February/février 2002 Volume/volume 96 Number/numéro 1 [692]

Journal

The Journal of the Royal Astronomical Society of Canada Le Journal de la Société royale d'astronomie du Canada

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February/février 2002

Journal

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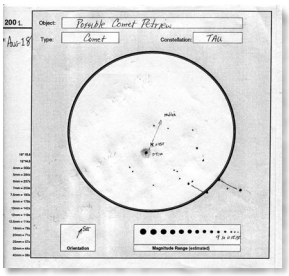

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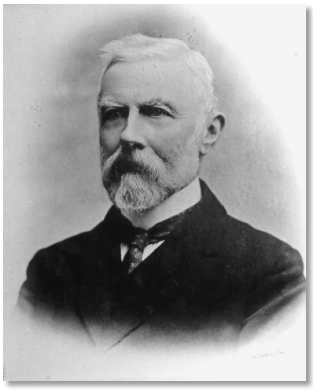

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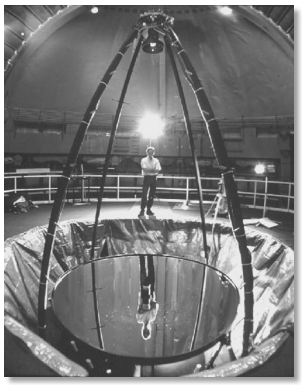

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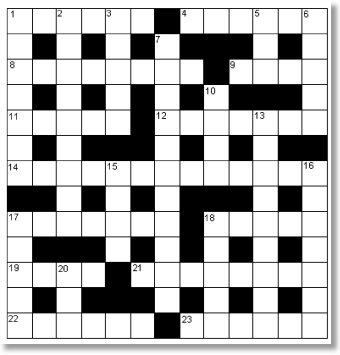

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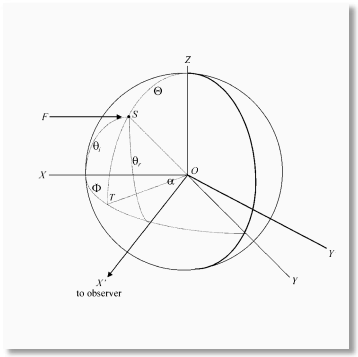

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President's Corner

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

I'm writing this month's column from a mountaintop in west-central Argentina. Located just on the other side of the Andes from La Serena, Chile, this is the new home for the Helen Sawyer Hogg Telescope (HSHT, affectionately referred to as, simply, "Helen").

Construction of the building is progressing well, though considerably behind the original schedule. It is obvious that we were overly optimistic, especially considering that everything is being done in-house. Building a seven-kilometre road to 2650 metres altitude through very rocky terrain was also a challenge. However, the building will be a fine one, with several significant improvements over the Chilean incarnation.

1) The building is round, to within much smaller errors than the Chile version, so there should be much less of a tendency for the dome to stick in certain inconvenient positions.
2) The building is much higher than before (essentially adding a middle floor), putting the telescope further from the thermals and thus minimizing poor seeing.
3) A dozen or so huge ventilation windows have been installed in the walls of the upper two levels, imitating the designs of the new generation of very large telescopes.
4) Since the nearest toilet will be 7 km away, it seemed prudent to add one, though it will be unheated.
5) An unheated control room will be useful in the early stages of semi-remote observing.

There is still a lot to be done, but the Argentine engineers and technicians are impressively competent, so they may well finish by their new deadline of the end of summer (though whose summer was not specified).

So, all that is very interesting, but what has it to do with the RASC? In several of my writings and lectures, I have claimed to be in favor of more interaction and cooperation among amateurs and professionals. I have also said many times that there is an incredible amount of talent in our society. If we put these two comments together with the above status report, some interesting possibilities begin to emerge.

I see at least two major possibilities for cooperation. One involves the non-astronomical talents that may be needed in the design and construction of buildings or instruments or computer programs or.... The other involves observing time for experienced amateurs on a fine telescope like Helen, a well-equipped telescope at a good site.

When the HSHT was located in Chile, there occasionally were a few free nights when travel schedules didn't quite mesh or when the Resident Astronomer wasn't available, but there weren't enough nights to justify a special trip. I knew some very

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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Printing
MacNab Printers Ltd.

The *Journal of The Royal Astronomical Society of Canada* is published at an annual subscription rate of $80.00 by The Royal Astronomical Society of Canada. Membership, which includes the publications (for personal use), is open to anyone interested in astronomy. Annual fees for 2002, $44.00; life membership is $880. Applications for subscriptions to the *Journal* or membership in the RASC, and information on how to acquire back issues of the *Journal* can be obtained from:

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

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

U.S. POSTMASTER: Send address changes to IMS of NY, P.O. Box 1518, Champlain, NY 12919.
U.S. Periodicals Registration Number 010-751.
Periodicals postage paid at Champlain, NY and additional mailing offices.

 ISSN 0035-872X

competent amateurs in La Serena who would make good use of the telescope even on short notice, so while they were usually not on the schedule, they did get to observe.

One of the smartest things I ever did in this regard was to give a few such nights to Alan Dyer and Terry Dickinson, who used them to take a series of absolutely gorgeous colour photographs, which have since appeared in several books and magazines.

Though observatories and university astronomy departments are not hiring many these days, there are some vacancies to be filled. While they certainly don't pay top dollar, the level of job satisfaction is high and talent is appreciated. Often the job description evolves with time to include newly learned skills. About fifteen years ago, I hired a young RASC librarian as a file clerk because he said he enjoyed that kind of work. Eventually, he learned valuable computer skills and became a full staff member, helping me to run the Chile telescope as well as writing programs, reducing data, and much more. Also, we recently hired a very active RASC member as telescope operator for the DDO 74-inch telescope and she seems very pleased at her good fortune. So, there are astronomy jobs out there if you are in the right place at the right time with the right skills.

During my whirlwind tour of RASC centres, I've seen some good domes and have seen or heard of some instruments that professionals would like to use. A good dome and building can make a great difference in the relative success of a telescope. There are precious few really well designed domes for small telescopes, either amateur or professional. Of course we're always in need of good computer programs like *Starry Night*. The Ottawa Centre has been particularly successful at integrating their love of astronomy with their businesses. The question, of course, is how to facilitate the exchange of ideas and the meeting of minds. That is part of what the General Assembly and the centre meetings are all about.

With our Web site, eStore, RASCals list, *etc.*, the need for computer expertise is endless. So, get involved, get acquainted with your local astronomers, get going, and enjoy it all. It is said that the reward is in the doing, and I believe it.

Editorial

by Wayne Barkhouse, Editor-in-Chief (barkhous@astro.utoronto.ca)

December 10, 2001, may go down in Canadian astronomical history as the beginning of a new "golden age" in Canadian astronomy. On that date, the culmination of several years of hard work by numerous people in science and industry (both professional and amateur) reached an important cross-roads with the release of the Federal Budget 2001. Hope for approval of the Long Range Plan (LRP) in Astronomy was on the line. The events of September 11, 2001 and the downturn in the economy, made for a degree of uncertainty in whether the Federal Government would be willing to provide the necessary seed money to help ensure Canada's participation in several key projects highlighted in the LRP.

Given below is an update on the status of the LRP since the announcement of the Budget on December 10, 2001. The following e-mail has been reproduced here with the kind permission of Russ Taylor (University of Calgary), President of CASCA.

Dear colleagues,

Many of us watched the announcement of the December 10 Budget with anticipation and expectation for Canadian astronomy. While the Long Range Plan for Astronomy was not explicitly listed in the Budget, there is nonetheless good news for astronomy in Canada. I am very pleased to announce that in the context of the budget announcements, the National Research Council is now reassigning priorities in order to move forward on critical elements of the LRP.

As outlined in ta letter to me below from Jacques Lyrette, Vice-President, Technology and Industry Support at NRC, we expect to make substantial progress this year in implementing the Plan. In particular, NRC expects to identify resources to complement the CFI proposal for the North American Program for Radio Astronomy — the agreement which secures Canadian participation in the Atacama Large Millimetre Array project — and to fully initiate research and development projects for the next generation of world observatories, the Large Optical Telescope and the Square Kilometre Array and Canadian Large Adaptive Reflector.

We will need to continue to press for government funding to complete these projects and secure access to the facilities for the long term. However, the LRP is launched, and we have reached an important turning point in Canadian astronomy for the next decade. The lobbying effort of the Canadian Coalition for Astronomy has raised the profile of astronomy in government to a very high level. Specific strong recommendations from the House of Commons Standing Committees on Industry and Finance support the Long Range Plan. The Minister of Industry has stated publicly that he will champion the LRP at the Federal Cabinet, and we expect this to result in the LRP being adopted as the approved policy of the government.

Through the commitment and efforts of the National Research Council, the Canadian Long Range Plan for Astronomy is alive despite the budget setbacks resulting from the horrific events of September 11. We have made great strides, but we are still short of the full amount required to continue the future development projects of the LRP beyond the next few years. Much remains to be done. We plan to continue the lobbying effort of the Canadian Coalition for Astronomy and continue to engage the government on the LRP. In early January I will be meeting with Minister Anne McLellan as the first step in the renewed campaign.

Thanks are due to many individuals and organizations in bringing the LRP to this successful waypoint.

We must acknowledge the continuing efforts of the National Research Council, particularly NRC's President, Dr. Arthur Carty, and NRC's Herzberg Institute of Astrophysics, the organization responsible for astronomical observatories in Canada.

Although the battle is not over, this is a great initial success for our community and was truly a team effort. The Long Range Plan was developed under the guidance of the Long Range Planning Panel, ably chaired by Ralph Pudritz. Many colleagues across Canada lent their time and energy to the campaign by writing letters and contacting local Members of Parliament. I would like to extend my thanks both on behalf of CASCA, and personally.

In our continuing efforts to obtain incremental funding for the LRP, we in the astronomical community also owe a debt of gratitude to the Cabinet Ministers and Members of Parliament who share our vision and support and champion the LRP. For the support garnered at the Industry, Science and Technology Committee and the Finance Committee, we are indebted to several key Members of Parliament. Maurizio Bevilacqua, (Chair of the Finance Committee) Susan Whelan, (Chair of the Industry, Science and Technology Committee), Mauril Belanger, Paddy Torsney, Marlene Jennings, James Rajotte, Tony Valeri (chair of the Liberal Economy Caucus).

The Honourable Gilbert Normand (Secretary of State for Science and Research), the Honourable Jim Peterson and the Honourable Ron Duhamel, pressed the issue of astronomy with the Minister of Industry and the Minister

of Finance on our behalf. And, of course, special thanks to Minister of Finance, the Honourable Paul Martin, who personally told me that he supports the LRP not only because of its economic benefits, but also because of his personal appreciation of the quest for knowledge and understanding of the nature of our Universe, and to the Minister of Industry, the Honourable Brian Tobin.

I would like to thank Temple Scott Associates (TSA) for their strategic advice, and for coordinating our lobby effort. Finally I would like to acknowledge the important contribution of Amec Inc. Peter Janson, CEO and Chair of Amec, not only participated directly in the key presentations to the Industry and Finance committees, but also provided the expertise of TSA.

Russ Taylor
President, CASCA

Correspondence
Correspondance

Markov 1

Dear Sir,

This letter is prompted by an article by Paul Markov which appeared in the August 2001 volume of the *JRASC*, 165, p. 2.

There has been an unfortunate misunderstanding about the "Registry of New Acronyms" (`vizier.u-strasbg.fr/viz-bin/DicForm`) operated by Working Group Designations of Commission 5 of the International Astronomical Union, and we urgently request that you bring the following clarification to the attention of your readers and potential submitters to the Registry of Acronyms.

The Registry is for newly discovered astronomical sources of radiation (outside the solar system), especially those that are part of large surveys or catalogues, to ensure that their designations conform to the IAU recommendations before their acronyms become referenced (even informally). We do not normally pre-register an acronym when just one source is being designated; instead we request that the author(s) ensure that their designation is unique. We only accept submissions for physical objects or sources of radiation. For example, we have declined submissions for designating images or plates, although if there is to be a catalogue for sources found on these images or plates, the Registry would accept an acronym for these sources whose designation might include reference to a plate or image number. Similarly, because asterisms are chance groupings, they should NOT be pre-registered.

The identification of stellar groupings is left up to the observers. Once a suspected stellar cluster is CONFIRMED, *e.g.* by proper motion studies, and accepted in a refereed journal, then a proper cluster designation is justified and an acronym could be submitted to the Registry. This does not appear to be the case of the "Markov" submission where the "object" was specified as "Assoc*" (although the "text" mentions its classification as uncertain); yet the *JRASC* article clearly states that all evidence to date points to the unlikelihood of it being a physical cluster. Therefore, "Markov" will be removed from the Dictionary of Nomenclature of Celestial Objects (`cdsweb.u-strasbg.fr/cgi-bin/Dic`) until such time as it is confirmed to be a *bona fide* physical cluster.

Sincerely yours,

Helene R. Dickel

[Paul Markov replies: I am in complete agreement with Helene Dickel's remarks. As described in my article in the August 2001 issue, there is no evidence that "Markov 1" is a true open cluster; rather, it is just an interesting chance alignment of brighter stars. Last summer, while doing some on-line research on the nature of this stellar grouping, I stumbled across the on-line Registry of Acronyms. I thought I'd better register the acronym, just in case this grouping turned out to be a real cluster. With a few mouse clicks, and a little bit of luck and guesswork, I was able to register the acronym and receive confirmation from the IAU — no questions asked! Obviously, the Internet has made available some very powerful astronomical tools to the amateur astronomer, even though some are intended for use by professional astronomers only! Since that time, it appears that regulations on registering acronyms have been tightened-up, and rightly so.

Nevertheless, Markov 1 (unofficial name as suggested by Dr. Brent Archinal) has gained quite a bit of popularity. I have received positive comments from several places around the globe and the asterism has already been included in an upcoming sky charting software package. Also, as previously noted, it is very likely that Markov 1 will be included in Dr. Archinal's book Star Clusters, *now due to be published in mid-2002.]*

News Notes
En Manchettes

THE 2001 LEONIDS

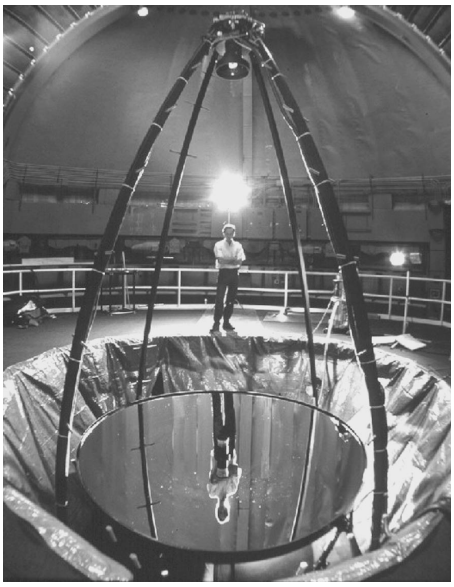
The annual Leonid meteor shower provided much of Western Canada with a tremendous display of shooting stars this past November. For many regions the weather was somewhat touch-and-go most of the day and evening of the 17th, but in the early morning hours of the 18th the clouds drew back to reveal a wonderful display of fireballs and trail-leaving Leonids. The collated observations presented by the International Meteor Organization (see www.imo.net for further details) indicate that two distinct peaks were recorded during November 18. The first occurred at about 10:30 UT over Western North America, while the second and more abundant meteor peak occurred over Asia at about 18:20 UT. The peak rate for Canadian and American observers was equivalent to about 1500 visual meteors per hour. The display was rich in fireballs and many observers reported seeing multiple meteors per second near the time of peak activity.

A number of research groups from around the world made predictions concerning the activity of the 2001 Leonids. Most groups predicted two peaks, as was observed, but no group produced particularly good predictions for both the peak times and the peak meteor rates. At present it appears the best prediction was that by a group headed by Esko Lyytinen in Finland. The prediction method employed by Lyytinen was similar to that successfully used by David Asher (Armargh Observatory) and R. McNaught (Australian National University) for the 2000 Leonids, and followed individual dust trails ejected by comet 55P/Tempel-Tuttle. Interestingly, while the method of following material ejected each perihelion passage was very successful last year, this time around the predicted times of maximum were no closer than about 20 minutes for the first peak, and were only about right (being several minutes early) for the second peak. Also interestingly, no group successfully predicted the enhanced meteor rates observed on the night beginning November 16. It would appear at this early stage of the Leonid "postmortem" that the theoretical models are able to pick out the most likely times of very high meteor rates, essentially solving what might be called the storm prediction problem, but that they are presently incapable of predicting peak meteor rates with any justifiable confidence.

A whole array of stunning Leonid photographs and digitized video sequences can be found at www.spaceweather.com/meteors/gallery_18nov01.html

AND MORE LEONIDS – THIS TIME DETECTED WITH LIQUID MERCURY

Numerous observing techniques have been used to study meteor trails, from visual to video and from radar reflection to radio-wave refraction. Perhaps the most difficult way to observer meteors, however, is with a large telescope. Typically the small field of view provided by a large telescope is a hindrance to meteor detection, but, if the meteor rates are high, as with recent displays of the Leonids, some detection is possible. Indeed, during the 1999 Leonid display, a 3-m liquid-mercury mirror telescope was successfully used to study Leonid meteors. The results of the 1999 observations have recently been published in the November issue of *Meteoritics and Space Science*. Dr. R. L. Hawkes, of Mount Allison University in New Brunswick, was part of the team headed-up by J. F. Pawlowski (NASA, Lyndon B. Johnson Space Center, in Houston) that conducted the study. The 3-m liquid-mirror telescope is normally employed in the detection of space debris, but the Leonid study was part of an overall



The 3-m liquid mirror telescope located at the Johnson Space Center Observatory near Cloudcroft, New Mexico. The 14 litres of mercury that constitute the telescope is made to form a parabolic surface by a rotation of the mirror assembly at 10 rpm. For further details have a look at www.sunspot.noao.edu/Nodo (image courtesy of Chip Simons Photography and NASA).

NASA project to qualify the Leonid meteoroid threat to space platform operations. The telescope has a 0.28-degree field of view and can detect stars to a limiting magnitude of +18.

During the nights of November 17, 18, and 19, 1999 the telescope detected some 151 Leonid meteors to a limiting magnitude of about +10. The meteoroid mass estimate associated with the faintest meteors detected by the telescope is about 10^{-9} kg. The study presented by Pawlowski and co-workers finds some interesting evidence to suggest that the very low-mass Leonids are more widely distributed in space than might be expected from the more traditional studies of higher-mass (that is brighter) Leonids.

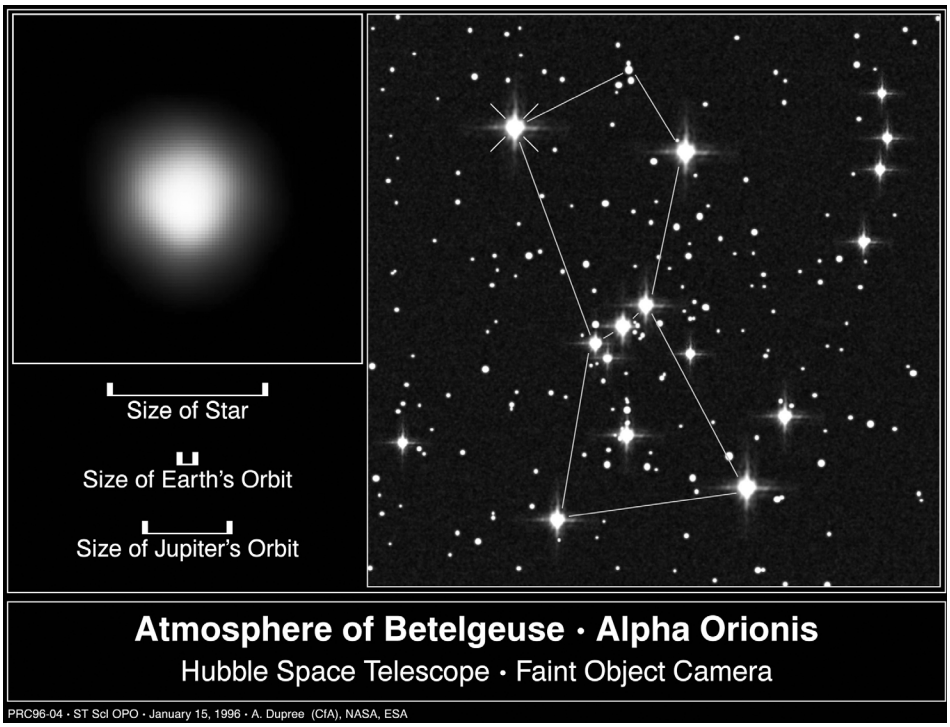
Working to a limiting magnitude of +10, the 3-m liquid-mirror telescope routinely detects some 140 sporadic

meteors per hour, and it is potentially, therefore, a very powerful tool for studying faint meteors. Perhaps more importantly, however, by using a 3-m telescope one can in principle study meteors at unprecedented spatial resolution. Although the high speed of Leonid meteors (71 km/s) means that the time to cross the telescope's field of view is about 0.023 seconds, the single video field images collected reveal details corresponding to a spatial scale of about 1km.

BETELGEUSE – BIG AND BUBBLY

Betelgeuse (alpha Orionis) is one of the largest stars known to astronomers, and it is also one of the very few stars that has actually been resolved to show a disk in a telescope. Betelgeuse is a spectral type M2 supergiant star, and at a distance of some 160 parsecs it has a diameter about 800 times larger than that of the Sun. Indeed, if transplanted to our Solar System, Betelgeuse would take up the space corresponding to the orbit of Jupiter.

The bloated nature and low surface gravity of stars like Betelgeuse led famed astrophysicist Professor Martin Schwarzschild to suggest back in 1975 that giant convection cells, with sizes comparable to that of the star itself, might develop with time scales on the order of 100 days. Recent numerical calculations have further suggested that stars such as Betelgeuse might possess three or four giant convection cells that would literally cover the observable stellar disk. Taking the matter one step beyond theory, however, Dr. David Gray at the University of Western Ontario has recently put the giant convection cell idea to the test. Writing in the November issue of the *Publications of the Astronomical Society of the Pacific*, Gray presents the results of his study of ninety-one spectra of Betelgeuse obtained with the 1.2-meter Elginfield Telescope between October, 1999 and February, 2001. Professor Gray has analyzed the spectra for variations consistent with the giant convection-cell hypothesis, but intriguingly finds none. Indeed, the picture that develops from the observations is one in which Betelgeuse has a large number of small convection cells appearing on its disk. Gray suggests that there are a few, albeit unlikely, ways in which giant convection cells might have been missed in his study; perhaps Betelgeuse only has giant convection cells on an intermittent basis, or perhaps the giant cells have "unusual" velocity characteristics not readily seen in spectra lines. For the moment, however, it appears that the giant convection cell idea is unproven, and that Betelgeuse, like a good glass of champagne, is just big and many-bubbled.



Hubble Space Telescope image of Betelgeuse. The intriguing aspect of this disk-resolved image is that there appears to be a large hot spot on Betelgeuse. The origin and nature of this hot spot is still a mystery. Further details are available at `oposite.stsci.edu/pubinfo/PR/96/04.html` (image courtesy of STSCI).

ST-ROBERT EXPOSED!

The St-Robert, Quebec meteorite fall took place on June 15,1994. Following extensive ground searches, many fragments were eventually found, totaling some 25 kg of meteoritic material. The St-Robert fragments have been classified as having an H5 (high nickel-iron content) chondrite composition, and the fall is one of the very few for which a reasonably well known orbit prior to Earth impact has been deduced. In a recent article in the November issue of *Meteoritics and Planetary Science*, however, a new study of long-lived radionuclides has revealed a more detailed evolutionary history for the meteorites. The lead author of the new research paper (there are 16 authors altogether) is Dr. I. Leya of the Isotope Geochemistry group in Zurich, Switzerland. Among the other authors, from various institutes in Switzerland, Germany, Canada, and the United States, are Dr. Alan Hildebrand (University of Calgary) and Dr. M. Bouchard (University of Montreal).

The new study has reported measurements on the concentrations of the long-lived radionuclides ^{10}Be, ^{36}Cl, and ^{14}C, and concentrations of the stable isotopes of He, Ne, and Ar. The authors have also measured the telltale tracks produced when galactic cosmic rays collided with the meteorite while in space. With the new data and extensive numerical modeling, the authors of have been able to piece together a pre-Earth encounter history for the St-Robert meteorite. It is suggested that once the meteorite was

"chipped" from the deep interior of its parent asteroid, it spent the next 7 to 8 million years, without further collision, being slowly nudged into a resonant orbit with Jupiter, and from there it was fast-tracked into an Earth-crossing orbit. The modeling also suggests that the pre-atmosphere ablation radius of St-Robert was ~0.45 metres, corresponding to an initial mass of about 1300 kg.

FROM THE PAST — AU FIL DES ANS

THE DISCOVERY OF COMET 1974g

The editor of this *Journal* has asked me to give a brief account of the discovery of what I believe to be the first "Canadian" comet.

Since 1958 I have been privileged to use the 48-inch Schmidt telescope on Palomar Mountain on a variety of research programs. My most recent 5-night run, which was mainly devoted to the study of bright variables in nearby galaxies, started on the evening of November 11, 1974. During the previous nights the telescope had been used by Dr. Allan Sandage. At lunch (his breakfast!) Sandage remarked that it would be important to find and study additional comets, similar to Comet Sandage, which have very large perihelion distances and never approach the sun very closely. Within hours of Sandage's suggestion a faint 17th magnitude comet with a short tail moved slowly across a yellow and blue plate of the Triangulum Nebula (M33). Figure 1, a copy of the discovery plate, shows the appearance of the comet in blue-green light on the night of November 11–12. The position of the comet on plates obtained on November 12, 13, 14, 15, and 16 (U.T.) is shown in figure 2. The figure shows that Comet 1974g crossed over the main body of M33 making subsequent measurements of its position exceedingly difficult. (The plates of November 15th and 16th had to be blinked in order to find which of the numerous nebulae on the plates was the comet!)

Preliminary orbital calculations by Dr. Brian Marsden (IAU Circular No. 2736) suggest that perihelion passage took place on August 14 of 1974 and that the comet is now moving away from the sun. His orbital elements give a perihelion distance of 6.02 a.u. which is greater than that of any other comet that has so far been found. This makes 1974g the comet of the century which is least likely to succeed!

by Sidney van den Bergh,
from *Journal*, Vol. 69, pp. 29, February, 1975.

Comet Petriew Discovery

by Vance Petriew (vance.petriew@saskeds.com)

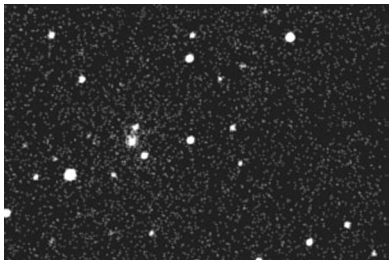
The 2001 Saskatchewan Summer Star Party (SSSP) in Cypress Hills Interprovincial Park was an event I'll remember for the rest of my life. My wife Jennifer and I were really looking forward to a weekend under the stars with our new 20-inch Obsession telescope. We had ordered the telescope in September of 2000 and finally received the mirror in July 2001. The SSSP was going to be the first "really" dark location to test the performance of the telescope. We were also a little unsure what the weekend might hold in store for us since our daughter, Emily, was only 8 months old and not sleeping through the night yet. As every new parent knows, sleep is a major concern with a young baby.

We set out from Regina on our 4-hour trip to darker skies. We checked into the hotel and proceeded to the Meadows to set up the telescope before it got dark. The telescope performed well but as with any new instrument, it takes a few months to get familiar with it. The first night of observing was very good, although there were pockets of warm air drifting through to blur the images for short periods of time. We learned our lesson with Emily since she slept as we observed. When we got back to the hotel at 4:00 a.m., she woke up and wanted to play. We never did get caught up on sleep for the rest of the weekend.

We spent most of Friday, August 17th, taking shifts with Emily and grabbing as much sleep as we could. We arrived at the Meadows late after giving an evening presentation to the attendees of the star party. I set up the telescope in the dark and didn't enjoy it much since my laser collimator was out of alignment and needed fixing. I used a flashlight and the film canister to do the collimation. It seemed to work all right but the images were not crisp. I tried for Pease-1, but the atmosphere wouldn't cooperate for a glimpse.

Alan Dyer came by the telescope and stayed for about three hours. He really enjoyed observing some of the fainter objects including the Crescent Nebula. There were quite a few people around my telescope so I decided to show them Stephan's Quintet. I started by finding the galaxy NGC 7331 in Pegasus. I got mixed up and went the wrong way only to stumble across a group of galaxies in the opposite direction from NGC 7331. Oops! Alan Dyer corrected me and I went the correct way to find Stephan's Quintet. I was relieved since those other galaxies were quite a bit fainter than I remembered Stephan's Quintet being. This wasn't the first time I navigated in the wrong direction and wouldn't be the last. Jones-1 was also an easy target for the 20-inch as were many other wonderful objects that night.

Most people started packing up their telescopes around 3:30 a.m. I didn't feel like it yet since Jennifer and Emily had gone back to the hotel around 2:00 a.m. Around 3:45 a.m., I tried looking for M1 for the first time with the telescope. For some reason, I started star hopping from the wrong star. I cruised around the area for a couple of minutes hoping to spot M1 while I was scanning but instead, I stumbled across a faint fuzzy object just south of β Tau. I almost passed it over since I was pretty sure it was another galaxy and not M1. M1 should have been brighter than this object, or so I thought. I went to the laptop to see if I could find out what this object was.



First Image of Comet by Alan Hale. Taken on August 19, 2001 with a 0.20m SCT from Cloudcroft, New Mexico, U.S.A. Alan Hale confirmed the observation of the new comet.

Just at that time, Rick Huziak from the Saskatoon Centre appeared out of nowhere for the first time that night and posed the question, "What are you looking at?" I couldn't really answer his question. I told him I thought it was a galaxy. After studying it for a couple of minutes, he figured it was probably a comet since the coma seemed to extend a long way without having a well-defined edge. My laptop didn't show any comets in that area of the sky but my comet data was a month old. Rick suggested we sketch the field. I didn't have a pen or paper since I was planning to do only visual observing during the star party. I figured out exactly where the object was by using β Tau as a reference. It was approximately 2 degrees away in the direction of the ecliptic. Steve Meister and Michael Plante from the Regina Centre were also there and took a look. They were the third and fourth

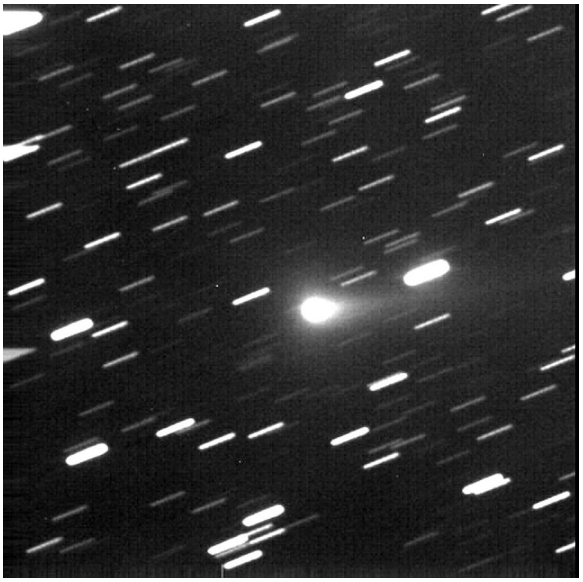


Image by D. D. Balam, 1.82-m Plaskett telescope, Dominion Astrophysical Observatory/National Research Council of Canada. The image is a 400-sec (stacked) image obtained on Sept. 7.51. Rate = 176″/hr at p.a. = 111 deg.

people to see the comet. When Rick and I were sure where the comet was in the sky, Rick went to get some paper. After he came back, he sketched the field. Using my 31-mm Nagler eyepiece with a one-degree field of view at 80×, we made our observations of the comet. After Rick completed the sketch, he went back to his telescope and laptop to dig up his data for all known comets brighter than magnitude 12. I didn't know it at the time, but his data was also nearly a month old. Rick then made various observations with his 10-inch reflector using magnifications up to 300×. He also alerted his friend, Paul Campbell from the Edmonton Centre, to the comet's presence. Paul found the comet in his 12.5-inch reflector to confirm the observation.

About 30 minutes later (around 4:45 a.m.), Rick returned with Paul to take a look at the comet through the Obsession. We determined it had moved approximately 2′ in the eyepiece over that hour. Paul told us his story of how he had star-hopped through that region down to M1 earlier in the evening and didn't come across the comet. He was nearly dumbstruck as he collapsed into the nearby lawn chair trying to figure out how he had missed it. We all smiled.

By 5:00 a.m. we were pretty confident with our observations and estimated the magnitude at 12.0. We later revised this to magnitude 11.0. The coma was approximately 3′ in diameter. We packed up the scopes since the sun was rising and the clouds just starting to float in. Rick and I went to the hotel lobby, where Rick wrote out the observing report on paper to get the details as accurate as possible. We calculated the comet's position in the sky to be $5^h\ 31.9^m$ and +28° 8′. The comet had a bright nucleus and a coma that slowly diffused into the background darkness. No elongation of the coma or tail was detected. I looked up the phone number for the International Astronomical Union in Rick's copy of the *Observer's Handbook*. I used the pay phone in the lobby at the Cypress Hills Resort Inn to phone the first number in the handbook. There was no answer at Brian Marsden's office. I phoned the second number, which was Dan Green's office, and got an answering machine. I left the message we had prepared and then decided to get some sleep. I took Rick back out to the Meadows in the van and came back to the hotel. All through the night, I was feeling that someone else in the world must have found the comet already, since the new moon in August is a great time to hold star parties. Surely someone at "Starfest" would have found it a couple of hours earlier.

Jennifer and Emily were already awake when I returned but Emily was just going back to sleep. I told Jennifer what had happened. We were tired and went back to sleep around 6:45 a.m. Emily got up again at 8:00 a.m.

Observation:
Potential Comet 3:48 a.m.
August 18, 2001
Magnitude 11.0
R.A. 5 hours 31.9 minutes
Dec. +28 degrees 8 minutes
Rick came over about 3:50 a.m.

The next morning, I checked my e-mail and found a message from Dan Green. Apparently he had tried phoning me at our house in Regina. In his e-mail, he asked for some information, which I promptly sent to him. I also downloaded the latest comet data from the Center for Astrophysics website at `cfa-www.harvard.edu/iau`. No matches were found in the data for our comet observation. Rick and I suspected that it could be comet Wild 4, but that was nearly 4 degrees away and shining at magnitude 19.8. Not a likely candidate, but one worth considering. We still didn't want to get our hopes up too high.

I received another e-mail from Dan Green around suppertime on Saturday announcing that he had contacted observers in Europe and North America to look for the comet. Reading between the lines, it was pretty clear that nothing matched the observation we had submitted so things were looking up! Dan mentioned in his e-mail that he hoped that the comet was REAL and that it was NEW. At that point, there were only two things going through my mind: can anyone find it again, and am I the only one to spot this comet?

Just before Alan Dyer's evening presentation, I made a special announcement in front of everyone gathered at the SSSP. I told them that I had perhaps found a comet the night before and that Richard Huziak and I had put in an observation report to the International Astronomical Union in Cambridge, Massachusetts. The e-mail I received back indicated that it could potentially be a new comet. The crowd gasped and started cheering and clapping. I explained that it would be like a dream come true as I nearly broke out in tears. I invited everyone to come over and take a look, if we could find it again.

— Original Message —
From: Dan Green
Sent: Saturday, August 18, 2001
4:07 PM
To: Petriew, Vance
Subject: possible comet

Thanks for the additional information, Vance. I've contacted several observers in Europe and North America to try and get confirmation and some accurate astrometry (if confirmed). If you get a chance to observe it tonight, please note the position as accurately as possible and the time as accurately as possible and forward that by e-mail ASAP. We're hoping it's new and REAL!

Cheers, Dan Green

Daniel W. E. Green
Harvard-Smithsonian Center for Astrophysics
Cambridge, MA 02138, U.S.A.

After Alan's excellent talk on the Milky Way, I went out to the Meadows. Jennifer stayed in the hotel to look after Emily. Later, she had wished that she had come out. I was happy she decided to get some sleep instead, since the weather was not good and she didn't miss anything. The wind was gusting and cold and I left the light shroud off so the telescope wouldn't blow around like a weather vane.

Alan Dyer came over, as did many other people (about 30 or 40), and we sat and chatted about astronomy-related topics. By midnight most people went back to their telescopes to retire for the evening. The cloudy skies were looking grim in the west. Don Moreau, a friend of mine who got me back into astronomy, stayed out at the Meadows with me. About 1:30 a.m., an opening in the clouds appeared in the southern sky. Could the opening be coming our way? It eventually came overhead and Don went looking for a few objects through the thin clouds. I decided that I had rested enough in the chair and began to collimate the telescope in the dark with the LaserMax even though it needed fixing. We waited and the sky started to clear in the north as Auriga climbed above the trees. Unfortunately, there was one cloud blocking the view in the area of the comet, even though the whole northern sky had cleared. After what seemed like half an hour, the cloud partially moved off. I found the star field where the comet was the night before through the hazy clouds and proceeded to pan in the direction that I though the comet was moving. No luck. After about 5 minutes, I gave up and started panning all around that part of the sky. I eventually found it and yelled out to Rick that I had found it again. He came over right away, as did many of the other astronomers that were in the area. At that point, I was very happy since that confirmed the object was indeed REAL! Only one question left to answer: was it NEW? The clouds were moving in fast. Don Moreau had a look at it before Rick arrived so we started to plot its position against the star charts. After about 3 minutes, the clouds moved in. We promptly packed up the telescope as a major wind started blowing and some very dark and menacing thunderclouds came overhead. Lightning lit up the Meadows like daylight as we packed the telescope into the van in record time. The first raindrops started falling just as I closed the hatch. We heard a crash from down the Meadows as a telescope blew over.

Image of P/2001 Q2 Petriew by Jack Newton. Taken on August 24th, 2001. 0.41m SCT — Osoyoos, British Columbia, Canada. One-minute exposures (in LRGB) with 16-inch Meade LX200 at f/10 and Finger Lakes Dream Machine CCD camera.

Don Moreau went back to the hotel and I stuck around to help turn things over so the wind wouldn't blow them away. We sat at the picnic table watching the clouds fly overhead. I kept thinking about Dan Green's comment about the object being real and that we now had confirmed it was real. I was hoping that somewhere in the world it would be clear enough to allow the professionals to find it and confirm the sighting as we had. As we sat, a small clearing behind the storm looked like it might come overhead but it headed in the wrong direction. We decided it was not worth staying up any longer hoping for one more glimpse. I hopped in the van and headed back to the hotel around 3:00 a.m. Emily had just finished eating and was fast asleep. I told Jennifer about the evening and that she didn't miss much. We went to bed at 3:30 a.m. because we were both very tired.

Observation:
Potential Comet 2:20 a.m.
Magnitude 11.0
We found the potential comet but only had a few minutes to locate its position in the sky. We couldn't do it. The view of the comet was faint because it was so low on the horizon and a thin haze further reduced its brightness. I'm sure it would not have been visible in a 12-inch telescope because it was that faint through the hazy clouds. The nucleus could be seen and the inner coma as well. At least we had found it again so we knew it was real. Of course, we would have to wait to find out if it was new.

Sunday morning I awoke and checked my e-mail around 10:00 a.m. There was no word from Dan Green. Many people came up to wish me luck with the discovery

Announcement at the SSSP 2001 (photo courtesy of Alan Dyer).

as they were checking out of the hotel. Jennifer and I packed up the van and checked out at 11:00 a.m. We ate breakfast in the restaurant with members of the Regina Centre. After that, I thought about checking my e-mail again but decided that it could wait. We headed out to the Meadows to take down our tent and pack the rest of our stuff. Sean Ceaser and Gail Wise from the Winnipeg Centre were there so we visited with them for quite a while. I showed them the position where the comet should be since they were staying at the Meadows for another night. John Mulvenna, from the Regina Centre, also came over for a chat while we were packing up. We took a few pictures and then left the park around 2:00 p.m. Emily was very good on the way home and slept most of the way.

When we arrived home, I went downstairs to check my e-mail. The confirmation from Dan Green came in at 11:21 a.m. so, had I checked my e-mail before heading to the Meadows, I would have known the outcome. The comet was officially named C/2001 Q2 by CBAT (Central Bureau for Astronomical Telegrams). I also had congratulation e-mails from Maik Meyer in Germany and from Greg Bryant in Australia. Apparently they knew about the final confirmation before I did! I came upstairs and told Jennifer the news. We both rejoiced! I struggled to hold back tears of joy since the whole weekend was one of building excitement with this being the climax.

— Original Message —
From: Dan Green
Sent: Sunday, August 19, 2001 11:21 AM
To: Petriew, Vance
Cc: Huziak, Richard
Subject: comet 2001 Q2

Congratulations! It looks like you have a confirmation:

Circular No. 7686
Central Bureau for Astronomical Telegrams
INTERNATIONAL ASTRONOMICAL UNION
Mailstop 18, Smithsonian Astrophysical Observatory, Cambridge, MA 02138, U.S.A.
IAUSUBS@CFA.HARVARD.EDU or FAX 617-495-7231 (subscriptions)
CBAT@CFA.HARVARD.EDU (science)
URL `http://cfa-www.harvard.edu/iau/cbat.html` ISSN 0081-0304
Phone 617-495-7440/7244/7444 (for emergency use only)

COMET 2001 Q2
Vance Avery Petriew, Regina, SK, reports his visual discovery of a comet during a star party at Cypress Hills, Saskatchewan, as shown below. The object's presence was also confirmed visually by R. Huziak (0.25-m reflector) and P. Campbell (0.32-m reflector) at Cypress Hills. The observations by A. Hale were made following a request by the Central Bureau.

2001 UT	R.A. (2000)	Decl.	m1	Observer
Aug. 18.42	5 31.9	+28 08	11.0	Petriew
19.45502	5 37 59.10	+27 47 07.8	13.2	Hale
19.46173	5 38 01.45	+27 46 58.4	13.0	″
19.47459	5 38 05.77	+27 46 45.4	13.4	″
19.48078	5 38 07.88	+27 46 36.9	13.4	″

V. A. Petriew (Cypress Hills, SK). Round coma of diameter 3′ with condensed nucleus and no tail. 0.51-m f/5 reflector at 80×. Motion about 2′ to the southeast over an hour. Magnitude approximate.
A. Hale (Cloudcroft, NM). 0.20-m Schmidt-Cassegrain reflector + CCD. Visual observations with a 0.41-m reflector on Aug. 19.47 showed a coma diameter of 2′.5 and m_1 = 11.0.

2001 August 19 (7686) Daniel W. E. Green

Daniel W. E. Green
Harvard-Smithsonian Center for Astrophysics
Cambridge, MA 02138, U.S.A.

There were five phone messages from the local newspaper, the *Leader Post*, since one of the local club members, Lorne Harasen, had alerted them to the possible discovery. I started phoning all my family, letting them know about the comet. Jennifer indicated that she would like to see the comet in the morning if it were clear, so with that in mind, we went to sleep.

On Monday morning, Emily awoke around 2:30 a.m. so at 3:00 a.m., Jennifer woke me up because it was clear. We packed Emily into the van and headed out to White Butte to take a look at the comet again. Jennifer wanted to see it before going to work on Monday afternoon. The telescope setup was quite easy and,

by 4:00 a.m., we had located the comet and looked at it for a while. It was difficult to pinpoint it on the star charts but I finally managed. I don't sketch things in the eyepiece but for this occasion, I did my first sketch ever of the comet and its position. After that, we took a quick look at Jupiter and Saturn before the morning twilight started getting too bright. Emily awoke as we were taking down the telescope. We finally crawled back into bed around 5:00 a.m., completing the third consecutive night that I had viewed the comet.

Observation:
C/2001 Q2
Magnitude 10.5
R.A. $5^h\ 42^m\ 7^s$
Dec. +28° 43′ 23″
Found the comet for the third night in a row. The nucleus was visible but fainter than at Cypress in the morning sky. I thought I detected some elongation to the coma but the twilight was starting to affect the contrast. Still no tail was visible. I sketched the field and calculated its coordinates.

Monday afternoon I went to work and spent most of the day answering e-mails from around the world and sending links to people to take a look at the first article up on the Web, posted at Sky and Telescope by Alan Dyer (www.skypub.com/news/010831.html). Monday evening, I did a photo shoot for the newspaper and answered a few phone calls. While reading my e-mail in the evening, it clicked with me who A. Hale was on the CBAT telegram. Alan Hale, of Hale-Bopp fame, was the one who had confirmed the comet. How cool is that?! I also received an e-mail from Maik Meyer mentioning that I was eligible for the Edgar Wilson Award. Another unexpected discovery! Even though I was still excited, I managed to get some much-needed sleep.

Tuesday morning got real busy in a hurry! At 6:00 a.m., I was awakened by a phone call from a local radio station wanting to do an interview. Apparently my picture was plastered across the front page of the local newspaper and from that point on, the word spread quickly across the country. I started receiving requests for interviews from TV and radio stations across Canada, from as far away as Newfoundland. Over the course of the next week, I did five TV interviews and approximately 30 radio interviews with the farthest one being from Newcastle, Australia. I also had numerous requests for website stories and pictures of the comet. Tuesday was another day of discovery since I found out that the orbital period of the comet had been calculated to be 5.5 years. This meant that the IAU could officially give the comet a name: "P/2001 Q2 (Petriew)" or "Comet Petriew" as I like to call it.

Vance and Emily (8 1/2 months old) in front of the 20-inch Obsession telescope (photo by Jennifer Petriew).

Over the course of the next two weeks, I was fascinated to receive e-mails from people all over the world. I took the time to reply to every one of them. E-mail arrived from many countries including Canada, Mexico, the U.S.A., Brazil, the U.K., Australia, and Portugal. I was equally fascinated to hear people tell me what they were doing when they saw me on national television. For example, our neighbours, who were vacationing on the East coast, were just sitting down for supper when they saw me on the news. They couldn't believe it was "the guy across the street" who had made the discovery. They were very excited and couldn't wait to get home to talk to me. It truly was exciting to watch the story unfold in so many countries across the world, especially on the Web! Dave Chapman, from Nova Scotia, has a wonderfully informative website on Canadian comet discoverers (www3.ns.sympatico.ca/dave.chapman/CanCom.html).

One of the highlights of the comet discovery was the communication I had with other people who have discovered comets in Canada. All of them understand what that special feeling is of finding something for the first time and having your name put up into the sky. They all agreed that finding a comet visually was the ultimate thrill. I think Michael Oates from the U.K. put it best in his e-mail to me:

— Original Message —
From: Michael Oates
Sent: Friday, September 21, 2001

7:28 AM
To: Petriew, Vance
Subject: Re: SWAN animation

Vance, I just want to congratulate you on your wonderful discovery, even though I have found 129 comets, I can safely say I would rather trade in quite a few of those for a visual discovery. That may sound daft, but there seems to be something rather special about finding one with your own eyes!

Regards

Mike

I'm also very appreciative of the number of contacts I have made with other astronomers who share the same enthusiasm for the night sky. Many of the seasoned and professional astronomers mentioned how wonderful it was to see an amateur find a comet before the automated telescopes like LINEAR and NEAT. At the time of the discovery, I didn't realize how rare amateur comet discoveries had become over the last few years but I soon learned from Maik Meyer's website (www.comethunter.de).

Even though the comet was not especially bright in this pass around the sun, there is a good chance that it will come close to Earth in future orbits. I'm grateful that my comet is a short-period one since most comet discoverers agree that a short-period comet is the next best thing to a big bright one like Hale-Bopp. One of the best things about the comet is the fact that I'll be able to show it to my children and grandchildren for years to come. That makes me very happy!

So what do I say when people ask my how I feel about the comet discovery? "VERY COOL!"

Vance with the 20-inch Obsession (photo by Vance Petriew).

Vance Petriew, a computer consultant living in Regina, has been interested in astronomy since he was a youngster. He attended the University of Saskatchewan where he taught undergraduate astronomy labs as a student. After a short lapse, he has recently returned to astronomy and is now the president of the RASC Regina Centre.

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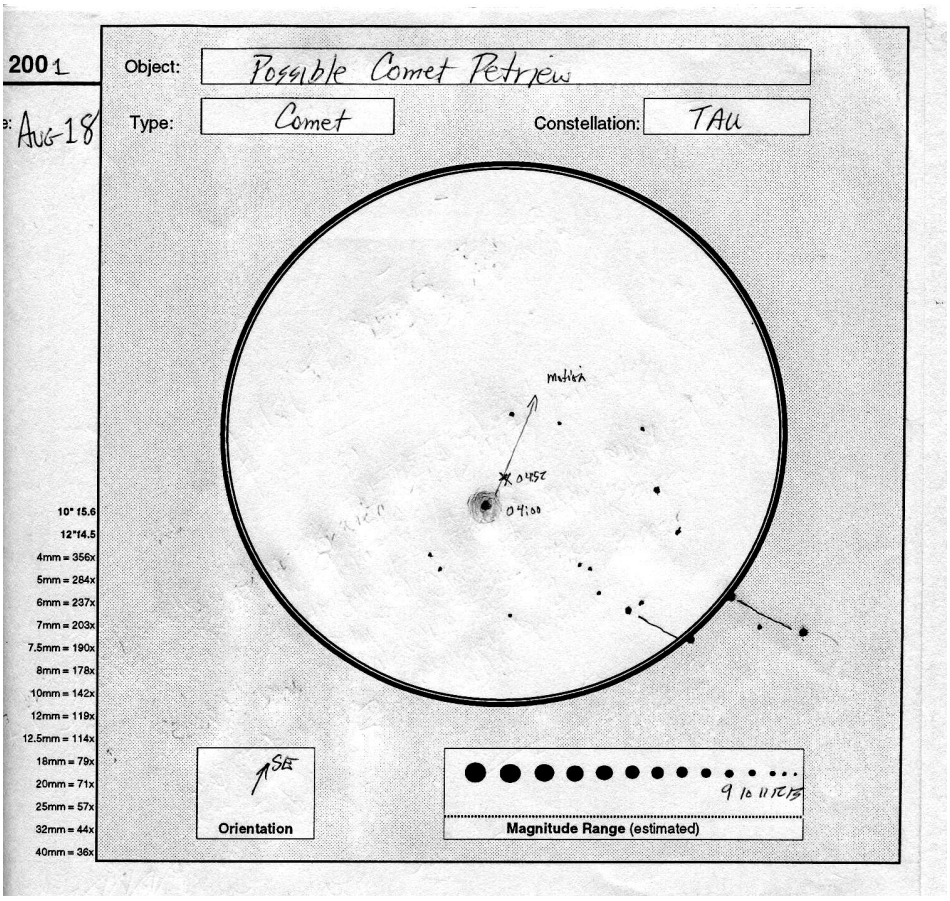
The Challenge of Bagging Comet Petriew

by Richard Huziak (huziak@SEDSystems.ca)

Vance Petriew is writing his story of the events that led up to the new comet that now bears his name being discovered at the 2001 Saskatchewan Summer Star Party (SSSP). But this article tells another story — from the viewpoint of the *other guy* involved with this discovery.

Vance's 20-inch Obsession scope was the hit of the observing field at the SSSP. As such, his scope was a busy place. When others weren't bothering him, I'd step in and challenge him to find a few hard-to-see objects as is often done at star parties. However, I had an ulterior motive. In the 20-inch, I was sure that most of these *challenge objects* weren't a challenge at all. I really just wanted to get a good look at some of these puppies! So, in the wee hours of August 18, 2001, I challenged Vance to find the large, but diffuse, planetary nebula in Pegasus called Jones 1. I walked away to do some observing through my humble 10-inch scope in the meantime. I found and sketched Susan French's Toadstool, the Integral Sign galaxy (UGC 3697), and the ultra-thin edge-on spiral galaxy NGC 100.



My discovery sketch for "Possible Comet Petriew," observed through the 20-inch Obsession scope.

Thinking Vance had had enough time to find Jones 1, at about 3:30 a.m. I walked the 40 metres back to his scope to get a glimpse. Vance, however, was looking at an object in Taurus, which he had chanced upon during an errant star-hop to M1, the Crab Nebula. He never made it to the Crab, and ended up about 1 degree ESE of beta Tauri, the upper horn of the bull. Vance stated that he had probably found a small galaxy, since he "tends to run into these things often with the 20-inch." He was trying to identify it on the *MegaStar* software he had running on his laptop. A galaxy in this part of the sky seemed pretty strange to me, since this area is either covered with the very thick star clouds of the Auriga Milky Way or the very dusty dark nebulae of Taurus. *Thar be no galaxies in this part of the sea*!

I stepped up to the 20-inch, and lo and behold, at the first glance, I had the answer. The object I was seeing was clearly a comet. I was certain it was. I have seen close to a hundred telescopic comets, and this one certainly did not look any different, except it was much brighter than most. I estimated its brightness at roughly magnitude 11. My heart jumped. I could not recall any other bright comets in the sky except for LINEAR C/2001 A2, which was 180 degrees away in the Sagitta area. A few weeks ago, I had downloaded the ephemerides for visible comets. From these, I also remembered that P/Wild 4 was somewhere in the area as well, but it was supposed to be at least magnitude 14 or fainter. "Vance — you have a comet," I whispered.

For those of you who haven't seen telescopic comets and compared them to faint galaxies, there is a recognizable difference. Even though faint comets and

galaxies can both be classified as "faint fuzzies," galaxies, no matter how faint or how fuzzy, always seem to have a definite edge, and you can always see definite dark sky beyond this edge. Comets on the other hand are not like this at all. They have extremely diffuse edges that usually meld very gradually into the background sky. They rarely have a distinct edge, and seem to spread out almost forever. Vance's comet had a very distinct though diffuse nucleus, and very soft and indistinct edges. A closer look also showed the comet was distinctly baby blue. I don't know of any baby blue galaxies!

It was 3:30 a.m. Although we'd been observing all night, I knew that the next few hours would not be easy ones, though they'd certainly prove to be very exciting. Vance couldn't believe his fortune, and denial came quickly. "Surely a comet this bright must have been discovered by LINEAR or another robotic program." He even suggested that it might be redundant to try report this object. I couldn't believe our fortune either, but I thought it best that we should at least consider reporting it, depending on what our next hour or two turned up. And so the process started.

Vance loaded and ran his latest download of the IAU ephemerides for all known comets on his laptop. However, the last download was about 4 weeks old. Maybe the comet had been discovered since then. In the meantime, I decided that I had better sketch the field, since we were not really all that sure exactly where we were! Remember that Vance had done an incorrect star-hop looking for M1 and was slightly lost. Despite a good view in the 20-inch low-power field, all we had for a wide-field reference was a *Telrad*. I was very concerned that we'd begin a star-hop back to some known star, lose our way, and maybe lose the comet in the process. So I got my sketchpad and did an accurate sketch, noting a distinct nearby asterism of stars that I was sure we could locate again, should we become lost. The sketch would also allow us to see if this object was indeed moving — proof that it was a comet. This sketch is reproduced as Figure 1.

As I sketched, Vance confirmed that P/Wild 4 was indeed nearby, but about 4 degrees to the SE, with no other comets in the area. I thought for a moment that this might be P/Wild 4 *if* the ephemeris was wrong, and *if* the comet was undergoing a very bright outburst. However, a potential ephemeral error of 4 degrees was so large that we eliminated this possibility. Vance and I then found the location of the sketched asterism in both *MegaStar* and my *Millennium Star Atlas*, identifying the field once and for all. I carefully plotted the comet in the atlas, and determined that at 4:00 a.m., the potentially new comet was located at 0531.9 +2808. This done, I walked back to my scope and dug out my paper copies of the comet ephemerides, which were about 1 week newer than Vance's copy. My search came up negative as well.

In order to confirm a comet discovery, there are a number of steps that need to be taken. First, you need to rule out that what you have seen is another known comet. The last thing you want to do is waste the time of the IAU Central Bureau for Astronomical Telegrams (CBAT) by reporting something that the whole world (except for you) seems to already know. We eliminated other comets to the best of our ability. Secondly, you have to note its discovery position accurately. This becomes its first ephemeral point, and this we did as well. Next, we had to see if the comet was moving, and try to determine its rate and direction of motion. This is very important, since movement means the comet is real (and not just a non-plotted galaxy in an atlas that may contain errors or omissions). Direction of movement also allows others to find it. Some comets and asteroids have been lost for long periods, since the days following their discovery had been plagued by foul weather and directions of travel weren't accurately known. We knew we were up against the clock, since the sky would be getting pretty bright in about one hour. We toyed with phoning someone from the Okanagan or Vancouver Centre to follow up the observations should dawn come before we could confirm movement. This was a backup plan, even if we did not know whom we might eventually call.

It was now hurry-up-and-wait time. With my sketch in hand, I returned to my 10-inch and quickly located the comet in the scope. I was surprized how easy it was to see. I also recruited Paul Campbell of the Edmonton Centre to find the comet in his 12.5-inch scope and keep a lookout for the first detectable movement. Within 15 minutes, we were both certain the comet had moved. This was wonderful, and now very exciting news. At 4:52 a.m., with the sky very bright, and only the nucleus still visible, I plotted the second position on my sketch. In the 52 minutes since my first sketch, the comet had moved two arc-minutes to the SE in position angle (PA) 135 degrees. This was less that the comet's diameter, but enough to be certain.

By 5:00 a.m. we were getting pretty tired. Despite the adrenaline rush, it had been a very long night, and we knew we were not even close to being done. With basic information, charts, and the laptop in hand, Vance drove us the 2 kilometres from the Meadows campground to the Cypress Hills Resort where a phone was available. It was important to get the report registered as soon as possible so that we would not be scooped by another observer. After all, this was a very bright comet and there were several other star parties that weekend!

Vance knew from an earlier attempt that he could not get a reliable modem connection through the resort phone lines so we decided to telephone the report in. I knew how to do this, as should everyone, since the information is in the *Observer's Handbook 2001* on page 9. While Vance continued double-checking information on the laptop, I wrote out the announcement in longhand, so that Vance would just have to read the words verbatim and not forget to include anything. At about 6:00 a.m., we were ready. Vance dialed CBAT's phone number and read the two-page announcement of a possible discovery of a magnitude 11 comet, 3 arc-minutes in diameter, moving at 2 arc-minutes per hour to the SE. We reported its position, description, reason for not considering it another type of object, who we were, where it was discovered, and as

much other relevant information we could think of. Phoning in the announcement on a weekend is not exactly the preferred method of rapid communication, but it's all we had. E-mail would have been better.

At 6:30 a.m., I finally got to bed. The kids woke me up at 7.

Needless to say, Saturday's daytime activities and the early evening banquet were quite a haze. I was re-presented with the RASC's Chant Medal (which I was unable to accept at the London GA), but I was so tired that I barely remember this, nor what I may have said in my somewhat rambling acceptance speech. Just as cool was Vance's proud moment where he stood in front of the entire assembled star party to announce that he had most likely discovered a brand new comet. He had been in contact with Dan Green of CBAT via e-mail earlier in the day, and Dan had stated that no one else had yet reported this comet! We were floored.

"Comet 2001 Q2. Vance Avery Petriew, Regina, SK, reports his visual discovery of a comet during a star party at Cyprus [sic] Hills, Saskatchewan, as shown below. The object's presence was also confirmed visually by R. Huziak (0.25-m reflector) and P. Campbell (0.32-m reflector) at Cyprus [sic] Hills..." reads CBAT Circular No. 7686 on Sunday, August 19, 2001. The next Circular corrected the place to Cypress Hills and gave more astrometric data. Dan Green also appended a note reading "Congratulations! It looks like you have a confirmation." This was indeed a very proud moment.

A few post-announcement comments made me even prouder of our achievement. Dan Green wanted to know who this "Rick Huziak" guy was. Vance responded by stating "Oh, he's just the guy who was awarded the RASC's Chant Medal" — 'nuf said! Dan also complimented us on the accuracy of the positions reported, stating that, even though they were visual, they fit very well into the astrometric data. I am also delighted that my estimate of 2 arc-minutes per hour was accurate to about 90% of the real rate and that the PA was off by only about 15 degrees — not bad for an arc so short! I was also delighted that the first astrometric measurements done on the comet were by none other than Alan Hale, of Hale-Bopp fame.

Lost Chances

As I walked back to my telescope only minutes after Vance had found that still-unidentified fuzzy ball, a strange thought crossed my mind that I could have told Vance that he had indeed found a faint galaxy, and I could have relocated the object in my scope and claimed the discovery for my own — after all, I *was* sure it was a comet. The thought disappeared as fast as it came. It wasn't a serious thought — just funny. (Vance and I go back a long way, to his University days when he was a member of the Saskatoon Centre. He's now with Regina). Of course, something like this would never occur, but two other strange events did happen, showing that some discoveries are purely the result of luck of the draw.

Vance's original target was the Crab Nebula, and he made a star-hopping error that is common, starting the search at the *top* horn of Taurus instead of the bottom horn. Near beta Tauri he chanced on the comet. Exactly 24 hours beforehand, I had also placed beta Tauri in the field of my spotter to use it as a star-hop starting point for a standard variable star program I do in Auriga. *The comet would have been in the low power field of my main scope*, and certainly was bright enough to have been seen, but I did not look in the main scope since the star-hop I use is a familiar one through the spotter. About an hour before Vance's discovery, Paul Campbell also began a star-hop from beta Tauri, *but instead of getting lost, Paul found M1*, and missed out on the comet. I find it curious that the three of us listed on the IAU announcement all looked at the field of the comet and two of us, both very experienced observers, missed it by pure bad luck.

Dual Names

After the discovery, there was quite a bit of discussion on the RASCLIST about why this comet was not named Petriew-Huziak since my participation was obviously quite extensive. This discussion took me by complete surprise, since it never occurred to me that this should even remotely be the case. The bottom line is that Vance had already discovered the comet when I showed up at his telescope to check up on Jones 1. If Vance hadn't discovered this object, I would not have had the chance to identify it! The situation was completely different than for Hale-Bopp, where there were two clearly independent discoveries, or with Shoemaker-Levy where there was a clear team goal to discover comets in collaboration. This comet is clearly Comet Petriew. I very much appreciate the credit that Vance so kindly gives me when he relays details of the discovery — heck, I even made the National News! I will be just as happy to see Comet Petriew in 5.5 years when it returns, no matter what its name is.

It was just a plum cool experience!

References

IAU Central Bureau for Astronomical Telegrams Circular No. 7686, August 19, 2001

IAU Central Bureau for Astronomical Telegrams Circular No. 7687, August 20, 2001

Rick Huziak is still looking for his first comet. In 33 years of star hopping he has had a few close calls, but no cigar (-shaped objects). He observes from Saskatoon and the Sleaford Observatory with telescopes clearly inferior to Petriew's 20-inch Obsession, but cares not a sniff about this, nor spends any time worrying or obsessing, or whining, or wishing for things he will never have, nor ever discover, nor... nor....

Radiances of Planetary Spheres

by Maxwell B. Fairbairn (mbfairbairn@hotmail.com)

The theory of planetary photometry has been given in full generality, in this journal, by Lester, McCall & Tatum (1979)[1]. As a finishing touch to that paper (hereafter referred to as LMT) we treat the radiances of planetary spheres in a little more detail. As a result, we present a small gallery of theoretical planetary spheres as seen from various phase angles, showing the distribution of radiance[2] across the projected discs.

Consider a sphere of radius a, centred at O in an $OXYZ$ coordinate system, irradiated by a plane parallel beam of radiant flux F from the X-direction, which will irradiate the surface of a hemisphere with base in the OYZ plane. A point S on the surface has Cartesian coordinates (x,y,z) or spherical coordinates (a,Θ,Φ) with $0 \le \Theta \le \pi$, $-\pi/2 \le \Phi \le \pi/2$.

At full phase, phase angle $\alpha = 0$, the distant observer sees a projected disc onto the OZY-plane, so that point S has projected coordinates (y,z) . At phase α, the observer sees a lune which will be gibbous for $\alpha < \pi/2$ and crescent for $\alpha > \pi/2$, projected onto the $OY'Z$-plane with coordinates (y', z) such that

$$y' = a \sin \Theta \sin (\Phi - \alpha) \qquad (1)$$
$$z = a \cos \Theta$$

with the restriction that only those points such that $\Phi > \alpha - \pi/2$ are visible.

The irradiance of point S is $E = F \cos \Theta_i$, where Θ_i is the angle of incidence, *i.e.* the angle between the surface normal at S and the direction of radiant flux. The angle of reflection towards the observer is Θ_r. From LMT equations (30) & (32) we have

$$\cos\Theta_i = \sin \Theta \cos \Phi$$
$$\cos\Theta_r = \sin \Theta \cos (\alpha - \Phi)$$

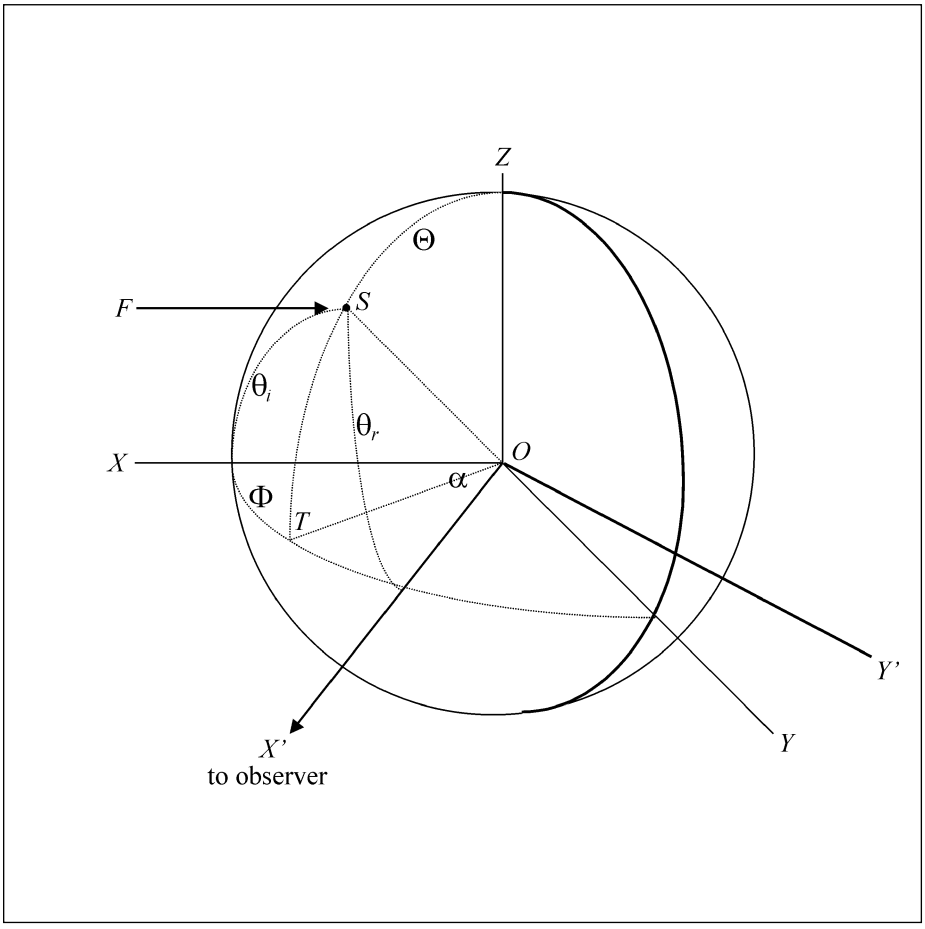
Three theoretical planetary spheres are considered in LMT, the Lambertian, the Lommel-Seeliger, and the Area Law. In order to avoid repetition, we will discuss just one and summarize the others, presenting equations not explicitly stated in the reference.

A Lambertian surface is one in which each element of area reflects its irradiance equally in all directions such that its radiance is the same from whichever direction it is observed, *i.e.* from LMT equations (2) & (8), its *bidirectional reflectance-distribution function* $f(\Theta_i,\phi_i;\Theta_r,\phi_r)$which we will simply call f, is a constant[3],γ. The radiance of point S is thus

$$L(\Theta, \Phi) = fE = \gamma F \sin \Theta \cos \Phi$$

such that its radiance is independent of phase and the sphere is limb-darkened, the radiance fading to zero at the limb.

Using the expressions in Table II in LMT, we summarize the radiances as follows



$\Theta = \angle SOZ$, $\Phi = \angle XOT$, $\alpha = \angle XOX'$, $\Theta_i = \angle SOX$, $\Theta_r = \angle SOX'$, $\angle X'OY' = \pi/2$

[1] Available in PDF format at `astrowww.phys.uvic.ca/faculty/tatum/jbt.html`

[2] In the theory of stellar atmospheres *radiance* L is known as *specific intensity* I. In either case the SI units are $W{\cdot}m^{-2}sr^{-1}$.

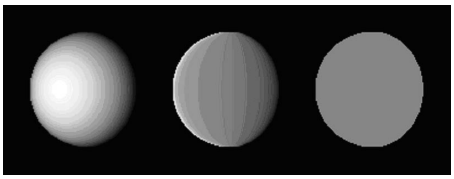
Relative Radiances of Spheres

Lambertian	$\gamma F \sin\Theta \cos\Phi$	$\gamma \le 1/\pi$
Lommel-Seeliger	$\dfrac{\gamma F \sin\Theta \cos\Phi}{\sin\Theta\cos\Phi + \sin\Theta\cos(\alpha-\Phi)}$	$\gamma \le 1/2\pi$
Area Law	γF	$\gamma \le 1/2\pi$

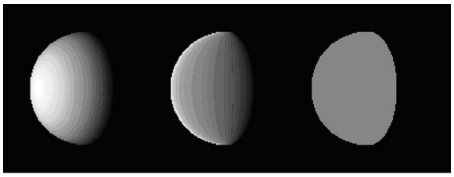
Equations (1) and the expressions in the above table were used to generate the images which follow.

Lambertian Lommel-Seeliger Area Law

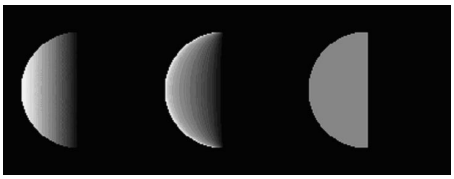
$\alpha = 0°$



$\alpha = 30°$

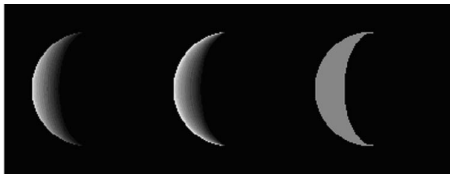


$\alpha = 60°$



$\alpha = 90°$

$\alpha = 105°$



$\alpha = 120°$

The Lommel-Seeliger sphere has the property that at full phase the disc is uniformly bright (*i.e.* constant radiance), whereas for other phases it becomes limb-darkened and indeed "terminator-brightened" relative to the full phase disc. At dichotomy ($\alpha = 90°$) it is noticeably crescent in appearance. The Area Law sphere does not show any variation in radiance at all, and so is not particularly interesting visually except that it does show the outline of all of the projected lune that is technically "visible".

It should be (re-) emphasised that none of the theoretical surfaces correspond to real physical laws, but merely provide analytical expressions for surfaces that may be approximated by real planets. The Lambertian surface is an ideal diffuse reflecting surface (and similarly the radiance of a black body is Lambertian), the Lommel-Seeliger surface is based on an absorption-scattering model, and the Area Law is a "law-of-convenience" that cannot be physically realized.

References

Lester, T.P., McCall, M.L. & Tatum, J.B. 1979, *JRASC*, 73, 233.

Max Fairbairn completed his MSc. in Astrophysics at the University of Victoria, BC, in 1972. Since then he has taught Physics and Computer Programming at various tertiary institutions. He lives near Sydney, Australia.

[3] The units of f and y are sr^{-1}.

J.L.E. Dreyer

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

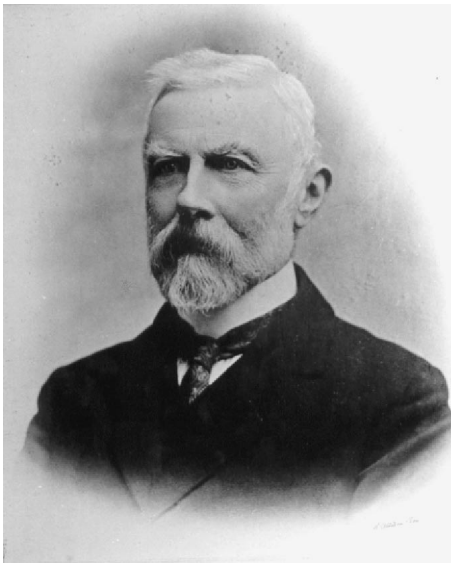
Beginning amateur astronomers are introduced typically to the deep sky (star clusters, nebulae, and galaxies) through observing the 110 objects in the Messier catalogue. Advanced observers move on to the New General Catalogue (NGC), which includes all the M-objects, and much more, 7840 objects in all. The NGC is certainly more "general" than the Messier catalogue, but it isn't so "new" anymore, having been first published in 1888. This is the story of the man who compiled the NGC: Johan Ludwig Emil Dreyer, whose 150th birthday takes place this March.

J.L.E. Dreyer was born in Copenhagen Denmark, on March 13, 1852. As a schoolboy, he excelled not only in science, but also in history, both of which contributed to his career achievements in astronomy and the history of science. As a young man, he moved to Ireland, where he assisted Lord Rosse (1800–1867) at Birr Castle, observing with the 183-cm reflecting telescope *Leviathan of Parsonstown*. Lord Rosse is best known for observing and sketching the spiral structure of the aptly named Whirlpool Galaxy (M51 or NGC 5194/5) through this telescope. For astronomy trivia lovers: Lord Rosse named the Crab Nebula in the constellation Taurus (M1 or NGC 1952). Scientific work continues at Birr Castle to this day under the patronage of the current Earl of Rosse, and there is a wealth of information at their Web site `www.birrcastle.com/birr/general/`

Following an appointment as assistant at Dunsink Observatory on the outskirts of Dublin, Dreyer became Director of the Armagh Observatory in 1882, a post he retained until 1916. The previous Director was Thomas Romney Robinson (1793–1882), the inventor of the cup anemometer for measuring wind speed. Robinson had begun a campaign to obtain government support for the financially stricken observatory. Dreyer was successful in carrying on Robinson's campaign, obtaining a grant of 2000 pounds. He used this to purchase a 25.4-cm refracting telescope built by Howard Grubb (1844–1931). This telescope is now used only occasionally, and not for serious astronomy, however Armagh Observatory currently is raising funds for its restoration. Both Dunsink Observatory and Armagh Observatory have active research and public programmes; their web sites are `www.dunsink.dias.ie` and `www.arm.ac.uk`, respectively.

Dreyer's enduring legacy to astronomy was the compilation and publication of the *New General Catalogue of Nebulae and Clusters of Stars* (1988). The "New" in the title acknowledges that Dreyer built upon the 5079 observations of Willliam Herschel and John Herschel, published in the *General Catalogue* (1864). Dreyer revised, corrected, and enlarged the GC, including contributions from several contemporary astronomers, paying particular attention to the accurate positions made possible by improved instrumentation. The NGC contains 7840 deep-sky objects, and continues to be a standard reference for amateur and professional astronomers alike. Dreyer followed up the NGC with the supplementary Index Catalogues: IC-I in 1895 and IC-II in 1908. The ICs listed newer, fainter objects, and brought the object count total to 13,226.

While at Armagh, Dreyer also participated in the study of the distances to the spiral nebulae such as M51. Using his precision telescope, he attempted to measure the parallax of the nebulae. That is, he attempted to measure the tiny apparent motion of the nebulae against the background star field that would be induced by the Earth's annual motion around the Sun, if the nebulae were much closer than the stars themselves. His null result provided strong evidence that the nebulae are distant objects, outside our own galaxy. This hypothesis was confirmed by 20th century astronomers.



J.L.E. Dreyer, author of the *New General Catalogue of Nebulae and Clusters of Stars* (1888), which continues to be a standard reference for astronomers today (photograph courtesy of Armagh Observatory).

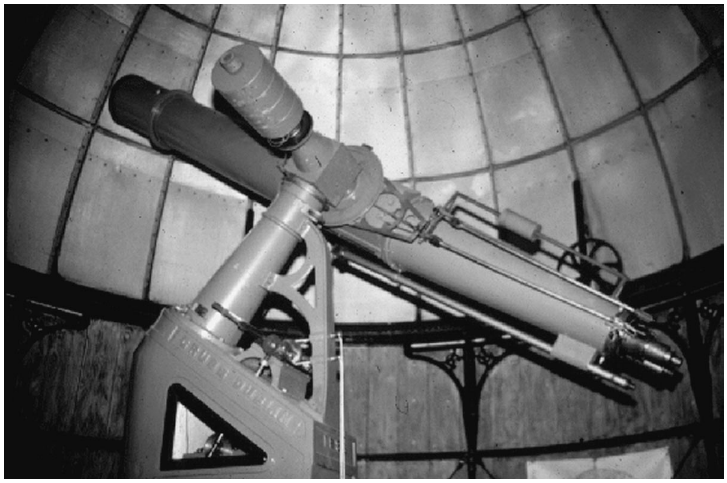
Dreyer is also known as a historian of science. Remarkably, the visual observations of the fellow Dane Tycho Brahe (1546–1601) had never been properly published and made available to the general public, despite the fact that these observations are the foundation upon which Johann Kepler (1571–1630) based

his laws of planetary motion. Dreyer published a biography of Brahe in 1890 and went on to publish 15 volumes of his observations, taken from records at the Royal Library in Copenhagen.

In 1906, Dreyer published *History of the Planetary Systems from Thales to Kepler*. This is a comprehensive history of astronomy before the time of Isaac Newton, and is still in print today under the title *A History of Astronomy from Thales to Kepler* (Dover, New York, 1953). I confess that I have had a copy of this in my library for some time (thanks to my wife's taking a first-year astronomy course at U of T), but I had not connected the author with the NGC until now!

By 1916, the funding for astronomical research at Armagh Observatory had declined substantially, and Dreyer went to Oxford, where he finished his days completing his work on Tycho Brahe. Dreyer received several professional distinctions in his lifetime: a Gold Medal from Copenhagen in 1874, the Gold Medal of the Royal Astronomical Society in 1916, and President of the Royal Astronomical Society (1923–1925). In 1875 he married Katherine Tuthill, an Irish lady from Kilmore, County Limerick. They had one daughter and three sons, one of whom commanded a battleship at the Battle of Jutland and rose to the rank of admiral in the Royal Navy. J.L.E. Dreyer died in Oxford on September 14, 1926.

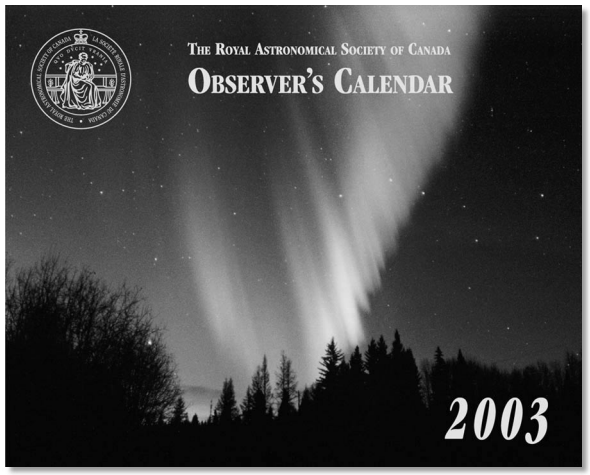
For more information on deep-sky objects, see page 258 of the RASC *Observer's Handbook 2002* for "The Messier Catalogue" and page 262 for "The Finest NGC Objects." Note that there are certificates for RASC members who observe all 110 objects on either list. Keeners may be interested in the NGC/IC Project, an ongoing professional/amateur collaboration, whose Web page is www.ngcic.org



The 25.4-cm (10-inch) Grubb refractor at Armagh Observatory used by Dreyer for positional measurements of nebulae for the New General Catalogue, and still in occasional use today (photograph courtesy of Armagh Observatory).

David Chapman is a Life Member of the RASC and a past President of the Halifax Centre. Visit his astronomy page at www3.ns.sympatico.ca/dave.chapman/astronomy_page

CALL FOR PHOTOS — 2003 RASC OBSERVER'S CALENDAR



All members of the RASC are encouraged to submit astronomical photos for consideration for publication in the 2003 *RASC Observer's Calendar*. Images can be of any type – deep-sky or solar system; prime-focus, piggyback, or fixed-tripod; emulsion- or CCD-based.

Electronic images under 2 megabytes in size may be sent by email to gupta@interchange.ubc.ca. Larger electronic images may be sent on CDs or disks (1.44 MB floppies or 100 MB Zip disks). Film-based images should be submitted, or be made available on request, as 8- by 10-inch prints or original negatives or slides.

Prints, negatives or slides, CDs, or disks (1.44 megabyte floppies, 100 megabyte Zip disks) should be sent to:

Rajiv Gupta
2478 1st. Ave. W.
Vancouver BC V6K 1G6

so as to arrive by **April 15, 2002**. For further information about submissions, please contact me by e-mail or by phone at 604-733-0682.

Rajiv Gupta
Editor, *RASC Observer's Calendar*

Baryons in the Universe

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

Baryons may sound like exotic atomic particles, but the family includes two with which we are very familiar: protons and neutrons. Curiously, though, they appear to provide only a tiny fraction of the total mass of the Universe. Determining that fraction to a good precision is quite difficult, yet very important with regard to establishing the overall characteristics of our Universe. Numerous independent methods have evolved to measure the density of baryons. Now, Tom Bania of Boston University, along with his colleagues Bob Rood of the University of Virginia and Dana Balser of the National Radio Astronomy Observatory in Green Bank, West Virginia, have used radio observations of singly ionized light helium (^{3}He+, which is made up of two protons, one neutron, and one electron) to determine that baryons make up just about four percent of the total mass needed to produce a "flat Universe" that is just closed (see January 3 issue of *Nature*). Bania, Rood, and Balser like to be known as the ^{3}He 3.

"Baryons may sound like exotic atomic particles, but the family includes two with which we are very familiar: protons and neutrons."

The observational project has been underway for almost twenty years, during which time they have measured emission from the "spin-flip" electron transition of ^{3}He+ (at a wavelength of 3.46 cm) from 60 H II regions and 6 planetary nebulae. This is the helium equivalent of the spin-flip transition that in hydrogen produces the famous 21-cm spectral line that has been used to map the distribution of atomic hydrogen in the Milky Way and many other galaxies in the nearby Universe. However, it is extremely difficult going from the observed quantity — helium line intensity — to an abundance with respect to hydrogen (^{3}He/H), which is the quantity of cosmological importance. First of all, the fraction of the helium that is singly ionized must be determined, and that depends on the temperature of the source. Many astronomical objects, such as H II regions and planetary nebulae, vary in temperature across the portion we see, meaning that it may be difficult to define for each a unique characterizing temperature.

Moreover, it has been known theoretically for some time that at least some stars have the ability to make ^{3}He, potentially contaminating the result, because it is the primordial abundance of ^{3}He — the amount created in the first few minutes after the Big Bang — for which we are looking. Elements created inside stars are distributed through the interstellar medium by stellar "winds" and explosions like supernovae.

Stars with masses like the Sun should make ^{3}He, which should be distributed by the winds that blow at the ends of the stars' lifetimes, as they evolve from the main sequence to become giants and subsequently to planetary nebulae. After that phase, all that is left of such a star is a white dwarf with a temperature of 100,000 K or so, surrounded by an expanding, dissipating cloud of gas. The planetary nebula phase happens when fusion reactions cease inside the core of the star, so that the upper layers can no longer be supported against gravity. Think of juggling balls — as soon as you stop putting energy into the balls with your hands, they fall to the ground. As part of the star collapses into the very dense and hot white dwarf, the outermost layers are heated so that they shine — producing the observed planetary nebula, which lasts for 10,000 or so years. Observations of multiple planetary nebulae have failed to reveal much evidence for the creation and dispersal of ^{3}He, but the constraints have been relatively poor.

Looking at a range of H II regions from near the centre of the Galaxy to beyond the Sun's position tells us how the abundance of ^{3}He has changed with time. This is necessary in order to correct the observations of the H II regions, which contain very young stars that are not more than 10 million years old, compared to the 13 or so billion years for the age of the Milky Way. Theoretical models have predicted that there should be more ^{3}He in the inner part of the Galaxy than the outer, and that the "proto-solar" value (as measured in the Sun, on Earth, and in meteorites and comets) should be less than the present value for the interstellar medium. The observations, however, have been in conflict with the theory, which includes not just predictions for the production of ^{3}He, but models of its distribution throughout the Milky Way and its incorporation into the molecular clouds out of which the young stars that make the H II regions have formed.

Over the years, the ^{3}He 3 have found that large, diffuse H II regions provide

specific advantages when one converts their line intensities to abundances. The gas densities and temperatures do not change much over the "beams" of the radio telescopes they used, thereby simplifying the determination of overall ^{3}He abundances and reducing the potential systematic errors (those associated with the assumptions made to estimate the abundances).

Combining all the recent theoretical and observational work together, the ^{3}He 3 conclude that the best upper limit for the primordial abundance of ^{3}He is $^3\mathrm{He/H} \leq (1.1\pm0.2) \times 10^{-5}$. They find that while some individual stars do contribute ^{3}He to the interstellar medium, the total contribution is smaller than the observational errors and therefore can be neglected.

To go from this abundance to a baryon density, one must start with the baryon-to-photon ratio of the Universe — in essence, this sets the temperature scale for "cooking" matter out of the energy available in the form of photons. Most readers will be familiar with the concept of matter-energy equality (such as Einstein's famous equation), and one implication is that a high-energy photon can spontaneously create a particle-antiparticle pair whose total energy (in terms of mass and motion) equals that of the photon. The inverse reaction is seen in accelerators today, where particles and antiparticles can be slammed together to generate photons and other particles. The early Universe was expanding very rapidly, and the resulting effect on the hot soup of photons and particle-antiparticle pairs was to cool them rapidly. Somehow a tiny excess of particles remained, which provided the baryonic mass of the present Universe.

"The convergence [of baryon density measurements] not only indicates that we do know the baryon content of the Universe, but also implies that there are no significant problems with our understanding of either Big Bang nucleosynthesis or the expansion associated with the Big Bang itself."

The bottom line is that the ^{3}He abundance gives a baryon density of $\Omega_B = 0.04$. This is substantially smaller than the total density of the Universe, where $\Omega = 1$ is the total mass+energy density of a critical universe (and that's the kind of universe in which we appear to live). This baryon density is the same as the value that has been determined by measurements of the fluctuations in the cosmic microwave background and from the primordial abundance of deuterium (heavy hydrogen). The convergence not only indicates that we do know the baryon content of the Universe, but also implies that there are no significant problems with our understanding of either Big Bang nucleosynthesis or the expansion associated with the Big Bang itself. Any problems that do exist with our understanding must be at the 10-20 percent level or less.

Should any of you feel inclined to declare the problem solved, you might bear in mind that general relativity solved a problem (the precession of Mercury's perihelion) that was at a much smaller level. It's important to look for agreement among many different methods, but revolutions in science happen because of discrepancies. To some, the quest for ever-increasing precision in measurements is wasted effort, but out of those seeds some mighty oaks have grown.

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Education Notes
Rubriques pédagogiques

TWO GOOD THINGS ABOUT LIGHT POLLUTION

BY JOHN R. PERCY
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Light pollution is the unnecessary illumination of the sky by artificial lighting.[1] Light pollution is the bane of astronomers' existence. Up to a century ago, almost everyone enjoyed, appreciated, and understood the skies. Now, rural dwellers, many aboriginal peoples, and people in non-industrial countries have access to dark skies in all their glory; the rest of us have lost them. Dark skies have inspired many a scientist and science teachers — not just astronomers. All people — especially students — should experience a dark sky at least once in their lifetimes. Therefore it is easy to state:

Three bad things about light pollution: (1) it is a symptom of ineffective and inefficient lighting, glare, light trespass, and lighting clutter (none of which contribute to greater security or to a more pleasing night-time environment); (2) it is a waste of energy — over a billion dollars a year in North America alone; (3) it produces the urban sky glow, which is destroying mankind's view of the universe.

Nevertheless, it is also possible to state:

Two good things about light pollution: (1) it makes for a pretty view of the earth at night, from a plane or from space; and (2) it provides exemplary STSE (science, technology, society, environment) activities for students in school or university.

Satellite images of the earth at night are fascinating; students could study these for hours, learning about geography and human population and its activity. The November 2000 issue of Air Canada's in-flight magazine *En Route* has a complete set of such images. There are also detailed, quantitative images on the WWW; see *Sky & Telescope* December 2001, page 24. The URL is `www.lightpollution.it/dmsp`

Light is one of those topics that is covered in school science in a rather cold, analytical way. Light, of course, is also a significant part of our everyday life. But we don't always deal with these everyday aspects of light in the curriculum. This is an opportunity to deal with them in a more holistic way. Here are some types of issues and activities that can connect light pollution to the curriculum. A major problem with light pollution is *awareness*; very few people have heard of the term. Every student should be exposed to the term and the issue, if only for a few minutes.

Topics and Activities: Several of these are outlined in the Resources given below, especially the "astrosociety" link. In **astronomy**, light pollution interferes with our ability to view faint and fuzzy objects in the sky. Activities can include counting the number of stars in a given area of the sky or measuring the brightness of the faintest star you can see in different situations; this is one of the few astronomy activities in which you have to think about controlling variables! Remember that the sensitivity of the eye increases with the number of minutes spent in the dark, so students must "control" for this variable. This activity also requires students to learn how to use star charts, which is a skill that lasts a lifetime. (It is tempting to avoid night-time observations in astronomy courses, on the grounds that "the stars come out at night, but the students don't," but every astronomy course should include some basic instruction in sky observing.) Students can also locate and study skyglows and identify the sources. In **physics**, they can use inexpensive transmission diffraction gratings to observe the spectra of different outdoor light sources (this project has aesthetic value and can be done on a cloudy night!) and think about how the intensity and effectiveness of illumination depends on the design and location of the light fixture. They can also be introduced to the unfamiliar units associated with light — lux, lumen, and candela! **In technology:** they can look in more detail at the engineering of residential, commercial, and street lighting, and how the technology relates to the needs of the users. Some of the most knowledgeable and sympathetic people, when it comes to light pollution, are the lighting engineers! **In society:** they can investigate issues of safety and security, debate the economic issues, and find out (and maybe use) the channels for achieving social change. This means understanding the roles of politicians, municipal managers and engineers, specifications and standards, and developers, as well as learning about the power of the media. In the **environment:** they can find out more about how light or darkness affects organisms both large and small; most of all, they can find ways of experiencing and appreciating the beauty of the night sky.

Light pollution is not explicitly mentioned in the "content" expectations of the school science curriculum, but virtually all of the skills and STSE expectations in the Pan-Canadian Science Project (CMEC 1997, Percy 1998) can be met through the preceding activities. There are therefore several places where they can be introduced, the most obvious being space and astronomy units. (If space and astronomy do not exist in your provincial curriculum — despite the recommendations of the Pan-Canadian Science Project — then we must work to get them there!) In Ontario, the science curriculum is divided into academic courses and applied courses; the latter courses are not as developed as the former. Many of the topics and activities in light pollution are especially suitable for the applied units because of their practical

[1] See Cohn & Sullivan (2001) for a comprehensive, recent review of this topic, and my article on pages 353–358 of that book for a more complete discussion of light pollution and education.

nature, their emphasis on human experience, environment and citizenship, and their connections with engineering and technology. Light pollution is an excellent topic for science fair and independent study projects since it involves investigations of various kinds — not just library research. It makes a useful project for humanities and social science students taking introductory astronomy courses (the generic "Astro 101"). I have great faith in what students can do as individuals and investigators if given the opportunity.

There are also many lectures and courses for adult learners, and the Centres of the RASC are very active in organizing these. Light pollution is a very appropriate topic for these lectures and courses because most adults are aware of the difference between dark skies and light-polluted ones.

Of course, not all education occurs in the classroom. Much occurs in planetariums and science centres, in youth groups, and in the print and electronic media. Students may experience dark skies in camps and parks. We must include all "informal educators" in our effort to publicize the issue of light pollution and how to reduce it. Like all education, it is most effective when it comes through partnerships and coalitions of the local "astronomical community."

What is being done in Canada? Emphasis in the school science curriculum is given to science in a Canadian context and Canadians' contributions to science and technology. There are several notable Canadian light pollution abatement initiatives and achievements. For many years, the town of Richmond Hill, Ontario, where the University of Toronto's David Dunlap Observatory (DDO) is located, has had by-laws and guidelines to suppress light pollution. "Local" observatories such as DDO have an important scientific role, as well as being available and convenient for public visits. Larger professional observatories have moved to darker locations or into space. In 1999, the world's first "dark sky preserve" — the Torrance Barrens Conservation Reserve, just west of Gravenhurst, Ontario — was approved, amidst wide media publicity. 2000 saw the opening of the McDonald Dark Sky Preserve in the Fraser Valley in B.C. In 2001, Oshawa adopted a better-lighting policy (and won a national award from the Royal Astronomical Society of Canada), and Calgary initiated a better-lighting retrofit of over 50,000 street lights. Other proposals include one to make Manitoulin Island into a national dark sky sanctuary.

Dark sky preserves have their advantages, but most people cannot spend the time or money to travel to these remote locations. We must reduce light pollution in and near cities as well. The solution is simple in principle: use more effective lighting fixtures — full-cutoff fixtures — with efficient light sources, giving light only where and when it is required.

Resources: Some Canadian science textbooks (*e.g.* Plumb *et al.* 1999) have sections on light pollution. David Crawford (Director of International Dark-Sky Association), John Percy, and Margarita Metaxa have produced an excellent resource for teachers, which includes most of the activities described above (`www.astrosociety.org/html/tnl/44/lightpoll.html`).

Astronomer-educator Margarita Metaxa organized an innovative Internet-based international project on light pollution, including high schools from several countries. Since students work in teams, this activity develops students' case-base learning skills (`www.uoi.gr/english/EPL/LP/lp.htm`).

The #1 general resource on light pollution is the International Dark-Sky Association, a non-profit scientific and educational society (`www.darksky.org`). The IDA has several Information Sheets containing ideas for activities, notably #127: Save the Stars: Activities for Elementary Students, K-3.

The Royal Astronomical Society of Canada light pollution abatement committee maintains a useful Web site (`www.rasc.ca/light/home.html`).

The RASC Kingston Centre has developed good resources for grade 6 and 9 astronomy teachers. Go to their Web site (`members.kingston.net/rasc/`), click on "education," and look at the sample grade 6 activity on light pollution. This excellent activity involves counting stars in a fixed area of the sky, so it is quantitative but not as difficult as measuring the observer's limiting magnitude.

La Fédération des astronomes amateurs du Québec publishes an excellent French-language booklet on light pollution: Protégeons la beauté du ciel nocturne (Éditions astronomiques inc., 4545, avenue Pierre-De Coubertin, CP 1000, Succ. M, Montréal QC H1V 3R2).

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Research Papers
Articles de recherche

Canadian Thesis Abstracts

Compiled by Melvin Blake (blake@aries.phys.yorku.ca)

The CFHT Open Star Cluster Survey
by Jason Kalirai (jkalirai@physics.ubc.ca)
University of British Columbia, MSc.

We have used the Canada-France-Hawaii Telescope to obtain deep and accurate multi-colour photometry of 19 open star clusters in our Galaxy. The quality and size of the data set are unprecedented when compared with previous studies of open star clusters. The clusters in the survey differ in richness, age, metal content, and location in the Galaxy and therefore provide a very diverse database for furthering the research in several areas of astrophysics. Some of the key issues which we address include the comparisons between the observational results and up-to-date theoretical stellar evolutionary models, star cluster dynamics, distance and age determinations, chemical evolution scenarios, and star formation histories. Of particular interest is the study of the properties of white dwarf stars, such as the initial-final mass relationship and the upper mass limit to production. The depth gained in the present survey (limiting *V* magnitude ~ 25) has allowed us to establish a large catalogue of white dwarf candidates, and our current spectroscopic investigations will provide the much needed observational constraints to white dwarf theoretical models.

The colour-magnitude diagrams for the rich, young clusters in the survey possess very tightly constrained, long main-sequences and show a much richer cluster population than previous studies. This thesis summarizes how this was done as well as key results for the two richest clusters in the survey, NGC 6819 and NGC 2099. For NGC 6819 we find: distance = 2500 pc, age = 2.5 Gyrs, size = 9.5´, and mass = 2600 $M_{\odot}$. The cluster is found to be dynamically evolved and exhibits mass-segregation effects. A strong cooling trail of white dwarfs is found to be in excellent agreement with a 0.70 $M_{\odot}$ theoretical white dwarf cooling model. For NGC 2099 we find: distance = 1500 pc, age = 0.5 Gyrs, size = 13.9´, and mass = 2500 $M_{\odot}$. The cluster exhibits some signs of dynamical evolution, although not as severe as for NGC 6819. The white dwarf cooling age of NGC 2099 is found to be in excellent agreement with the turn-off age.

Society News/Nouvelles de la société

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

With Christmas over and the New Year at hand, I hope everyone got those special astronomical presents that they were all dreaming about.

Bonnie and Isaac at the National Office have been busy over the last few months getting memberships and orders filled, from both the post office and the eStore, which has recently become quite busy. You can visit the eStore by going to www.store.rasc.ca. The eStore can handle new and renewal memberships along with orders for the *2002 Calendar, Observer's Handbook 2002* and the *Beginner's Observing Guide*.

National Council Meetings

On October 27, 2001, a National Council Meeting was held with representation from 16 Centres out of 26. Thanks to Michael Watson for securing a room for the meeting. Each member of the Executive and Chairs of the committees all gave reports, which are available online at www.rasc.ca/membersonly.htm (members only section – the username is 'member' and the password is 'chant99'). Many issues were discussed with the major one being the decoupling of membership fees, presented by the Constitution Committee. Michael Watson remarked that the objective of decoupling is not to separate the Society from the Centres, which are an integral part of the Society, but that the beneficial effects of decoupling of fees would allow independence of action at both the National and Centre levels. Each Centre representative was instructed to take back all information and talk to the Centre members regarding this proposal. It will have been discussed again at the National Council meeting on January 26, 2002 (before you read this), and Council members will vote on a motion to put this proposal to a vote by all members at the Annual meeting which will occur at the Montreal General Assembly in May. The meeting adjourned at 17:15.

Upcoming Events

The General Assembly will be held in Montreal on the May, 2002 long weekend, namely May 17 to 20. There will be more information presented at the next National Council meeting, and a General Assembly package will be mailed out to all members of the RASC. You can also visit their website at: www.rasc.ca/ga2002

Congratulations

At the National Council Meeting on October 27, 2001, Pat Browne (Ottawa Centre) and Michael Stephens (Saskatoon Centre) received their Messier Certificates, and Jan Wisniewski (Kingston Centre) received his Finest NGC Objects Certificate.

The last of the 5-year membership certificates were approved for 2 members of the Regina Centre and 32 members of the Calgary Centre (for a complete list of names, please see the minutes of October 27, 2001 NC meeting). There was one 25-year Membership Certificate handed out to Dr. David J.I. Fry of the Calgary Centre.

On Circular No. 7766 of the IAU, RASC member Ajai Sehgal of Woodinville, WA along with Tim Puckett of Mountain Town, GA reported a discovery of an apparent supernova (mag. 17.4) on an unfiltered CCD frame taken at the Puckett Observatory on Dec 4.44 UT. SN2001gh in NGC 4162 is located at RA $12^h\ 11^m\ 53.18^s$ and DEC +24° 06′ 49.4″ (equinox 2000.0).

Congratulations to everyone on behalf of the RASC for your accomplishments.

Passing Friends...

In November, the highlight of the month was the Leonid meteor shower. However, this great event took a turn for the worse when one of Regina's prominent members, John Mulvenna, was tragically killed in an accident while driving his daughter back to Saskatoon. A card of sympathy was sent to the Mulvenna family and sympathies were sent to the Regina Centre on behalf the RASC. Our thoughts and prayers are with the friends and family members of the Mulvenna family.

DISAPPEARING RAINBOWS

and the "THIRD" rainbow

by T. Alan Clark, Calgary Centre (taclark@ucalgary.ca)

In his recent article on rainbows in this journal, Alister Ling describes how the physiological effect of an after-image of a bright rainbow leads to a fleeting "third" rainbow in the dark space between primary and secondary bows (Ling 1999). However, Ling missed the other distinct and even more startling physiological effect when observing a rainbow, namely its disappearance if an observer stares fixedly at it. This disappearance of the bow begins at the point of observation but slowly spreads along most of the rainbow. A momentary loss of concentration and movement of the head or eyes will immediately bring the reappearance of the rainbow, and it will then appear to be bright and the colours vivid. If, after the rainbow has disappeared, one glances away deliberately towards dark clouds, the bright but rapidly fading after-image of the reversed-colour rainbow will be seen, as discussed by Ling. Eventually, after the observer follows this staring procedure several times, the disappearance of the primary bow will be remarkably, even frighteningly, rapid, and the whole rainbow will disappear within a few seconds. My daughter, Jill, and I "discovered" this effect several years ago while looking at a spectacular primary rainbow. This physiological/psychological phenomenon was discussed with (and subsequently verified by) one of the authors of the excellent book on atmospheric optical effects, *Color and Light in Nature*, by Lynch and Livingston, and is now included as a note in their second edition (Lynch and Livingston, 2000). When coached in the staring technique, most people can experience this effect. The disappearance of indistinct objects when stared at in this intense way is well-known (see for example, Riggs 1953), but the non-localized nature of the rainbow almost certainly serves to enhance this remarkable effect. Observers should be warned that this exercise could become mildly addictive, since rainbows disappear almost as soon as one looks at them after following this procedure many times. For some observers, this makes the observation of rainbows a very frustrating experience!

The true "third" rainbow, predicted to occur at an angle of about 40° away from the line to the Sun (Walker 1976), has never been satisfactorily photographed. However, contrary to Ling's comment, there have been several reliable visual reports of its observation. These were reported by Jearl Walker in *Scientific American* in 1978 (Walker 1978), perhaps the most reliable of which was J.R. Prescott in Australia. Pedgley (1986) subsequently reported a similar observation. Both of these were made under "ideal" conditions for seeing this elusive bow, a faint, diffuse, coloured arc being seen against very dark clouds as a low Sun appeared below these clouds. The present author (Clark 1992) also saw a similar but smaller bow under these same conditions, though its size was not consistent with that predicted for the "third" rainbow. Observers of the sky should be on the lookout for this rare apparition. When bright rainbows are seen under these conditions, simply turn around, shade the sunlight from your eyes and scan the sky at about this angle from the Sun.

In the classroom, the rainbow represents an excellent springboard for a discussion of geometric optics. Depending upon the level of the students, this discussion can range far beyond the simple ideas of refraction and reflection in water droplets and the dispersion that produces the colours, to include more esoteric topics such as wave interference to produce the supernumerary bows inside the primary bow (often misinterpreted as a "third" rainbow) and the polarization of the light within a rainbow. In view of the above effects, this discussion can also extend to physiological effects of visual observations.

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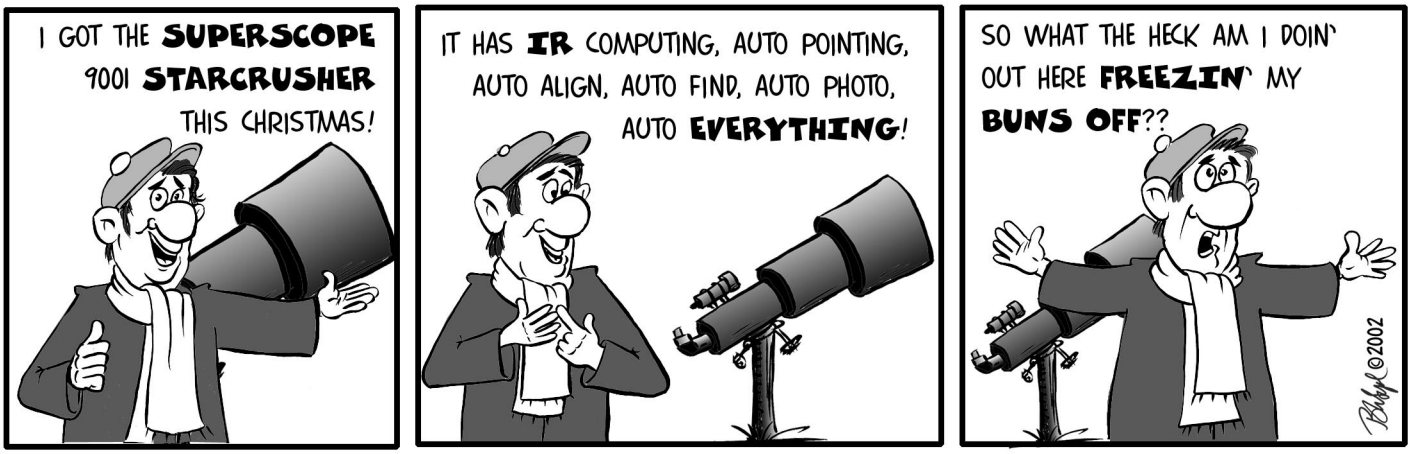
Alan Clark is Professor Emeritus in the Department of Physics and Astronomy at the University of Calgary and a long-time member of the Calgary Centre. He still carries on an active research program in solar spectroscopy and is a regular user of the McMath-Pierce Solar Telescope on Kitt Peak, Arizona.

ANOTHER SIDE OF RELATIVITY

Uncle Ernie discovers that old habits die hard!



New Clock Casting a Long Shadow in Pinawa

by Michael Attas (michael.attas@nrc.ca)

Figure 1 — General view from south (photo Pat Sullivan)

A new astronomical landmark appeared on the Canadian landscape this past summer. In a ceremony on July 14, 2001, the Pinawa Heritage Sundial was officially opened to the public. The 5-metre tall steel structure, on a 10 × 10 metre platform, is a bold symbol for the town of Pinawa, Manitoba (Figure 1). Atomic Energy of Canada Limited (AECL) created the town in 1963 on the edge of the Canadian Shield in eastern Manitoba to house workers for its second national research lab. Since the recent downsizing of the lab, the town has been exploiting its potential as a tourist destination and high-tech business centre. The sundial has become a meeting point in the town's street market area, poised between marina and mall, linking lake, land, and sky (Figure 2). Its design combines dramatic beauty with scientific precision in a true reflection of its human and natural surroundings. The motto, "Time to Celebrate," emphasizes the passage of time in a positive way, unlike some of the gloomier sayings often found on sundial bases.

Figure 2 — Gnomon from west (photo Pat Sullivan)

Retired engineer Carl Sabanski, the driving force behind the project to build the sundial, described many of its unique features. Built as a millennium project, it features the work of local artists and craftsmen, as well as volunteer scientists, engineers, and surveyors (Figure 3). Mild steel was chosen for the gnomon, the triangular piece casting the shadow. It has been carved with a dozen symbols, gradually changing from steel-gray to red to brown, and will continue to evolve over the next few decades. The horizontal dial, or base, consists largely of local materials, especially Canadian Shield granite. Etched granite slabs in the base (Figure 4) echo the stylized designs of the gnomon, which were cut out using a high-precision computer-controlled plasma torch. More details of the sundial's construction, as well as colour photographs, can be found at Carl's Web site, `www.escape.ca/~sabanski/sundial/sundial.htm`

Figure 3 — Barrie Burnett (left) and Carl Sabanski putting the finishing touches on the dial (photo Bud Biddiscombe)

Figure 4 — Granite carvings on outer dial (photo Pat Sullivan)

In a tour led by Barrie Burnett, surveyor and retired AECL technologist, I learned that two aspects of the construction required extreme care for accurate time telling. In order to be parallel to the Earth's axis, the gnomon had to point due north, and its angle from the horizontal had to equal the local latitude: 50° 08′48″. Over the length of the gnomon this angular accuracy required fabrication tolerances of only a few millimetres. The dial markings were also positioned very precisely. Because of the thickness of the upper edge of the gnomon, its shadow is cast from slightly different locations depending on the time of day. To account for this, there are actually two semicircles of dial markings separated by a gap of 15 centimetres, the so-called "noon gap" (Figure 5). The shadow is formed by the edge of the gnomon, and the relevant edge changes up to three times during the day. The brochure available at the site explains it as follows: "Before 6:00 a.m. 'local apparent time' (LAT), the shadow will be cast from the east edge of the gnomon; between 6:00 a.m. and noon LAT, the shadow will be cast from the west edge of the gnomon; between noon and 6:00 p.m. LAT, the shadow will again be cast from the east edge of the gnomon and finally after 6:00 p.m., the shadow will again be cast from the west edge of the gnomon. Noon LAT will be cast from both edges of the gnomon and therefore this is where the gap is applied." (In winter the pre-6 a.m. and post-6 p.m. comments don't apply, because it's dark!)

The base consists of two concentric sets of markings, or dials, both constructed out of recycled steel railroad track (Figure 6). The outer one tells local apparent time, and is aligned with the axis of the gnomon, so that it reads 12 noon when the Sun is directly south. The inner dial is offset from the outer one, so that it tells Central Daylight Time (*i.e.*, summer clock time in the Central time zone). The amount of offset is one hour and 23.5 minutes: the hour for daylight saving, and the 23.5 minutes to compensate for Pinawa's longitude within the Central time zone. Both dials have their hours divided into quarters with small brass plugs, so that it is possible to read the position of the shadow to the nearest 5 minutes. For greatest accuracy, a seasonal correction for the equation of time must also be applied. Its value varies between extremes of about +14 minutes in February and –16 minutes in November. This correction compensates for the small variations in the angular rate of apparent movement of the Sun caused by the tilt of the Earth's axis and the slightly elliptical orbit of the Earth around Sun. A graph in the brochure allows visitors to make that correction themselves. (The analemma multiple-exposure photo of the Sun in the previous issue of the *Journal* is a pictorial representation of the same phenomenon.)

Local astronomy buffs are delighted with the sundial, and are already discussing refinements. Plans to illuminate the monument during the evening have taken into account the effect of artificial lighting on observing conditions. Pinawa's clear, dark skies will not be affected, nor will the excellent southern exposure over the Winnipeg River. Some ingenious tinkerers are already contemplating ways to light the sundial so that it will cast a moving shadow through the night, and still tell time. A moving "anti-Sun" or a track-mounted set of spotlights turned on in sequence could be rigged up to do this. All of us agree it would have to be solar-powered!

Figure 5 — Pair of rails marking local noon, separated by 15 cm to form the "noon gap" (photo Barrie Burnett)

When Dr. Attas is not shamelessly promoting his home town of Pinawa, he works at the National Research Council's Institute for Biodiagnostics in Winnipeg, investigating optical and spectroscopic methods of diagnosing disease. He is also Associate Editor (General) of the JRASC.

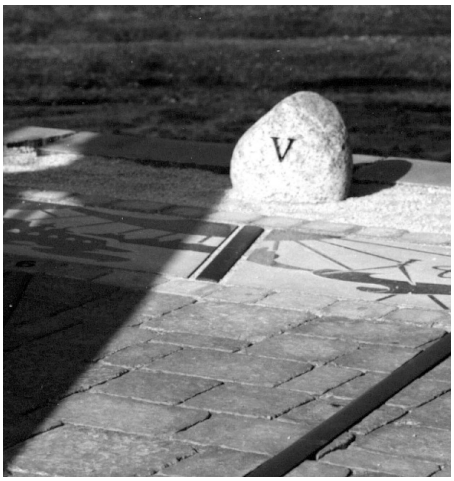


Figure 6 — Shadow falling on inner and outer dials (photo Barrie Burnett)

Reflections from a Chant Medal Winner[1]

by Richard Huziak (huziak@SEDSystems.ca)

On July 1st, at the General Assembly in London, I was presented with the National Chant Medal in recognition of "significant astronomical work in amateur astronomy in Canada." Cited were several items: recent work that I have done in variable star research, including submission of over 14,000 variable star estimates to the AAVSO (now over 21,000); work into correcting AAVSO charts; researches into missing and incomplete labeling of variable stars in the *Millennium Star Atlas* (see note); and mention of probably a bazillion school talks that I have done to promote astronomy.

I was unable to get decent flights to the GA, so I was not able to accept this award in person. I would have loved to be there, since the presenters were scheduled to be Dr. John Percy and David Levy. Jim Young, of the Saskatoon Centre, kindly accepted the award on my behalf. The award was then re-presented to me in person at this year's Saskatchewan Summer Star Party, by Jim. At the SSSP, I was able to give a small speech about what this award meant to me, which I'd like to relay in the next few lines. (And maybe I'll make a bit more sense here, since the star party presentation occurred only hours after Vance Petriew had discovered his comet, and he and I had spent time well after sun-up getting everything confirmed and sent in. I was dead tired when I gave my speech!)

The award was a total surprise. The Saskatoon Centre did a bang-up job of keeping it completely secret. Besides, I never thought what I was doing in astronomy was anything unusual; the work was done out of love for this hobby. Award or not, I would do it anyway.

To me, astronomy is observing. For the last 33 years, I've observed just about every different type of phenomenon in the sky and I've always encouraged others to observe. However, to change general observing into something more valuable, you have only to write down what you see. If you record your observations, then these observations may become valuable to others. Notes and sketches are all that are required. In this hobby, amateurs can still make significant and recognized contributions to the advancement of astronomy through visual observing using very modest telescopes and a pencil and paper.

Richard, with his telescope, holding the Chant Medal.

Astronomy is also a field in which amateur and professional astronomers cooperate every day, and the distinction between the two is sometimes very gray. Just as amateurs are awed by new data from the Hubble Space Telescope, professionals are also awed by the dedication of amateurs who observe a very large variety and number of astronomical targets on a regular basis. Professionals often rely on amateurs to do long-term monitoring of different objects and to alert them when certain celestial events occur, such as the eruptions of dwarf novae. Professional astronomers simply do not have the time nor resources to do this kind of monitoring, so amateur observations are often used to trigger satellite or professional observatories into action.

Fields of study such as variable stars, asteroid and lunar occultations, fireball chasing, meteor counting, aurora and noctilucent cloud observing, and planetary studies allow amateurs to observe for fun and yet make valuable contributions to astronomical databases used for both professional and amateur research projects. Why not check out the AAVSO, IOTA, NLC Can/Am, IMO, NAMN, MIAC, or any other amateur/professional group that would value your reported observations? You could gear a new observing program around counting

[1] Extensively revised from the first printing in Saskatoon Skies, Sept. 2001

meteors, observing asteroids or measuring variable star brightness. You do not have to be a member of any of these organizations to report your observations, nor do you necessarily have to observe more frequently to participate.

Contributing data to research is a natural evolution of observing, yet fewer than two-dozen amateurs in Canada contribute any variable star observations to the AAVSO. A similar number respond to calls from the IOTA for asteroid occultation events, and only that many help Mark Zalcik out each year to report noctilucent clouds, even though there are at least 10,000 RASC and independent amateurs in Canada. Maybe my work in amateur research will encourage at least one other observer to begin a regular and recorded observing program. It is really just a lot of fun, very easy and always a blast!

The Chant Medal also helps a whole lot — a sign that it is worth the while. I'd like to thank the members of the Saskatoon Centre for nominating me for this award. (I still do not know who all the ringleaders were.) The medal will be framed and will occupy a place of honour on my wall for all time!

Note: For *Millennium Star Atlas* errors and omissions, see `prana.usak.ca/~sarty/astronomy.html#MSA`

Rick Huziak is still looking for his first comet. In 33 years of star hopping he has had a few close calls, but no cigar (-shaped objects). He observes from Saskatoon and the Sleaford Observatory with telescopes clearly inferior to Petriew's 20-inch Obsession, but cares not a sniff about this, nor spends any time worrying or obsessing, or whining, or wishing for things he will never have, nor ever discover, nor... nor....

Orbital Oddities

BINARY
FINERY

by Bruce McCurdy (bmccurdy@freenet.edmonton.ab.ca)

The funny thing about stargazers is that we often use the stars as a backdrop for the planets, or as reference points on our way to the deep-sky objects, but we sometimes forget to take time to gaze at the stars themselves. Among the most forgiving of objects, stars shine through city light, twilight, moonlight, cirrus, haze, and/or aurora with relatively little loss of detail. As one who does most of my observing from the city, and a lot of it during the summer due to my seasonal employment at the public observatory of the Odyssium (formerly known as the Edmonton Space & Science Centre), I have learned to tailor my observing habits to what is visible, rather than dwelling on what I cannot see.

Many worthwhile observing projects can be based on stars: the *Observer's Handbook* has lists of bright stars, nearby stars, and variable stars. One can also pursue cool red stars, or hot Wolf-Rayet stars, or even the growing number of stars now known to have planets orbiting them. One class of object that I have found particularly appropriate for the pleasure of both the public and myself is double stars.

If stars are the currency of the galaxy, double stars are the most common denomination. In fact, the majority of stars in the sky are actually double or multiple systems. There are many exotic variations: eclipsing binaries, spectroscopic binaries, X-ray binaries, contact binaries, recurrent novae; each class fascinating in its own right. Indeed, a professional astronomer of my acquaintance has specialized for many years in a particular subclass known as ellipsoidal binaries, without suffering any readily apparent psychological damage.

To the amateur, the most accessible stars of this type are the visual doubles. There are a range of targets accessible to the casual or novice observer armed only with a pair of binoculars, through department store "675 power astronomical telescopes" and right up to quality refractors and large reflectors. Almost any scope will resolve many of the best pairs right in the backyard. The more doubles you see, the more you will realize that there is an endless variety, from "identical twins" to pairs exhibiting large magnitude and/or colour contrasts. Colourful doubles in particular are among the most romantic objects in the sky, and can even be shared with loved ones who demonstrate no strong interest in astronomy. Of course it might be pointed out that the long term stability of their relationships is based on the fact they never get *too* close.

Visual doubles come in three main classes: optical pairs, where the two stars are on almost the same line of sight but are at vastly different distances from us and therefore unrelated to each other; physical doubles, where the stars appear to be moving through space together although no orbit has been determined; and binary stars, where repeated observation over decades or centuries has yielded evidence of orbital motion between the two.

The term "binary star" was coined by none other than Sir William Herschel, who can be regarded as the father of double star observing (Jones 1979). Herschel began with the notion that close stars of unequal brightness were excellent candidates for determining stellar parallax, on the reasonable assumption that the brighter of the two should be the closer. Discovering many of the most famous pairs, around 1779 he began to catalogue them with his customary brilliant technique and careful record-keeping, eventually listing over 800 pairs. By the turn of the century Herschel had made the logical leap that rather than exhibiting parallax, changes in his doubles' relative positions were instead due to orbital motion. Of particular import were Herschel's measurements of xi Ursae Majoris. According to Burnham (1978):

> "xi Ursae Majoris is a fine close binary of great historical interest, found by Sir William Herschel in 1780, and announced as a physically associated pair in 1804 when the change in PA [position angle] since discovery amounted to 59°. This star was the first binary to have an orbit computed, by M. Savary in 1828; as Miss Agnes Clerke phrases it, the star was 'the subject of the first experiment in the extension of Newtonian principles to the sidereal universe'." (see Figure 1)

Of course, since Newtonian physics

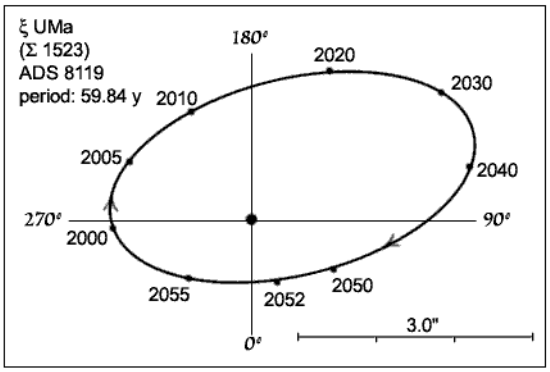


Figure 1 — xi (ξ) Ursae Majoris (RA 11^h 18^m, Dec +31.5°). Alula Australis was the first star for which orbital predictions were made. This is an ideal pair for detecting orbital motion, as the system is only 25 light-years away, so the two stars are resolvable despite an orbital period of just under 60 years. Furthermore, the two stars are of similar but unequal magnitudes (4.3, 4.8) making them easy to resolve and identify. Unfortunately, periastron was last achieved in 1993 (near the position marked "2052"), so the relative motion has since slowed considerably, although the two are now nicely separated at 1.8 arcseconds.

By convention, each diagram shows the apparent motion of the fainter, or secondary, star around a "fixed" primary. In fact, the two stars actually orbit a common centre of gravity, or barycentre. This is the view in a standard Newtonian telescope, with north (0°) at bottom and east (90°) to the right.

All diagrams provided courtesy of Richard Dibon-Smith.

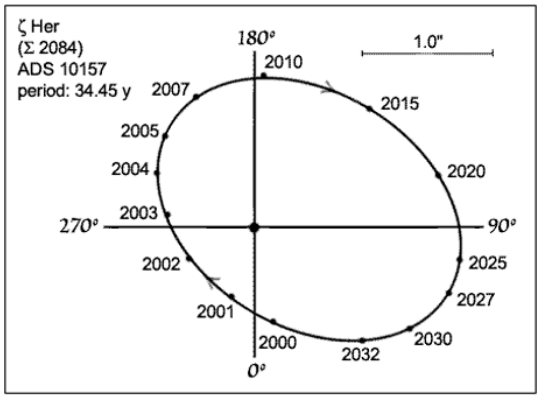


Figure 2 — zeta (ζ) Herculis (RA 16^h 41^m, Dec +31.6°). This pair exhibits exceptionally rapid motion, with a change in position angle of 147° between 2000 and 2005. At 0.7 arcsecond separation the system should be resolvable, however there is a significant magnitude contrast between the two (2.9, 5.5), meaning the secondary is 10 times fainter than the primary. This has proven to be an elusive target to split, however resolution should be within the range of large reflectors with clean, well-collimated optics.

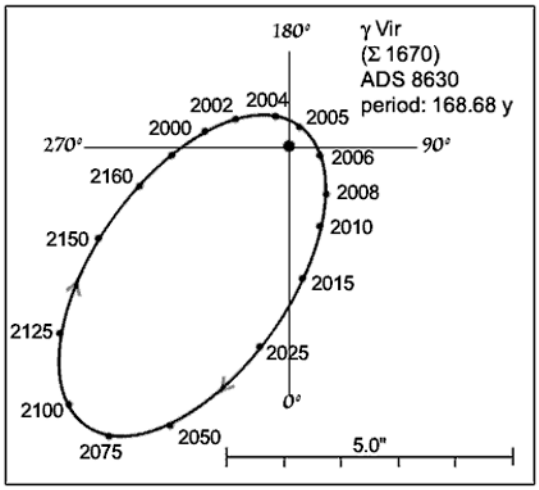


Figure 3 — gamma (γ) Virginis (RA 12^h 42^m, Dec –1.4°). Porrima features a pair of stars virtually identical in magnitude (each 3.5) and spectral type, which makes them nearly impossible to tell apart. Because of their similarity in mass, the barycentre of the system would be almost precisely midway between the two. They are now rapidly approaching the 2005 periastron of their sharply elliptical orbits, whose combined effect resembles that of a periodic comet. At present the distance between the two is closing, from 1.1" in 2002.0 to 0.9" in 2003.0. The last periastron is described in *Burnham's Celestial Handbook*:

"Sir John Herschel calculated the orbit in 1833 and predicted that at the closest approach the two stars would be inseparable in any but the greatest telescopes. This was verified in 1836 when the apparent separation diminished to 0.3" at periastron passage, and the star appeared as single even in Herschel's telescope at the Cape of Good Hope. Within a few months the pair had widened, and soon became an easy object for small telescopes."

I plan to continue to observe this system at least annually. Interestingly, six years from now when the pair have again separated to roughly one arcsecond, they will have undergone a change in PA of about 180°; in effect they will have switched positions. Because its components are dead ringers for one another, however, the system will appear virtually identical then as it does now.

rule the "sidereal universe," then Kepler's Laws apply as well. Elliptical orbits remain the norm. Like the Moon at perigee or the Earth at perihelion, binary stars move fastest when they are at periastron (closest to each other) and therefore hardest to resolve. The best action, therefore, occurs with the tightest pairs that one's instrument can resolve. Further complicating the issue are perspective effects like the system's distance from us (closer is better, alpha Centauri is best), and the orientation of the orbit to our line of sight (edge-on is worst, face-on best). Under favourable circumstances binaries with orbital periods measured in the tens of years are sufficiently separated to be resolved in a good telescope, and such systems will exhibit changes in their position angle and separation in relatively short periods of time (*ie*. a few years). Many of their orbits are well known, however, this is not invariably the case, as we will see.

Assuming satisfactory seeing conditions, resolution of tight doubles depends on both aperture and the quality of the telescope's optics. The Odyssium's observatory houses the Edmonton Centre's own 18-cm Astrophysics *Starfire* refractor, which delivers in spades on the latter. According to the excellent article on multiple stars in the *Observer's Handbook 2002* by Brian Mason (2001), "the resolving power in arcseconds can be estimated as 120/D, where D is the diameter of the telescope objective in millimetres,". In the case of the *Starfire*, that is 120/180, or two-thirds of an arcsecond. The optics of that instrument are of such excellent calibre that on a good night we can very nearly reach this theoretical limit, routinely resolving pairs of similar magnitude separated by as little as 0.8 arcseconds such as epsilon Equulei.

For the past four years those of us on the observatory's Sunday evening shift (Terry Samuel, Sherrilyn Jahrig, Bob Casgrain, and myself) have been systematically observing, at the rate of a couple per week, each accessible double in the *Starfire's* computer catalogue. Originally we were simply enjoying the "snapshot" view, concentrating on resolution and colour contrast, however, readers of this column may know I prefer my universe to be dynamic. It was not long before I had enough of snapshots and I wanted to see these things move. We acquired an excellent reference source, *StarList 2000*, by Richard Dibon-Smith of Toronto, that has extensive details on many of the best double stars, including schematics of their orbital motion (Dibon-Smith 1992). Several examples of these appear in the accompanying figures. Each presents a unique observing challenge; refer to the captions for details.

One Sunday last spring I dropped in on the 1338th entry in the enormous multiple star catalogue compiled by the 19th century pioneer F.G.W. Struve. This particular object is located in eastern Lynx, an often-overlooked constellation which contains many superb multiple stars. I comfortably split the pair, listed at magnitudes 6.5 and 6.7, and estimated their separation to be right around 1.0 arcseconds. In routinely checking this observation with *StarList 2000*, I was surprised to find that the two stars were projected to be only 0.4 arcseconds apart. (refer to Figure 5a.) This was well below the theoretical limit for the telescope; something was amiss. Unfortunately, at that point the telescope could no longer track the star as it had run into the leg of the mount's tripod, an occasional problem we have with stars in the northern sky. (Lynx has been frustrating me for years because of this.)

The following week I had another look, a little earlier in the evening, and again had no difficulty in resolving the pair. I also calculated a position angle of approximately 280° (the fainter star was almost due west of the primary), which differed significantly from *StarList* which showed a P.A. of 16° (~NNE) in 2000.0. In addition to the Sunday night regulars, Alister Ling happened to be on hand to confirm the observation, before we were once again defeated by the tripod leg.

The third week I waited until much later in the evening when the star emerged beyond the other side of the obstructing leg and we could have a good long look. On that occasion the legendary double observer Larry Wood was present to confirm the observation. We both took pains to ensure we had the correct star, accessing the telescope's "go to" capability as well as more traditional methods using a finder and *Sky Atlas 2000*. Right star, wrong data.

Finally satisfied with our collective observations, it was now time for a little research. My first hit on the Internet was "The Double Star Observer" which contained a link to what it considered the best site for drawn orbits, Richard Dibon-Smith's own Web site (`www.dibonsmith.com/orbits.htm`), which has orbits for 150 doubles including Struve 1338. The orbit here was identical to that in the book, listing an orbital period of 219.7 years. (While scant on details, *Burnham's* also lists a period of 220 years.) The computer program *Guide 6.0*, however, told a different tale: the detailed data indicated a double star with a period of 389.05 years, with its separation having decreased from 1.8 arcseconds at Struve's first observation in 1829, to a most recent of 1.0 arcseconds at P.A. 281 in 1994. This agreed very nicely with what we had observed.

At this point I contacted Richard Dibon-Smith by e-mail. I was very gratified with the speed of his response, three e-mails within four hours! Richard, a self-described "Canadian writer and astronomy enthusiast," wrote in part:

> "A quick check revealed two things. First, the period reported on my site and in my book comes directly from the *Sky Catalogue* data, vol 2, p. 179, top of the list, where they cite a period of 219.7 years. They also give the 2000 ephemeris as PA 16 and sep 0.4″(as my graphic shows). Then I checked the *Washington Visual Double Star Catalog* (Worley *et al*. 1996) and came up with the surprising [sic] information that the last PA and sep reported there show 281 degrees and sep 1.0″. So your observations are indeed accurate and somewhere along the way an apparently erroneous period was published, either by *Sky Catalogue* or by their source. The error has been corrected and you should find

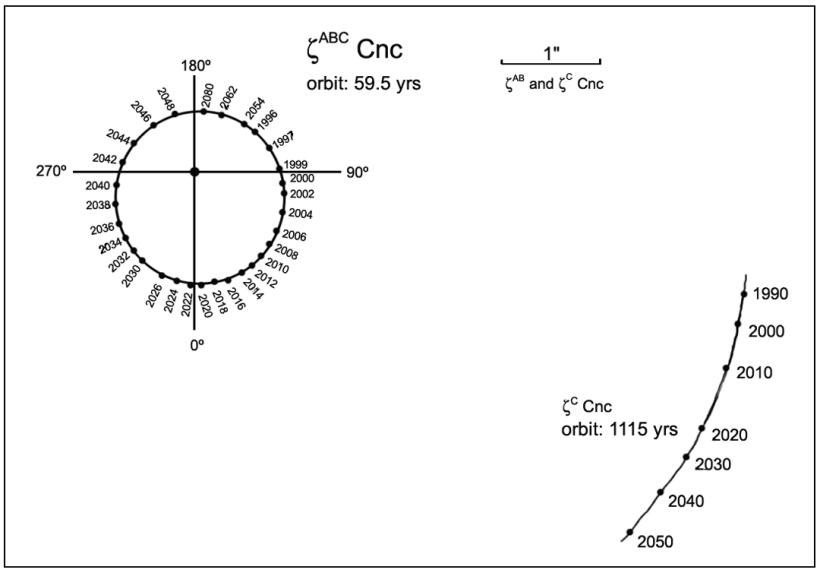


Figure 4 — zeta (ζ) Cancri (RA 08h 12m, Dec +17.6°). This nearly face-on triple system of magnitudes 5.6, 6.0, and 6.2 presents an intriguing opportunity in 2002. As noted in *StarList 2000*:

"The two components stars to the primary are shown here with their orbits to scale. The closer companion revolves every 59.7 years; the more distant companion every 1150 years. If the orbital elements are accurate, the two will be in alignment in the summer of 2002. However, this will not be visible to us. In the spring of 2002, just before the system is blotted out in the sunset, zeta AB will be on one side of zeta C, and when the stars come back into view later that year, zeta B will have passed its slower companion."

The orbital elements, however, may have changed. As routinely noted in the *Observer's Handbook*, "note that data for 2002.0 have been changed for some systems due to improvements in orbits or more recent measurements." Indeed, the position angle for zeta AB at 2001.0 was advanced by 3° in the *Observer's Handbook 2001* over the 2000 edition, suggesting that the three should be in virtual alignment around the time this article goes to press. In the spring of 2001, the three were positioned at an obtuse angle of very close to 180°, but in the author's opinion the inner star had not quite reached alignment at that point in time.

(a) (b)

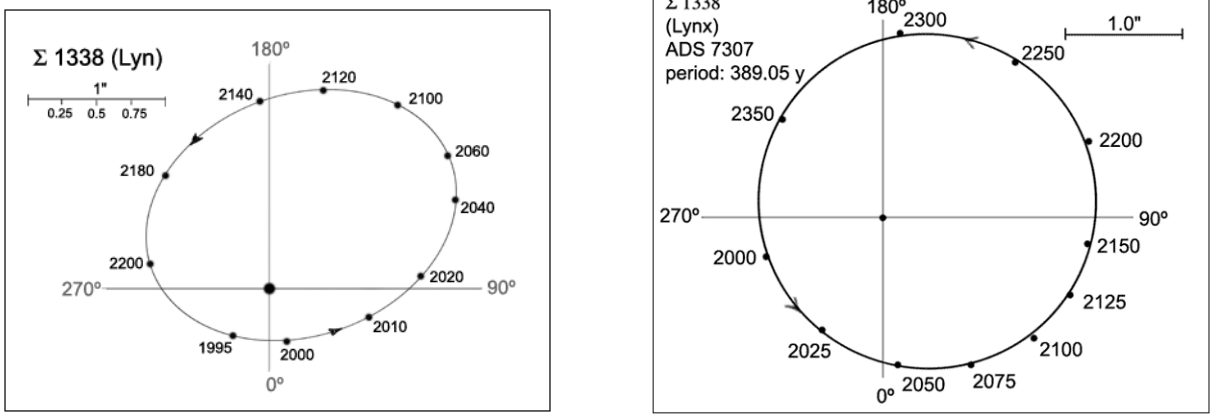


Figure 5 — Struve 1338 (Σ1338) (RA 09h 21m, Dec +38.2°). The "before" and "after" view of the binary system described in the text. Figure 5a at left is based on the 219.7–year orbit provided by Starikova as published in several current catalogues. Figure 5b at right is the more circular 389–year orbit calculated by Arend, which is consistent with the observations of the author in 2001. Note that as with the other charts, the upcoming orbit is shown. To look backwards in time, simply subtract the period from the dates shown. Therefore "2180" on the first chart and "2350" on the second both equate to an observed position in 1961, while a date around 1918 could be derived for passage through the 180° point in either scenario. Struve's first observation of this system was a PA of 121° in 1829, which fits both curves reasonably well. To use Sinnott's words, the "limited arcs of orbit" of both were quite similar for this entire period, but diverged sharply over the subsequent 40 years. This serves to illustrate how difficult is the task of establishing an orbit with incomplete information. At 130 light-years, this pair is considerably more distant than the others highlighted here. Accordingly the system will exhibit little change in the coming years.

a more accurate orbit of Struve 1338 on the Web site. Once more, I appreciate the email as I strive to make the site as reliable as possible." (R. Dibon-Smith 2001, private communication)

So it was very gratifying indeed to see an error I had detected, corrected *at the source* the day I reported it. The wonders of the computer age! Correcting his book will be more problematic — at least until the next edition — although I have taped a printout of the new orbit (Figure 5b) into the observatory's copy.

Since Dibon-Smith had regenerated an error from *Sky Catalogue 2000.0* (Hirshfeld & Sinnott 1985), a current reference book which may well have a new edition published in the foreseeable future, I undertook to follow up further. I e-mailed Roger Sinnott, one of the co-authors of *Sky Catalogue 2000.0*. He responded:

"Thanks very much for pointing out that our orbital elements for Struve 1338 don't match current observations. In *Sky Cat* v*2*, we used the elements by G. A. Starikova, published in 1966. These are the elements with the 219.7-year period. (We used Paul Couteau's tape of 1982 as our main source. We only substituted elements from the Worley-Heintz 1983 catalog when they seemed significantly better.) The other elements, with the 389.05-year period, are those given by S. Arend in 1953. They are published, for example, in the 1970 Finsen-Worley catalog. And, as your observations indicate, they appear to be more correct. In fact, I just checked the *Fifth Catalog of Orbits (2000)* at `ad.usno.navy.mil/ad/wds/hmw5frames.html` and Arend's 1953 elements are what they list for this star. It is not uncommon for two rather different sets of elements to fit the observations along a limited arc of an orbit. But eventually they diverge, and that's the proof that one set is correct and the other wrong. That's what seems to be going on here. We appreciate your letting us know about this!" (R. Sinnott 2001, private communication)

So in this case we had two sets of "competing" orbital predictions dating back at least 35 years. In the interval, the stars have continued their inexorable orbit, proving through direct observation one of the two predictions to be more correct. The incorrect prediction, however, seemingly took on a life of its own, its mutant genetic blueprint being passed intact from one generation of catalogues to the next.

The moral of this story is that even the best books are guides, not gospels. Do not believe everything you read, but actually look for yourself. You might be surprized at what you see.

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Acknowledgment

The assistance of Richard Dibon-Smith is gratefully acknowledged.

Bruce McCurdy is an amateur astronomer and astronomy enthusiast. A past president of the Edmonton Centre, he has been active in public education for the past 15 years. His binary interest in both observation and theory, combined with a passion for writing, has resulted in Orbital Oddities *becoming a regular feature in* JRASC.

Walking to the Stars

by Fae Mooney (faemooney@kermode.net)

"All we need to see a myriad of wonders that others miss is the two eyes with which we were born." — Fred Schaaf

Can we ever again be satisfied to just look up into a clear black sky at those tiny specks of light with just our own two eyes? Does anything less than a glamorous Hubble Space Telescope image disappoint us?

How do we, lovers of the night sky, capture the interest of the general public, those we try to encourage to join with us in our passion? After all, how can we possibly compete with those beautiful and very colourful and detailed sights revealed by Hubble? Many of us are no longer satisfied to just look up without a lens before our eyes. What can we do to recapture that simple-yet-spectacular delight of embracing the whole broad sky with just "the two eyes with which we were born"?

Starting over: Fred Schaaf suggests in his 1989 book, *The Starry Room*, that what we need first, before scopes, computers, and other high-tech toys, even before knowledge or expertise, is eyes, feet, and imagination — or a sense of wonder.

Eyes: to first take in The Great Panorama, before zooming in for a closer, more detailed look through binoculars or telescope. Only then can we begin to truly comprehend the incredible magnitude of what we see when magnified through a lens.

You may call mere naked eye observing a poor person's astronomy, but Fred Schaaf believes that we can't fully appreciate the starry sky until we have first used only our eyes. Our own two eyes are the first and only things we need to get started in astronomy, he says. But then, he adds, perhaps there is something else we need even before we start using our eyes — our feet!

Feet: to take us away from manmade night lights to where we can have a clear view of those heavenly lights and celestial vistas, to acknowledge the majesty of our Universe. And then —

Imagination: to appreciate the magnitude of it all. Imagination undoubtedly will carry us into the realm of science fiction, and that's okay with Mr. Schaaf, to a point: "Science fiction writers have long imagined spaceships that would take us to the stars," he tells us. But "the Einsteinian ultimate speed limit of light scorns their fancies about breaking it, and otherwise the journey takes too long... Yet I say that the first, and in one key respect best, way we can reach the stars is not with hyperspace-drive, warp engines, or hydrogen-scoop time-dilation space-craft...

"Now I am certainly not belittling the ability of the eyes, nor the goal of a working starship (which I not only hope but believe we will some-century build to carry us bodily and gloriously to the stars)...

"But we must walk to the stars before going there any other way," Mr. Schaaf states emphatically. "What I mean by this jesting yet profoundly serious statement," he explains, "is essentially what C. S. Lewis meant by one of his comments in an essay on science fiction. No man could find an abiding strangeness even on the moon, Lewis wrote, if he could not also find an abiding strangeness in his back garden. My point is just that; it will not do the human spirit any good to visit the stars by spacecraft" (or any other way), without first experiencing that walk away from buildings and manmade lights to the stars.

Any future space traveler, Mr. Schaaf believes, who has not first made "the simple walk of wonder" out under that canopy of twinkling celestial lights will find his journey beyond our solar system ultimately disappointing. And what about the greatly magnified view of the heavens that we see today? How can those tiny pin pricks of light twinkling shyly above our heads (if we bother to look up at them at all), unless we possess a sense of wonder, be anything but disappointing? Perhaps our sense of wonder is the most important of the three. It's what will motivate us to use the other two. And imagination will provide the fuel.

Preparation: There is one more thing I would add to Mr. Schaaf's list — a comfortable *chaise longue*. Call it the captain's chair if you like. There is nothing more we will need for our journey, except perhaps a warm comforter and a thermos of hot chocolate. The course has been laid in, so stretch out and enjoy —

The Journey: You gaze eastward, Mr. Schaaf describes, "and see that the Earth is rolling you toward a bold new headland of stars. You are on your way to them." Without leaving this dear Earth, you are departing to the heavens. "Somehow you seem to know not only that you are travelling, but also that you are travelling to what is wonderful..." You are walking to the stars!

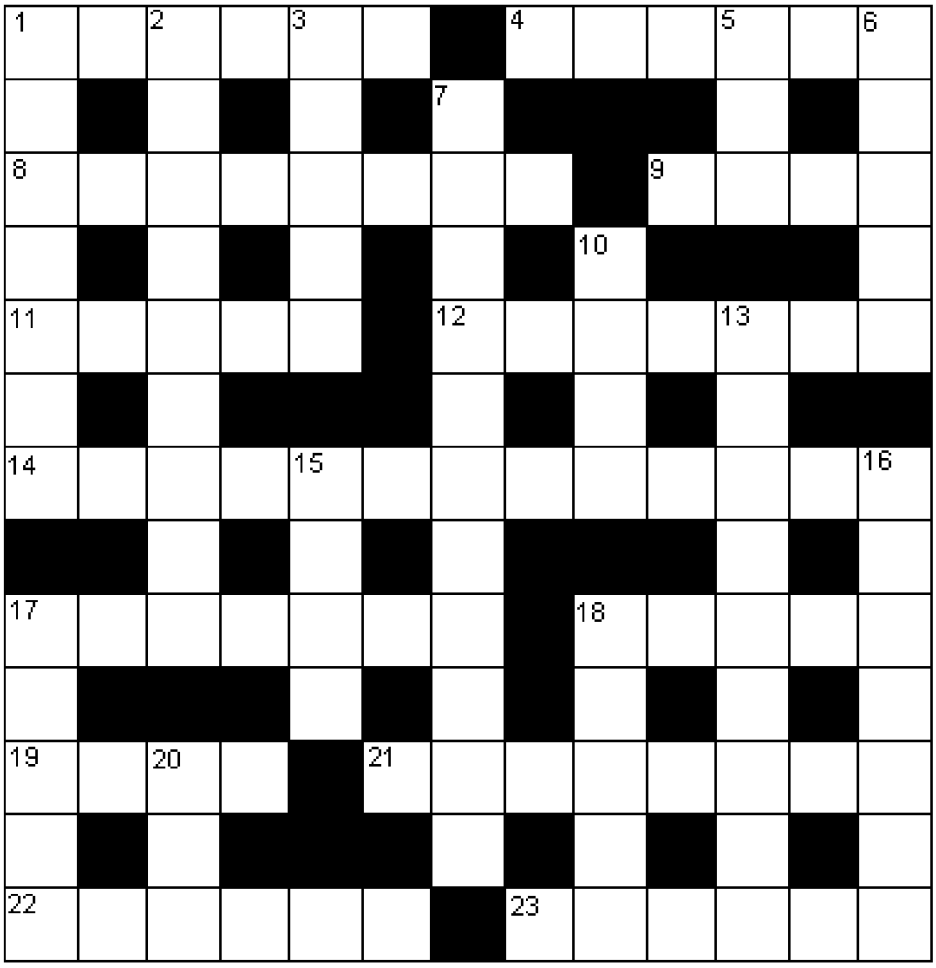
Starry-eyed dreamer Fae Collins Mooney is a member of our newest centre in Prince George. She lives in northwestern B.C.

Astrocryptic

by Curt Nason, Moncton Centre

ACROSS

1. Why in hell is it in Taurus? (6)
4. I'm so backward in the country club, I must be from outer space (6)
8. Orion beheaded after exaggerated PR placed him around Saturn (8)
9. Part of the centaur Sagittarius will bear up in the sky (4)
11. Ecliptic butter churned from infrared sea (5)
12. Puts in orbit before Kepler, being the first around Earth (7)
14. Somehow entropy unites Sudbury particle flavours (8,5)
17. Periodic error corrections in star movement will record stellar composition (7)
18. Sadder description of M31's absorption lines (5)
19. Right ascension in Coma Berenices and Cancer (4)
21. George's floppy size limits resolving power (4,4)
22. More is somehow less if the same atom has different properties (6)
23. Einstein mount (6)



DOWN

1. Some resistance seen in Chinese dynasty to northern transfer orbit (7)
2. Horribly late, I dump data on the variable's delta m (9)
3. After Easter starts, Uranus loses an element to the SE wind (5)
5. Russia's ageless mirage is no more (3)
6. He built quality telescopes for a bird after the beginning of the century (5)
7. Rotating GoTo pairs on display form the basis of the magnitude system (6,5)
10. Interstellar material found within the Indus-Tucana region (4)
13. Make a minute pun about a planetary-like element (9)
15. Northcott returns in time to sight Uranus (4)
16. Old Arab observatories are cans, oddly enough (7)
17. Former stellar classification adapted from diffuse Chi Persei cluster (5)
18. I hear he would evaporate water to determine the behaviour of gases (5)
20. Albertan Planetrium-Observatory initially used a short refractor (3)

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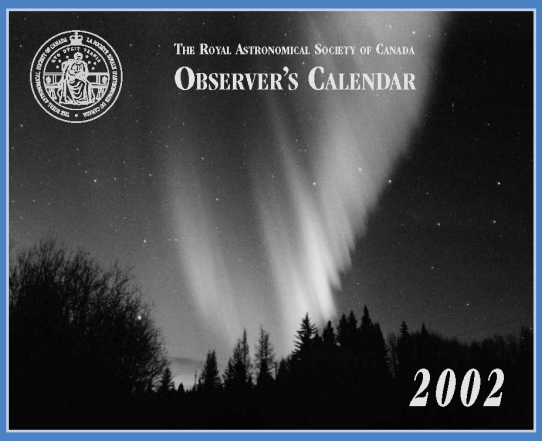

Observer's Calendar — 2002

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.

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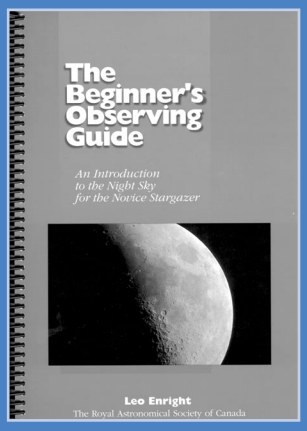

The Beginner's Observing Guide

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