author's impressions of the January 20–21 total lunar eclipse as viewed from his observing site in Sharbot Lake, Ontario, along with a series of ten photographs taken of the eclipse at various stages from before second contact to after third contact. Data concerning each of the photographs are included for each eclipse photograph. A one-page supplement shows two photographs of the Moon less than two weeks later when it was in conjunction with the planet Venus in the morning sky before sunrise on February 2.

Photometric Study of NGC 1907, Marjorie Gonzalez and Jennifer West, University of Manitoba

As an undergraduate third year project, the authors took images of NGC 1907 at different optical wavelengths, and used the analysis software IRAF to obtain photometric data from them. A colour-magnitude diagram (CMD) of the cluster has been obtained from the data.

Van Gogh and the Starry Sky, Vesna Zdjelar, University of Manitoba

Mankind has the rare opportunity to meet the most intimate vision of life — nature and art — of one of the greatest artists in history, Vincent van Gogh, through a strange diary in the form of a remarkable collection of letters written to his brother Theo and friends such as Paul Gauguin. Fully describing the painter's life and thoughts, van Gogh's "Letters" has been an inspiration for the author as an astronomer and an inspiration to inquire into the starry sky motifs that had drawn the attention of the great 19th century painter. Analysis of two paintings, with a planetarium simulation for determining the celestial objects on one of them, are presented in the display.

Education Notes
Rubriques pédagogiques

SHARING THE ASTRONOMICAL ADVENTURE

by Mary Lou Whitehorne
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Abstract. RASC Centres and individual members provide astronomy activities and educational resources in widely diverse ways across Canada. Such efforts, either formally or informally, direct or indirect, reach thousands of people every year. They will become even more important in the future as the new Pan-Canadian science curriculum is implemented in Canadian schools, and teachers everywhere seek out RASC members to help them cope with the unfamiliar subject of astronomy. This article outlines some of the types of educational efforts undertaken by RASC members, and asks members to respond in kind by sharing their experiences with the rest of the RASC so that others will be inspired to take up the torch and spread the astronomical word even further.

Résumé. De diverses façons à travers le Canada, des activités astronomiques et des ressources éducationnelles sont fournis par les centres de la SRAC et par des membres individuels. Chaque année, ces efforts, soit officiels ou dénués de formalité, directs ou indirects, touchent des milliers de personnes. Ces activités deviendront encore plus importantes à l'avenir lorsque le nouveau curriculum pan-canadien en science est implanté dans les écoles au Canada, et lorsque les enseignants à travers le pays demandent l'aide des membres de la SRAC afin d'affronter ce sujet mal connu qu'est l'astronomie. Cet article passe brièvement en revue plusieurs programmes éducationels entrepris par des membres de la SRAC, et demande aux autres membres de partager avec nous leurs expériences dans ce domaine afin que d'autres membres soient encouragés à participer à ces activités qui répandent davantage les connaissances de l'astronomie. SEM

1. Okay, Everyone, Stand Up and Take a Bow!

The RASC does a remarkably good job at public education, especially when you consider that it is an organization composed entirely of volunteers. Every year the Society publishes the *Observer's Handbook*, and recent years have seen the addition of the *Observer's Calendar* and the *Beginner's Observing Guide*. Those publications are distributed ever more widely every year. The Society also has lots of other activities taking place that are not primarily educational in intent, but that is the end result nevertheless.

Take, for instance, star parties and public observing sessions, which give people an opportunity (sometimes it is their first experience) to see the starry heavens for themselves. They are not silent events — communication occurs between guest and host. Frequently that communication is considerable in its scope and content. People go away from such celestial picnics with smiles on their faces and many new ideas and facts in their heads. For some it is the catalyst for their own personal odyssey of learning.

Other fairly common events that bring astronomy to the people are mall displays and other similar efforts. They, too, bring astronomy to life for many folks, but there is much more that RASC members do to provide a cosmic connection for people of all ages. How many Centres and individual RASC members visit schools and make educational presentations? How many volunteer with youth groups and with science centres, museums, and planetariums? How many offer continuing education courses at night school? What about elder-hostel programs? I suspect that there are plenty of interesting activities taking place very quietly that the rest of us never hear about. They may not be "official RASC activities," but many Canadians benefit from such unsung volunteer contributions.

2. It is Time to Sing!

We know from Laura Gagné's recent Education Notes article in the February *Journal* (Gagné 2000) that the Kingston Centre is very active in public education. (Check out their web site: go to `www.rasc.ca` and click on `Kingston Centre.`) The Society established a national public education committee at the 1999 annual general meeting, and as a result there is now an education section for the RASC web site. One of the committee's objectives is to bring together and share with the entire membership the educational initiatives undertaken by all of the Society's Centres and members. What has your Centre been doing? What have you been doing? What types of activities have been the most successful? Tell the rest of the Society what you have been up to!

Here is an example from my own files. A fine arts teacher who wanted to engage several grades of elementary school classes in an activity with an astronomy and space theme contacted me. The intent was for the activity to be a type of "term project," so it had to be more than just a "hit and run" endeavour. It required several different levels of involvement because of the spread in age and grade level, and it needed to have an arts-and-crafts focus. I admit that I had to think about it for a couple of minutes, but this is what I outlined for her:

A large-scale (three metres across) astronomy and space diorama display. The background would be produced by the upper elementary grades and would involve research into painting and production of papier maché planets, asteroids, and meteoroids. Additionally, a large painting of the Milky Way Galaxy as a background scene was to be hung on the wall behind the diorama. The lower grades would produce colourful constellation figures to surround the diorama. All students would also use ordinary household items (styrofoam cups and balls, pipe cleaners, milk cartons, yogurt containers, popsicle sticks, construction paper, *etc.*) to create fanciful, imaginary aliens, space ships, planetary rovers, space stations, communications stations, and the like to fill the diorama. The base for the diorama was to be covered with sand (and perhaps even a coating of flour and cocoa) so that the papier maché meteoroids could be thrown forcefully (fun!) into it, creating impact craters and a "realistic" alien landscape upon which to build their space colony.

The teacher was thrilled with the scope that such an activity would have for creative expression, as well as for the ample opportunity it would provide for students to learn about the solar system, the stars, and the Galaxy. Additional benefits included the potential for team work, planning and organizing, problem solving, interaction between grade levels, and just plain fun that they would have building their imaginary planet.

3. Your Contributions, Please!

Now that I have given you something to think about, why not write something yourself for the *Journal's Education Notes*? Or, if that is not your style, scribble some notes and send them to the chairman of the Public Education Committee (his co-ordinates are at the end of this article). He would be happy to compile ideas, suggestions, reports, and anecdotes about educational activities carried out by RASC members, and to publish them in the *Education Notes* section.

Now is the time to contribute. School boards across Canada are implementing the new science curriculum, and there are thousands of teachers out there who will be looking for assistance as they tackle the new and foreign (to them) subject of astronomy in their classrooms (Whitehorne 2000). By putting our collective heads together, we can help each other to assist those teachers who will inevitably seek us out and ask for our assistance with their astronomy classes. Astronomy is going to be a part of almost every grade six and grade nine science class in Canada. Here is your chance to help make a difference in the classroom by contributing to the RASC's efforts to broaden the scope of astronomy education in Canada.

Articles intended for *Education Notes* can be submitted by electronic mail to the *Education Notes* editor, or individual success stories can be sent to:

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Chair, RASC Public Education Committee
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Toronto, Ontario, M6J 2T7
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Whitehorne, M. L. 2000, JRASC, 94, 130

MARY LOU WHITEHORNE is a relative newcomer to the RASC, having been a member for only sixteen years. Some years ago she committed the sin of becoming a Life Member, and so feels a degree of compulsion to carry out the RASC's motto of promoting astronomy and allied sciences. To that end she does a lot of work with Starlab *portable planetariums and with teacher workshops. She sometimes also sticks her paddle unbidden into RASC business at both the Centre and National levels.*

Society News/Nouvelles de la société

Submitted by Kim Hay, National Secretary (kimhay@kingston.net)

Even with the pilots' strike looming, many RASC members arrived in Winnipeg, Manitoba at the end of June for the 2000 General Assembly, which was hosted by the Winnipeg Centre. Congratulations to Jay Anderson (GA Committee Chair) and all the Winnipeg members who helped to make the 2000 General Assembly a great success. Over 120 members were present for the various meetings, talks, evening events and of course the finale, the Banquet.

The GA's Banquet held many special moments for everyone. Our Past President, Randy Attwood was presented with a plaque to show our appreciation to him for the work that he has done over the last two years as President of our Society, as well as a stone sculpture from the members of the Winnipeg Centre. Our new President is Dr. Bob Garrison, who was previously 1st Vice President.

Dr. Roy Bishop, who edited the last 19 issues of *The Observer's Handbook*, and who stepped down as Editor this year, was presented with a plaque on behalf of all the members of the RASC. The plaque, which was 50 × 60 cm in size, framed the first and last cover of *The Observer's Handbook*, the RASC Crest, and an inscription for Dr. Bishop's dedication and enthusiasm in editing the *Handbook* on behalf of the many members who have enjoyed it over the years. Our new *Observer's Handbook* Editor is Dr. Rajiv Gupta. Dr. Gupta is also the Society's 1st Vice President.

Dr. Dave Turner, who was the Editor of the *Journal* of the RASC for the past six years, also stepped down this year. He was also presented with a plaque, on behalf of all the members of the RASC, for his editorship and guidance of the *Journal* through many changes and improvements. The plaque, which was 50 × 60 cm in size, framed the first and last covers of the *Journal*, the RASC Crest, and an inscription of our thanks for a great job done over the years. The new Editor-in-Chief for the RASC *Journal* is Mr. Wayne Barkhouse.

I personally want to thank all the above gentlemen for their time, dedication, and wisdom over the years to guide the RASC in its current direction, and wish those new to their positions good luck for the future years.

For those who could not attend the 2000 General Assembly in Winnipeg, I hope that you all will be able to attend the 2001 General Assembly, which will be hosted by the London Centre in London, Ontario from June 29 to July 1, 2001. For more information on next year's General Assembly, please point your browsers to the RASC website, `www.rasc.ca`.

The Service Award, established in 1959, is a bronze medal presented to members who have performed outstanding service to a Centre or to the National Society. This year's recipient is Mr. Phil Johnson of the Calgary Centre. The Executive of the Calgary Centre sent the following letter to the National and the Awards Committees giving their reasons for nominating Mr. Johnson:

The Executive of the Calgary Centre is nominating Phil Johnson for the Service Award. Phil joined the club in 1988. Since that time he has made a significant contribution. He has been a behind-the-scenes volunteer who is always there if there is a job to be done.

Phil has sat on Council for ten years. In that time he has been to most, if not all, of the volunteer public education events. These include Astronomy Day, Zoonival, Saturn night, Caroline public education events, tours at the Wilson Coulee Observatory (WCO), and any special events at the Science Centre.

He is also one of the volunteers who is always there to help with any building projects. He helps with upkeep and installing new projects at the club's Wilson Coulee Observatory. These include helping to install the 14-inch Celestron Schmidt-Cassegrain at the WCO. He has always helped with the yearly upkeep on the WCO.

Phil has been one of the main people to help the Site Director get the C14 checked or fixed. He is now helping to install several radio dishes and computers so that a radio-observing program can be established at the WCO.

Phil has also been one of the people working on projects at the club's Eccles Ranch Observatory at Caroline, Alberta. This has been an ongoing project for over five years. Some of the items include helping build a 16 × 40 foot building, setting up two domes, ripping out fences and general maintenance on the site.

Phil has taken the time to build several battery-driven star trackers. Some he sells to individuals. Most of the star trackers he lends to people so that they can take astrophotographs without having to get into the massive telescope set-ups to do it. His star trackers have been around the world with people on many eclipse tours and vacation trips. Phil also runs the club's telescope building workshop. In fact, Phil initiated this program. He always built his own scopes and decided to help others build affordable scopes to use. Over the years at least 55 telescopes with apertures of up to 10 inches and three scopes with *apertures of 12.5 to 17.5 inches have passed through his hands. His wife Joan has been a great help by giving up their house over the winter for people to build their scopes in the living room.*

Joan Johnson approached the Calgary Centre to propose an art gallery showing of people's astrophotos and home-built telescopes. Phil has done all the work of assembling over 200 frames, hauling chairs, telescopes, pictures and running errands for this huge undertaking. The two of them have been at the show every day for three weeks straight. To make this show more interesting, Phil is building an eight-inch telescope at the gallery so that the general public can see how a scope gets built.

Also, for several years, Phil and another member, Gary Florence, took care of the magazine subscriptions. To receive the discount price for the magazines Sky and Telescope *and* Astronomy, *the entire club had to sign up for magazine subscriptions. Since not all of the club members wanted this, a separate astronomy club was set up for RASC members who wanted magazine subscriptions. Phil and Gary managed the new club and took care of all the subscriptions and all other administration.*

Thank you,
Carol Weis
President of the Calgary Centre.

As you can see by the above activities Mr. Johnson has undertaken in the years that he has been a member of the Calgary Centre, he has benefited both the Centre and the RASC itself. Congratulations Mr. Johnson on your award. You are an inspiration to all of us.

The Plaskett Medal, a joint award of the RASC and CASCA, consists of a gold medal, and is presented annually to the graduate from a Canadian university who is judged to have submitted the most outstanding Doctoral Thesis in astronomy and astrophysics in the preceding two years. In May, the Plaskett Medal was awarded to Dr. Alexei Razoumov (`www.astro.uiuc.edu/~razoumov`) from the University of British Columbia, who is currently at the Astronomy Department, University of Illinois in Urbana. Congratulations Dr. Razoumov on your award, and we in the RASC wish you luck with your future studies. At the time of the General Assembly, Dr. Razoumov was off to Tsukuba, Japan, to attend a meeting on galaxy formation.

Ballots & Proxies

In the April mailing of the *Journal/SkyNews*, every member received a ballot and a proxy form explaining what was going to be voted upon at the Annual Meeting held July 2, 2000 in Winnipeg, Manitoba. The first vote was for the 2nd Vice President position, in which we had two candidates, Peter Jedicke and Mary Lou Whitehorne. As a result of the ballot counting and checking by the two scrutineers (Bonnie Bird and Dr. Roy Bishop) approved at the 1st National Council meeting, the new 2nd Vice President of the RASC is Peter Jedicke. Peter is also the National Recorder and agreed to continue in that role until a candidate is selected by the Nominating Committee to fill that position.

The second vote was on the motion put forth by the Finance Committee that the current fees be increased by four dollars for regular memberships. The proposed increase was approved and the new membership fees are $40.00 for Regular, $25.00 for Youth and $800.00 for Life. These prices do not include any surcharges that individual Centres may apply. The September renewals will be mailed in August, with the balance to follow.

As a result of the third vote, it was approved that Tinkham & Associates will be the RASC's Auditor for the coming year.

Congratulations

At the first council meeting on June 30, 2000, the following members were recognized as having completed the requirements for the Messier Certificates: Brian White, Hamilton, Eric Brown, Ottawa, Lee Macdonald, Ottawa, Roland Prévost, Ottawa, Janice Tokar, Ottawa, Jose Ordenes, Sarnia, Ken Noesgaard, Saskatoon, Susan Sawyer-Beaulieu, Windsor, and Raymond J. Andrejowich, Winnipeg. Also on June 30, 2000, the following members were recognized as having completed the requirements for the NGC Certificates: Roland Prévost, Ottawa and Darrell Chatfield, Saskatoon. Congratulations to all the above members who have accomplished viewing these two lists of fine objects and have received their certificates.

The American Institute of Physics awarded RASC member Dan Falk its 1999 award for excellence in Science Writing in Physics and Astronomy (Broadcast Media) for his CBC Radio piece "From Empedocles to Einstein." Dan is the son of Mike Falk, Halifax Centre Librarian, and was a member of the Halifax Centre himself before leaving Halifax to study journalism at Ryerson College in Toronto. Congratulations Dan.

Just arrived from IAUC7468... SUPERNOVA 2000cy IN MCG +3-40-2 T. Puckett, Mountain Town, GA; and D. George, Ottawa, ON, report the discovery of an apparent supernova (mag 19.5) on an unfiltered CCD frame (limiting mag 20.5) taken with the Puckett Observatory 0.60-m automated supernova patrol telescope on July 26.11 UT. Congratulations Doug and Tim on your newest discovery. You may have noticed that in the June issue of the *Journal* Tim and Doug had reported SN 2000K, using images taken from the Puckett Observatory.

Get Well Wishes

Get well wishes to Geoff Gaherty of the Toronto Centre who is at home recovering from a kidney operation. Take care Geoff, our thoughts are with you.

Till next time, may the skies be clear and free of light pollution in your backyard.

GA 2000

Winnipeg:
The RASC General Assembly for 2000

by Phil McCausland, London Centre (pjam@julian.uwo.ca)

This year the RASC General Assembly (GA) took place in the "centre of the universe" — no, not Toronto, but in Winnipeg, the midpoint of (southern, populated) Canada. I can attest to the truth of it, because it took nearly 36 hours to travel by train to Winnipeg over the vast landscape from London, Ontario. At times I felt totally lost, so my final arrival on Friday afternoon at Union Station in downtown Winnipeg actually did feel like coming upon the centre of everything.

And there was much activity around — the area was in preparation for Saturday's celebration of Canada's birthday. Because it was marvelously sunny and warm outside, I considered ducking out of the station and down the track into the Forks, where all the action was. Fortunately I decided to explore the (cool, dry) Union Station instead, and was pleasantly met by Andora from the Winnipeg Centre at the main entrance!

After getting settled in at the University of Manitoba GA site at St. John's College, I began to meet friends I knew previously as well as a few new folks. That is really what GAs are all about: getting together with astronomy friends from across the RASC and beyond! Spectacular thunderheads were building and rolling in on the heavy evening air as we finished off the barbeque and headed over for the wine and cheese reception at the nearby golf club. After everyone had arrived, the weather broke with a fantastic downpour of pea-sized hail! As viewed by attendees from the covered balcony, sharp cloud-to-cloud lighting bolts could be seen popping off overhead and to the south every ten seconds or so. It was going to be a tough act to follow…

Friday night's wine and cheese party at the GA brought on the Murphy slide show and the song contest. On invitation, Michael Watson gave an excellent slide astrophoto presentation of his nebular, conjunctional, and "eclipsular" interests. He previously had given an Australian skies slide show at the 1986 Winnipeg GA. We saw some of those fabulous southern sky slides, too! Winnipeg Centre's Jay Anderson showed some awesome videos of local tornadoes in action, and mentioned in passing that the violent storm earlier in the evening had sported a wall cloud, just short of producing a funnel. Yikes! Some welcome!

I am sorry to say, with apologies to all concerned, that I cannot remember much of the following presentations (I swear it was not the wine), except for Randy Attwood's thrilling rocket launch videos as viewed from cameras on the rockets themselves. No, he was not launched into space (although he perhaps wished he had been!). Somewhere along the way, in a presentation by Richard Schmude, there were a lot of Tweety birds. I am serious! I only had two glasses of wine!! There were indeed many stuffed Tweety birds in a loosely astronomical theme, slide after slide of them until I began to wonder where "Murphy's Law" came in. By then I was distracted by events from outside — more furious blue flashes of another thunderstorm cell. Come to think of it, there were few actual "Murphy" slides shown by any of the presenters. Perhaps it is time to rename the event "Astronomical (Mis)adventures" or something of that type, to more fully reflect the true content of the evening.

Songs followed, to an electric light show and the irregular accompaniment of thunder. Kudos to the organizers! There were many songs, some new, some multimedia: Orla Aaquist of the Edmonton Centre singing "Contact" and other songs from his Web site, Winnipeg's Scott Young accompanying some of the groups on guitar, and of course some old favourites from Peter Jedicke and his choralers (KaBOOM! KaBOOM!). Orla won the contest, and performed an encore to much appreciation.

Back at the campus residence, the GA continued into the wee hours, as everyone prepared in their various ways for the coming day of papers. Early next morning, guest speaker Steve Edberg of the Jet Propulsion Laboratory, NASA, spoke on the diminishing distinction between asteroids and comets. The minor bodies of the solar system may well form a continuum of early solar system debris, in composition as well as in the range of interacting dynamical reservoirs, from orbits in the Oort cloud and Kuiper belt to the inner solar system.

The papers (I will not go into detail for all of them) were well-attended, and engaging. They were also punctual, with Jay Anderson (session chair) wolfishly ready to cut the throat of any speaker who went overtime! Unfortunately, the only speaker who went overtime was me, but my throat was saved by the fun topic (meteorite collecting on a frozen lake) and the nearness of lunch!

In the afternoon, CCD imager *extraordinaire* Don Parker gave an excellent talk on the value of amateur imaging of Mars. Amateurs are on the cusp (pun intended) of Arrestingly beautiful and useful Lunar and Planetary Observations. That is as close to a plug for ALPO as I will dare. Don Parker's talk was wonderfully shameless about, among other things, promoting the Association of Lunar and Planetary Observers, from which it is possible to find out much more about quality amateur observing, for pleasure and science!

Well, anyway, as the evening of Canada Day approached, we headed downtown by bus to The Forks for supper and the fireworks. Countless thousands of merrymakers and the outdoor performance of the Winnipeg Symphony Orchestra in the deepening twilight made the coming light show all the more special. And it was equal to the moment, with lit water cannon columns and excellent firework combinations, all while the orchestra played the theme from the 1999 Winnipeg Pan Am Games. It was one of the best Canada Days I have had! Even the bus ride back from the crowded downtown was fun.

Once again the GA carried on into the wee hours of the morning, on many topics not covered in the paper session… Next morning, I was not at the CCD paper session, so I cannot say much about it. Neither can Stan Runge, who slept in and unfortunately missed taping it! Now we will never know what happened. Maybe someone who was there and was not asleep can write about what transpired that morning, and let Stan and me off the hook! (Well, Phil, among other things you missed another spectacular talk by Don Parker — Ed.)

What would the RASC GA 2000 be without a General Assembly? "RASC 2000?" Okay, I will not pursue that thought, but suffice to say that no meeting of the General Assembly is complete without a General Assembly meeting. If you think you are confused, ask National Secretary Kim Hay about tallying proxy votes. Actually, she was very calm about it, and the General Assembly on Sunday afternoon was fun to participate in, as always. This year we welcomed two new Centres (Charlottetown and Moncton) as well as a membership fee increase. Well, welcome or not, there is a fee increase. There is also a newly-elected Executive Council, and new editors for the *Observer's Handbook* and the *Journal*. I urge you to find out more from your Centre representative (or become one); the RASC is an exciting, growing Society, and in the interest of astronomy we each have much to contribute!

During the later afternoon, I browsed the poster displays, and was most impressed by Vesna Zdjelar's well-presented exploration of starry skies in van Gogh's artworks; I have been attracted to them, sometimes wondering what the original starry view was like. Zdjelar's treatment was scholarly, both in finding likely dates for the paintings' inspirations from planetarium software and van Gogh's correspondences, as well as in examining the artist's manipulation of the celestial objects' positions and qualities to find better composition. I enjoyed that poster for quite awhile!

The incoming executive council of the RASC.
Front row from left to right: Rajiv Gupta, 1st Vice-president; Robert Garrison, President; and Peter Jedicke, 2nd Vice-president. *Back row from left to right*: Michael S.F. Watson, Treasurer; Bonnie Bird, Executive Secretary; and Kim Hay, Secretary.

With Sunday evening came the Winnipeg GA-ending banquet. Outgoing RASC President Randy Attwood presented framed first and last issues of the *Handbook* and *Journal* to their respective outgoing editors, Roy Bishop and Dave Turner. New RASC President Bob Garrison thanked Randy for his service to the Society over the last two years. There were much deserved honours all around! Representatives from the London Centre then gave a short presentation that was nonetheless of "monolithic" proportions, inviting all to gather in 2001 for the General Assembly in London. Everyone at the banquet went "ape" over it!

As befits a GA at the "centre of the universe," the final word was given to Wendy Freedman, who delivered the Helen Sawyer Hogg Lecture on her work determining the age of the universe. Over the last decade and a half she has led research using the *Hubble Space Telescope* to refine the Cepheid variable calibration for measuring extragalactic distances, in an effort to determine the Hubble constant, one of the factors essential to the description of the expanding universe's age and evolution. Her talk was wide-ranging and anecdotal, and was attended by a large public audience in addition to the GA participants.

Back at the residence, most everyone gathered for the Winnipeg 2000 GA's last hurrah. No motions were passed at this impromptu assembly, even though most of the Executive members were there and we had quorum to boot! Next morning there were many good-byes over breakfast, as everyone departed on the post-GA tour or otherwise left, taking memories of the excellent Winnipeg 2000 RASC GA with them.

Perhaps now you are curious about the RASC GA? Possibly you are a new RASC member or you have not been to a General Assembly previously. I assure you that it is more fun than I have been able to write about here. Perhaps you may just have to check it out for yourself. Make the time to come join your fellow RASC members at the 2001 GA in London, and to find out how much fun a General Assembly can be!

Phil McCausland, 30, comes from St. John's, lives in Windsor, and occasionally attends meetings of the London Centre, of which he is a member. When not collecting meteorites off a frozen lake or taking long train trips, he is getting ever closer to completing a Ph.D. in Geophysics at the University of Western Ontario.

National Council Report: 2000 General Assembly

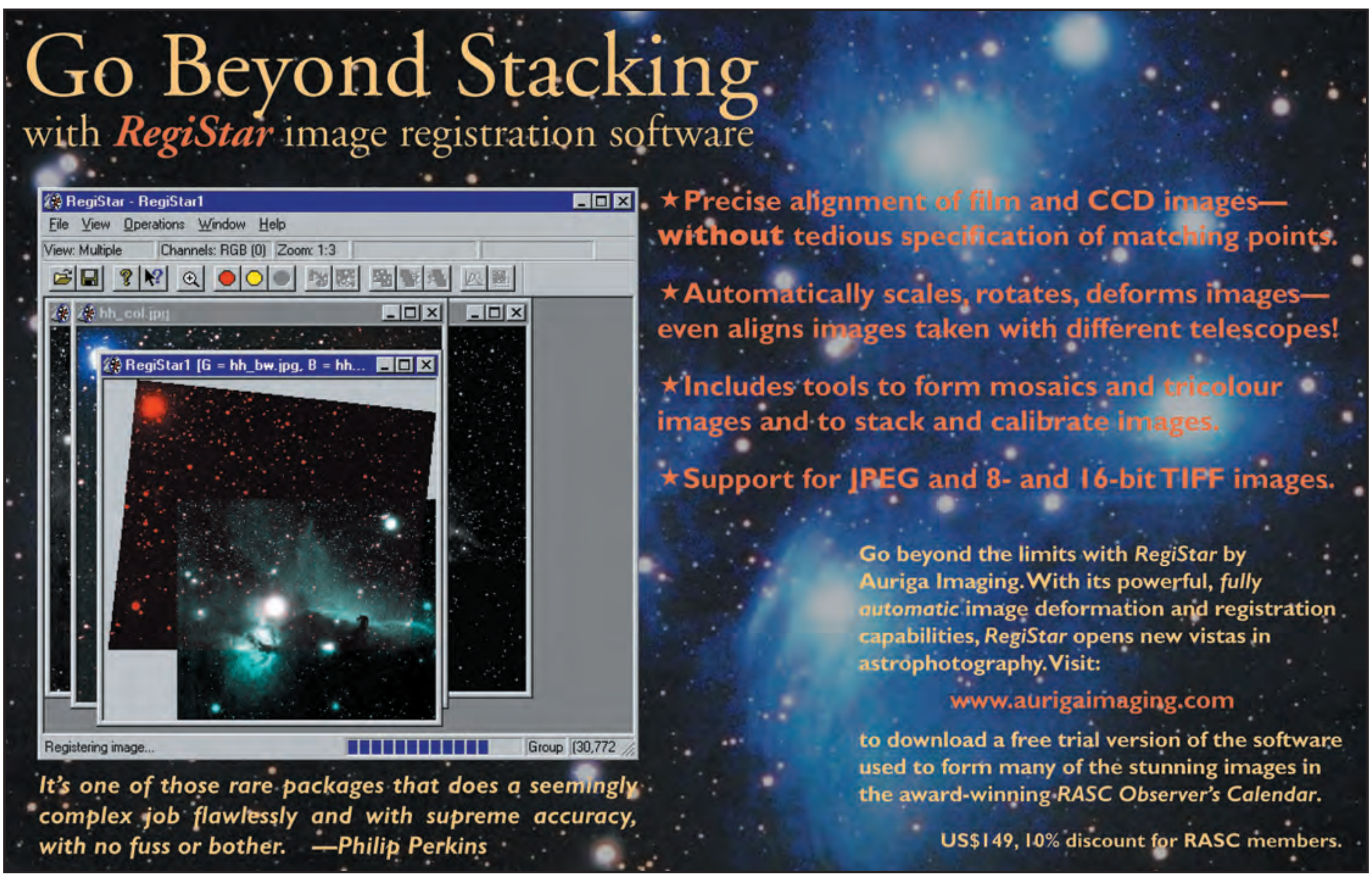
GA 2000

by Mary Lou Whitehorne, Halifax Centre Alternate Representative (whitehorne@stmarys.ca)

It was my pleasure to attend the 2000 General Assembly in Winnipeg as Alternate National Representative for the Halifax Centre, thus giving our hard working and multi-talented Dave Lane a bit of a respite.

Before I get into the events at the National Council meetings, I must first report that the Winnipeg Centre managed handily to maintain their well-deserved reputation for putting on a great GA. It was very well organized, ran smoothly, and rumour has it that there were some very productive "members' meetings" that ran well into the small hours on a couple of occasions. The meeting facilities were great, the paper sessions, talks, tours, and entertainment were delightful, and delegates were welcomed and treated like royalty. We were even treated to a spectacular electrical storm on one evening. That must have been the work of Jay Anderson! Thanks, Jay, it was great! However, Winnipeg Centre now runs a considerable risk with their present track record for hosting successful events, for they will be expected to do it again before too many years pass! My compliments and thanks go to all the organizers and

> **"…we have two new Centres of the Society: Moncton, N.B., and Charlottetown, P.E.I.! Congratulations to both new Centres and welcome to the RASC!"**



members of the Winnipeg Centre for their hard work, dedication, and great good cheer in hosting the Society for such a memorable General Assembly.

It goes without saying that National Council meetings can sometimes be long and tedious. This time they were held to schedule nicely and a lot of business was transacted. The agenda was quite full and everyone dug in so that we could wrap up in time to enjoy the festivities planned for later in the day.

The challenge that faces this reporter right now is how to reduce fifty or so pages of reports and notes to a column or two of easy reading for the interested member! For starters, every executive officer and committee chairperson submitted reports to the Council. Much of this material can be found published in the pages of the *Journal*, on the RASC web page (`www.rasc.ca`), in the *Annual Report*, or in the meticulously kept minutes of the National Recorder.

Several important items of business deserve mention here. First, we have two new Centres of the Society: Moncton, N.B., and Charlottetown, P.E.I.! Congratulations to both new Centres and welcome to the RASC! Halifax Centre has had close ties over the years with both groups and expects that, even though some Halifax Centre members will be lost to the new Centres, overall it will be a very good thing for everyone to have this kind of growth in the RASC. We in the Halifax Centre look forward to good things in the future with our two new neighbour Centres.

Another item of interest and importance is the increase in Society membership fees. The motion at the Annual Meeting passed with a very large majority, setting the Society on the path towards a more realistic fee structure that should support the present levels of service to members. The new fees become effective on September 1st, 2000.

There have also been significant changes to the composition of our National Executive. Randy Attwood completed his two-year term as President of the Society and he has now moved into the more relaxing post of Past President. Stepping into the top spot is Dr. Robert Garrison. Our First Vice President is Dr. Rajiv Gupta, who is also Editor of the RASC *Calendar* and the new Editor of our flagship publication, *The Observer's Handbook*. Obviously, Rajiv is a man of many talents (although maybe a little crazy to take on so many responsibilities) and we are very fortunate indeed to have his able assistance and expert guidance at our disposal. Second Vice President is the well-known and very enthusiastic and energetic Peter Jedicke of the London Centre. Peter is also the National Recorder for the time being, and with his presence on the National Council we can look forward to lively debates and entertaining Council meetings.

Other major changes occurred with respect to the Society publications. Roy Bishop has stepped down as *The Observer's Handbook* Editor, and as mentioned above, Rajiv Gupta has taken over that position. He is also the *Calendar* Editor and that position has changed status so that it is now an appointed office on National Council. The *Calendar* has become an important source of revenue for the RASC and with that in mind, $1500.00 has been dedicated to the production of a full colour brochure to promote the product and further increase sales and revenues.

Still with publications, Dave Turner is long overdue for a break and he has stepped down as Editor of the *Journal*. Wayne Barkhouse has volunteered to take up the reins and has already begun work on upcoming issues. Still with the *Journal*, its editorial structure is changing. Wayne Barkhouse is the new Editor-in-Chief, Dave Lane is the Production Manager, Dr. Doug Hube has agreed to become the Research Editor, and Michael Attas will be the Popular Editor. The hope is, to use an old cliche, that "many hands will make light work." The *Journal* is a huge amount of work and no one individual in their right mind should be expected to carry the entire load. In an effort to "catch up" from unavoidable delays and an overload of work, it was decided to combine the August and October issues for this year. Hopefully, with this combined issue and the new editorial structure in place, the *Journal* can return to and maintain its normal production schedule.

It is obvious from the committee reports that RASC members and special interest groups have been very active over the past year. Several members received membership and observing awards. The New Observing Certificates Committee is looking into a variety of options for observing programs to encourage new and not-so-new members to improve their observing skills. Anyone interested in contributing to this effort is encouraged to contact Chris Fleming, 6 Doulton Street, Apt. 3, London, ON, N5W 2P5. Phone (519) 453-9655.

Other items of interest include the fact that the updated RASC *Manual* will soon be available on the Society web site. Check it out, it is very handy information! You may also have noticed an insert in your June *Journal*. It has to do with CASCA (Canadian Astronomical Society/Societe Canadienne d'Astronomie) and government support of astronomy research in Canada over the next ten years. It included a sample letter that you might want to consider sending to your local MP in support of solid funding for astronomical research in Canada. If you cannot find it, go to `www.casca.ca` for more information. Sometimes even astronomers are obliged to become political! Speaking of CASCA, there is a proposal afoot that some sort of sharing arrangement be established between the RASC and CASCA regarding administrative duties. This is in the very early stages with no clear picture of what the final outcome might look like.

Lots and lots of other issues were discussed at National Council, from Presidential travel policy, to the costs of running the Society, to dates for future GAs, and the long term aims and goals of the RASC. Public education is an issue of increasing importance and the Public Education Committee is working to define a suitable role and reasonable objectives for the RASC in this matter. There is certainly room here for lots of collaboration between the RASC, CASCA, and other interested parties, especially since the new national science curriculum in Canada's schools contains a significant amount of astronomy.

The Society must also look after its

National Office property in Toronto, and the Property Committee has been very conscientious in the performance of its duties over the years. There is now a new tenant installed in the upstairs apartment and funding has been approved to look after the costs of new appliances, locks, and other routine maintenance.

I encourage everyone to keep abreast of what is happening in our Society by reading our publications, attending meetings, visiting our web site, reading minutes of Council meetings and the Annual Reports. Do not forget to ask your Centre Rep about what is going on!

The second National Council meeting at the GA occurred on July 2nd and saw the new Executive take its place. The composition of all of the National, Executive, Standing and Special Committees was confirmed. The next National Council meeting is scheduled for October in Toronto, and the next Annual General Assembly will be held over the July 1st long weekend at Fanshawe College in London, Ontario. See you there!

Mary Lou Whitehorne has been an active member of the Halifax Centre for more than a decade. Recently she has championed the cause to have bathroom facilities (Mary's Loo?) built at the centre's observatory in St. Croix. Mary Lou is usually successful at anything she puts her mind to, so by the time you read this that project will have been completed.

Using The Observer's Handbook

by John McDermott, Windsor Centre

One of the main benefits of membership in the Royal Astronomical Society of Canada is receiving the *Observer's Handbook*, which is issued annually by the National Office. The *Handbook* is an invaluable tool for those who wish to make the best use of all conceivable observing devices, from the unaided eye to binoculars and telescopes. It is also helpful for finding the locations of observatories and planetariums across Canada. The *Handbook* is recognized in Canada and around the world as a definitive source of astronomical information.

The *Observer's Handbook* is divided into sections, each devoted to a specific category of information. It also contains a Table of Contents at the front of the book and an Index at the back, the use of either of which will direct you to the appropriate section.

The following quiz is one I prepared for the Windsor Centre. Its purpose is not to test knowledge of astronomy, but rather to initiate use of the *Handbook* by members, since the answers to all questions are found in the *Handbook* itself (although I admit that some of the answers may be found more easily elsewhere). It is my hope that, by using the *Handbook* to answer the questions, readers will discover for themselves what a wealth of information it contains. Perhaps some will greatly increase their appreciation of this valuable guide.

Good luck and good observing!

John McDermott is a member of the Windsor Centre who, over the past five years, has made a project out of reading through The Observer's Handbook *to find items of interest to include in a quiz for Centre members.*

Observer's Handbook Quiz

1. Who was the editor of the *Observer's Handbook* from 1958 to 1970?

2. Who discovered Sinope (a satellite of Jupiter)?

3. What is the radius of the Sun?

4. In what year did the first flyby of Mercury occur?

5. What does the term "libration" mean in reference to the Moon?

6. What was peculiar about the sky on May 3rd and May 4th, 2000 (it has not occurred in 38 years)?

7. July 2000 was a busy month for eclipses. How many took place that month?

8. In what way does the orbit of Pluto in the year 2000 differ from that of 1999?

9. How many comets have been discovered by David Levy?

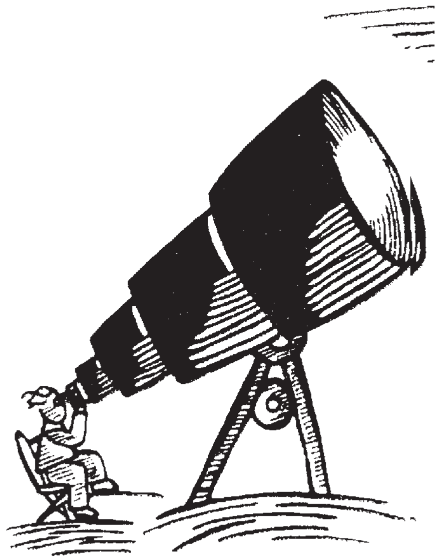
10. What is the common name for the constellation of Pavo?

11. What is a characteristic of semi-regular variables? Provide an example of one.

12. During which season is Messier 54 visible and in what constellation does it lie?

Answers found on page 204

Ask Gazer



Hello Gazer,

I see that you have chosen to perpetuate the old Ptolemaic 80-epicycle myth. Actually, of course, like all myths, this myth is not true. Owen Gingerich has had quite a bit to say on this subject. (See his book the Eye of Heaven, *p.197.) Actually, the question that is really interesting is what Kepler made of having two foci, but only one of them occupied. He was a fellow who placed a lot of stock in numerology, and I think it would have really bugged him that he had a "left-over" focus having no purpose.*

Walter Zukauskas
Dalhousie University Physics Department
Walter.Zukauskas@Dal.Ca

Dear Walter:

I received your letter several days after having been forwarded the letter from Owen Gingerich. Unfortunately, I was otherwise occupied and was unable to reply to the letter in the issue in which it appeared. On his first point, he is correct: the early models did not use circles centred on the Earth, or it would have been difficult to explain some features of the orbits of the Sun and Moon. I inadvertently oversimplified things while setting out the early belief in a geocentric model of the solar system. His second point is the same one that you raised: the Ptolemaic model did not have 80 epicycles, and that, in fact, the Copernican model used even more than the Ptolemaic. I have at hand ten relatively recent astronomy textbooks, and eight of them either do not go into that much detail about the Ptolemaic system or they give Dr. Gingerich's explanation, almost verbatim. One textbook mentions that the Ptolemaic system required "dozens of circles" while the final one gives the 80-epicycle explanation. Guess which one I consulted to make sure that I had it right?

His third point is also absolutely correct. I was referring to the approximate length of time from Kepler's childhood fascination with the planets until his discovery of the laws of planetary motion. I should have explained it more clearly, rather than making it sound as if he spent the entire time actually working on the calculations. That would have been an extreme case of single-minded determination! On his last point, "and he did not 'get the math wrong' when, at an earlier stage, he used an ellipse as an approximating figure," I can only quote the only source that I had: "He tried various oval-like curves, calculated away, made some arithmetical mistakes (which caused him at first to reject the correct answer) and months later, in some desperation tried the formula for an ellipse…" The source: *Cosmos* by Carl Sagan. Still, I do plan on getting a copy of *Eye of Heaven* and reading it. I am sure that it will be an interesting and informative read.

This issue of astronomical myths brings up the entire issue of whether it is now possible for people to stay up-to-date in all areas of a topic as broad as astronomy. There is so much information being generated that it is almost impossible to keep up with the new material, let alone try to keep up with changes to data that were considered fact in the past, and are now known to have been in error. It would appear that it is best to consult several sources and hope that if you do err, that someone corrects you quickly so that the myth will eventually be just that, a historical footnote. Thanks Dr. Gingerich!

Gazer is a member of the Halifax Centre who wishes to remain anonymous. Gazer's true identity is known only to past editors of Nova Notes, *the Halifax Centre's newsletter. Questions to Gazer should be sent to gazer@rasc.ca.*

Observe Planets Early

by Harry Pulley (hpulley@home.com)

To get a good view of Jupiter and Saturn before the cold weather arrives, you will have to stay up late or wake up early. Both planets rise not long after sunset this fall but do not reach a usable altitude until after midnight. Below thirty-five degrees of altitude the seeing is generally very poor. From after midnight to sunrise the gas giants are higher up, in a steady region of air.

Those not accustomed to observing planets in the morning may be in for a treat. In my experience of observing from southern Ontario the seeing is usually much steadier in the morning compared with the evening. The ground, driveways, and rooftops have finished cooling off, air conditioners are finished running, and the winds have died down. Such morning characteristics are conducive to excellent seeing conditions. The views of Saturn and Jupiter are astonishing, almost to the point of being unreal, when seen through such calm air.

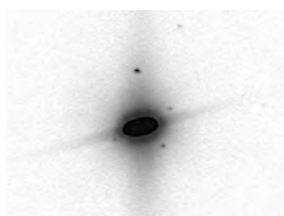
If you are going to stay up late or wake up early, you should take more than a thirty-second peek through the eyepiece. For a more involved observing session, try looking for, sketching, timing, and estimating the brightness of the interesting features of the gas giants.

Saturn

Saturn does not have the rapidly changing cloud belts of its larger sibling, but steady air gives it an appearance worthy of a very long look and of taking the time to make a sketch. Look for near and distant satellites, the shadows of the planet on the rings and vice versa, divisions in the rings including the dusky crepe ring, and even spokes within it (see Alan Whitman's December column, JRASC, 93, 282, 1999). On very rare occasions there will be variations in the cloud belts of Saturn large enough to be seen in small telescopes.

While Saturn's appearance does not change much over short periods of time, changes to the size, shape, and shading of belts and zones will occur throughout the season. Such changes are noticed easily if you sketch the planet regularly and estimate the brightness of the various belts.

Sketching Saturn and its rings freehand is often difficult because of the rings, even though you have a long time to sketch the mostly static image. The task is made easier through the use of



A recent image of Saturn, overexposing the planet to show all the satellites normally observable with amateur telescopes. It was taken on July 23rd at 7:27 UT. A 1-second exposure at f/9 using my Vixen 200-mm Catadioptric telescope with ST-5C CCD camera. The wide swaths away from the planet are diffraction spikes from the spider. The satellites are, clockwise from top, Titan, Iapetus, Dione, Rhea, and Tethys.

pre-made observing forms. You will need several of them to match different ring angles. This autumn the rings are more open than last year, angled at about twenty-three degrees.

If you are not interested in sketching, you can record objectively the shade of the belts and zones of the planet and the ring divisions using a scale ranging from zero for pure black to ten for pure white. To enhance contrast, I find that yellow and green filters work well on the ringed planet. I use #8 light yellow and #56 light green filters at high power or in small telescopes, and #12 and #15 yellow and #58 dark green ones at lower power and in larger telescopes.

The smaller satellites of Saturn are quite dim and can be difficult to see. With averted vision, a satellite will often pop into sight where it was invisible with direct vision. Make sure your optics are clean of dust, and try to prevent the build-up of dew, as small impediments greatly increase the scatter of light from Saturn, and finding satellites is hampered by any hazy glow. Use *The Observer's Handbook* to search the appropriate area for each satellite, and be careful not to be fooled by background stars. Sketching the moons several days in succession can help distinguish the satellites from the background stars. Do not use filters while searching for satellites. If convenient comparison stars are available, brightness estimates may be made of the satellites. This is especially interesting for Iapetus, which varies significantly in brightness (see *The Observer's Handbook* for predictions).

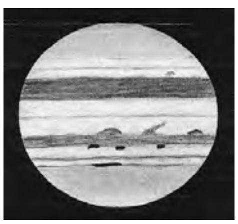
Jupiter

While Saturn is often called the showpiece of the sky, serious planet observers find Jupiter, the so-called King of the Planets, much more interesting with its constantly

A sketch of Jupiter with veiled southern equatorial belt, projection and festoon, plus temperate belts and polar zones (00:40UT October 29th, 1998, #23A and #8 filters, Vixen 200-mm Catadioptric, 186-225×). All sketches are by the author.

A sketch of Jupiter with tapered southern equatorial belt, multiple projections, festoons, barge, and interesting north polar details (03:27UT August 31st,1998, #82A and #12 filters, Vixen 200-mm Catadioptric, 186-225×).

changing cloud patterns. Look for belts, zones between the belts, dark and light spots, and streaks. Many planetary textbooks contain nomenclature identifying and classifying the different features. By sketching the planet you will notice both short term changes, since Jupiter rotates quickly, and long term changes, since the long term weather patterns change during



A sketch of Jupiter with equatorial belt, southern temperate belt, dark spot #1 which I was the first observer to report in June 1998, bars, projections, and festoon (09:50UT August 2nd, 1999, 6-inch dobsonian, 199-242×).

the apparition.

Like Saturn, Jupiter is not easy to sketch, but for the opposite reason. It turns so quickly, making a complete rotation in about nine hours and fifty-five minutes, that a sketch finished in more than ten minutes will not have all features recorded in their correct positions. The rotation of what is essentially a ball of gas also causes the equatorial region to bulge out. For that reason, the equatorial region completes a rotation approximately five minutes faster than the rest of the planet and makes it squashed in appearance rather than a perfect circle. That factor may be taken into account using prepared sketching blanks. Even a ten-minute full-disk sketch will not record weather details as accurately as one would like, but it does make for a good overview image.

In another drawing technique known as a strip sketch, the observer draws a vertical "strip" showing the middle portion of the planet every fifteen to thirty minutes. If one is dedicated, it is possible to view Jupiter for a whole night or a few successive nights to create a strip sketch that covers

A sketch of Jupiter with RSH, bar, projection, condensations, and my dark spot #1 again (08:55UT July 3rd, 1999, 6-inch dobsonian, 199-242×).

the entire atmosphere of the planet. With the aid of computer software, you can map the resulting sketch onto a three-dimensional sphere to create an interesting view of the drawing.

If sketching is not your thing, or you want even more accuracy, an even better way to record the position of details is to do transit timings. To record them, you watch Jupiter as a feature approaches the central meridian of the planet. The central meridian is the line of longitude that passes directly down the middle of the planet between the north and south poles. When a feature first touches the central meridian (CM), you record its preceding time; when it is centred on the CM, you record its transit time; and when it leaves the CM, you record its following time. An experienced observer can use the times to calculate a longitude that is accurate to within two degrees, sufficient to follow weather patterns on the gas giant. As with Saturn, objectively recording the brightness of features is also valuable.

To bring out the contrast in belt details, colour filters can be used. I usually employ the same yellow and green filters mentioned for Saturn above, plus the #82A light blue filter. To bring out particular red features, I use darker #38 and #80A blue filters. Red filters, #23 and #25, enhance the contrast of blue features against the rest of the globe.

The Galilean satellites are always interesting. You can see them moving about, sometimes going in front of or behind the planet or its shadow, or casting their shadows on the cloud tops. Again, consult *The Observer's Handbook* for predictions.

Take a moment to note the brightness, colour, and size of the satellites, and you will learn to identify them by appearance in a large enough telescope. I find it possible to do this using a 100-mm scope, and it should be easy using one with a 150-mm or larger aperture.

Eclipses of the satellites are occultations, and like those involving our own Moon, it is useful to time such eclipses. The timings may be used to determine accurately the position of the satellite. The timings were used to define the navigation program of the *Galileo* probe currently in orbit around Jupiter.

Hopefully, the above descriptions have provided ideas for your own planet-observing sessions, and have given you reasons to enjoy the morning observing hours.

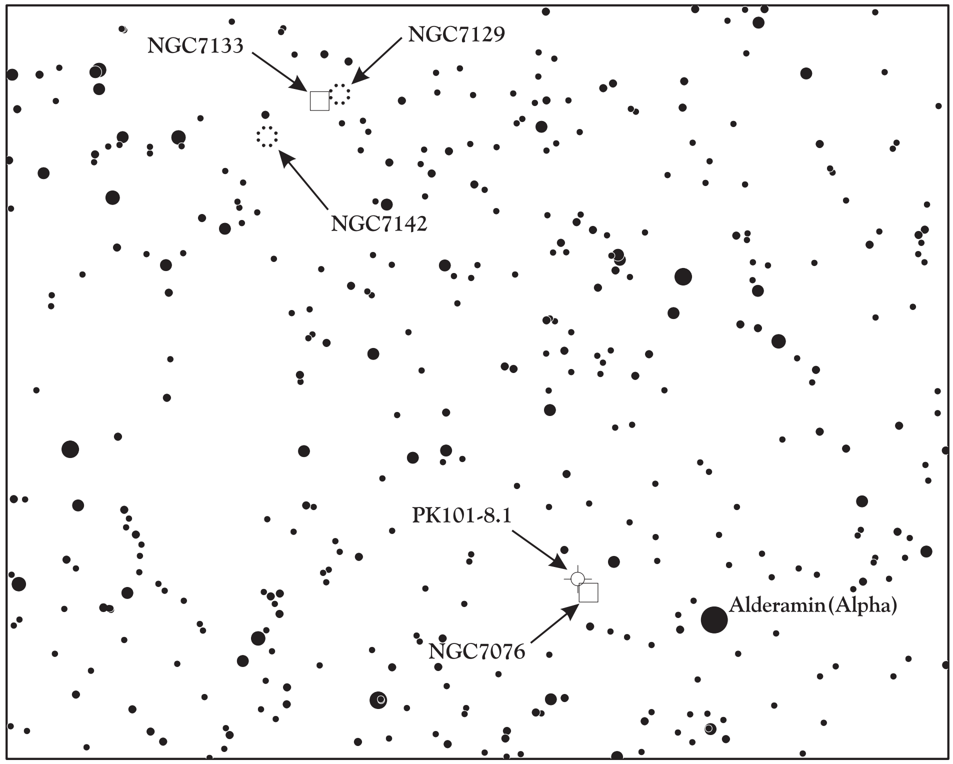
Harry Pulley lives in Guelph, Ontario. He is treasurer and past-editor of the Hamilton Centre . He is also acting co-ordinator of the Mercury Section of the Association of Lunar and Planetary Observers, and contributes observations to other sections. He loves to observe, sketch, and photograph all sorts of celestial objects, but solar system objects are his targets of long-term study. He has recently begun using a CCD camera.

Mysteries in Cepheus

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

Cepheus the King holds a dominating position high in the northern sky after sunset in early October, yet the constellation is often ignored in favour of its more illustrious neighbours, Cassiopeia to the east and Cygnus to its south. Why this should be has always puzzled me, as Cepheus is an interesting hunting ground for the amateur astronomer, containing a wide variety of deep-sky objects, from bright nebulae to remote galaxies. I fear that its lack of a bright Messier object is the reason why it is so often ignored, and unjustly so, for the pleasures of the King are subtle and there are mysteries here as well. Let us look at two.

On a pleasant evening in early September, my starting point was the bright star Alpha Cephei (Alderamin), which dominates the southwestern sector of the constellation. Chart 33 of *Uranometria 2000.0* indicated two deep-sky objects less than one degree east-northeast from that luminary: the "bright" nebula NGC 7076 and the planetary nebula PK101+8.1. I was particularly interested in NGC 7076, an object discovered by Sir William Herschel two centuries ago. The field was located easily enough. Two field stars, one of magnitude seven, the other of magnitude eight, lay just to the north of the two objects, which would aid greatly in identification. My lowest power eyepiece revealed the two stars though nothing else — not surprising when hunting for faint objects. Oftentimes objects are located only when higher power eyepieces, which increase contrast, are employed. When I switched to my 13-mm Nagler and examined the field I was initially disappointed. Nothing seemed to be visible. I slowly scanned around but nothing obvious could be seen. Then my attention was drawn to a faint, out-of-focus star, immediately south of two faint field stars.



A 5-degree high chart in Cepheus showing stars to about 9th magnitude (ECU Chart prepared by Dave Lane).

This must be it, I thought. I had one of the deep-sky objects, but which? I checked *Uranometria* to see how the two objects were plotted. PK101+8.1 was located immediately northeast of NGC7076. I would have to check to the northeast and the southwest of the object I had found.

Carefully scanning the field for several minutes failed to reveal the second object. My 7-mm Nagler was of no help and seemed to dim the object that I had been able to find. What was more disturbing was the fact that I seemed to have found the fainter object, PK101+8.1, judging by its position in relation to the two bright field stars. Also, its hazy, round glow certainly suggested that what I had was a planetary nebula. An error, perhaps, in *Uranometria*? A quick check of the atlas' companion volume, *The Deep Sky Field Guide*, quickly resolved the issue. NGC 7076 and PK101+8.1 were one and the same object, the correct location being the planetary nebula symbol on the *Uranometria* chart. Returning to the eyepiece revealed a third faint star to the north of the planetary. The nebula itself was a faint, poorly defined, small, round glow, much easier to see at 146× than at 272× when it occasionally appeared stellar. That was not the central star though; the catalogues quoted its magnitude at 17.2, far beyond the reach of my reflector.

Later that evening I chanced upon another intriguing field and a mystery that I feel I still have not fully resolved. About four degrees northeast from Alpha Cephei is a tight clutch of open clusters and associated nebulosity. The objects in question are NGC 7129, 7133, and 7142 which all lie within 30 arcminutes of each other. Locating the field with the 40-mm "finder" eyepiece revealed a beautiful sight. All three clusters appeared to be in the field of view. What I took to be NGC 7129 was a coarse cluster of stars from eighth to eleventh magnitude well separated from the sky background. NGC 7133 begged for higher power: several bright stars seemed to be bathed in a bright nebulosity. NGC 7142, the only object that it turned out I had correctly identified, was a beautiful round cluster of faint stardust; dozens of stars were individually resolved in my 15-inch reflector.

I made sketches of NGC 7129 and 7133 but already I was having doubts. NGC 7129 was discovered by Sir William Herschel but NGC 7133 was not uncovered until much later by the French astronomer Guillaume Bigourdan. In the references that I had available NGC 7129 was described as a cluster with nebulosity, but the bright, coarse cluster I had observed was very obviously nebula-free. If this was NGC 7129, how could Herschel possibly have missed NGC 7133, a bright nebulosity so close by?

After returning home I checked some references to clear up the mystery. The *Deep Space CCD Atlas: North* by John Vickers had an image of NGC 7129, which it identified as the bright nebula I thought was NGC 7133. In the caption was the following notation: "[NGC] 7133 is described as 'part of 7129', yet its position is a full frame east, where no nebulosity was detected." Next I checked *RealSky CD* which has a feature whereby fields can be called up by NGC number. When I requested the field for NGC 7129, the atlas presented a field immediately west of the bright nebulosity where nothing was visible. When I called up NGC 7133, the bright nebulosity was presented, albeit a little above the centre of the field. Next up was Skiff and Luginbuhl's *Observing Handbook and Catalogue of Deep Sky Objects*. This reference identified NGC 7129 as the bright, nebulous star group. As for NGC 7133, it was "...a few arcminutes NE... appears as a small, faint patch... extending to only 1 arcminute, and has a single star involved on its South side." *The Deep Sky Field Guide* to *Uranometria* seemed to concur, calling NGC 7129 "[a] reflection nebula enveloping a compact cluster." About NGC 7133, catalogued as a nebula, it said: "A faint star involved in the South part." When I examined the *RealSky CD* field surrounding the bright nebula I did indeed find an extremely faint nebulous patch involved with a faint star. The only problem is that the catalogues say that NGC 7133 is 3×3 arcminutes in size, and Skiff says it appears about one arc minute in diameter visually. The bright nebulosity is 7×7 arcminutes in size. If Bigourdan was able to observe this faint patch of nebulosity visually, it was an extraordinary observation on his part.

So where does that leave us? It would seem obvious that the bright nebulosity is indeed NGC 7129 and the object that Herschel observed. Could NGC 7133 be a re-observation of the same object many years later? This is certainly a possibility but Guillaume Bigourdan was a meticulous observer, certainly one of the late 19th century's finest, and it is unlikely that he would make such an error.

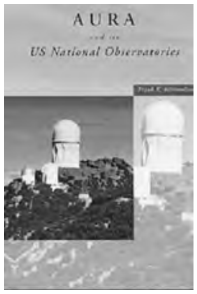
What of the coarse grouping of stars that I so easily mistook for an NGC object? An examination of Chart 33 from *Uranometria* shows that the four brightest members of the "cluster" are plotted as individual stars immediately southwest of NGC 7129. They, along with seven or eight fainter stars, formed an obvious grouping in a low power eyepiece. Do they form an actual cluster or is this the result of a chance alignment of stars in space?

We are indeed fortunate as amateur astronomers to have great printed resources easily available to us to help us pursue our hobby, but it is important to remember that no atlas or catalogue is perfect because the sources from which they are drawn are often imperfect. Many of the objects in the NGC and other catalogues have actually seldom been observed by anyone except their discoverers and not all astronomers were careful, meticulous observers. Errors happen and are sometimes perpetuated by researchers who do not adequately verify their sources. The further one goes in the pursuit of visual amateur astronomy, the more likely one is to be confronted by these errors or conflicts. Do not take the accuracy of your charts for granted!

If you are interested in this sort of thing and have Internet access, I highly recommend consulting the Web site of the NGC/IC Project. This is a collaboration between professional and advanced amateur astronomers whose stated goal is to verify and correct all errors found in the *New General Catalogue* and its extension, the *Index Catalogue*. There is a wealth of fascinating information here as well as identification charts taken from the Digitized Sky Survey. You can access the site at `www.ngcic.com.`

Happy hunting!

Mark Bratton, who is also a member of the Webb Society, has never met a deep sky object he did not like. He is one of the authors of Night Sky: An Explore Your World Handbook.



AURA and its U.S. National Observatories, by Frank K. Edmondson, pages 367 + xv, 25.5 cm × 18 cm, Cambridge University Press, 1997. Price US$80, hardcover (ISBN 0-521-55345-8).

My first scan through *AURA and its U.S. National Observatories* left me with the impression that it might be sub-titled as an autobiogaphy of the author. Frank Edmondson was closely associated with the founding of AURA (the Association of Universities for Research in Astronomy), and he certainly looms large in the text. The number of photos that include him does nothing to dispel that impression. Edmondson was a vice-president and later president of the Board of AURA that oversaw its early years, and he has a unique perspective of the organization's development. Reading the account of the growth of AURA and its subsequent choice by the U.S. National Science Foundation (NSF), and still later by NASA, to take over the operation of other facilities, suggests that his role deserves attention. One has to be impressed by the fact that the book was based on more than 90 interviews conducted by Edmondson of some 85 astronomers and science administrators, including Helen Sawyer Hogg; the individual comments of the interviewees are not generally obvious though.

This volume is an administrative history of AURA with little scientific content. The book's organization basically follows a time line, and the story is developed in five divisions: The beginnings, AURA is created, New directions for AURA, Cerro Tololo's neighbors, and Epilogue. The illustrations are primarily of individuals, including a few in which there are facilities or equipment in the background. AURA arose as a result of the creation of the NSF in 1950 and, in the wake of the success of the Hale 200-inch telescope, as a result of the eagerness of American astronomers to expand the number of large instruments at their disposal. The book is mostly devoted to optical facilities, but, in the early 1950s, the establishment of the National Radio Astronomy Observatory and National Astronomical Observatory were also issues predating and influencing AURA's establishment, which occurred in 1957. Eventually AURA expanded to include Kitt Peak National Observatory, Cerro Tololo Inter-American Observatory, Sacramento Peak Observatory, and finally the National Solar Observatory

There is little doubt that AURA's observatories, as well as the astronomers using their facilities, have had a major impact on astronomical progress in the last half of the 20th century. This volume provides historians with a more detailed view of the issues with which astronomers had to wrestle, written as it is by one of those closely associated with the institution's first decades. Here one encounters and discovers the roles played by many of the top astronomers of the mid-twentieth century — Victor Blanco, Geoffrey Burbidge, Art Code, Leo Goldberg, W. A. Hiltner, Geoffrey Keller, Nicholas Mayall, Alen Meinel, and C. D. Shane, to name a few. It was a period of unmatched expansion and growth in both optical astronomy and astronomical knowledge, and Edmondson is rather forthright in his presentation of the roles played by the various participants. He is not shy about noting problems with personalities or styles that had an impact on the way that AURA developed.

AURA's early space programme, called the Satellite Telescope Subcommittee, became active in 1959, less than two years after the launch of *Sputnik*. The ARPA programme, as it was called, did not come to fruition as hoped, but it did produce the Orbiting Astronomical Observatories (OAO), including successes like the *Copernicus* satellite, and was the conceptual beginning of the *Hubble Space Telescope* project — a very long story in itself, as we all know, and ultimately and arguably more important to the history of astronomical knowledge. Edmondson also includes chapters on the origin of the European Southern Observatory, early plans for South Africa, and the subsequent decision to share a site on Cerro Tololo with AURA's facility. Although Edmondson's account of AURA's activities ends in the mid-1980s, the last chapter, written by current AURA President, Goetz K. Oertel, attempts to look toward the future of AURA and its observatories.

The audience for the book is, I suspect, rather limited to those who have a specific interest in one of AURA's facilities or one of the key players. The narrow focus on the administrative history and development of AURA, though of interest to some, is primarily of value in that it provides a look into the forces that shaped an important and influential segment of American astronomy in a period of rapid expansion. One can envisage that the book, because of the very thorough documentation of events (over eighty pages of notes!), will become a primary reference for historians of science interested in the further analysis of astronomical endeavours since the 1950s.

Is there a Canadian connection to the book? Yes, in the sense that in the mid-1960s astronomers were debating the establishment of a national observatory for Canada loosely based on the AURA model. The Mount Kobau National Observatory was the result, but with development well under way, arguments between university-based astronomers and government astronomers gave Pierre Trudeau's government an excuse to cut the project in 1968. To date and over thirty years later, Canadian astronomers involved in the 4-metre Queen Elizabeth II Telescope are still reluctant to discuss the project's progress, limitations, and ultimate demise. It is time that someone told that story with the same forthrightness used by Edmondson in his story of AURA.

Randall Brooks

Randall Brooks is Curator of Physical Science and Space at the National Museum of Science and Technology. His primary interest is the development and role of instruments in scientific discovery.

The Elegant Universe, by Brian Greene, pages xiii + 448, 13 cm × 20.5 cm, Vintage Books, New York, 1999. Price $22.50, softcover (ISBN 0-375-70811-1).

For those with the talent for it, theoretical physics is something akin to a vigorous sport. Its symbols and abstractions, so mind-numbingly dry to the uninitiated, ripple with kinetic intensity once the elite of the game takes the field. We who must strain to follow the action from the sidelines are frequently treated to moves that appear as implausible as they are breathtaking. Yet they are not miracles and illusions but plays on the same reality that forms the ground beneath our feet.

Reality is not without its demands. As Brian Greene reminds us in *The Elegant Universe*, unless string theory "… accurately describes our universe, it will be no more relevant than an elaborate game of Dungeons and Dragons." That sobering reflection comes midway through a superb book, written as a non-technical introduction to the fundamentals of string theory. Despite the cautionary note, neither Greene nor anyone else working in string theory (or more correctly, M-theory) can say for sure whether it provides the definitive description of how the universe works. What Greene does achieve is a lucid account of a powerful but complex interpretation of nature, and a convincing argument for why it remains a course worth pursuing.

The first hundred pages or so of the book consist of a review of general relativity, quantum mechanics, and the irreconcilable differences that exist between the same two highly successful vehicles of modern physics. For fans of popular science literature, it is traditional fare, which Greene presents in a tried-and-true manner. But it is just an appetizer. Greene quickly moves from early to late 20th century physics, chronicling the rise and fall and rise of string theory as a means of unifying physics under one theoretical roof. It is science history hot off the press, including the pivotal developments in string theory, which occurred through the '80s and '90s.

In briefest terms, string theory replaces the dimensionless particles of quantum theory with one-dimensional closed loops (imagine a universe full of tiny rubber bands). Just as a guitar string can resonate at different harmonics or frequencies, the differences we perceive between various particles, such as quarks and electrons, are all attributed to strings vibrating in different modes. Heavier particles are made of strings that vibrate more energetically than the strings that make up lighter particles. As Greene demonstrates, the menagerie of particles currently required by the standard model of particle physics is well matched to the suite of allowable vibrational modes in string theory. Significantly, there is even a mode that corresponds to the graviton, the quantum of the gravitational force and the first milestone on the road to unifying relativity with quantum mechanics.

With such a promising beginning, Greene traces the further implications of string theory in a lively, conversational style. Among the most provocative outcomes is the realization that we live in a universe with ten spatial dimensions. Among them are the familiar three dimensions of daily life on a human scale. The rest are infinitesimally small, curled up into convoluted packages of space. (To picture how such micro and macro dimensions can co-exist, imagine a simpler case, in which space is an infinitely long, extremely narrow straw. Here, one dimension, defined by the length of the straw, is large-scale; a second dimension, defined by the straw's circumference, quickly turns back on itself and is microscopic.) To the uninitiated, resorting to unseen dimensions may seem like an act of theoretical desperation. Greene shows how the extra dimensions are a necessary by-product of string theory and how they naturally lead to some of the basic properties of particle matter, including mass and charge.

As inventive and accessible as Greene's explanations are (supplemented with a few well-conceived illustrations), by the midpoint of the book it is impossible to see string theory as anything but a work in progress. With each new revelation about the universe according to strings, more questions arise. Why are spatial dimensions not all macroscopic, instead of just three out of ten? Why are there no extra time dimensions as well? Greene readily admits, "If string theory is right we should eventually be able to extract the answer[s], but as yet our understanding of the theory is not refined enough to reach that goal."

But all is merely preamble to the most pressing question of all: Can there be an experimental test of string theory? To that Greene offers some tantalizing maybes, but definitive results are clearly a long way off. One reason is that a true test of string theory requires at least indirect access to the most extreme environments imaginable, such as black holes and the very early universe. With respect to the latter, recent developments in cosmology, including the revival of the cosmological constant and investigations into the nature of dark matter, could spell important implications for strings. For now, the business of string theory is still about exploring an extremely complex and disorienting mathematical domain. It is not about calculating numbers that can be checked in the lab — at least not yet.

It is the last point that sums up the good news/bad news story of string theory. While its promise as a decoder of nature is nothing short of intoxicating, its practice can easily induce mathematical hangovers. Certainly there is beauty in physics, just as there can be beauty in sports. Yet for all of us watching the unfolding theoretical game that Greene and his colleagues are playing, the book's title starts to seem disingenuous. How "elegant" can a universe be, when the equations are too scary for all but a handful of its inhabitants? The fact is that sports and physics are both often messy struggles — and no less compelling for being so. In the end our reality may not be the prettiest one imaginable, but for us it is the only game in town.

Ivan Semeniuk

Ivan Semeniuk is a science journalist and producer with Discovery Channel, Canada.

Our Cosmic Origins: From the Big Bang to the Emergence of Life and Intelligence, by Armand Delsemme, pages xix + 322, 16 cm × 24 cm, Cambridge University Press, 1998. Price US$24.95, hard cover (ISBN 0-521-62038-4).

"Where did I come from?" Every kid asks that question and, fortunately for science, so do some adults. Some even try to provide answers, as Armand Delsemme does in *Our Cosmic Origins*.

Delsemme has had a distinguished research career concentrating on comets and their role in bringing volatiles and organic molecules to Earth. It is a field with far-reaching implications. Beyond the astrochemistry lies the more fundamental question of whether comets aided the emergence of life on Earth by providing water and even the stuff of life itself.

In *Our Cosmic Origins* Delsemme looks at the question of origins from an enormously broad perspective. Beginning with the Big Bang, he traces the history of matter, from the birth of galaxies to the synthesis of the elements inside stars, and their key role as the raw material of planet formation. The progression leads naturally to the emergence of life on Earth and its subsequent history, including the development of intelligence. Finally, Delsemme considers the possibility of extraterrestrial life and prospects for the future.

The style is straight ahead and razor sharp, as Delsemme makes his case for the development of the components of our universe from large to small scale, simple to complex. Along the way we are treated to a feast of information on how time began or life developed. One does get the impression that the universe is exactly the way Delsemme describes it, however, since he rarely acknowledges alternative points of view. Our current knowledge is made to seem nearly complete.

While the early chapters on cosmology and astrophysics provide a reasonable overview of our understanding of those subjects, the author bogs down in the later chapters dealing with humanity. The section on the evolution of the brain is less than three pages long and cannot do justice to the subject. Information on the evolution of race is presented as fact, when much speculation actually remains. Delsemme suggests that "When different cultures confront each other on the scientific or industrial level, there is no harm if the best prevail…" But what is "best"? Who decides?

Delsemme makes the case for the natural and inevitable emergence of intelligence. Many people would agree that in an essentially infinite universe it would be odd if life did not arise elsewhere. But Stephen Jay Gould, for example, has sounded a cautionary note. Gould suggests that intelligence lies on just one of a huge number of evolutionary paths that life might follow. We may be rarer than we think.

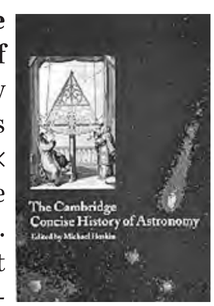
The book is dated or in error in a number of instances. On page 29 we are informed that "… NASA still hopes to launch the *Cassini* mission at the beginning of the twenty-first century." *Cassini* actually left Earth over two years ago. The discussion of the Martian meteorite is now dated and its interpretation is not as straightforward as Delsemme would like us to believe. The author then wonders where else in the solar system we might look for life. In his discussion he completely ignores Europa, suggesting that worlds with icepacks over liquid water provide only "far-fetched" possibilities. Delsemme also says that, based on deuterium/hydrogen ratios found for the planet, Venus once had an extensive ocean. That might be true, but he pays absolutely no heed to other reasons for the observed ratio, such as ongoing cometary impacts and volcanism.

There are many individual, interesting facts sprinkled throughout the early "cosmological" pages of this book. But since the writing is aimed at those advanced beyond the introductory astronomy level, much of the information will remain inaccessible for those relatively new to astronomy. Mine the early pages for their nuggets, but remain mindful of the oversimplifications.

Philip Mozel

Philip Mozel holds a B.Sc. in Microbiology. He has worked as a Producer/Educator at the McLaughlin Planetarium and taught school programs at the Royal Ontario Museum and Ontario Science Centre. He is a past National Librarian of the RASC. Most recently, in May, he completed a Bachelor of Education degree at York University.

The Cambridge Concise History of Astronomy, edited by Michael Hoskin, pages xiv + 362, 17.5 cm × 24.5 cm, Cambridge University Press, 1999. Price US$26.95, soft cover (ISBN 0-521-57600-8).



Editor and main contributor Michael Hoskin informs the reader in the opening pages that this work focuses mainly on Near Eastern and European astronomy. With that we are whisked through three thousand years of Mayan, Aztec, "Stonehengian," Babylonian, and Egyptian astronomy in a scant twenty-four pages of the first two chapters. Following that, Hoskin seems to be on more familiar territory with a leisurely presentation of the six centuries of philosophical groundwork laid down by Socrates, Plato, and Aristotle — the period of Greek and Roman Antiquity that started circa 600 BC and ended with the 150 AD publication of Ptolemy's *Almagest*. En route, several millennia of Chinese astronomy are dispatched in a short, one-and-a-half page inset.

After the *Almagest* and the collapse three hundred years later of the *Pax Romana*, chapter three picks up the "whistle-stop" pace again, compressing a thousand years of Islamic astronomical records compiled during Europe's Middle Ages into a ten-page synopsis. It ends with a seemingly luxurious five-page inset on astrolabes. Despite the editor's claim that Near Eastern and European astronomy are the focus of the book, the brief chapter on Islamic astronomy forms the bulk of the Near East content. After the Islamic sidebar, the history is almost entirely European. Not until the first important American contributions begin to appear in the nineteenth century do we leave Europe again.

Events leading up to and including (i) the Copernican revolution, (ii) the transformation of planetary astronomy from geometry to physics by pre-Renaissance and Renaissance giants like Brahe, Kepler, Galileo, and Descartes, and (iii) the crowning achievements of Newton and Newtonianism are fully detailed in chapters four, five, and six, respectively. The familiar stories of Copernicus' "death-bed" publication, Kepler's radicalism and deep interest in astrology, Galileo's recanting, and Newton's "war" with Hooke are all found here, with nothing new added to the folklore. Characterizing Kepler as "frank and open about his mistakes" though, and as one who "required his readers to share with him both triumphs and disappointments on the road to discovery," is reminiscent of modern-day NASA scientists living or dying with their highly-publicized successes and failures on recent Mars missions.

Notwithstanding its concentration on European astronomy, the book makes no mention of Giordano Bruno, the Italian philosopher and writer who, unlike Galileo, was burned at the stake in 1608 for not recanting his beliefs about Copernican theory and heliocentric worlds. Perhaps that is because, in the author's words, science is immensely more complex than simply "getting it right," an important theme of the book. "Normal science often consists in the gradual clarification and elaboration of what is at first confused," but Bruno, steeped in mysticism and magic, disdained scientific observation and mathematics, features that characterized the works of contemporaries like Kepler and Brahe. Yet it is ironic that Kepler's own work was recognized as being "conceptually suspect both in its mathematics and in its underlying physics." In some respects Kepler, who was as much of a mystic in his own right as Bruno, was also as "guilty" as Bruno of simply "getting it right." In his own lifetime he was fortunate to have had the safe confines of Tycho Brahe's castle in Denmark to flee to in 1600 during the Reformation. Had he not, he could just as easily have found himself in a predicament similar to that of Galileo or Bruno.

While the end of the "Newtonian" era in chapter six brings the reader to the mid-seventeenth century and the halfway point of the book, its second half is only two very long chapters. It is a dry, factual presentation, focusing less on individual characters and their achievements, and concentrating on cataloguing astronomy's last three hundred years. It highlights the important contributions to stellar astronomy, astrophysics, and cosmology from the work of meticulous, dedicated astronomers and scientists like Halley, Messier, Herschel, Hubble, and Baade, as well as a host of other lesser-known players. They form the front line of what Hoskin refers to as "the heroic saga of the hard-won rejection of the patently true in favour of the absurd." That is not a misprint.

A final short chapter provides only the briefest treatments of the great advances of the last half-century. Work on radio astronomy and other non-optical astronomical techniques, the discovery of pulsars, black holes, dwarf stars, novas, neutron stars, and other oddities of the universe are only briefly touched upon, while the newest and most exiting field of astronomy, extrasolar planet searches, is not mentioned at all. The few pages allotted to recent developments and the space-based astronomy of the *Hubble Space Telescope* and other spacecraft appear to be added as an afterthought without being integrated into the body of the text.

In the end, this concise history is a traditional work that takes us on a nostalgic, albeit selective, "journey," sporadically documenting classical astronomy's progress from the social and cultural activity it was in pre-history, to the period of Greek antiquity characterized by its great leaps of intuition, the flourishing of Islam during the millennium-long hiatus in Europe, and the Renaissance, Post-Renaissance and pre-modern eras. It stops well short of modern times.

The book is attractive, well-bound, well-written on quality, semi-gloss paper and very well illustrated with interesting photographs, lithographs, drawings, and sketches from various archives, including a page of raw observation data from Hubble's own notes. It shows a hand-drawn light-curve of a Cepheid in the Andromeda Nebula. Wide, two-inch, outer margins were found useful for lightly penciling in notes while reading, and only a few typographical errors were found. There are no equations in the book, but since it is promoted as a final-year undergraduate or first-year graduate text for students of astronomy, familiarity with basic physics and the science and techniques of astronomical observation is a prerequisite to enjoying the "journey."

Denis Legacey

Denis Legacey is a member of the Montreal Centre, an amateur astronomer, and an avid supporter of space exploration and development initiatives. He has worked for ten years as a *project leader in the simulator manufacturing industry, and is currently self-employed in project management consulting.*

The Solar Corona, by Leon Golub and Jay M. Pasachoff, pages xiv + 374, 17.5 cm × 25 cm, Cambridge University Press, 1997. Price US$39.95, soft cover (ISBN 0-521-48535-5).

It is deceptively easy to believe that the physical processes and models that have been developed over the last century to explain the creation and evolution of the Sun through collapsing clouds of gas, nuclear burning, the solar wind, and magnetism have been sufficiently well advanced that there is not much else of interest to discover. Reading *The Solar Corona* may convince you that nothing could be further from the truth and remind you of the old adage: the more you learn about something the more you realize how little you know.

Throughout the text the authors expertly explain the basic theories of solar corona generation and the dynamics of flux-tubes, sunspots, flares, the solar magnetic field, and solar wind, with well-written, easy-to-read prose, organized presentation of material, and reviews of the latest ideas. Comparisons with observational data are treated with as much importance as the theories themselves, and concepts that are key to understanding the theories are clarified with simple, illustrative models. They are backed up or finally dispelled with photographs and data from missions going back to *Skylab* (1973), and include *Helios 1* and *Helios 2* in 1974 and 1976, the *Solar Maximum Mission* (SMM) in 1980, Japan's *Yohkoh* in 1991, *Ulysses* in 1992, and *Soho* in 1995. Where time or space limit longer discussions, subjects are accompanied by numerous references both in the text and in an extensive list at the end.

The book opens with a brief introduction on how the solar corona is defined, and what its connection is with the solar magnetic field. It takes us through the early history of coronal studies that, until recently, could only be done during total solar eclipses. Some fairly technical sections on the physics of the electromagnetic spectrum, spectroscopy, the Bohr model of the atom, and plasma radiation precede attempts to explain the 22-year solar cycle, coronal structure, and magnetic field reversals through current dynamo theories. Surprisingly, "no true standard model exists."

A number of the models that were presented require fairly advanced mathematical techniques for their formal development, but those sections are highlighted with an asterisk. According to the authors they are at the end of a chapter and can be safely omitted in an introductory course. Since about twenty-five to thirty percent of the text was "asterisked," however, it might be advisable to read through those sections anyway, skipping some of the more complex formulas. There was usually enough important and useful physics information to be picked up between the paragraphs and lines of equations to justify reading them.

The book goes on to evaluate ground-based eclipse observations, radio-wavelength data, and coronagraph data in connection with known properties of plasma radiation and studies of flares. Space-based observations are covered in two chapters: (i) the first thirty years from about 1950 (when sounding rockets were used) until 1980, and (ii) the last twenty years. A chapter on activity in the inner corona separates them.

Notwithstanding the success of modern magnetohydrodynamics (MHD — a long section on ideal MHD theory is included), two major unresolved puzzles of solar physics remain. One involves explaining how the corona is heated to a temperature of millions of degrees Kelvin while the surface is only about six thousand degrees Kelvin. The other is to explain the wealth of fine structure exhibited in the corona. Current possible answers are discussed. The subjects of the final two chapters are solar and stellar flares, and solar-terrestrial physics, including the effects of coronal mass ejections on Earth. In summary, the book is intended as an "introduction to the physics of the solar corona" and serves that purpose well. Cgs (centimetre-gram-second) units are used on the whole throughout the text. Virtually anywhere that calculations were performed or that observational data and parameter values were inserted into equations to provide order-of-magnitude results and a sense of scale (a frequent occurrence), the units were usually clearly specified. In light of incidents like last year's loss of the *Mars Climate Orbiter* as a result of a mix-up in units, that would seem to be an important consideration.

Physically the book is a well-bound, well-written publication on quality, semi-gloss paper, with numerous well-labeled graphs, tables, and figures. Many recent and relevant photos (all black and white) from Earth-based and space-based instruments are used to illustrate concepts. Nothing seemed redundant in the sense of attractive, eye-catching, *Hubble Space Telescope* photos being used as filler. Wide, two-inch margins on the left-hand side were found useful for lightly penciling in notes while reading. Not surprisingly, the few typographical errors that were found were never spelling mistakes, but grammatical errors like typing "then" instead of "than," or "on" instead of "in" and vice versa. In the index several entries had incorrect page number references that were offset by at least a page. As for reference material, current addresses of relevant Web sites are included in the preface. Page xi has a full up-to-date listing including one for the list itself that is updated regularly on the Internet. It is at `http://www.astro.williams.edu/corona`. The Web site also has an errata page.

Denis Legacey

See previous.

Obituary
Nécrologie

Isabel K. Williamson
(1908–2000)

Occasionally it is fun to browse through old copies of Centre newsletters, for they often take us back into times long gone. The Montreal Centre's newsletter *Skyward* is an example. Since its inception in March 1948, the newsletter has documented the activities of one of the world's most active groups of amateur astronomers, the Montreal Centre of the Royal Astronomical Society of Canada. Isabel Williamson edited *Skyward* for some 22 years after that first issue, carefully including in every issue the events that had taken place at the Centre and the names of those who participated or contributed in some way. Miss Williamson always felt that it was of the highest importance to credit members in the newsletter, in the hope that they would continue and expand their love of the night sky.

When Miss Williamson died on Junend 2, 2000, at the age of 92, she left a huge legacy in at least two generations of Montrealers who have learned the night sky through her efforts and mentoring. Her teaching was direct and geared to each individual's needs. When I first walked into the Observatory behind Molson Stadium, to cite a personal example, Miss Williamson was the very first person I met. She greeted me with a big smile, and we began talking about my interest in astronomy. Before I even had a chance to sit down, she had presented me with a map of the Moon with a suggestion that I find all 326 lunar features on it, plotting each one on a map I would draw myself. That project would take the clear nights of the next two years.

Her ability to organize people in one activity or another is something that Isabel Williamson enjoyed throughout her life. It began, of necessity, with her own family. At the age of 16, while living on Upper Belmont Avenue (coincidentally, I grew up on the same street forty years later), she was awarded a scholarship to McGill University. Sadly, that same year one of her father's business partners defrauded the business, causing it to fail. Isabel and her sister Maude thus did not accept the scholarship, deciding to go to work instead. Years later, she bought her family a house on Belmore Avenue in the western part of Montreal. Around 1940, she discovered astronomy; the RASC would benefit from her enthusiasm and energy for the next 30 years.

As a new member to the Montreal Centre, I learned that the next Williamson project was the Centre's Messier Club. For me, it was an adventure that would last five years, from 1962 to 1967, and involved searching for, finding, and recording notes on all of the one-hundred plus objects in the catalogue of Charles Messier. That eighteenth century French comet hunter kept a list of objects around the sky that could be mistaken for comets, and today his list serves as an ideal introduction to distant clusters, nebulae, and galaxies of the sky. In the early 1940s, Miss Williamson started the first Messier Club, at least in North America. "Its main purpose," she wrote later in the Montreal Centre's history *Fifty Times Around the Sun,* "was to stimulate members into becoming active observers instead of being content to look through the telescope at objects that others had located." Today, the Messier Club has been copied both by the National Office of the Royal Astronomical Society of Canada as well as by the Astronomical League in the United States.

Meteor observing was Miss Williamson's other major interest, partly because the program made use of her great skill in organization. She began observing meteors around 1940, and by 1946 had acquired considerable experience. For the Draconid meteors that October 9th, she organized a team of 25 observers and recorders. Observing through specially built frames to reduce and standardize the amount of sky covered by each participant, the group counted 2888 meteors in three hours. Their site was located on the grounds of Lower Canada College, a historic private school on Montreal's west end. Some of Canada's most respected figures participated in that and several other meteor watches. Miss Williamson reported later in *Fifty Times Around the Sun* that Henry F. Hall, Dean of Sir George Williams University in Montreal and the man after whom the Hall Building in downtown Montreal was named, was stopped by police on his way home from a meteor watch. He was carrying his own deck chairs home from the observing site. "Where are you going with those chairs?" he was asked.

By the 1960s, meteor observing was a mainstay of the Centre's activities. Our most memorable night during that time was August 12/13, 1966, the night of the maximum for the Perseid shower that summer. Miss Williamson's lively account of that night appeared in *Skyward's* September 1966 issue:

> "There was the usual overcast sky when we left Montreal. (As one of the team remarked, we would not feel comfortable if the sky were clear when we left on one of those jaunts.) We drove through the usual rain shower. We arrived at our destination and determinedly went about setting up the equipment, trying to ignore the heavy clouds. We went indoors for the usual briefing. [Miss Williamson began each meteor shower night with a careful and extensive briefing of what each observer was expected to do and not do: 'No flash pictures or you will be shot at dawn!' She also told us about the 'Order of the Hole of the Doughnut,' awarded to observers who spot every hundredth meteor.] At 9:45 p.m. E.D.T. one or two stars were visible, and we decided to 'go through the motions' for the benefit of newer members of the team. Light rain was actually falling at 10 p.m. when we took up our observing positions, but a few stars were still visible. The first meteor was called within the first five minutes, and two more in the next five, which encouraged us to continue. Then the sky began to clear. By 11:30 p.m. there was not a cloud in the sky, and we enjoyed perfect observing conditions right through until dawn. In six hours of observation we recorded 906 meteors, thus breaking our record for all showers except the famous Giacobini-Zinner shower of 1946. It was a fantastic night."

Perhaps it is the Meteor Observations that led to Miss Williamson's greatest fame. The Giacobini-Zinner shower of 1946 led to Miss Williamson's receiving the Chant medal — the highest honour the Royal Astronomical Society of Canada can bestow on an amateur astronomer — on January 14th, 1949. From the citation printed in the *Journal* of March-April, 1949, pages 66–67:

> "Miss Williamson has been one of the mainstays of this Centre since she first joined the Society in 1941, and it is no exaggeration to say that the present flourishing condition of the Centre is due in large measure to the amazing amount of time, energy and enthusiasm she gives to our affairs. ... During 1948 the Centre commenced publication of a monthly mimeographed bulletin entitled *Skyward*, containing news items, announcements, and jottings regarding our activities. Miss Williamson voluntarily assumed editorship of this valuable paper, and now has the onerous job of collecting and editing the material, cutting the stencils, and attending to the mailing. With our membership of nearly 300, that is no small task. ... It is undoubtedly in the field of practical observations that Miss Williamson has made her greatest contribution to astronomy. Mainly because of her efforts, the Montreal Centre is making regular observations in several fields, to an extent unequalled by any amateur group in the Dominion. Her particular interests lie in the study of meteors and of the aurora. In that connection, Dr. Gartlein of Cornell University, leading authority on the aurora, has stated that her aurora reports have not been equalled by any group in a large city, while Dr. Millman has said that the meteor observations made under her direction, particularly the Giacobinid shower of 1946, provided the most valuable information obtained from any group, amateur or professional."

In the afterglow of her Chant Medal award, Miss Williamson became President of the Montreal Centre, a position she held from 1950 to 1952. From 1957 to 1964 she was Assistant Director of Observations, and Director of Observational Activities from 1964 to 1968. As part of her work, she designed observing forms to guide observers into making careful observations in several different branches of observing. Over the years she also served as Recording Secretary (1942–1950), and Librarian (1954–1957.) The details of running a Centre did not escape Miss Williamson. She was also very fond of Obadiah, the Observatory piggy bank — actually there were two Obadiahs always ready to accept small donations from people on their way in or out of the observatory. I always enjoyed reading her little "Observatory Pig goes Shopping" articles in *Skyward*.

In late 1965, Miss Williamson introduced me to a new book she had just purchased for the Centre's library. Written by the comet hunter Leslie Peltier, it was called *Starlight Nights*. I was captivated by that book, and forever thank her for showing me its quiet wisdom and spirituality. A spiritual person herself, Miss Williamson understood the importance of going beyond equations, and around 1970 she decided to cut back on her activities at the Centre and in astronomy. She did, however, continue her lifelong activity with St. Andrew's Dominion Douglas Church located a few blocks from her childhood home.

Although her activity with the Centre stopped, she occasionally visited the Centre's Observatory in recent years. In 1982, the Society's Service Award, long overdue, was presented to her. "In over 30 years of active membership in the Montreal Centre," the citation read (see the October 1981 issue of the *Journal*, page 265), "Miss Williamson was almost solely responsible for its evolution into one of the liveliest groups in North America. By involving a large number of Centre members as chairmen of various observing areas, and by giving us roles of responsibility for observational data, Miss Williamson created an atmosphere of purpose in which every interested member could play some useful role. ... For over 30 years the Montreal Centre was blessed with the enthusiasm and capable direction of Isabel Williamson. Those of us who were raised under her stewardship, and who shared the fondest memories of her work at the observatory, are deeply moved and honoured to nominate her for the Service Award." The 1980s also saw the naming of the Centre's Observatory "The Isabel K. Williamson Observatory."

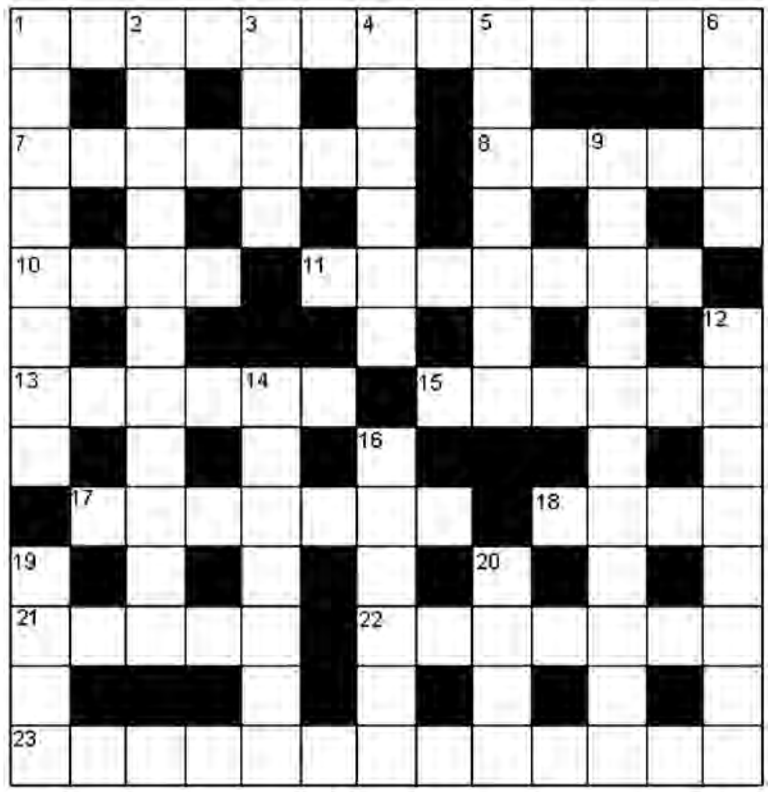
Over the years I maintained contact with Miss Williamson, visiting her during my trips home to Montreal. About two months ago I telephoned to tell her that the long out-of-print *Starlight Nights* was in publication again, and offered to send her a copy. She was delighted that the book had such an impact on me, as much of an impact on my astronomical career as did Miss Williamson herself. But she also told me that she was getting very weak and tired, and was often unable to answer the phone. That was the last time I spoke with her.

There are few people who have had so much influence on astronomy, and astronomers as Miss Williamson had in Montreal. We have lost a precious resource and most enthusiastic astronomer who, by teaching and by example, told us how astronomy should be done.

David H. Levy

Astrocryptic #8

by Curt Nason, Halifax Centre



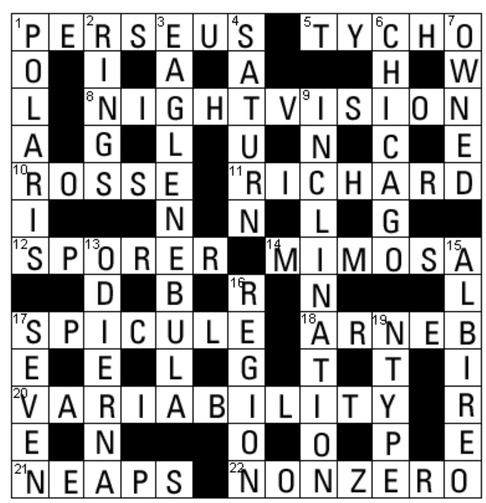
ACROSS

1. Filter developed by one with a halogen ray PhD (8,5)
7. Start the Mars mission by turning half the filter to fast forward (7)
8. Lager disrupted my observing, as did the reflected light (5)
10. Aurora had no choice but to leave a halo (4)
11. Ten is returning from endless hell after its launch in 1974 (6,1)
13. Sagittarius cited in listing of research errata (6)
15. As the Fates would have it, I misread a recap of their tale (6)
17. Televises part of the *Hipparcos* results from a dirigible (7)
18. Damages a planet (4)
21. Lowell thought he saw it in the Farmers' American Almanac (5)
22. Mama in one division of the rings (7)
23. Make nine trains out of beta decay emissions (13)

DOWN

1. Helium and lithium release half a calorie at the first rising of Sirius (8)
2. Those light patterns are really grating on my nerves (11)
3. Cygnus species seen in splendid colors (4)
4. Oculars give self-reflection after finishing a beer (6)
5. Leo's second shiner resembles a bagel I ate (7)
6. Lines of rotation in parallax estimates (4)
9. Nova Scotia is on a group of young stars (11)
12. Disperse the meteors (8)
14. Fifth Greek to have planets in Great Sky River (7)
16. Part of ICBM is coursing to land in the Gulf of St. Lawrence (6)
19. Recorded proceedings from attempt to contact aliens (4)
20. Computer operator returns in rare supernova event (4).

The answers to last issue's puzzle



Answers to *The Observer's Handbook* Quiz

1. Ruth Northcott. (p. 5)
2. S. Nicholson, 1914. (p. 19)
3. 696,265 km. (p. 25)
4. 1974 by Mariner 10. (p. 28)
5. It is the apparent rocking motion of the Moon as it orbits around Earth. (p. 56)
6. There were no solar system bodies visible to the unaided eye in a dark sky. (p. 67)
7. Three. (p. 117)
8. It was closer to the Sun than Neptune from 1980 to 1999, and is now farther from the Sun than Neptune once again. (p. 174)
9. Twenty-one (at last count). (p. 213)
10. The Peacock. (p. 217)
11. Semi-regular variables exhibit appreciable periodicity in their light variations, accompanied by intervals of irregular light variation. An example is R Ursae Minoris. (p. 241)
12. The Summer Sky, and it is located in Sagittarius. (p. 258)

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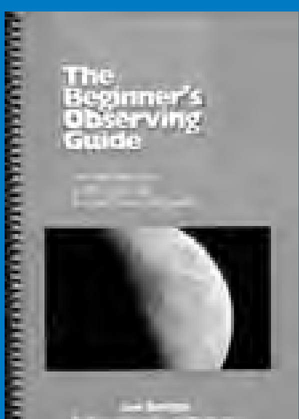
Observer's Calendar — 2001

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.

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. The 1998, 1999, and 2000 editions each won the Best Calendar Award from the Ontario Printing and Imaging Association (designed and produced by Rajiv Gupta).

Price: $14.95 (members); $16.95 (non-members)
(includes taxes, postage and handling)



The Beginner's Observing Guide

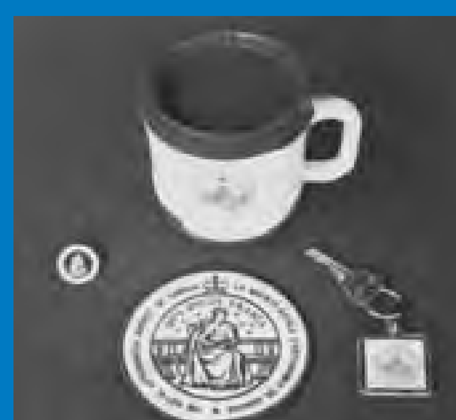
This guide is for anyone with little or no experience in observing the night sky. Large, easy to read star maps are provided to acquaint the reader with the constellations and bright stars. Basic information on observing the moon, planets and eclipses through the year 2005 is provided. There is also 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 otabinding which allows the book to lie flat).

Price: $15 (includes taxes, postage and handling)

Promotional Items

The RASC has many fine promotional items that sport the National Seal. Prices include postage and taxes. Included are a *Cloth Crest* (size 11cm with the background white and the stitching in royal blue - $11), *Lapel pins* (blue, white, and silver - $5), *Golf shirts* (white, available in small and medium - $24), *Stickers* (size 7.5cm, blue with white overlay - $1 each or 2 for $1.50), *Thermal mugs* (in blue and white - $5.50), *Toques* (Black with Yellow lettering - $17), *Key chains* (Clear arcylic and Blue/white - $2.50).



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