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Journal

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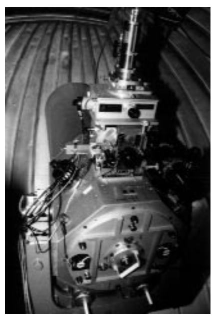

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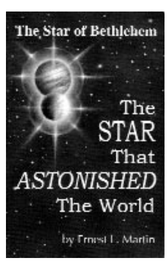

Star gaze from Jack Newton's back yard at the 1998 RASC GA! Page 43

ACROSS THE RASC
DU NOUVEAU DANS LES CENTRES

Cover Photo:
The Sleaford Schoolhouse, site of the Saskatoon Centre's new observatory.
See page 10.

President's Corner

By Doug George, RASC National President

This issue marks the first anniversary of the new format for the *Journal*. Over the last year our editors have done an excellent job of bringing us a quality publication — there is something for everyone in these pages. I would like to encourage all members to consider contributing articles about their observing projects, equipment and experiences, and to share their knowledge of the sky.

During 1997 astronomy and space science were in the news constantly. Who can forget the sight of Comet Hale-Bopp floating above city lights or its full grandeur from the countryside? Views through a telescope showed enormous jets that swung completely around over the course of a night.

Most surprisingly, last year the dark shroud of mystery surrounding the gamma ray bursters finally began to part. New observations place the bursters at phenomenal distances, making them the most powerful explosions ever seen in the cosmos.

Another Hubble servicing mission brought new instrumentation on-line and new discoveries followed soon thereafter — including the largest star ever observed. *The Mars Pathfinder* mission drew unprecedented attention as the first robotic rover wandered through the Martian terrain. *Galileo* made many unexpected discoveries among the moons of Jupiter. *NEAR* imaged the asteroid Mathilde, and the *Cassini* probe to Saturn was launched.

There were some sad events as well. The famous astronomer/geologist Eugene Shoemaker, well known to many RASC members, was killed in a car crash in Australia during a field trip to research ancient craters. Caroline Shoemaker was also seriously injured but survived. In a remarkable and touching tribute, Gene's ashes were placed on board the *Lunar Prospector* before launch. By now, Gene has finally achieved his life-long dream of travelling to the Moon.

As we look forward to 1998, we can expect the pace of astronomical discoveries to continue. Hopefully we will not have too many more natural disasters. Maybe we will even get some clear skies!

Journal

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

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 1998, $36.00; life membership is $720. 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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From The Associate Editor

by Patrick Kelly

It is time for a pop quiz! Answer the questions then check the answers which can be found on page 51. Give yourself one point for each correct answer. I will meet up with you after you have finished.

1. Which human is credited with inventing the warp drive?
2. What variety of grain was consumed by the tribbles?
3. With what type of event do you associate the emission of chroniton particles?
4. Which species conquers others by assimilating them into their collective?
5. "Wise men can hear profits in the wind" and "once you have their money, never give it back" are two examples of what?
6. What is the Cardassian name for Deep Space Nine?
7. What are the windows of Federation starships made of?
8. What class of vessel is the *U.S.S. Voyager*?
9. What is the main weapon used by Klingons in hand-to-hand combat?
10. What two quadrants does the Bajoran wormhole link?
11. Commander Data's "brain" is based on what type of technology?
12. In the field of engineering, Mr. Scott claims that these cannot be changed. What are they?
13. What type of crystals are needed to focus the matter-antimatter reaction in a warp drive?
14. Which two groups fought at The Battle of Wolf 359?
15. Which race, infected with an incurable disease, is notorious for capturing people to provide them with replacement organs?
16. What species is Neelix?
17. Dr. Richard Daystrom is known for two major inventions. Name one.
18 Who was the captain of the *Enterprise C*?
19. What Klingon food is best served live?
20. What is the title of the leader of the Ferengi?
21. What was the name of Khan Noonian Singh's sleeper ship.
22. These tiny probes can be injected into people to repair internal damage at the cellular level. What are they called?
23. What is the name of the treaty between the Federation and the Klingon Empire?
24. What was the name of the Romulan admiral who was tricked by his own government into defecting to the Federation?

Is there some genetic combination that seems to predispose a joint interest in astronomy and science fiction? Is it that Star Trek gives us an opportunity to actually imagine what may be happening at those little points of light that we point our telescopes at?

Well, how did you make out? I would be willing to bet that most of you did quite well — certainly better than the general population. What is it about science fiction in general, and *Star Trek* in particular, that captivates so many amateur astronomers? While it is true that not all amateur astronomers are "of the Body," it is amazing how many are.

I can remember being interested in the stars as far back as my memory will go. I can also remember always being interested in *Star Trek* and I am not talking about when it went into syndication. I mean when it first ran as a television show — yes, I know that I am dating myself! Even before that, I was captivated by other science fiction shows (some of which are now enjoying success in reruns) such as *Thunderbirds, Stingray* and *Fireball XL5*. I will also publicly admit that when I got older I also enjoyed both *Space: 1999* and *Battlestar Galactica*.

Is there some genetic combination that seems to predispose a joint interest in astronomy and science fiction? Is it that *Star Trek* gives us an opportunity to actually imagine what may be happening at those little points of light that we point our telescopes at? Would we still have as much of an interest in astronomy if there were no science fiction television shows? I would be interested in hearing what impact, if any, that science fiction of any kind, has had on readers. I would be even more interested to hear from those that do not have an interest in science fiction.

Lastly, I would like to pass on the following message to all RASC members for the new year: *Qapla' ej chalmey Huv* (which translates from Klingon as *Success and clear skies*).

Digital Imaging Has Gone Too Far

by Joseph O'Neil, London Centre (joneil@multiboard.com)

I recently took in an exhibit of Egyptian artifacts, some over 6000 years old, at the Detroit Institute of Arts (DIT). One fine exhibit was a statue of a family in which the most important person had the largest image, regardless of actual physical size. Even in antiquity, art was used to convey not reality, but an idealistic representation of how people wanted to see the world. Fast forward to modern times, and despite the use of computers versus granite and alabaster, we continue the same tradition. Hardly an image in any magazine now goes to press without some sort of adjustment or refinement in the digital darkroom. Why then, if art is never a perfect representation of reality, do people not disparage manipulation of photographic images?

Before photography, images of new lands seen by explorers were brought back by artists hired for the trip. Unfortunately the artists were often "influenced" to portray images in such a manner as to help the explorer raise interest in his journeys and thus raise new capital for further exploration. Even so-called impartial artists often took liberties with images for the sake of art. I purchased a book of reproductions of the art of David Roberts during my trip to the DIT. This artist made sketches of Egypt and Nubia during the 1840s, but he often moved monuments and pyramids, exaggerated scale, and took many other liberties, all simply to produce better artwork. Before photography most people never trusted artwork to be true to life.

Photography was perhaps the first medium to provide some degree of impartiality from the creative forces of the artist. It was a medium that could be considered either art or archival. Photographs taken on the battlefields of the American Civil War may have provided the defining moment when a new age of innocence was born. Early artwork and written reports of the battlefield slaughter were dismissed until reinforced by the photograph. Digital computer imaging has now destroyed that short-lived age of innocence. I believe the defining moment of our loss occurred when both *Time* and *Newsweek* ran front cover photographs of O.J. Simpson during his trial; one of the magazines purposely darkened the skin tone of O.J. Simpson to give him a more sinister look.

It was an important moment for a couple of reasons. First, it demonstrated that even the most respected newsmagazines, not just tabloids, were not beyond the use of digital manipulation. Second, it revealed that the public had a threshold not to be passed, although the line of balance between what is acceptable manipulation and what is too much is still undefined. Even though the revulsion against the O.J. image was universal, by what exact, measurable standard did people make that decision? Perhaps there was none, but it was more like the American judge who, during a pornography trial, stated, "I cannot define it, but I know it when I see it."

How then does this relate to astronomy? First, let me say it is not a debate over film versus CCDs, as both can be manipulated. I am reminded of the story of a group of men who opposed the new steam shovel at a construction site. "Why not hire a hundred men with shovels instead?" they yelled, to which the steam shovel operator replied, "Indeed, why not hire a thousand men with spoons!" Manipulation of photographs has always taken place in the chemical darkroom, but now we have incredible potency in everyday hands. Digital imaging is the "atomic bomb" of the photographic age, and some people are treating such awesome potential in the same fashion that a 16-year old would react if given the keys to a brand new sports car — power without responsibility. Astronomy at either an amateur or professional level is first and foremost a science. We use film and chips to preserve and bring out that which we cannot see with our eyes. The problem now is the ease with which we can push the limit too far, and instead of bringing out hidden worlds we are now inventing them.

A few months ago I saw an image of the Horsehead Nebula in one of the popular astronomy magazines. It was originally a black and white image, but the artist deliberately coloured it red for aesthetic reasons. It was not a tri-colour exposure combined to give a correct colour image; it was a single exposure where the artist arbitrarily added red to make it look nice. To my sense of reason, that image crossed the line. We should not be adding new ingredients to an existing image. It might be argued that the Horsehead *is* red, so the artist was just making it more realistic, but I argue that one is then missing the point. A precedent has been established. What is the true colour of space? Being colour blind myself, I never see red in the Horsehead Nebula, so why should I trust your opinion over mine? Better yet, to paraphrase an old saying, "if the star shines red light, but nobody can see it, does red really exist?"

There is more to the problem: colour films suffer a shift in cast over a long exposure, CCDs are more sensitive to infra-red light than the human eye, and not every human being sees colour the same way. We already have enough problems refining our technology to try and reflect an average of what the human eye sees, without adding artificial factors such as colour enhancement.

A friend of mine practices astrophotography simply to have "pretty pictures" to hang on the wall. I felt much the same way until Comet Hyakutake. About a week before the head of the comet disappeared forever below the horizon, I took some piggyback shots. A year later there was a message on some of the Internet mailing lists from a researcher at a university in the southern U.S. who was seeking photos of Comet Hyakutake taken during its last few weeks in our skies. He was investigating the changing tail structure of the comet as it came close to the Sun. Having on hand a few extra 8 × 10s I had printed in my darkroom, I sent some off his way.

I received a very nice e-mail reply thanking me for my images. In it he explained that he had been having a terrible time finding the pictures he needed, since most pictures were taken when the comet was near Polaris and many of the pictures in magazines were "enhanced" for aesthetic appeal. I was amazed since the quality of my simple efforts was nowhere near as good as what is seen in magazines. Yet they turned out to be exactly what he needed.

I firmly believe that any person who takes an image of the night sky, even a simple star trail shot, is producing an image of importance, and it should be preserved for possible later use. Television has polluted our minds to the extent that the public now believes all-important research is accomplished during the last ten minutes of the hour, just before the Klingons attack. True research is like building Mt. Everest one grain of sand at a time. We do not have the capacity to judge what is or can be important to future generations. If we destroy the integrity of an image solely for the purpose of marketing that image, we are then committing a sin against reason and the use of critical analysis. There will always be a heated debate over when a line is crossed, and mistakes will be made. Yet I see a world of difference between those who use the computer to "push the envelope" of research and those who seek simply to gain public acclaim.

The December 1997 issue of *Popular Mechanics* headlined an article called "Faking Photos — How to Manipulate Images That Fool Even the Experts." With an image (pun intended) of digital photography forming in the public consciousness, I fear the wonderful potential of CCD technology will soon be wasted. What good is any image if nobody believes it? It now rests on the shoulders of digital imagers to make known to the public what standards, if any, they have, and why they chose them. I predict that very soon digital images of all kinds will no longer stand alone as truth of any kind without the reputation of the original photographer to back them up. The time to start establishing such public strength of character is now.

A member of the RASC London Centre for the past 10 years, Joe O'Neil has been interested in astronomy since grade school. His family-owned funeral home in London was opened by his father in 1963. In his spare time he enjoys planetary and lunar observing from the light polluted skies of London, and black and white astrophotography from the family farm near Granton, Ontario, about 5 kilometres due north of Western's Elginfield Observatory.

1999 RASC CALENDAR • CALL FOR PHOTOS

Photos for the 1999 *RASC Calendar* will be selected in early May 1998 in anticipation of a late May press run. The calendar will be printed earlier this year than in the past, in order to attempt a wider distribution to retailers.

All members of the RASC are encouraged to submit astronomical photos for consideration. Images can be of any type — deep-sky or solar system, prime-focus, piggyback, or fixed-tripod, and emulsion- or CCD-based. Lunar and planetary submissions are particularly welcome, as recent editions have been largely lacking them.

In order to preserve the highest quality possible, film-based images should be submitted as 8x10 prints. Preliminary electronic versions of the images are also welcome. CCD images may be sent in any standard electronic image format.

Prints and disks should be sent to:

Rajiv Gupta
2478 W. 1ST Avenue
Vancouver BC
V6K 1G6

so as to arrive by April 30, 1998. Electronic images (under one megabyte please) may be sent instead by e-mail to **gupta@interchange.ubc.ca.** For further information about submissions, please contact me by e-mail or by phone at (604) 733-0682.

The success of the *RASC Calendar* depends largely on the quality of images submitted. I look forward to receiving, for consideration, images of the same high quality as those that have made recent editions successful.

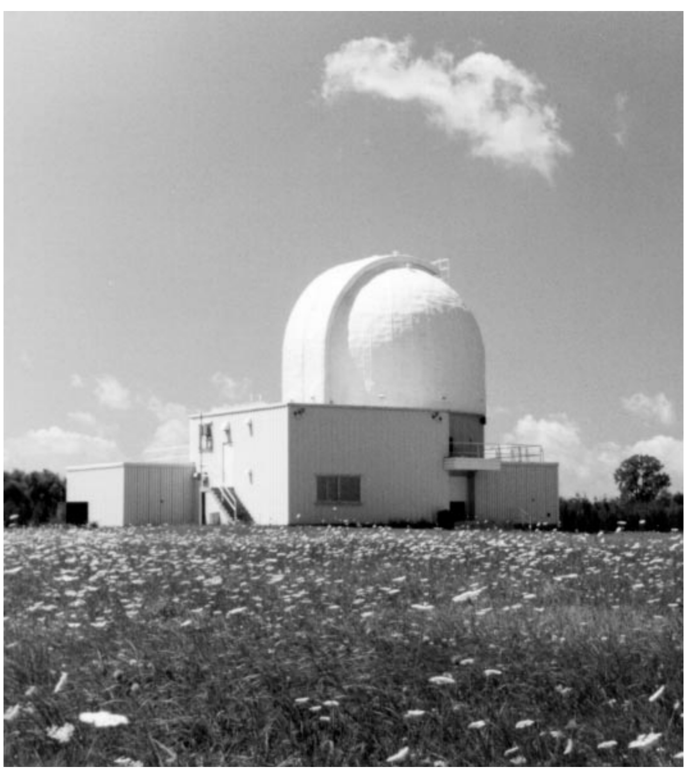
Rajiv Gupta
Editor, *RASC Calendar*

News Notes
En manchettes

THE PLANET OF 51 PEGASI

The controversy concerning the detection of a planetary companion to the star 51 Peg was described by Leslie Sage in the April 1997 issue of the *Journal* (JRASC, 91, 65, 1997). The focus of the controversy was an analysis by David Gray of the University of Western Ontario of his spectroscopic observations for the star obtained at the University's Elginfield Observatory. Additional work has been done on the star, including additional spectroscopic observations by David Gray — admittedly under poor seeing conditions and battling cloudy skies — as well as observations by research groups led by Timothy Brown using the facilities of the Whipple Observatory in Arizona and by Artie Hatzes and Bill Cochran using the facilities of the McDonald Observatory in Texas.

The controversy for 51 Peg originates with the original radial velocity measurements presented by Michel Mayor and Didier Queloz of the Geneva Observatory, and whether or not the inferred line-of-sight shifts they detected for the star arise from its orbital motion about an unseen companion with a mass roughly one half that of the planet Jupiter or from some type of non-radial pulsation. David Gray's observations indicated that line profiles in the star's spectrum underwent changes in shape with the same period as the radial velocity changes, a feature suggestive of pulsation. That result was confirmed by Gray in collaboration with Artie Hatzes through an analysis of Gray's observations in conjunction with non-radial oscillation models. Other observers have not been able to corroborate such line shape changes, and David Gray's most recent observations also produce comparably null results. Since an analysis of David Gray's original spectral scans also indicates that the star's spectral lines are indeed undergoing Doppler shifts (as well as line shape changes according to Gray's original observations), the evidence for orbital motion of 51 Peg about an unseen companion appears to be reasonably secure.

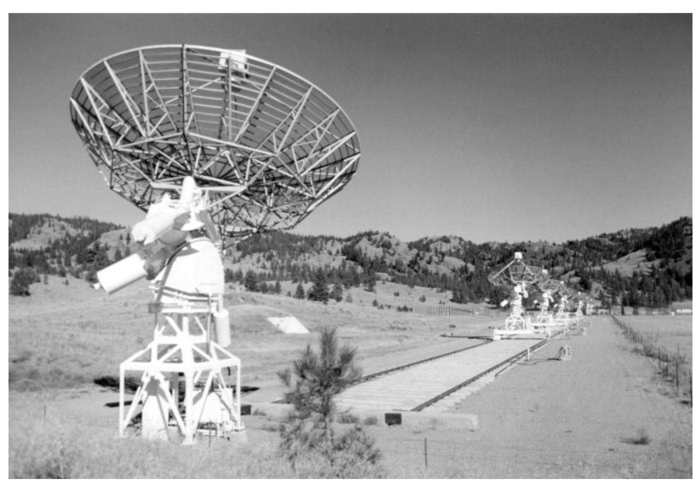


The Elginfield Observatory of the University of Western Ontario

EXTENDED LIFETIME FOR DRAO

As a result of budgetary pressures on the level of support for Canada's National Research Council (NRC), the Herzberg Institute of Astrophysics (HIA) had planned to cease operation of the radio telescopes at the Dominion Radio Astrophysical Observatory (DRAO) in Penticton, British Columbia, in March 2001. The DRAO is carrying out a detailed major survey at wavelengths of 21 cm and 74 cm for a 70° portion of the galactic plane visible from the northern hemisphere and was expected to complete observations for the survey by the year 2001. In mid-December 1997, Donald Morton, HIA Director-General, announced that the DRAO would stay in operation past the original date, although the work of DRAO scientists is still undecided at this point. The decision to extend the lifetime for the operation of the DRAO was made jointly by Jacques Lyrette, NRC Vice-President of Technology and Industry Support, and NRC President Arthur Carty.

The Canadian Galactic Plane Survey is a partnership involving 40 scientists from Canada and other countries, and



The antennas of the aperture synthesis array used in the galactic plane survey at the DRAO.

is intended to provide a detailed picture of the northern Milky Way at 21 cm. Such observations, in combination with data from telescopes in the United States, Britain and China, will provide the means for examining the inner workings of our Milky Way galaxy in exquisite detail. The observatory is one of three processing centres for the new astronomical technique of space very-long baseline interferometry (VLBI), in which ground-based radio telescopes are used in combination with one or more radio telescopes in space to simulate observations by a radio telescope larger than the Earth. The project, which is supported by the Canadian Space Agency, involves radio telescopes in Australia, the United States, Europe and Russia in conjunction with observations obtained by HALCA, a Japanese space-borne radio telescope.

The DRAO has been the home of Canada's solar radio monitoring program since 1990, and has continued the NRC program begun in 1946. Such information is useful in studies of global warming and atmospheric ozone depletion, as well as providing vital information for communications satellite companies, electric power utilities and oil exploration teams. The engineering expertise of DRAO scientists is currently being used to develop a spectrometer for the new "radio camera" for the James Clerk Maxwell Telescope on Mauna Kea, Hawaii, and is being utilized in NRC's Industrial Research Assistance Program to provide local companies with help in areas as diverse as antenna engineering and software development. The observatory also plays an important educational role by providing tours for students of all ages, public education programs, high school work experiences in science and technology, and training for many students from Canadian universities, including undergraduates in science, computer science and engineering.

The main building of the DRAO and the 25-m radio dish.

ASTEROID DISGUISES I

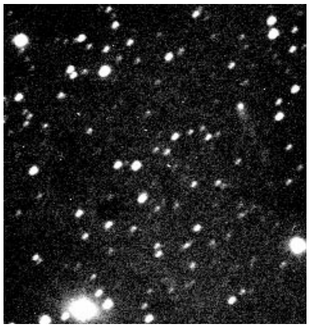
The advantages of charge-coupled devices (CCDs) for imaging purposes is tied to their high quantum efficiencies, linearity and panoramic properties, but the least expensive devices are still rather small, which means that they are limited by the modest angular fields of view that they subtend at telescope foci. Such limitations do not pose severe restrictions for some types of observing, and the use of CCD imaging in searches for extragalactic supernovae, in particular, has developed into a rather competitive endeavour. The highly aggressive nature of this area of research became evident in early September 1997, when the Central Bureau for Astronomical Telegrams received two independent reports of the CCD discovery of a 15^{th} to 16^{th} magnitude supernova in the galaxy NGC 772. As described by Brian Marsden in *International Astronomical Union Circular* No. 6736, the objects in each case were asteroids that happened to be passing through the field of NGC 772.

The misidentification of asteroids as supernova candidates is a recognized hazard in supernova searches carried out for galaxies near the plane of the ecliptic, which is why tests are always made for possible motion of candidate objects. In the instance described here, no motion of the candidates was apparently detected in the course of a few hours of observation, and checks for known minor planets that might be in the field did not reveal any coincidences. A careful check by Brian Marsden, however, indicated that the first supernova candidate — which was located only 2´ northeast of the centre of NGC 772 — was minor planet (5240), then very close to its morning stationary point. A second candidate located roughly $2\frac{1}{2}$´ from the centre of NGC 772 was minor planet (1887).

Although the misidentifications were reported to the observers within hours of the original report, the first observer's image had already been placed on the World Wide Web together with a report of it being a "confirmed" supernova. A follow-up editorial by Brian Marsden in *International Astronomical Union Circular* No. 6737 summarized the standard requirements for supernova discoveries. They are: (i) a precise astrometric measurement of the object's position, specifying date, time and magnitude, (ii) observations on a second night to verify that the object is in precisely the same location, (iii) a demonstration that the object was not present on comparable images on some other occasion, and (iv) confirmation of the object's nature from its spectrum. The fourth requirement is clearly difficult even for experienced professional astronomers, but amateur astronomers can still perform the first three. Provided observers stick to the standard procedures in such cases, cases of false discoveries may become a thing of the past.

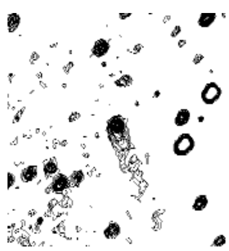
ASTEROID DISGUISES II

As part of his observational research on minor planets, Dave Balam of the University of Victoria regularly performs follow-up observations of newly discovered asteroids for other researchers around the world. On the night of June 8, 1997, he used the Plaskett telescope of the Dominion Astrophysical Observatory to image a few members of a group of five newly-



Newly discovered comet C/1997 L1. This image has been produced by the co-addition of the three discovery images after shifting each image to compensate for the plane-of-sky motion of the object. The discovery images were obtained with the 1.82-m Plaskett telescope of the National Research Council of Canada at the Dominion Astrophysical Observatory on (UT) 1997 June 08.37 and at the Xinglong station of the Beijing Astronomical Observatory (IAUC, No. 6677). The image is oriented with north up and east to the left and is 9´.5x9´.5 in dimension.

discovered objects that had been reported a few nights earlier by J. Zhu and other observers at the Xinglong Station of the Beijing Astrophysical Observatory in China. He noticed on his images that one of the objects had a distinct cometary tail (see figure) about one arcminute in angular extent. The tail was evident on all images, but is best seen in the co-added image shown here. The discovery was later confirmed by observers in Europe and the object was given the designation Comet C/1997 L1 (Zhu-Balam). According to calculations by Brian Marsden, the comet has an orbital period of over 300 years and was caught roughly seven months past perihelion passage on its way back to the outer part of the solar system. It was over 5 A.U. from the Sun when first detected, about 36 million kilometres further from the Sun than it was at perihelion and on a very highly inclined orbit with respect to the major planets of the solar system.



A contour plot of comet C/1997 L1 showing its tail. The field of view is 3´x3´, centred on the comet's coma (north is up, east is left).

FIREBALL OVER VANCOUVER ISLAND

At 6:13 a.m. Pacific Standard Time on the morning of December 17, 1996, a spectacular fireball roared in a southwesterly direction over Vancouver Island. It was reported by hundreds of witnesses ranging from Port Hardy in the north, Salem (Oregon) in the south, Vernon in the east and offshore vessels in the west. The event was followed a few days later by a colossal snowstorm on Vancouver Island that delayed an investigation by Jeremy Tatum and Laura Stumpf of the University of Victoria. Although details of the event will be published elsewhere when seismic data can be added to eyewitness accounts, a preliminary analysis suggests that an impact on Vancouver Island was possible. The uncertainties are such that a systematic ground search is probably not warranted.

Early in the investigation Tatum and Stumpf became aware that interviewing a significant number of witnesses in the vital few days after an event was not possible for one or two investigators. What was clearly needed was a network of trained interviewers around the province who would be willing to drive out at a moment's notice to the witnesses nearest to them, armed with the necessary compasses, clinometers and maps. A letter was sent out to local newspapers, astronomy clubs and colleges, and the two made a television appearance and gave a radio interview appealing for volunteers. Laura Stumpf also travelled to Yakima to attend a meeting of the Northwest Astronomers (an informal professional group), and gave a paper there to summon up some enthusiasm for such a project in the U.S.A. The two arranged for four training sessions on consecutive Saturday afternoons. They were held in September 1997 at the University of Victoria, the MacMillan Planetarium in Vancouver, Malaspina College in Nanaimo, and the private residence of amateur astronomer Les Disher in Courtenay. Thirty-eight responses were received from the initial appeal, and twenty-seven volunteers turned up at the training sessions. There is now a team of trained interviewers scattered over British Columbia and Washington State, all eager and waiting for the next big fireball.

Unbeknownst to Tatum and Stumpf, the creation of a similar Global Superbolide Network (GSN) was discussed at a workshop held at the Sandia National Laboratories in Albuquerque, New Mexico. The new network is to be headed by Zdenek Ceplecha of Czechoslovakia, and the techniques of training interviewers, interviewing witnesses and measuring angles will be similar to those of the British Columbia network. There are two differences, however. It is intended that the GSN should be a worldwide network, with its volunteers to be flown to training sessions and supplied with compasses, clinometers and global positioning devices. The test of either system must await the next big fireball, when it will be seen whether the initial enthusiasm of the volunteers has survived what might be a long wait. If successful, it is hoped that similar networks might be set up across Canada, particularly in areas that are more favourable to meteorite recovery than the mountainous and forested terrain of coastal British Columbia.

FAREWELL TO UTSO-CHILE, HELLO UTSO-ARGENTINA

On July 1, 1997, the University of Toronto closed the door on its Chile operation. The move was in response to the severe cutbacks in federal funding during the past four years. In August 1997, Bob Garrison (Associate Director for Chile Operations of the David Dunlap Observatory) and Hugo Levato (Director of the Complejo Astronómico El Leoncito — CASLEO — in Argentina) put together an agreement to move the telescope and dome to El Leoncito, just on the other side of the Andes from Las Campanas. The Argentines will maintain and operate the telescope at no cost to Canada, and will guarantee 25% of the time to University of Toronto astronomers. The move will take place in January 1998, but it may take several months to achieve full operation.

Brian Beattie and Bob Garrison spent three weeks in Chile during November and December sorting through 27 years of accumulated equipment and supplies. The telescope was dismantled and accessories packed in preparation for the move. Photographic equipment was given to Chilean amateurs, many books were contributed to a university in Concepçion, furniture was donated to a family in a nearby town, and other useful items were returned to Toronto.

As noted by Bob Garrison, "As though to salute the achievements of the Helen Sawyer Hogg telescope (affectionately referred to by the Chileans as 'Helen'), the sky put on a magnificent display during the first week in December. All five visible planets (seven if we include Earth — which was certainly visible — and the Moon — which is almost as big as Mercury) were lined up along the ecliptic. The panoramic view of the western sky from the deck of Casa Canadiense was spectacular; even Mercury was brilliantly visible in the yellow-red of the lingering sunset. Venus appeared as a laser-like beacon. The thin crescent Moon passed Mercury, then the others in succession as it grew to First Quarter. There were a few tears of sadness, but also of recognition that we mere humans not only can experience beauty for the joy of it, but also can appreciate the meaning of it all. That is what the careful studies of astronomy by hard-working observers and theoreticians over the millennia have given us; yet as Helen Hogg's book proclaims, 'The Stars Belong to Everyone'."

ERRATUM

The following corrections should be made to the Education Notes article "Elementary Methods for Estimating Astronomical Distances" by Russell D. Sampson and Janet S. Couch, published in the October 1997 issue. Equation (2) should not have a minus sign, and in Table I the value for α Boo for x'(Sampson) should read 9.56 m rather than 8.78 m.

Readers should also be aware that the magnitude relationship used in §4 of the article is appropriate for stars but not solar system objects. The brightness of planets is the result of reflected sunlight, and depends not only upon the distance of the planet from the Sun as well as from the Earth, but also upon the reflectivity of the planet at the appropriate phase angle.

Feature Articles

Articles de Fond

Saskatoon's New Sleaford Observatory

by Richard Huziak,
Saskatoon Centre

The Sleaford Observatory site is a no longer used three-acre schoolyard. Sleaford school was in operation from 1912 to 1959. The yard is surrounded on three sides by a mature Caragan, Maple and Ash windbreak. The site provides ample room for currently planned observatories and future expansion. *(Photo by Erich Keser)*

Three years ago the Saskatoon Centre began looking for a site for a new observatory. After twenty years our traditional Rystrom Observatory, located only 5 kilometres south of Saskatoon's city limits, had become too light polluted. Saskatoon's annual million-dollar dome of wasted light had already reached the zenith and beyond, and the situation would only get worse.

We formed a "New Observatory Committee" and laid down the criteria for a new site. The main issues were dark skies, freedom from future light pollution, security, winter accessibility, affordability, preferred ownership of the land, location on a lot that was or could be severed, proximity to available electrical power, long-term stability, and location within a reasonable driving distance.

Soon after the search began, we realized that there was another group in town that had identical interests: the University of Saskatchewan (UofS) Department of Physics and Engineering Physics. For many years, the UofS physics department had used the Cranberry Flats Conservation Area south of Saskatoon as an observing area for their astronomy labs, but that involved lugging out the telescopes, setting them up, and dismantling them at every observing session. The university had longed for a permanent observatory, but until now did not have the means of establishing one independently. Since the physics department only offered classes in astronomy, and not a formal program, they could not obtain funding to establish their own remote observatory. It was clear that we would both benefit from the establishment of a new, joint observatory. (The physics department does operate an historic observatory on campus with a 7-inch vintage Cooke refractor, but the telescope has long been used only for public viewing).

It became immediately obvious that a partnership between the groups could only be beneficial. Since the major costs of building and maintaining an observatory could be shared, each group would have less of a strain placed on it. Furthermore, the RASC has the manpower to provide inexpensive labour to construct the buildings that would otherwise have to be contracted out if the university were to go it alone. The RASC could also supply expertise for the design of the observatories and telescopes that the department does not have. The university, if it owned the land, would be property-tax free as an educational institution, whereas the RASC would have to pay municipal taxes.

Out of the discussions it was agreed that a legal partnership would be established, and a joint committee then proceeded with the procurement, design, construction, and maintenance of the new observatory. So the search continued. We secured maps of every rural municipality within a 45-minute driving distance to the east and south of Saskatoon. Those directions were chosen for two reasons, to minimize the distance to the new observatory from the University and mostly because Saskatchewan is so flat that in the other directions you can see the light dome for a hundred kilometres or more!

It took us much longer than anticipated to find a new site. Some sites seemed quite adequate, but either lacked accessible power or could not be severed from the parent quarter at a reasonable cost. Many potential sites were zoned for commercial construction within their regional municipalities, so future dark skies could not be guaranteed. Some large plots of land were also destined to become sprawling subdivisions in the near future. After three years we had identified more than 60 potential sites and had eliminated each one of them for one or more major shortcomings in our list of criteria. In the search we had driven an accumulated distance of over 3000 kilometres over the grid roads of Saskatchewan.

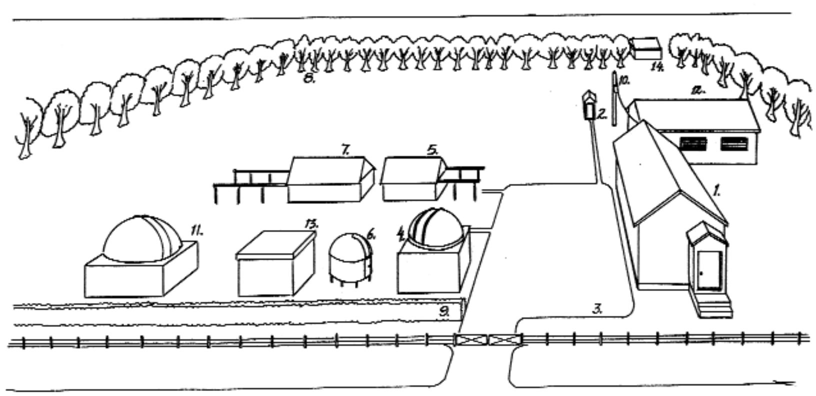
We finally came to evaluate the last of the long list of candidates, an abandoned schoolhouse in the defunct hamlet of Smuts, Saskatchewan. As we were debating whether we wanted an observatory that we may very well have to name the Smut Observatory, Erich Keser chanced on a neglected old school site that met virtually every criterion with flying colours. The site is now known as the Sleaford Observatory.

The old Sleaford School Site provided us with a three acre plot of severed land sixty-two kilometres outside of Saskatoon. Although it lies at the outer edge of our search area, it soon became clear that the site was what we were looking for. After a few informal observing sessions to test the skies, we met with the community and presented our hopes. The response was very positive. The community was delighted that the school site would once again be utilized for educational purposes, and agreed to sell the site to us for one dollar. Although we controlled our emotions during the meeting, I am sure the community could hear the loud "Yahoo!" that we let out as we drove joyfully away! As it always seems with local government cutbacks, the completion of the land transaction and filing took many months. With that out of the way, we began construction in early October of 1997 by moving our Rystrom Observatory warm-up shelter to its new home at the Sleaford site, and managed to trench in and connect the power before the first snow.

With the dreams and resources of the UofS and the RASC, the plans for the observatory are ambitious to say the least. The site plan calls for at least eight new structures to exist at the site within the next few years (see reference chart). With the warm-up shelter (chart reference 13) already there, we can already use the site for observing this winter. We plan to bring over the Rystrom Observatory's existing 3-metre dome (ref. 6) with its 200-mm Celestron telescope next spring. We have also constructed a research-grade 0.4-m telescope with the University's machining assistance, and will also build its new home (ref. 4) next year using a 4-metre aluminum dome we purchased a few years ago. The University also plans to construct a 10-metre long roll-off observatory next year to house four piers for their arsenal of student telescopes, which include two 200-mm catadioptrics, a 125-mm Zeiss photographic refractor, and a 350-mm Celestron.

A year or two later the RASC intends to construct a similar roll-off observatory to house our portable 315-mm Dobsonian and the University's 300-mm research-grade Schmidt camera. The camera will be carried on a professional equatorial mount supplied by the RASC which is on permanent loan from the Canadian Space Agency.

Future plans also include the construction of the "Sleaford Southern Observatory" (ref. 14). This small building will provide a pad and pier to allow an unobstructed view of the southern horizon, since the existing shelter belt (ref. 8) provides about 6 degrees of obstruction. The University is also



The Saskatoon Centre's Sleaford Observatory is now being constructed on the three acre site of the former Sleaford School. The two westernmost acres will house the currently planned observatories. The third acre, to the east of the tree line seen on the left, will be reserved for future expansion. The view is looking toward the south. (*Sketch by the author*).

Index to Buildings at the Sleaford Observatory

1. Existing Sleaford Schoolhouse
2. Existing outhouse
3. Planned parking lot
4. RASC 16-inch telescope dome (1998)
5. RASC 12.5-inch & 12-inch Schmidt camera roll-off (1999)
6. RASC 8-inch existing Rystrom dome (1998)
7. U. of S. 4-pier roll-off observatory (1998)
8. Existing treed shelter belt
9. Proposed hedge
10. Existing power pole
11. Proposed UofS Large Telescope
12. Clubhouse (2001)
13. Existing Warm-up Shelter
14. Proposed Sleaford "Southern" Observatory

considering the construction of a "Large Telescope" in the 0.6 to 1 metre class (ref. 11) if they can raise funding. We also plan to build a clubhouse (ref. 12) so we can have meetings and classes at the site, plus all the other conveniences of home, such as our library and an eating and sleeping area. It is still uncertain if we will renovate the existing Sleaford Schoolhouse (ref. 1) instead of building the new clubhouse, since the school is on a badly damaged foundation that just might be too expensive to repair.

We are very ecstatic with the progress-to-date on the new Sleaford Observatory. As always, plans are bigger than pocket books, but through joint co-operation between the two groups we have completed an amazing amount of work so far, carrying on in the thirty-year tradition of co-operation between the two groups. Fundraising and planning will continue through the winter, and we are impatiently waiting for the spring thaw to continue work on our latest dream.

Richard Huziak has been an active amateur astronomer for 29 years. He is currently the President of the Saskatoon Centre. His interests entail talking to school kids about astronomy and observing variable stars, noctilucent clouds, asteroid occultations, deep sky objects, meteors and fireballs. He has built two telescopes and has three others in a permanent state of construction.

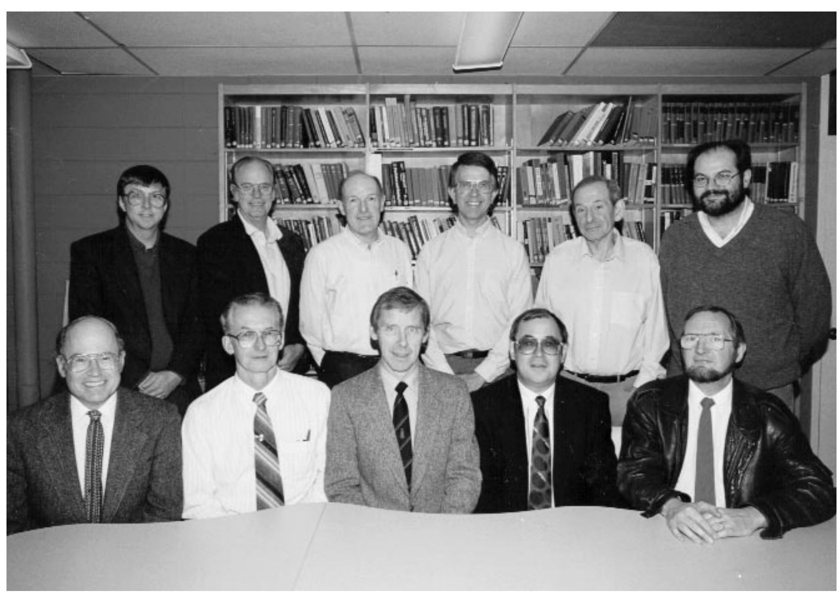
Astrophysics at the University of Alberta

by Douglas P. Hube, Department of Physics,
University of Alberta, Edmonton, Alberta, T6G 2J1

Introduction

The history of astronomy at the University of Alberta began with the faculty appointments of Professors J. W. Campbell and E. S. Campbell in the Department of Mathematics in the early 1920s. While their research and teaching responsibilities were primarily in mathematics, both spent summer and sabbatical time at the Dominion Astrophysical Observatory, Victoria, both published and taught in the area of astronomy, and both were founding members and presidents of the Edmonton Centre of the RASC. Dr. Max Wyman was a general relativist in Mathematics who served as president of the Edmonton Centre and, in addition, served as President of the University. The first University Observatory was built in the late 1930s when a home-made 12-inch telescope was donated by Mr. Cyril Wates. It was located on what is now the parking lot of the Northern Alberta Jubilee Auditorium. In the early 1960s, responsibility for the astronomy courses was transferred to the Department of Physics. Professor G. L. Cumming, a geophysicist and yet another president of the Edmonton Centre, supervised the purchase of a 12-inch Tinsley reflector and the building of the Devon Astronomical Observatory southwest of Edmonton. In 1977 the 12-inch telescope was mounted inside a roll-off-roof structure on top of the Physics Building on campus, and a 20-inch reflector, designed and built in-house, was installed at Devon.

Research in astrophysics at the University of Alberta is described here using "astrophysics" in its broadest sense as well as a definition for the "University of Alberta" (UofA) that includes both closely affiliated — The King's University College (KUC) — and otherwise connected — Athabasca University (AU) — institutions. Our areas of research activity now include, among others, instrumentation, laboratory astrophysics, impact geology, the interstellar medium, near-Earth space, normal and exotic stars, black holes, galaxy formation and the "Big Bang." Our research tools include classical and modern techniques, as well as instrumentation, in optical and radio astronomy, new and innovative techniques in atomic spectroscopy, general relativity, field theory, and others. Faculty



Some of the individuals who have been active in astrophysics at the University of Alberta, and whose work is described here. **Front row, left-to-right:** Gordon Rostoker, Doug Hube, Tony Kernahan, Valeri Frolov and Eric Pinnington. **Back row, left-to-right:** Martin Connors, Fred Vaneldik, David Routledge, Don Page, Werner Israel and Wojciech Rozmus.

and students working in that broad research area are found in the Department of Physics (optical astronomy, laboratory astrophysics, cosmology and black holes, and space physics), the Department of Electrical and Computer Engineering (radio astronomy), The King's University College (optical astronomy), and Athabasca University (planetary surfaces and space physics). Within the Department of Physics the "Astrophysics Focus Area" constitutes the largest of the four formally recognized research areas.

Brief descriptions are given here for most of the current research programs in astrophysics, and the infrastructure upon which they depend. Brief descriptions are also provided of a few of the local initiatives in education. Readers who require more details — especially potential undergraduate and graduate students — are encouraged to write to faculty members whose names appear below, or to direct a more general enquiry to the relevant department. Information is also available on the Internet.

Research Programs

1. Atomic Physics and Spectroscopy

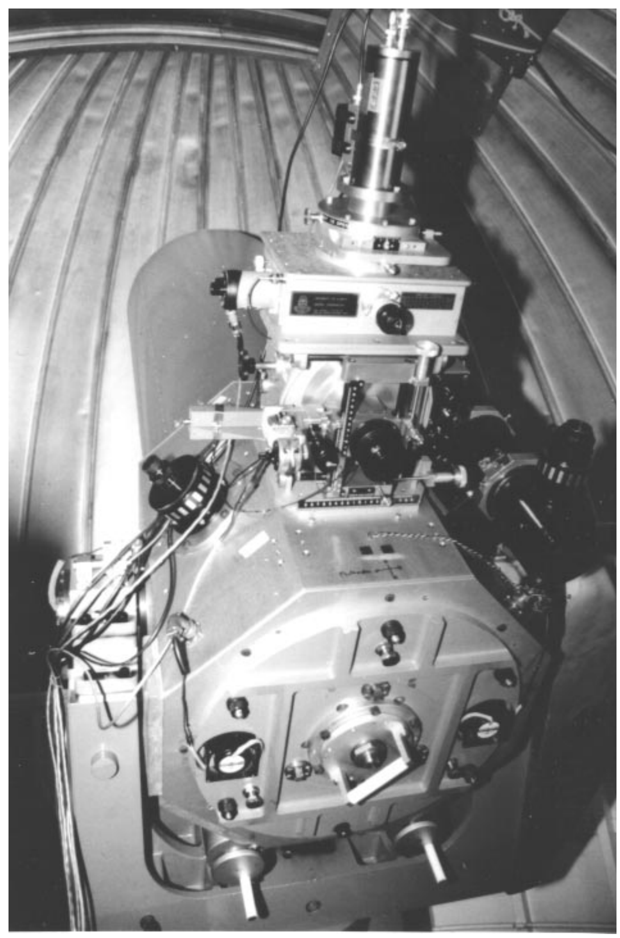
Knowledge of the chemical compositions and physical conditions of stars is essential to an understanding of the origins and evolution of everything from Earth to the universe itself. Much of that knowledge comes from spectroscopic analyses of starlight. Those analyses, in turn, require knowledge of the fundamental properties of atoms, ions and molecules. Eric Pinnington and Tony Kernahan measure the characteristic transition times between atomic energy levels. The "beam-laser" technique is used in which a beam of singly charged ions of the element of interest is obtained from a 350kV accelerator, and is then excited using tuned laser radiation. Measurements of atomic lifetimes[1] for members of the iron group of elements have been used to determine the abundances of iron, manganese and chromium in the Sun. At present, work is in progress on copper and silver.

2. Space Physics

The study of solar-terrestrial interactions is appropriate in a university in northern Canada where we are treated to frequent auroral displays. Here we are studying how energy from the solar wind penetrates the near-Earth environment and how that energy flows through the magnetosphere-ionosphere system. Magnetospheric substorms — which may be accompanied by brilliant displays of the northern lights — are being studied as indicators of significant energy deposition in the high latitude ionosphere. Gordon Rostoker uses data from the Canadian Space Agency's ground-based CANOPUS array of instruments to gain information about the extent of the ionospheric disturbance during substorm activity. The research has relevance to industries and utilities involved in electric power generation and transmission because they are affected by geomagnetic transients generated by substorms. The work is also of interest to communications companies whose satellites operate in the hostile space environment.

The electrical currents which flow in the upper atmosphere cause magnetic effects that are measured at ground level. As his Ph.D. project, Martin Connors is using modern mathematical routines with a three-dimensional model of the near-Earth current systems to deduce the nature of those upper-atmosphere phenomena from their measured effects at ground level.

John Samson pursues experimental, computational and theoretical studies of energy transport in space plasmas[2]. The experimental work employs ground-based arrays of magnetometers, cameras and radars. Large-scale parallel computer systems are used to construct models of near-Earth



The 0.5-m telescope at the Devon Astronomical Observatory has a two-star photometer at one of the folded-Cassegrain foci.

[1] The "lifetime of an atomic state" is the characteristic time that an atom remains in an excited state before spontaneously decaying to a lower energy state. That time is one of the factors which determines the strength of a spectral line.

[2] A plasma is most simply described as a gas composed of electrically charged particles.

Servicing one of the antennas of the DRAO synthesis telescope.

space. The theoretical program involves studies of magnetohydrodynamic instabilities leading to complicated flow patterns in the plasma within the Earth's magnetosphere.

3. Optical Astronomy

Doug Hube and Brian Martin (KUC), along with a series of graduate students, notably Dave Lyder, Eric Steinbring and Stefan Cartledge, have used the 0.5-m reflector at the Devon Astronomical Observatory — the *other* "DAO" — to obtain photometric data for a variety of variable stars. Their particular interests lie in the study of eclipsing binaries and ellipsoidal variables of early spectral type, as well as Delta Scuti variables. Brian Martin is collaborating in an international observing campaign on Delta Scuti variables. Multicolour photometry of the well-known Algol system SW Cygni is also being pursued, while U Cygni is the target of a student project that has goals of detecting and understanding light curve asymmetry near times of minima and searching for evidence of accretion disk activity.

In an expanded collaboration that includes David Routledge, Fred Vaneldik, Janet Couch, Chris Morbey (optical designer at the Dominion Astrophysical Observatory), Barry Arnold (optics fabrication), Roy Schmaus (electronics, software and hardware), graduate students and undergraduates David Hume and Tyler Foster, a prime focus (f/4) CCD camera has been installed on the telescope. The camera will be used for a continuation and expansion of the stellar photometry program, and for a new program to detect — in the visual and infrared regions — supernova remnants (SNRs) known previously from radio and X-ray surveys. By comparing optical (broadband and spectral line filtered) images, radio images and X-ray images of SNRs, we hope to be able to describe and understand their thermal and physical structures, as well as the nature of their interactions with the surrounding interstellar medium.

4. Radio Astronomy

Research in radio astronomy revolves around Canada's two operating radio telescopes: the synthesis telescope at the Dominion Radio Astrophysical Observatory (DRAO), and Canada's 25% share in the James Clerk Maxwell Telescope (JCMT) in Hawaii. David Routledge and Fred Vaneldik lead a research group whose efforts are directed toward the technical development of centimetre- and millimetre-wavelength radio astronomy. There are collaborations with the Herzberg Institute of Astrophysics (HIA) and with the Alberta Microelectronic Centre (AMC). Projects in the recent past have included designing and building a variety of specialized instruments, and the study of fundamental problems in electronic devices for radio astronomy applications. As her M.Sc. project, Anne Thorsley is performing holographic measurements of the complex aperture illumination of the antennas of the synthesis telescope. For his M.Sc. project, Leonid Belostotski is developing a millimetre-wavelength local oscillator and signal return system for synthesis telescopes. Future projects include development of amplifiers using innovative cooling techniques and the investigation of the electromagnetic interactions between antennas at close spacing.

The objective of collaboration with the HIA sub-millimetre group is to develop focal-plane antenna/receiver units for the JCMT. A focal-plane array will give the JCMT the ability to observe several sources simultaneously. To that end, we wish to capitalize on the high precision and mass-production benefits of the planar integrated-circuit fabrication technology developed by the microelectronics industry. The involvement of the AMC provides facilities for state-of-the-art sub-millimetre fabrication that are unsurpassed elsewhere in Canada.

The projects described above, and several others that have not been mentioned, have been carried out by graduate students and are often co-supervised by HIA scientists. Routledge and Vaneldik are engaged in observational investigations of galactic objects and their interactions with the atomic and molecular interstellar medium.

5. Planetary Surfaces

Martin Connors took advantage of the early availability of *Magellan* Venus data to study crater floor slope and tectonic deformation on that planet. The study of Venus crater floors is one of two known "paleoslope" indicators for the planet, the other being the better known fact that in some cases ancient lava channels have flow directions, as indicated by flow patterns, in what is now the uphill direction.

The research into impacts on Venus led to a consideration of terrestrial impacts, in particular the KT-boundary impact event that is widely believed to have led to the extinction of the dinosaurs. Connors has joined in collaboration with Alan Hildebrand, the 1992 Helen Hogg Lecturer at the RASC GA'92 in Calgary. Most recently, as part of a joint British, Canadian, American and Mexican expedition to the Chicxulub site on the Yucatan Peninsula, high spatial resolution — steps as small as 50 metres — gravity measurements were made across the Cenote Ring that is believed to be close to the crater rim. Preliminary analyses indicate steep gravity gradients and support the earlier suggestion that the crater diameter is approximately 180 km. The gravity measurements will be combined with land and marine seismic studies, with geological surveys, and with aerial photography to further refine maps of the crater.

Martin Connors, October 1996, on the rim of Cenote Nabula — that is the correct spelling — in the Yucatan Peninsula of Mexico. The cenote is, in turn, on the rim of the buried Chicxulub crater that has been identified with the KT-boundary impact event.

6. Plasma Physics

Theoretical studies of several fundamental processes in plasmas are being conducted under the direction of Wojciech Rozmus. Many of them are directed toward an understanding of laser-plasma interactions, including scattering, focussing and the creation of instabilities, all with application to inertial confinement fusion programs. Other problems under study, such as transport processes in plasmas and the derivation of generalized linear hydrodynamical equations, have relevance to processes in stellar interiors and space plasmas.

7. Theoretical Astrophysics: Cosmology, Black Holes and Strings

The theoretical cosmology group in the Department is an international leader in the study of general relativity. Of particular interest are the applications of general relativity to the understanding of the earliest epochs in the history of the universe and to the internal structure of black holes. Bruce Campbell, Valeri Frolov and Don Page in the Physics Department, and Hans Kunzle and Gerry Ludwig, Department of Mathematical Sciences, are collaborators in research and co-supervisors of graduate students working in that area.

Campbell's research is centred on the physics of elementary particles and their interactions as described by relativistic quantum field theories. The construction and testing of grand unified theories will lead eventually to success in describing the physics responsible for the development of the universe from the earliest moments of the "Big Bang" to the present. Theories with "supersymmetry" — theories that unite fermions and bosons, for example superstring theories — have implications for the understanding of black holes and cosmology.

With a team of research associates, postdoctoral fellows and graduate students, Frolov is studying three fundamental questions: (i) what is the microscopic origin of black hole entropy that, for a single, massive, black hole, is much greater than the total entropy of matter in the visible part of the universe? (ii) how do cosmic strings interact with black holes? (a recent result is that the final stationary configuration of a cosmic string captured by a black hole is remarkably simple and possesses several striking geometric properties), and (iii) what is the nature of the tidal interactions and disruption of relativistically moving stars by massive black holes? The investigation of physical effects in very strong gravitational fields is a natural step toward the unification of general relativity and quantum mechanics. Ultimately that will lead to a deeper understanding of the nature of space and time and of the formation of the universe.

Page's research in quantum cosmology is directed toward an understanding of the universe as a whole, within the current fundamental framework of quantum theory. The universe was once so small that a quantum description would have been essential. That initial description will explain certain basic features of the universe that are observed today, including homogeneity and isotropy on the large scale and lumpiness on the small scale. In particular, one needs principles for the boundary conditions of the universe in order to select the actual universe from the infinite set of plausible universes that obey the same set of dynamical laws.

One of Page's graduate students, Robert Thacker, is studying clusters of galaxies, the largest dynamically organized structures in the universe. Their large size and complex structure are related closely to the underlying cosmology and, consequently, they are useful probes for large-scale structure issues. A wealth of observational data is available, ranging from radio to X-rays. In collaboration with David Salopek, Thacker is simulating galaxy clustering in an attempt to understand how observations of X-ray emission from clusters can contribute to an understanding of the underlying cosmology.

Kevin Kornelson testing a sub-millimetre radiometer front end at 4 K in a liquid helium cryostat.

Educational Initiatives

Of no lesser significance than our research activities are our educational activities. The UofA (Department of Physics), KUC and AU all offer general astronomy courses to undergraduates, both those majoring in science programs and those majoring in other areas. The UofA (Departments of Physics and of Electrical and Computer Engineering) offers more advanced and specialized undergraduate and graduate courses in the relevant disciplines. In addition, several of the people identified previously have given short courses or series of lectures through the Faculty of Extension, Grant MacEwen Community College, or under the auspices of local seniors, and other, organizations.

Athabasca University specializes in distance education and allows students in both remote locations and those from large metropolitan areas equal access. Its first astronomy course was developed in 1989 by Tony Willis, who is now at the DRAO. That course was innovative in having computer-based laboratory exercises. It was updated in 1994 and the exercises were modified to use the *Skyglobe* planetarium program and data from the Astronomical Data Center's CD-ROM. A second course at a more introductory level is now offered in association with the ACCESS education broadcasting system. Students may enroll in science project courses for individual directed study on astronomical topics.

The King's University College is a small (500 student) three-year degree granting institution that offers two terms of introductory astronomy for both science and non-science majors. Both have a significant laboratory component that entails projects at the college observatory and the use of *Project CLEA* materials. Course materials are available on-line at:

www.kingsu.ab.ca/~brian/brian.htm

For senior science-track students, an advanced level astronomy projects course is offered. It is a reading/experimental project that introduces students to faculty at other institutions and to the methods of scientific research.

Conclusions and Comments

The University of Alberta and closely affiliated institutions are very active in a wide variety of scientific research projects in the general area of "astrophysics." Indeed, a majority of the recognized areas of astrophysics are addressed to some degree within our institutions. Most of the programs described are growing both in sophistication and in the numbers of people involved, and several are growing in terms of their technical applications and eventual commercial applications.

An important feature of our research programs is the large and growing number of collaborative projects involving faculty and students in different areas, between different departments of the University and between different institutions. Graduate students in particular can benefit from such collaborations in terms of both broadening their knowledge and expertise and pursuing especially interesting scientific goals.

We are also proud of our involvement with the two astronomical societies in Canada. The University of Alberta has hosted four General Assemblies of the Royal Astronomical Society of Canada during the past quarter-century, the most recent in 1996, and hosted the annual meeting of the Canadian Astronomical Society/La Société Canadienne d'Astronomie in June 1997.

Acknowledgements

I thank the many colleagues whose names appear above and who have provided details of their research programs. I apologize to those whose submitted material has been drastically shortened in the interests of balance and limited space. An important source of detailed information was the "Internal Review Report for the Department of Physics" assembled in collaboration with Lynn Chandler. The research activities described above receive financial support — directly and indirectly — from a number of sources, including the host departments and the collaborating institutions that have been named, the Province of Alberta, the Canadian Institute for Advanced Research (CIAR), and the Natural Sciences and Engineering Research Council.

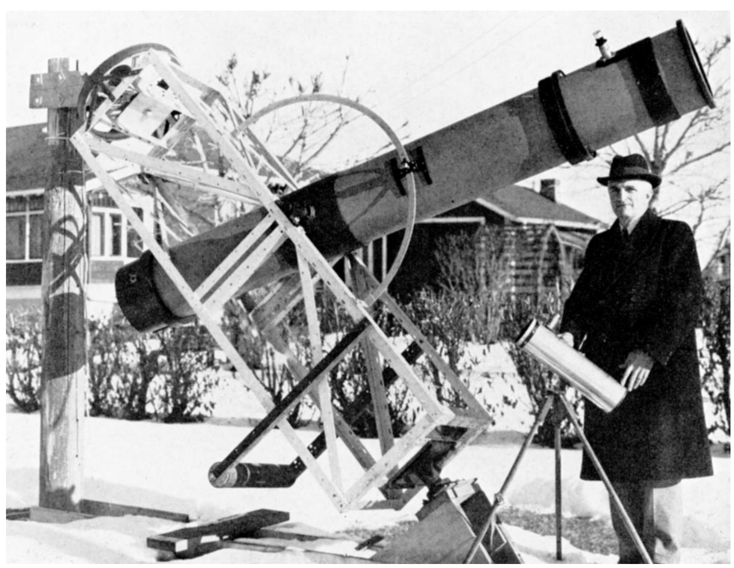
Doug Hube is a professor of physics and astronomy in the Department of Physics at the University of Alberta. He was National President of the RASC between 1994 and 1996, and continues to serve the Society as chairman of the Nominating and Awards Committees. His research interests lie primarily in the study of binary stars. His hobbies include the making of stringed instruments and a passion for long distance running.

FROM THE PAST AU FIL DES ANS

The Wates Telescope and The University of Alberta Observatory

On Thursday, May 20, of this year a formal ceremony was held at which a 12.5–inch reflecting telescope was presented to the University of Alberta and at which the observatory, housing this and a few other instruments, was opened.

The telescope was the gift of Mr. Cyril G. Wates, a valued member and past president of the Edmonton Centre of the Royal Astronomical Society of Canada, and it will stand as a monument to the zeal and skill of the donor, for it was entirely designed and constructed by him. A technical employee of the Edmonton telephone department, Mr. Wates is a man of exceptional mechanical ability, and of ardent interest in any hobby which he takes up. For many years he has been an enthusiastic member of the Alpine Club of Canada and he has given himself unstintingly to the service of that organization. Then about twelve years ago he became interested in amateur telescope making, and numerous articles in the *Scientific American* attest to the meticulous care and thoroughness with which he pursued this hobby. He soon had a 9–inch telescope completed and this he mounted in a small observatory on the bank of the Saskatchewan River valley just opposite his residence. It is perhaps not unnatural that one who had enjoyed the thrill of viewing vast expanses of terrestrial silent grandeur from mountain peaks should also find pleasure in using his telescope to observe the silent grandeur of the sky.



The 12–Inch Newtonian Reflector and 4–Inch Richest-Field Telescope.

J. W. Campbell
from *Journal*, Vol. 37, pp. 265, September, 1943.

Robert Burnham Jr.
Gone But Not Forgotten

by Dale Jeffrey, Saskatoon Centre

The skies are clear and dark in Saskatchewan tonight, and as I pack up my telescope and accessories, I automatically include my ragged three-volume paperback copy of Robert Burnham Jr.'s *Celestial Handbook*. I do not think I could observe without it. Over the years, while my telescope and star charts are the tools of my observing, Robert Burnham has become my companion. My scope and charts are essentials to finding the "where" of an object, but Burnham has always told me much more of what I am seeing; he tells me the "what" and even the "why" of the night sky. He tells me about other observers, about the origins of a star or nebula, the historical background, and also something about the context of the object. An evening with Burnham at the eyepiece leads me not only to the Crab Nebula in Taurus, but through Minoan civilization! Yet, I have never met the man.

Artwork reproduced with the permission of the Phoenix New Times

Unfortunately, I will never be able to. Robert Burnham Jr. passed away at the age of 62 in absolute obscurity on March 20th of 1993. Until November of 1997, however, those of us in the astronomical community were ignorant of his death, and of the last sad years of his lonely life. Yet he accompanied most of us night after night, offering his science and his philosophy as we shivered beside him at our eyepieces, and, somehow, at star parties, when disputes over celestial objects arose, one or more of us endeavored to settle the debate by quoting Robert. Secretly perhaps, many of us revered those three volumes as a kind of astronomical Holy Writ.

Robert died from complications following a heart attack. He had been found disheveled and ill-kept in San Diego's Balboa Park, previously supporting himself by selling paintings of cats to tourists who were unaware of his identity. He lived alone in a run-down hotel, had gangrene in one foot, as well as pneumonia. When he died there was no one to contact, and so he was cremated without a memorial service and his relatives were unaware of his death. The hospital only knew, from his scant possessions, that he was a former serviceman, so his remains were interred under a misspelled headstone, along with other veterans, at Point Loma's Fort Rosecrans National Cemetery.

Robert, who had only a high school education, co-discovered a comet on the night of October 18th, 1957. His find was shared by a Swiss observer and a Russian, and became known as Comet Latyshev-Wild-Burnham. That was the time of American paranoia over apparent Russian space superiority following the launch of Sputnik, so Americans were keen to praise Robert Burnham for his comet discovery. None other than Senator Barry Goldwater sought out Burnham, and his interview of Burnham was aired on American radio.

Robert was a recluse. As a young student he maintained a "laboratory" at his parent's home, and when he was introduced to astronomy he began by building his own telescope. With that rather crude reflector he discovered the comet which was previously described, as well as one which bore his name exclusively: Comet Burnham 1958a. Upon his return home from service in the Air Force during the Korean War, Robert took a job as a shipping clerk. Living at his parent's home, he was able to set aside enough money for a small refractor, and then the components of a larger reflector. He then began the process that was eventually to lead to the *Celestial Handbook*. He began making notes on every astronomical object on which he could obtain information, and his pile of notebooks began to multiply.

In 1958 Mr. H. Giclas of Lowell Observatory asked Burnham to lunch, inviting him to visit the observatory at Flagstaff the next weekend. After the visit, Robert was invited to work at the Lowell Observatory doing proper motion studies, seeking stars close to our own Sun. What was to be a two-year contract lasted over twenty years. By 1979 Robert and his co-workers had identified over 9,000 high-motion stars, several comets, 1500 asteroids, and 2000 white dwarf suspects, as well as thousands of variable stars. Throughout the process Robert lived in a small cabin in the woods of the Lowell property, and alone he continued to compile, and initially self-publish, his *Celestial Handbook*. Then, in 1979, Robert found himself unemployed, the project at an end.

Robert had hoped that the royalties from his handbook would support his modest lifestyle. Instead, his work became a kind of "loss-leader" for astronomical book clubs, and his royalty cheques were abysmally small. Friends suggested that he apply for government assistance, but Robert was too shy to appear in public, and so, retiring into penury and obscurity, he was assisted only occasionally by unsolicited charity.

Overcome by loneliness, hunger, depression, and despair, Robert was eventually hospitalized in a mental institution after being found walking aimlessly on a public beach, unaware of who he was, the apparent victim of a complete mental collapse. Shortly after his release his niece took him in. She said that he was in terrible condition, but he retained his hope that one day the royalties from Dover Books' publication of the *Celestial Handbook* would arrive and provide him with financial salvation. At last his semi-annual royalty cheque for 1985 arrived. It was for only $300. The next year he again waited for a cheque, which he anticipated would be much more substantial — the one for the new Japanese edition. It arrived, for $800. It was the end of hope for the man who had been, for many of us, our guide to the universe.

The time between 1986 and Robert's death in 1993 is shrouded in mystery. Somehow this self-taught scientist had become a tawdry seller of paintings of cats, which he apparently sold without enthusiasm on California beaches and parks. No one knew who he was, perhaps least of all him.

Robert's estate, such as it is, is now being managed by his sister, Viola Courtney. Mrs. Courtney had displayed considerable kindness towards Robert while he was alive, and now that he has died she has endeavored to wrest the full amount owed in royalties from Dover Publications. According to a recent article on Robert's death, written by Tony Ortega of the *Phoenix New Times*, she has only recently received three years of back royalties owed to Robert's estate. Moreover, she has waited over a year for Dover to provide an accounting of *Celestial Handbook* sales for the final eight years of Burnham's life.

I can never tell you, Robert, how much your work has meant to me. I wish I had known you in life, and I am sure that many of my fellow astronomers wish that they had known of your suffering. Unfortunately, we never got to help you, or even to thank you for the tremendous help which your work has been to us. You have shown us the heavens, and yet I feel that you have been shown the very darkest side of Earth. Still, we will remember you each night as we do that which you have taught us to love. In some way, with our tattered copies of your *Celestial Handbook* under our arms, we will take you with us to the eyepiece, where you will long remain our trusted friend and guide.

Please note that there is no relation between Robert Burnham Jr. and Robert Burnham, formerly of the editorial staff at Astronomy magazine. For more information concerning Robert Burnham Jr., please see the World Wide Web page for the New Times and the excellent article by Tony Ortega, at www.phoenixnewtimes.com/archive. Readers should open the full list of "News and Features" and search for an article called "Sky Writer" Artwork reproduced with the permission of the Phoenix New Times.

Dale Jeffrey is a member of the Saskatoon Centre of the RASC, happily observing from the dark skies of Laird, Saskatchewan.

Second Light

Looking Halfway Back to the Big Bang

by Leslie J. Sage

What kind of universe do we live in? Is there enough mass to stop it expanding forever? Astronomers have been asking such questions for the last half of the century and groping in the dark for answers. Finally there are indications that we are at least on the right track. The recent detection of a supernova at a redshift of $z = 0.83$, which is about halfway back to the Big Bang, suggests that we live in a universe in which there is not enough mass to stop the expansion.

One of the biggest problems we encounter when we try to answer fundamental questions about the universe is that it is very difficult to determine the distances to objects. For nearby galaxies, especially using the *Hubble Space Telescope*, we can look for Cepheid stars — pulsating variable stars that have a distinctive relationship between their period of oscillation and their intrinsic brightness. In principle all you have to do is measure the period and the apparent brightness of a Cepheid, combine that with the known period-luminosity relationship, and use a little arithmetic to give you the distance. In practice, of course, it is more complicated, but the idea is simple. Yet even though Cepheids are bright stars, it is impossible to observe them at distances that correspond to more than a tiny fraction of the way back to the Big Bang. We need intrinsically brighter objects. (Distance and time are related by the fact that light travels at a finite speed.)

Astronomers have tried various schemes to allow them to determine distances to objects that are very far away. In general they are sufficiently accurate to allow us to say approximately how far away they are, but not accurate enough to satisfy cosmologists who want to distinguish between competing models of the universe. (For example, is the geometry of our universe flat or curved?) To make further progress we need to know the precise calibration of the intrinsic luminosities for a class of objects that can be observed most of the way back to the Big Bang. That is a very tall order indeed, because even in principle there are just a few objects that put out enough energy to make them reasonable candidates. Such objects are supernovae, gamma-ray bursters and whole galaxies. Gamma-ray bursters are impractical for a number of reasons: they are short lived, produce not enough energy in the right range, and there are not enough of them. Galaxies evolve substantially with time; they undergo mergers, and the number of bright stars in them generally decreases with time as the supply of gas to make new stars is used up. We therefore have no guarantee that a galaxy in the local universe looks anything like a galaxy in the early universe. That leaves supernovae, which are on average about as luminous as a small galaxy.

But supernovae come in different types — for example, Ia, Ib, and II — all with different characteristics, and even within a particular type there is a wide range of intrinsic luminosities. Is there any way to sort out the differences and to use the observations to determine the true luminosity? Several years ago two groups, one based at Cerro-Tololo Inter-American Observatory in Chile and the other at Harvard, found that they could use the shape of the light curve for a type Ia supernova to determine its luminosity relative to others to a high precision. Even without such a diagnostic tool some groups believe that a "normal" type Ia supernova is a reasonably good standard. That is quite a remarkable achievement since we still do not really know what makes type Ia supernovae! (They are thought to originate in the explosive destruction of a white dwarf star that has accumulated gas from a companion star, but the underlying physics is not yet well understood.)

Now, Saul Perlmutter and the other members of the "supernova cosmology project" have found a type Ia supernova at a redshift of 0.83 and spectroscopically confirmed its redshift (through the Doppler shift) (1 January 1998 issue of *Nature*). If we live in a flat universe, that corresponds to a distance that is more than halfway back to the Big Bang. Peter Garnavich and his co-workers have found an even more distant supernova (at z = 0.97), but its redshift has not yet been confirmed spectroscopically (the result is in press with the *Astrophysical Journal Letters*).

The spectroscopic confirmation is important, because there is no guarantee that supernovae in the early universe looked the same as supernovae today. But Perlmutter has shown that in fact the supernova looks entirely normal by "local" standards. It is by far the most distant spectroscopically-confirmed supernova and the uncertainties in the measurement are for the first time smaller than the predicted differences between some models of the universe. Although Perlmutter is being very cautious about his interpretation of the result, he finds that, if there is no cosmological constant, the density of mass in the universe is only about 20% of that needed (the "critical density") to stop the expansion of the universe. If there is a cosmological constant of the right magnitude to make the universe flat, then the matter density is about 60% of the critical density. Garnavich finds an even lower mass density!

Where does this leave us? The indications are that we live in a low-mass-density universe, regardless of the cosmological constant. (That is consistent with other types of observations, such as the clustering of galaxies.) Moreover, we can expect that yet more distant supernovae will be found soon, which means that within a few years we should have a much clearer idea of what our universe is like.

Dr. Leslie J. Sage is Assistant Editor, Physical Sciences, for Nature *Magazine.*

Reflections

Chinese New Year and Groundhog Day — Ancient Calendar Days

by David M. F. Chapman

In the RASC *Observer's Calendar*, the date 1998 January 28 is only mildly interesting: there is no historical anniversary to celebrate, and the only celestial event noted is the New Moon. However, to ethnic Chinese all over the world, that day is New Year's Day: the first day of the Year of the Tiger in their traditional calendar.

It is no accident that there is a New Moon on that day, as the traditional Chinese calendar is partly based on the phases of the Moon. Every month begins on the day of a New Moon, including the first month of a new year. Because of the lunar connection, the Chinese New Year does not occur on the same date every year. For example, the Year of the Ox started on 1997 February 7, and the Year of the Hare will start on 1999 February 15. The reason for that is simple: twelve complete lunar months of 29.5 days do not add up to a solar year of 365.25 days. Although the New Year jumps around because of it, the Chinese came up with a clever correction to keep their lunar calendar approximately in step with the seasons, which are determined by the Sun. The correction ensures that their New Year always begins in the last third of January or the first two-thirds of February.

I need to digress a little to mention the Islamic calendar, which is a purely lunar calendar. Each month begins at sunset on the evening that the first crescent of the New Moon is observed. The months in the Islamic calendar alternate between 29 days and 30 days in duration, to keep the calendar in step with the sequence of New Moons, which occur about every 29.5 days. Every two or three years, an extra day is added to the 12th month to fine-tune the calendar. Because the Islamic calendar follows the Moon and not the Sun, the year has only 354 days and lags behind the widely-used Gregorian calendar by 10 to 12 days every year. It means that Muslim holy days slowly back up through the seasons as the years pass. (For example, the next Islamic New Year falls on 1998 April 28.) Every 33 solar years, the lunar and solar calendars fall back in step.

The Chinese reconcile their lunar calendar with the Sun by resetting it every year to form a lunar-solar calendar, as follows: the New Year starts on the day of second New Moon after the Winter Solstice. In that way, the Chinese New Year can start anywhere between the 20th of January and the 20th of February. (I have not been able to verify this simple empirical prescription, and I would appreciate hearing from any reader who can improve on it; all I can say is that it works for all the published Chinese New Year dates I can find, although one must imagine one is in Peking to get the day correct in some years.) The Hebrew calendar is also a lunar-solar calendar with a similar correction.

If you find this confusing, don't forget that our standard calendar also has a movable feast based on the Moon: Easter. The formula for determining the date of Easter is equally complex, so the date is not easy to predict. If you ask someone in Peking when the New Year starts or someone in Rome when Easter Sunday is, the answer is the same: "Look on the calendar!"

In the same season of the year, on 1998 February 2, we have Groundhog Day, the day when — according to folklore — the groundhog emerges from hibernation and forecasts the weather for the rest of the winter. If the groundhog sees his shadow, he scampers back to his den for another six weeks of winter; if not, then Spring is already underway.

The date of Groundhog Day coincides with the Christian church festival of Candlemas, whose origin can be traced to pagan candlelight processions to purify the fields for planting. The candles represented the power and fertility of the Sun's light. One of the many weather rhymes that show the connection between Candlemas and Groundhog Day is:

"If Candlemas is fair and clear,
There'll be two winters in the year."

The timing of this tradition comes from the Celtic calendar, which divides the year into eight equal parts based on the Sun's motion. At the solstices, the Sun attains its highest or lowest elevation in the sky at noon, marking the start of Summer or Winter; at the equinoxes the days and nights are equal, marking the beginning of Autumn or Spring. The solstices and equinoxes divide the year into four quarters. The Celts divided the intervals between these quarter days in half, creating four cross-quarter days. The cross-quarter day halfway between the Winter Solstice and the Spring Equinox was Imbolg, now known as Groundhog Day or Candlemas.

At first glance it appears that Chinese New Year and Groundhog Day are a world apart and unconnected. Where Groundhog Day is locked into the solar calendar, Chinese New Year follows the Moon. Note, however, that the average date of the Chinese New Year works out to be February 4 or 5, which just happens to be the true midpoint between the December Solstice and the Vernal Equinox in the modern calendar. (The date of February 2 for Groundhog Day must have been set at a time before the Gregorian calendar came into effect, when the calendar dates for the quarter days were a few days earlier.) Leaving astronomy behind and moving into the folklore domain, it is interesting to note that the Chinese New Year's Eve customs include staying up all night with all the lights burning in the house and setting off fireworks at midnight. This oriental custom is reminiscent of the pagan candle burning at the same time of year in the occident.

After several months of short days and long cold nights, the days of early February are becoming noticeably longer and the Sun's higher elevation is beginning to warm the earth again. It is not yet Spring, but Spring is surely on its way!

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

Research Papers
Articles de recherche

ABSTRACTS OF PAPERS PRESENTED AT THE 1997 CASCA ANNUAL MEETING HELD IN EDMONTON, JUNE 14-18, 1997

Plaskett Medal Lecture

The Helium-Rich Atmospheres of the DB White Dwarfs, Alain Beauchamp, C.A.E. Électronique, Ltée.

White dwarfs with effective temperatures between 10,000 K and 30,000 K are divided into two basic atmospheric groups: the DA stars, which have hydrogen-rich atmospheres, and the DB stars, which have helium-rich atmospheres. Progress in our understanding of the helium-rich DB white dwarfs has been severely hampered by the relative paucity of such stars and by difficulties encountered with the treatment of both the broadening of the He I lines and convection. After a brief review of previous studies of DB white dwarfs, we present the detailed spectroscopic analysis we have carried out. It is based on optical spectra secured for nearly 80 DB white dwarfs, and was used jointly with ultraviolet spectrophotometry of 25 DB stars culled from the *IUE* archives. The data were analyzed with a new generation of synthetic spectra, which incorporate the best description currently available of the helium plasma at the required physical conditions. The He I line profiles include Stark, resonance, and van der Waals broadening. Stark profiles for all He I lines were recomputed within an overlapping line formalism that included, among other effects, the excitation of forbidden components. The new synthetic spectra are in very good agreement with optical observations for all He I lines observed in DB stars, including gravity-sensitive lines. Two new forbidden transitions in the neutral helium atom are predicted in the red part of the spectrum, and are satisfactorily modeled. The requirement of a good correlation between the effective temperatures determined independently from the *IUE* distributions and He I line profiles in the optical band provides a constraint on the treatment of convection in DB atmospheres. Finally, a comparison of the DB and DA mass distributions yields significant differences that must be explained by stellar evolution theories.

Petrie Prize Lecture

Supernovae and their Cosmological Implications, Alex V. Filippenko, University of California at Berkeley.

Supernovae are extremely luminous, can be individually calibrated, are reasonably well understood, and should be fairly insensitive to evolutionary effects. They therefore have enormous potential for the determination of fundamental cosmological quantities such as the Hubble parameter, the mass density of the universe, and the cosmological constant. They can also be used to show that large redshifts are consistent with the expansion of space, rather than with some competing hypotheses such as "tired light." As with any cosmological yardstick, however, great care is required to obtain accurate results. Here I review the use of supernovae as cosmological probes, highlighting the main conclusions achieved thus far and providing a preview of coming attractions.

Invited Talks (theme "Gravity and Dark Matter")

Dark Matter Distribution in Spiral and Dwarf Galaxies, Claude Carignan, Université de Montréal.

The presentation reviews what has been learned about the distribution of dark matter in spiral and dwarf galaxies after more than two decades of observations and modeling. Pointed out in particular are the systematic differences found in the distribution of dark matter as a function of morphological type. Finally, we examine how dark matter is distributed relative to the other components of galaxies.

Gravitational-Wave Astronomy, Eric Poisson, University of Guelph.

It is likely that direct observation of gravitational waves will occur within the next several years, thanks to a new generation of interferometric detectors such as LIGO. Here I describe the basic physics of gravitational waves, how they are detected, and what information can be extracted from them. The main focus is on the most promising source of gravitational waves for interferometric detectors: coalescing compact binaries.

Simulations of Galaxy Formation and Clustering, Robert Thacker, University of Alberta.

Understanding galaxy formation remains a "holy grail" of modern cosmology. Until recently most insight into the process has come from detailed analytic studies, such as those of White & Rees (1978), which during the 1980s matured into semi-analytic studies. The advent of giga-flop supercomputing has opened a new avenue of research during the 1990s — simulating galaxy formation. Such research, although now entering the mainstream, remains challenging and stimulating, both because of the complexities of the physical process being studied and the programming problems inherent in the modeling. Here I present a brief review of the "standard model" of galaxy formation and also present some first results from simulations performed on the U.K. Computational Cosmology Consortium supercomputer, COSMOS. The research is being conducted as part of an international collaboration, with H. M. P. Couchman (Western Ontario), F. R. Pearce (Durham, U.K.) and P. A. Thomas (Sussex, U.K.) and is supported by a NATO collaborative research grant.

The Formation and Structure of Galactic Halos, Larry Widrow, Queen's University.

The existence of dark matter has placed astronomers in a rather awkward position. There is overwhelming evidence that 90–99% of the mass in the universe is non-luminous. Yet the nature of the dark matter remains a complete mystery. Moreover, our understanding of how dark matter distributes itself is woefully incomplete. The flat rotation curves of disk galaxies give a rough idea of the density profiles for dark matter halos but say little about their shape, spin, and extent. The irony is that dark matter is relatively easy to study theoretically and, through N-body simulations, experimentally. Here I address some of the fundamental questions that surround the formation and structure of galactic halos. Discussed are attempts to connect the structure of dark halos with the spectrum of primordial density perturbations, the connection between the shape and spin of the dark halos and the formation of disk galaxies, and the impact our ignorance of the shape of our own Galaxy's halo has on our ability to interpret dark matter search experiments such as MACHO.

Contributed Talks

The Temperature Evolution of Subgiant Stars: A New Constraint on Globular Cluster Ages, Peter A. Bergbusch, University of Regina, and Don A. VandenBerg, University of Victoria.

It is a well-known prediction of stellar evolutionary calculations that the rate at which stars evolve between the turnoff and the lower red-giant branch is a function of mass. The colour-magnitude diagrams of young open clusters, for instance, show a Hertzsprung gap on the subgiant branch that arises because of the Schönberg-Chandrasekhar limit to the mass of an isothermal core that can be sustained by a star in thermal equilibrium. Although the limit is not exceeded in the 0.8–0.9 $\mathcal{M}_\odot$ stars that are currently leaving the main sequences in globular clusters, calculations suggest that, even for such relatively low masses, the mass dependence of the rate of $T_{\rm eff}$ evolution is still appreciable. It offers the possibility of using the *horizontal* distribution of stars between the turnoff and the giant branch to measure the turnoff masses, and hence the ages, of globular clusters. The distinct advantage of the approach over other ways of determining their *absolute* ages, is that it is completely independent of distance (and reddening) uncertainties. Here we explore the potential of such temperature functions to refine current estimates of globular cluster ages.

Omega$_b$ via Oort's Method, R. G. Carlberg, University of Toronto, S. L. Morris, National Research Council, H. K. C. Yee, University of Toronto, E. Ellingson, University of Colorado, R. Abraham, Institute of Astronomy, Cambridge University, P. Gravel, University of Toronto, C. J. Pritchet, University of Victoria, T. Smecker-Hane, University of California, Irvine, F. D. A. Hartwick, University of Victoria, and J. E. Hesser, J. B. Hutchings, and J. B. Oke, National Research Council.

The baryon density of the universe is equal to its baryon-to-light ratio, $\mathcal{M}_b/L$, multiplied by the luminosity density. We estimate $\mathcal{M}_b/L$ from rich galaxy clusters. We find that $\Omega_b = 0.014\,h^{-3/2} - 0.019\,h^{-3/2}$, which includes the stellar mass at a mass-to-light ratio of 5 $h\mathcal{M}_\odot/L_\odot$. The value of Ω_b implies a photon-to-baryon ratio of $\eta = 4.0 \times 10^{-10}$ to 5.2×10^{-10}. Such a "high" value is in good agreement with measurements of low deuterium abundance in high-redshift Lyman α clouds, but is in considerable tension with measurements of He and Li at low redshift. Deletion of the light of the cD galaxies from the observed values of L causes Ω_b to rise by about 50% and the variance to increase by a factor of 3, which suggests that the stellar component cD is closely connected to the history of the gas in the central region of the clusters.

The Origin of the Multiple Globular Cluster Populations in Giant Elliptical Galaxies, Patrick Côté and Ronald O. Marzke, National Research Council, and Michael J. West, Saint Mary's University.

The systems of globular clusters (GCs) surrounding many giant elliptical galaxies show distinctly bimodal metallicity distributions. The bimodality is often cited as evidence for the formation of giant elliptical galaxies via mergers with gas-rich spiral and irregular galaxies. In models of that sort, the metal-rich GCs are thought to have formed during the merger process. We explore an alternative possibility: that such metal-rich clusters represent the elliptical's *intrinsic* cluster population, while the metal-poor population of GCs arises from the capture of GCs through mergers and tidal-stripping of other galaxies. Starting with plausible assumptions for the dependence of mean GC metallicity on parent galaxy luminosity and for the luminosity function of the host galaxy cluster, we derive theoretical GC metallicity distributions which are strikingly similar to those observed for the best-studied giant ellipticals.

Planetary Spectroscopy With the Infrared Space Observatory, G. R. Davis, University of Saskatchewan, D. A. Naylor, University of Lethbridge, M. J. Griffin, P. G. Oldham, and P. A. R. Ade, Queen Mary and Westfield College, B. M. Swinyard, Rutherford Appleton Laboratory, G. S. Orton, Jet Propulsion Laboratory, D. Gautier, Th. Encrenaz, and E. Lellouch, Observatoire de Paris, S. B. Calcutt and P. G. J. Irwin, University of Oxford, Th. De Graauw, SRON, and M. Burgdorf, LWS Instrument Dedicated Team.

The Infrared Space Observatory (ISO) is a satellite mission for infrared astronomy and was launched by the European Space Agency in November 1995. The spacecraft carries four complementary instruments which carry out a wide variety of astrophysical measurements. One of the instruments, the Long Wavelength Spectrometer (LWS), provides medium- and high-resolution spectroscopy over the spectral range 43–197 μm (Clegg *et al.* 1996; Swinyard *et al.* 1996). The authors comprise the ISO solar system team. We present some of the early results from the LWS planetary programme (Davis *et al.* 1996; Encrenaz *et al.* 1996; Griffin *et al.* 1996). Foremost among them is the first-ever detection of the R(1) rotational line of HD at 56.23 μm in the atmosphere of Saturn. The D/H ratio in the outer planet atmospheres has profound cosmological implications, since the atmospheres are thought to have evolved little since the formation of the solar system. Comparison of that measurement against a radiative transfer model of the saturnian atmosphere gives a best-fit D/H ratio of 2.3×10^{-5}. D/H values between 1.5×10^{-5} and 3.5×10^{-5} are also compatible with the data. Such a result is intermediate between the saturnian value derived from ground-based measurements of methane and its deuterated isotope, and the preliminary determination of the jovian D/H ratio measured by the mass spectrometer in the Galileo probe.

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A Statistical Study of the Environment of CfA Seyfert Galaxies, M. M De Robertis and K. Hayhoe, York University, and H. K. C. Yee, University of Toronto.

The hypothesis that galaxy-galaxy interactions are largely responsible for triggering activity in galactic nuclei is well entrenched within the current active-galaxy paradigm. Yet the evidence with respect to Seyfert galaxies, based almost exclusively on heterogeneous samples and analyses involving the Palomar Observatory Sky Survey, is rather ambiguous. For that reason we have carried out an *R*-band, large-format CCD survey of the environment of 33 CfA Seyfert galaxies and 46 non-active galaxies also selected from the CfA Catalog and matched in luminosity, morphology and redshift with the Seyfert sample. The average Seyfert galaxy-galaxy covariance amplitude for galaxies brighter than $M_R = -19.5$ and within 250 kpc is statistically not significantly different than the control galaxy-galaxy amplitude (which is consistent with the amplitudes from field-galaxy samples). Furthermore, within 50 kpc and to a brightness limit of $M_R = -17.5$, Seyfert hosts have a companion fraction which is not statistically significant larger than the control sample. The mean environment of Seyfert 1s is rather different from Seyfert 2s in the sense that Seyfert 2s have a larger covariance amplitude. Such evidence is problematic for the so-called *Unified Model* of AGN. It is suggested that if the interaction model is correct, at least in the case of Seyfert galaxies, activity is more likely the result of the accretion or merger of a dwarf companion originally bound to the Seyfert host rather than an external merger of a more massive system.

The Large Adaptive Reflector (LAR) — A New Design of Radio Telescope, P. Dewdney, National Research Council, A. R. Taylor, University of Calgary, M. Barakat, InfoMagnetics Technical Corporation, N. Bartel, York University, L. Bauwens, University of Calgary, G. Beach, TCOM LP, E. Cannon, University of Calgary, W. Cannon, York University, C. Carignan, Université de Montréal, J. DeLaurier, University of Toronto, R. Fauvel, University of Calgary, P. Feldman, National Research Council, D. Halliday, Coast Steel Fabricators Ltd., L. Higgs, National Research Council, M. Ito, University of British Columbia, J. Irwin, Queen's University, N. Jacob, InfoMagnetics Technical Corporation, G. Lachapelle, University of Calgary, T. Landecker, National Research Council, D. Lo, Coast Steel Fabricators Ltd., M. Meng, University of Alberta, B. McCutcheon, University of British Columbia, G. Reader, University of Calgary, R. Redman, National Research Council, D. Routledge, University of Alberta, E. Seaquist, University of Toronto, L. Shafai, University of Manitoba, N. St.-Louis, Université de Montréal, S. Stiemer, University of British Columbia, J. Templin, National Research Council, W. Teskey, University of Calgary, A. Willis, National Research Council, F. Vaneldik, University of Alberta J. Vallée, National Research Council, and B. Veidt, National Research Council.

The report by the National Research Council (NRC) Planning Committee for a New National Radio Astronomy Facility recommended that Canada adopt the Square Kilometre Array (SKA) as its highest priority for a new national radio astronomy facility, and should now contribute to an international effort assessing its feasibility and to provide its share of the innovative technology to build such a telescope. The LAR is an innovative design for a radio astronomy antenna that could provide the technology needed to build the SKA at a reasonable cost. The concept (Legg 1996) to construct a long focal-length parabolic reflector illuminated from an airborne platform promises the advantages of a traditional steerable parabolic reflector, but allows the construction of much larger antennas. Engineering research initiatives are planned in the areas of system design, airborne platforms, reflector design, 3-D position measurements, control systems, electromagnetics, receivers, radio frequency interference, and aperture synthesis. They will be carried out collaboratively in seven engineering departments in Canadian universities, three industrial facilities, supported by two NRC institutes with the scientific oversight of a team of Canadian radio astronomers. The initiatives are also an opportunity to provide training for highly qualified personnel in priority areas for Canada, linking astronomy with engineering and industry. The paper provides details of some of the technical advances needed to make the concept a successful reality.

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The Origin of Brightest Cluster Galaxies, John Dubinski, Canadian Institute for Theoretical Astrophysics.

The origin of the brightest cluster galaxies (BCGs) has been a long-standing puzzle in galaxy formation. Three theories have been put forward to explain the origin of BCGs. They derive from the connection between the high luminosity of the galaxies and their location in the bottom of cluster potential wells: (i) accretion of the existing galaxy population through dynamical friction, otherwise known as galactic cannibalism, (ii) star formation from cooling flows expected in the high density, rapidly cooling centres of cluster X-ray halos, and (iii) a rapid episode of galaxy merging in the early history of the formation of the cluster, as expected in hierarchical structure formation. We present results, using a new approach to cluster N-body simulation, that strongly support the third theory. A cosmological dark matter simulation of a galaxy cluster is first run to the current epoch. Galactic halos forming at $z = 2$ are identified in the dark mass, which eventually becomes the cluster. The 100 most massive halos are replaced with equilibrium N-body models of disk galaxies of the appropriate mass and scale, and are simulated along with the remaining dark matter. The simulation produces a realistic cluster of galaxies surrounding a massive, central elliptical galaxy residing in the bottom of the cluster potential. The simulated BCG forms through the merger of several massive galaxies falling together along a filament early in the cluster history between $z = 2$ and $z = 1$. The long axis of the BCG is aligned with the original filament and the long axis of the cluster of galaxies — a demonstration of the Binggeli effect. The BCG has a de Vaucouleur $R^{1/4}$ law surface brightness profile and a flat velocity dispersion profile with scales similar to observed galaxies. Galactic cannibalism over a Hubble time only accounts for a modest fraction of the accreted mass in the simulation — from $z = 1$ to the present, the mass grows by $\sim$25%.

Observation of Comet Hale-Bopp at the 1.667 GHz OH Line, John Galt, Dominion Radio Astrophysical Observatory.

The DRAO 26-m antenna has been used to study spectra of the comet since February 19, 1997. Line shapes changed from emission to absorption about March 13, and most spectra show asymmetry with a steeper edge on the low velocity wing.

The Constancy of the Gravitational Constant Using Helioseismology, D. B. Guenther and René Tanaja, Saint Mary's University.

We have used the high quality *p*-mode frequency data obtained by the GONG instrument during the first half year of its operation to test the constancy of the universal gravitational constant *G*. The GONG (Global Oscillation Network Group) instrument consists of six ground-based telescopes encircling the Earth, which work in synchronization to record, every minute, Doppler shift images of the surface of the Sun. The reduced data give the complete global non-radial acoustic mode (*p*-mode) oscillation spectrum of the Sun. By comparing the *p*-mode oscillation spectrum of our most refined solar model calculation (helium and heavy element diffusion, OPAL equation of state, OPAL and Alexander opacities), altered to include a power law variation in *G* with time, to the observed solar oscillation spectrum, we are able to set tight limits on the maximum allowed variation in *G* over the last 4.5 Gyr (the age of the Sun). The possibility of a varying *G* is motivated by recent theories attempting to unify gravity with other gauge theories (Marciano 1984). Celestial mechanics has provided the strongest current epoch constraints, determining that $|(1/G)dG/dt| < 10 \times 10^{-12}\,yr^{-1}$ (Müller *et al.* 1991; Shapiro 1990). By comparing the *p*-mode frequency small spacings, which are especially sensitive to the structure of the deep interior, we are able to tighten the constraint by almost an order of magnitude.

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Ground-Based Gamma Ray Astronomy with the STACEE Detector, D. S. Hanna, McGill University (on behalf of the STACEE Collaboration).

Gamma ray astronomy has traditionally been carried out using space-based detectors such as the Compton Gamma Ray Observatory, currently in orbit. Such instruments are limited by their size and the steeply falling spectra of gamma ray sources to energies less than about 10 GeV. Ground-based gamma ray telescopes have recently begun to detect astrophysical sources at energies above several hundred GeV by sampling the Cherenkov light generated by the collision of gamma rays with the Earth's atmosphere. I describe here progress in the quest to lower the energy threshold of the atmospheric Cherenkov technique to where it overlaps with satellite energies. The strategy is to synthesize an enormous collection mirror using heliostats at a solar power plant. The physics goal of the endeavour is to measure the energy spectra of sources between 10 GeV and 500 GeV, a range over which many of the sources disappear, possibly because of intergalactic absorption effects. Such effects have implications for models of galaxy formation in the early universe.

Events Associated with Star Formation as seen in Cepheus A, V. A. Hughes, Queen's University.

The questions: How do stars form? What triggers a cloud to collapse? Do low mass stars form first followed by more massive stars which then disperse the surrounding gas and inhibit further formation? and What is the origin of the observed jets and outflows? are just a few of the unanswered ones. There are known regions of massive star formation where some events are observed, such as Orion, but since they lie at the centre of optically dense clouds, it is necessary to study them using infrared and radio observations. Some progress has been made recently from observations of the southern H II region NGC 6334 (Kraemer *et al.* 1997), which consists of a slowly rotating molecular disk measuring 2.2 pc × 0.9 pc and having a mass of 2000 $\mathcal{M}_{\odot}$. It contains clumps suggested to be "protoclusters" of condensing stars, together with ionized outflows normal to the disk. However, no long period monitoring of the region has been carried out. One region that has been monitored since 1981 is Cepheus A, and a number of the details are becoming clearer. A well-defined jet is seen travelling in the SE direction. It has a highly non-thermal jet shock (Hughes 1993) with associated infrared lines of H_2 and [Fe II] (Goetz *et al.* 1995), and a further but older jet travels in an easterly direction. There are two highly time-dependent non-thermal sources (Hughes 1991), and two non-thermal objects moving apart at a relative speed of 370 km s^{-1}, one decreasing in flux density with time and the other increasing, which have all the indications of originating from a protostar (Hughes 1997). The latter objects appear to be a new type of time-variable radio source. In addition, a further source is observed which appears to be an H II region, as would be produced by a B3 star, but there are components that appear to be in orbital motion. An application of the virial theorem shows that they have masses of a few solar masses orbiting within a cloud of several hundred solar masses, consistent with the model of Bonnell & Bastien (1992).

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ISO Observations of Protostellar Cores, Lewis B. G. Knee, National Research Council, S. C. Russell, Dublin Institute for Advanced Studies, and P. J. Richards, Rutherford Appleton Laboratory.

We have made observations of 21 optically selected dark globules (Bok globules) using the Infrared Space Observatory (ISO). All except one lack associated IRAS sources, and so are potentially sites of future star formation. Scans across the globules were made at 100 microns and 200 microns using the ISOPHOT photopolarimeter, supplemented in some cases with $C^{18}O$ (1–0) observations with the Swedish-ESO Submillimetre Telescope (SEST). The resulting dust emission profiles are complicated, with many globules showing double- or triple-peaked far-infrared emission peaks. The profiles at 100 microns and 200 microns are also often very different. It challenges the common notion that such globules have simple internal structures easily amenable to radially symmetric modeling. Some globules have far-infrared profiles that are significantly more centrally condensed than their optical dimensions. A few show much greater condensation at 200 microns than at 100 microns. We suggest they are particularly promising candidates for globules in the process of collapsing to form protostellar condensations.

A Coherent Lenticular Faraday Rotation Feature in the Galactic Interstellar Medium, T. L. Landecker, A. D. Gray, and P. E. Dewdney, National Research Council, and A. R. Taylor, University of Calgary.

Observations with the Synthesis Telescope at the Herzberg Institute's Dominion Radio Astrophysical Observatory have revealed a striking, coherent, magneto-ionic feature in the galactic interstellar medium, which so far has been detected only as Faraday rotation of galactic synchrotron emission. Lenticular in shape as projected on the sky with a size of about 2° × 1°, the feature presents itself in images of the polarization angle, and partially overlaps the H II region W5 (IC 1848). On a radial path from its centre of symmetry ($\alpha_{J2000} = 02^h 55^m$, $\delta_{J2000} = 60° 24'$), the angle of polarization rotates smoothly through almost a complete cycle. Neither the angle image nor the image of the weakly-polarized intensity of the feature show any morphological similarity to the total intensity emitted from W5. Searches for a "central object" have yielded only a nearby F4 V star, probably unrelated. The observed Faraday rotation effect could be produced by: a) a local increase or decrease of electron density threaded by a magnetic field, b) a uniform electron density threaded by a funnel-shaped magnetic field, or c) a combination of both. In addition, a smooth background of polarized emission is required. Since the dense, turbulent environment of W5 has depolarized all emission from behind W5, the distance to the lenticular feature cannot exceed that of W5, about 2 kpc. Other observations lead us to believe that at least 0.5 K of non-thermal emission arises between us and W5, which would provide the necessary background emission. If the line-of-sight depth is equal to the width of the feature, if $B = 2\ \mu$G, and if the distance is a fraction, *f*, of the distance to W5, then the following relations for the excess electron density and total mass are found: $n_e = 1/f\ cm^{-3}$ and $\mathcal{M}_{H\,II} = 3 \times 10^3 f^2\ \mathcal{M}_{\odot}$. Therefore, if the object is close to the Sun, n_e becomes very large, and if the object is close to W5, the excess (or deficit) mass of ionized gas becomes very large.

Star Formation in Cam OB1, David A. Lyder, Dominion Radio Astrophysical Observatory and University of Victoria.

The recently completed Ph.D. thesis by Lyder examined star formation in Cam OB1. From that study it was concluded that star formation was probably triggered by the collision of several molecular complexes in the region. There appear to be three distinct spatial and temporal groups of stars that have been formed as a result, either directly or indirectly, of the collision. The star forming efficiency is low (1–2%), consistent with what is seen elsewhere in the Galaxy, while the current mass function of the stars is similar to the cloud mass function for the parent molecular clouds. Star formation in Cam OB1 is consistent with a model whereby the star formation rate is enhanced by the increase in favourable collisions between molecular cores, *i.e.* collisions leading to the loss of angular momentum and subsequent collapse of the cores.

The Multiple Star Forming Complex NGC 6334: Line and Continuum, W. H. McCutcheon, University of British Columbia, T. B. H. Kuiper, Jet Propulsion Laboratory, H. E. Matthews, Joint Astronomy Center, G. J. White, Queen Mary and William University, G. Sandell, Joint Astronomy Center, E. Sutton, University of Illinois, and T. Sato, Kwantlen University College.

NGC 6334 is one of the most active galactic sites of star formation known, and is of particular interest among known H II region/molecular cloud complexes because it contains 4–6 distinct sites of massive star formation. The luminosities of the forming stars indicate spectral types ranging from B2 to O7. Large-scale CO spectral line maps reveal a narrow ridge of emission, nearly continuous over the entire complex (about 7.5 pc in length). The major sites of star formation are roughly aligned with the molecular ridge. Site I, with a large velocity outflow and an abundance of spectral lines, may be the most evolved. Site I(N) may be the youngest of the major sites. Dust maps of the northern part of the complex show the same narrow ridge of emission defined in the line maps. They also reveal more detail around I and I(N) and suggest that protostars are developing. The line and continuum observations are discussed here.

The Gemini Adaptive Optics System (GAOS), S. L. Morris, G. Herriot, S. Roberts, G. Singh, M. Fletcher, and T. Davidge, National Research Council.

The Gemini Adaptive Optics System (GAOS) is being designed and built by the National Research Council in Victoria for the Mauna Kea telescope. It consists of a focal-ratio preserving optical design (allowing rapid deployment and retraction of the AO), a 177-element adaptive mirror, a tip-tilt mirror, and a Shack-Hartmann Adaptive Optics Wavefront Sensor (AOWFS) with 12 $\times$ 12 sub-apertures. The system is designed to deliver near diffraction-limited performance close to bright (natural) guide stars in the near infrared (*H* and *K* bands), and will allow operation over the wavelength range from 0.5–5 μm. It will feed all of the Gemini instruments. Described here are the science drivers considered in the design and explanations for some of the design trades that are already made or in progress. The facility should be installed on the telescope in the period 1999–2000.

The Gemini Multiobject Spectrograph, R. Murowinski, National Research Council.

GMOS is the Gemini Multi-Object Spectrograph currently under development jointly by the National Research Council in Canada and PPARC in the UK. Two copies are being built, one for each of the Gemini telescopes. GMOS is the only optical instrument being provided (scheduled delivery late 1999) for Gemini North, and the only instrument being provided to both sites. As such, it is expected to be a workhorse instrument. It has four observing modes: imaging, long-slit spectroscopy, multi-slit spectroscopy and integral field spectroscopy. In February GMOS successfully completed its final design review, and is now under fabrication. The author presents an overview of the instrument and its current set of primary scientific requirements. He also discusses some of the more demanding technical challenges and the solutions that have been adopted. Finally, a review of the current status of the project is presented.

Bars and the Chemistry of Disk Galaxies, Jean-René Roy, Université Laval, and Jeremy R. Walsh, European Southern Observatory.

We explore some intriguing effects of bar properties, such as strength and age, on the chemical composition of disk galaxies. While large disk Sb–Sc galaxies show O/H abundance gradients becoming flatter with increasing bar strength, the latest type spirals display either a very strong radial gradient or no gradient at all. The subtle effect of bars in galaxies of larger mass, which is to produce a shallow gradient, becomes in small mass disk galaxies a purely on or off effect.

JCMT Imaging of Cometary Molecular Clouds in the Perseus Chimney, A. R. Taylor, University of Calgary, J. A. Irwin, Queen's University, H. E. Matthews, National Research Council, and M. H. Heyer, University of Massachusetts.

Recently Normandeau *et al.* (1996) reported the discovery of a galactic chimney emerging out of the galactic plane above a cluster of O stars associated with the W4 H II region. Two compact molecular clouds have survived the evacuation of the chimney and show evidence of dynamical effects from the energetic radiation of the nearby O stars. The age of the star cluster and the formation time of the chimney indicate that the clouds have been subject to intense ultraviolet radiation for several Myr. We have obtained high-resolution images of the clouds in the CO (2–1) line using the on-the-fly imaging technique with the James Clerk Maxwell Telescope. We have also obtained CO (3–2) images over a more limited area for one of the clouds. Our observations reveal a striking arrow-shaped CO globule, with the symmetry axis of the arrow pointing toward the most luminous cluster star. A bright IRAS point source is coincident with the apex of the arrow, and is likely an embedded protostar whose formation may have been triggered by the propagation of a shock front into the cloud. An LVG analysis carried out using both the JCMT data and CO (1–0) observations from the Five Colleges Radio Astronomy Observatory (Heyer *et al.* 1996), yields a temperature of 30 K and density of 10^4 cm^{-3} for the molecular gas at the apex. The total mass of molecular hydrogen in the region surveyed in $C^{18}O$ (5.3 pc^2) is $\sim 800\,\mathcal{M}_\odot$ for an abundance ratio of 2×10^{-7}. The velocity gradients about the symmetry axis of the arrow are well represented by a simple model of symmetric advance about the cloud centre of an ionization front driven by the ultraviolet radiation from the nearby O star. The overall morphology and kinematics of the globule are in marked agreement with the hydrodynamical simulations of photo-evaporation of cometary globules (Lefloch & Lazareff 1994), although in our case the survival time scale is much longer.

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A Curious Near-Earth Asteroid, Paul Wiegert and Kimmo Innanen, York University, and Seppo Mikkola, University of Turku.

At least 400 minor planets are known to be on orbits which approach that of the Earth, and many tens of thousands more similar objects are presumed to go undetected. The gravitational attractions of such objects with the Earth and inner planets can produce remarkable behaviour: one particularly intriguing object is discussed.

Posters

Measuring Age Differences of Galactic Globular Clusters, Pascal Bergeron, Université de Montréal.

During the last decade there has been a debate in the field of globular clusters about two issues: whether the Galaxy's globular clusters are coeval and whether age is the second parameter affecting the morphology of the zero-age horizontal branch (Stetson *et al.* 1996). An answer to both questions requires accurate relative age dating. The difference in colour between the main sequence turn-off and the red giant branch has been shown to be a strong function of globular cluster age (VandenBerg *et al.* 1990; Sarajedini *et al.* 1990) and a weak function of metallicity. We have searched for variations in that colour difference among 10 northern galactic globular clusters using a homogeneous set of photometric observations in the *V* and *I* bandpasses obtained with the focal reducer of Mont Mégantic (same telescope, detector, filters and reduction procedure). We discuss implications about the Galaxy formation time.

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A Small Telescope Group for Direct Distance Determinations of Near Earth Asteroids, R. M. Blake, York University and the Institute for Space and Terrestrial Science, North York, Ontario.

Near-Earth asteroids pass closer to Earth than any other bodies in the solar system. It is therefore important to have precise orbital elements to track such objects. Asteroid orbits are chaotic, however, and many such objects have been observed on only a few occasions. Presented here is a plan to establish a small telescope group at volunteer institutions across Canada to perform distance determinations of near-Earth asteroids. It is an ideal project for small telescopes scattered across a large geographic area. Improved orbital elements may be obtained with far fewer observations than is otherwise possible. Interested parties will be invited to participate in an observational trial to determine the feasibility of the project.

Wide Field Imaging Polarimetry as a Probe of the Interstellar Medium, J. C. Brown and A. R. Taylor, University of Calgary, and A. D. Gray, T. L. Landecker, and P. E. Dewdney, National Research Council.

The Canadian Galactic Plane Survey (CGPS) images are revealing widespread, highly structured polarization features in the plane of the Galaxy. The features may be explained by the effects of differential Faraday rotation in the magneto-ionic component of the interstellar medium acting on the diffuse synchrotron radiation from the galactic disk. We present Stokes I, Q, and U images of a sample region from the CGPS that exhibits the phenomenon. In addition, we analyze the effect of a diffuse ionized filament in Cygnus X on the rotation angle of the background polarized radiation, and use the effect to measure the line-of-sight magnetic field within the filament.

A Multi-Frequency Compact Source Analysis of the Canadian Galactic Plane Survey Pilot Region, C. L. Butenhoff and A. R. Taylor, University of Calgary, and D. A. Green, Mullard Radio Astronomy Observatory.

To test the feasibility of the Dominion Radio Astrophysical Observatory's Canadian Galactic Plane Survey, pilot observations of the massive star formation region W3/W4/W5 were taken (Normandeau *et al.* 1997). The data from the observations consist of continuum maps at 408 MHz and 1420 MHz, with spatial coverage of $14^\circ \times 10^\circ$ ($l \times b$) and $8^\circ \times 6^\circ$ ($l \times b$), respectively. The spatial resolution is 3.5 x 4.0 arcminutes (EW × NS) at 408 MHz and 1.00 × 1.14 arcminutes (EW × NS) for the 1420 MHz observations. Minimum source flux density detection levels are ~2 mJy and ~18 mJy for the 1420 MHz and 408 MHz maps. Also included in the data set are 1420 MHz Stokes Q and U polarization maps, as well as source lists obtained from the Mullard Radio Astronomy Observatory's 151 MHz galactic plane survey (Vessey & Green 1997). The 151 MHz source list is complete to 200 mJy, while the source detection limit of the polarization maps is 1 mJy. Close to 2000 sources were detected in the 1420 MHz continuum maps, and approximately 1100 in the 408 MHz maps. Differential source density plots reveal a slight excess in counts above the extragalactic source population indicative of a galactic population. The data set is also used to calculate spectral indices between the 408 MHz and 1420 MHz maps and fractional polarization intensities at 1420 MHz. Because of their steep spectral indices (on average between −1.2 to −3) and high fractional polarization (> 20%), the spectral index and polarization information can be used as a means to produce a list of pulsar candidates. Because of high dispersion measures in the pilot region, such a technique for pulsar detection may prove more sensitive than conventional pulsar searches.

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The VSOP Space VLBI Mission — the Canadian Component, B. Carlson and A. R. Taylor, University of Calgary, P. E. Dewdney, Dominion Radio Astrophysical Observatory, B. Petrachenko, Natural Resources Canada, W. Cannon, D. Baer, G. Feil, B. Feir, P. Newby, and A. Novikov, Institute for Space and Terrestrial Science/Space Geodynamics Lab, B. Scott and D. A. Del Rizzo, University of Calgary.

The VSOP satellite (now named HALCA) was launched from the Kagoshima Space Center in Japan on February 11, 1997. The launch was completely successful, and subsequently the sub-reflector and the main reflector were successfully deployed. Tests have verified basic functionality of telemetry links to ground tracking stations, on-board receivers, and antenna pointing capability. Work is proceeding on finding space-ground fringes. The deployment of the Canadian S2 recorders is proceeding, and several Earth-based VLBI tests have been successfully correlated at the Dominion Radio Astrophysical Observatory in Penticton. The Canadian Correlator is complete and on-line. Operational software is almost complete. It includes software to automatically generate correlator control files and models from GRT and TS logs, a VLBI tape management database program, automated FITS format export software, and automated fringe searching software. First data from the satellite recorded on S2 recorders is expected on May 16, 1997. The VSOP space-ground system will make continuum and spectral line observations at 1.6, 5 and 22 GHz with a maximum resolution of 90 micro-arcseconds, detecting sources with a sensitivity of about 100 mJy. Rapidly changing space-ground interferometer baselines provide good *u-v* coverage. The total observing time on the spacecraft has been divided roughly into three parts — 50% for General Observing Time (GOT) available by open application, 25% for a survey of high brightness temperature sources and maser sources (the VSOP Survey), and 25% for engineering time. The Survey is by invitation of the VSOP mission under the auspices of the Survey Working Group. It is a priority for the Canadian group who are currently working on the processing of a VLBA pre-launch survey. Many of the Survey observations will be carried out by the Canadian VLBI system. The first round of applications for GOT occurred in 1995 and covers the period from about August 1997 to December 1998. The second deadline for observing proposals will be March 1, 1998. Canadian observers are urged to apply.

Dynamics of Pulsating Ap Stars: Measuring Velocity Variations at the Few-m/s Level, François Chagnon and Jaymie M. Matthews, University of British Columbia.

Rapidly oscillating Ap (roAp) stars are ideal targets for stellar seismology, thanks to their high-overtone non-radial modes. One way of independent mode identification is to compare the light amplitudes to the corresponding radial velocity (RV) amplitudes. Also, lines arising from different ions in the chemically stratified and inhomogeneous atmosphere of an roAp star sample different depths and surface sectors of the non-radial spherical harmonics, making it possible to resolve the dynamical behaviour of the star. The challenge? The small photometric amplitudes of the stars (< 1 millimag!) imply RV amplitudes of less than 100 m s^{-1}. To meet that challenge we obtained high-resolution, high-S/N CFHT coudé spectra of two roAp stars (HD 42659 and 10 Aql) to search for RV variations at their respective photometric periods of 9.7 and 11.6 min. Each spectrum contains a mercury emission line imposed at the spectrograph pupil by an arc lamp to act as a precise RV fiducial point, allowing us to search for oscillations with amplitudes as small as ~10 m s^{-1}. The technique is similar to that adopted by the Doppler planet searches to find small barycentric wobbles induced by unseen companions.

Faraday Depolarization Jets in the Supernova Remnant G127.1+0.5, R. A. Christie, University of British Columbia, and A. R. Taylor and S. M. Dougherty, University of Calgary.

The λ21-cm polarization images of the Canadian Galactic Plane Survey project reveal faint jets of polarized emission centred on the shell-type supernova remnant G127.1+0.5. Analysis of the images suggests that the polarized structure is produced by depolarization of the diffuse synchrotron background from the Galaxy arising from differential Faraday rotation effects in the magneto-ionic medium within the remnant. Such an effect would be produced by magnetized jets or conduits emanating from the centre of the remnant. The presence of the jets may provide a clue to the cause of the barrel-shaped structure of the remnant itself. Such jets have never been detected before and are not detectable by any other means. The jets/conduits may represent the wake of the expansion of the cylindrically symmetric remnant, current transfer of energy, or momentum from a jet source at the centre of the remnant. The CGPS polarization images will provide a sensitive probe for the effect in a large number of supernova remnants.

Phase-Coherent Pulsar Data Analysis Using the S2 Baseband Processing System, D. A. Del Rizzo, W. Van Straten, and N. Bartel, York University; W. Cannon, Institute for Space and Terrestrial Science/York University, R. Wietfeldt, Jet Propulsion Laboratory/National Aeronautics and Space Administration, and M. Bailes, Melbourne University.

The process of recording phase-coherent pulsar data and subsequent software dispersion removal provides us with a means of achieving data collection at the limits of high time resolution. That allows for more precise measurements of pulse timing and the study of fast signal fluctuations within an integrated pulse profile. Until recently, such research has been limited by the recording systems used to collect data at the telescope. With the development of the S2 Recording System (S2) and its Tape-to-Computer Interface (TCI), we are able to record a phase-coherent pulsar signal at baseband frequency, and subsequently transfer the data directly to disk. Baseband recording, coupled with the increasingly higher performance of current computer hardware, allows us to analyze the data much more quickly and efficiently. We give an overview of the S2 Baseband Processing System for phase-coherent pulsar observations, present preliminary results from our analysis of pulsar data, and discuss plans for future developments.

Quasar Quest, Serge Demers and Benoit Frappier, Université de Montréal, and M. J. Irwin, Royal Greenwich Observatory.

We describe a term project currently offered to physics majors. It involves the IRAF analysis of 1-D spectra of emission line objects. Most of them are quasars; a few Seyfert galaxies are also available. The goals of the project are to identify lines, to determine the redshifts, and to establish the nature of the objects. Properties of objects, such as the absolute magnitude and degree of ionization, are then compared. Such a project fits nicely with a course on Extragalactic Astronomy given at the same level.

Searching for Variable Radio Sources Using the Canadian Galactic Plane Survey Data, Sean M. Dougherty and Russ Taylor, University of Calgary.

Large-scale radio surveys have led to the discovery of variations in the radio emission from a number of different types of stellar systems, most notably in X-ray binaries *e.g.* LSI 61°+303 (Taylor & Gregory 1982). Variations have been observed on time scales ranging from hours to weeks. The Canadian Galactic Plane Survey (CGPS) radio continuum data base is ideally suited to searches for such variable sources. As a consequence of the observing method, sources with variations on time scales of hours, days and months can be identified directly from the CGPS data. A deep search for variability can be carried out on tens of thousands of compact radio sources in the galactic plane. We present here a method of identifying intra-day variations from the data, and illustrate its application on one of the survey regions.

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VLBI Astrometry of the Ultra-Compact Nucleus of M81, A. Ebbers, York University and Dominion Radio Astrophysical Observatory, N. Bartel and M. F. Bietenholz, York University, and M. P. Rupen, National Radio Astronomy Observatory.

M81 has been shown to have an extremely compact flat-spectrum core with a possible steep-spectrum jet. We report on position determinations of the brightness peaks of the source at several frequencies relative to the position of the early supernova 1993J, with uncertainties as low as 0.07 mas. At early epochs the supernova was largely point-like at any frequency and therefore an ideal phase reference. We describe the frequency dependence of the position determinations and discuss whether the results can support a model with a core and one-sided jet for M81.

The Canadian Galactic Plane Survey, S. Gibson, A. R. Taylor, D. Leahy and S. Dougherty, University of Calgary, C. Carignan and N. St-Louis, Université de Montréal, M. Fich, University of Waterloo, N. Ghazzali, G. Joncas, S. Pineault and M. Normandeau, Université Laval, C. Heiles, University of California, J. Irwin and J. English, Queen's University, P. Martin, D. Johnstone and S. Basu, Canadian Insititute for Theoretical Astrophysics, W. McCutcheon, University of British Columbia, D. Routledge and F. Vaneldik, University of Alberta, P. Dewdney, J. Galt, A. Gray, L. Higgs, L. Knee, T. Landecker, C. Purton, R. S. Roger, K. Tapping, T. Willis, and G. Moriarty-Scheiven, National Research Council, C. Beichman and S. Terebey, California Institute of Technology, N. Duric, University of New Mexico, D. Green, Cambridge University, M. Heyer, University of Massachusetts, H. Wendker, Hamburger Sternwarte, and Z. Xi-Zhen, Beijing Astronomical Observatory.

In April 1995 the Dominion Radio Astrophysical Observatory, in collaboration with a consortium of university astronomers, began a project to image the atomic hydrogen and radio continuum emission from the interstellar medium of the Milky Way galaxy. With the aid of a mosaic of 190 synthesis fields, the survey will cover the region $75^\circ < l < 145^\circ$ and $-3^\circ < b < +5^\circ$, with angular resolution of ~ 1 arcminute. The atomic hydrogen cube will yield a 3-dimensional image with spatial resolution of order 1 pc over regions several kiloparsecs in extent. In the continuum, full Stokes I, Q, U and V images are produced at 1420 MHz, and Stokes I at 408 MHz. The CGPS survey is being carried out as part of an international collaboration to image the Milky Way, at a common resolution, in emission from all major constituents of the interstellar medium: the neutral atomic gas, the molecular gas, the ionized gas, dust and relativistic plasma. For many of the constituents the angular resolution of the images will be more than a factor of 10 better than any previous studies. We present initial images from the project as well as highlights of some early scientific results.

Revealing Palomar 2: A New Outer-Halo Cluster, W. E. Harris, P. R. Durrell, G. R. Petitpas, T. M. Webb and S. C. Woodworth, McMaster University.

Palomar 2 is a distant and heavily obscured globular cluster which, unlike the vast majority of such clusters, is located near the galactic anticentre direction ($l = 171°$, $b = -9°$). Though it is possibly one of the rare outer-halo clusters that are important tracers of the mass distribution and formation history of the halo, virtually nothing has been known about it till now. We have used new CCD images in *V* and *I* obtained from the UH8K camera at the CFHT to obtain the first colour-magnitude diagram for the cluster. Our photometry, reaching $V_{lim} \cong 24$, clearly shows the principal sequences of the cluster, though with substantial overall foreground absorption and differential reddening. The colour-magnitude diagram has a well populated red horizontal branch with a sparser extension to the blue, similar to clusters such as NGC 1261, 1851, or 6229 with metallicities near [Fe/H] $\cong -1.3$. Several indicators suggest that the foreground reddening is $E_{B-V} = 1.24 \pm 0.03$. From the magnitude level of the horizontal branch we estimate a true distance modulus $(m-M)_0 = 17.1 \pm 0.2$, placing it $\sim$ 34 kpc from the galactic centre. Star counts from our data were used to define the core radius, half-mass radius, and central concentration of the cluster. Its integrated luminosity $M_V^t \cong -7.9$ makes it brighter and more massive than all but one or two other clusters in the outer halo. Very rough arguments based on its half-mass radius and radial velocity suggest that Palomar 2 is now moving in toward perigalacticon on a highly elliptical orbit (e ≥ 0.7).

Hubble Space Telescope Observations of NGC 2419: Constraints on the Formation of the Milky Way, J. E. Hesser, P. B. Stetson, R. D. McClure, and S. van den Bergh, National Research Council, W. E. Harris, McMaster University, M. Bolte, Lick Observatory, D. A. VandenBerg, University of Victoria, H. E. Bond, Space Telescope Science Institute, G. G. Fahlman and H. B. Richer, University of British Columbia, and R.A. Bell, University of Maryland.

NGC 2419 is a populous globular cluster in the far galactic halo at $R_{GC} \sim 90$ kpc. Available data suggest that NGC 2419 has always resided in the softer potential of the outer Galaxy. With [Fe/H] $= -2.1$, NGC 2419 appears to be a chemical twin of NGC 6341 (M92) in the inner halo at $R_{GC} \sim 10$ kpc. The question we seek to answer is: How do their ages compare? Cycle 4 & 5 data from WFPC2 on HST have been reduced with ALLFRAME to produce a *V* (F555W) and *I* (F814) colour-magnitude diagram (CMD) for NGC 2419 that reaches to $M_V = +8$. In superposition, the CMDs for NGC 2419 and M92 are virtually indistinguishable. Such similarity suggests that a global star cluster formation event occurred over a huge volume in the protoGalaxy. That the most metal-deficient globular clusters with good CMDs all have the same ages to within $\sim$0.5 Gyr further constrains Galaxy formation scenarios.

Scientific Opportunities and Challenges for the Dominion Astrophysical Observatory Telescopes from 1998 Onwards, James E. Hesser, National Research Council.

The opportunities: 1.8-m & 1.2-m telescopes with powerful instrumentation for optical and infrared imaging and for optical spectroscopy with a wide range of resolving powers, as well as user-friendly, efficient computer operation, and a yearly average of 42 visitor publications over the last 5 years. The challenge: reduce the operational load so that one-full-time technical staff member can shoulder it from April 1998 onwards; technical backup continues from the Instrumentation Group subject to time-critical contract obligations (*e.g.* Gemini). Community feedback: responses since CASCA '96 favour roughly equally model 1 (reduce the number of instrument configuration changes to be consistent with the requirements of the most highly ranked scientific programs in a period) and model 3 (dedicate large chunks of observing time to one or two projects on major scientific problems). Recent developments: experimentation with block scheduling and fewer weekend changes in the past year have been encouraging. We are increasingly optimistic that an effective model is within reach, although some further equipment changes (not yet funded) would greatly improve performance and reliability. New operational model: scientific demand should drive the balance between the models. While scheduling flexibility and service observing must be curtailed, the emerging operations mode will be compatible with the needs of most styles of major projects, including thesis research. We urge the community to consider the scientific opportunities these well-instrumented telescopes offer.

The Low-Resolution DRAO Survey of H I Emission from the Galactic Plane, L. A. Higgs, M. Davies, J. A. Galt, G. J. Hovey, L. B. G. Knee, K. F. Tapping, and A. G. Willis, Dominion Radio Astrophysical Observatory.

The DRAO Galactic Plane Survey of H I emission, which is currently underway with the Synthesis Telescope, requires single-dish observations of H I emission to provide structural information that is missing from the interferometric observations (the so-called "short spacing" data). A fast survey of about 1000 square degrees of the galactic plane, which will be used for that purpose, is now being carried out using the DRAO 26-m telescope. The survey of H I line emission will be fully sampled spatially, yielding nearly 25,000 spectra covering the velocity range from -260 km s^{-1} to $+160$ km s^{-1}. The survey will be completed in 1997 and the data will then be corrected for the effects of side-lobe contamination. Initial results of the survey are presented here.

Galaxy Evolution in the $z = 0.4274$ Cluster MS1621.5+2640, J. B. Hutchings and S. L. Morris, National Research Council, R. Carlberg and H. K. C. Yee, University of Toronto, E. Ellingson, University of Colorado, R. G. Abraham, Institute of Astronomy, Cambridge University, and T. A. Smecker-Hane, University of California, Irvine.

We discuss the galaxy population of the rich cluster MS1621.5+2640 at $z = 0.4274$, based on spectra and imaging in a field $\sim$9 by 23 arcminutes across. The sample comprises 277 galaxies, of which 112 are cluster members, 7 are near-members, and 47 are field galaxies in the redshift range $0.37 \leq z \leq 0.50$. The results are analyzed and compared with the $z = 0.2279$ rich cluster Abell 2390. MS1621.5+2640 has a higher blue fraction, a younger stellar population, and is a less evolved cluster, as expected from its higher redshift. We do not find evidence of significant starbursting activity compared with the field, although the small population of outlying near-members are blue galaxies that may be gravitationally affected by the cluster. Details of our results and stellar population models are presented. There is evidence for two populations of cluster galaxies: those with sudden truncation of star-formation and those with a gradual decrease over many Gyr.

A New Light Curve Analysis of RT Lacertae, K. Kijewski and E. F. Milone, University of Calgary.

RT Lacertae is an eclipsing, double-lined, spectroscopic binary with a beta Lyrae type light curve, which exhibits an appreciable and variable O'Connell effect. As a consequence, it has been considered an RS CVn type binary; infrared and ultraviolet spectroscopy have also suggested the presence of a thick disk and a transient gas stream in the system. Photometric data obtained at the Rothney Astrophysical Observatory with the RADS instrument on the 41-cm telescope in the summer of 1996 along with infrared and radial velocity data are analyzed. Initial solutions were determined by a preliminary parameter space search with the simplex algorithm. Final solutions and probable error calculations were performed with the Wilson-Devinney light curve analysis program. Spot-absence modeling cases are presented, and also discussion of the necessity of spot-inclusive cases.

Catalogue of 280 Molecular Outflows, T. D. Kneller, University of Alberta, and P. A. Feldman, J. M. MacLeod, and R. O. Redman, National Research Council.

Previous catalogues of molecular outflows have consisted of lists and tables of data, ranging from co-ordinates of known outflows to lists that include bipolarity, velocity ranges, etc. Catalogues by Bally & Lada (1983) and Fukui (1993) have been used to locate and study outflows believed to be caused by very young stars at the earliest stages of their formation. The catalogues, and those published by Staude & Elsässer (1993) and Wu *et al.* (1996) were used as starting points for preparation of a much more detailed catalogue containing a compilation of the better images, contour maps and spectra published on molecular outflows. Observations of as many different molecular transitions as possible were included. Altogether there are ∼280 outflows in the catalogue. It is as complete as possible to the end of 1995 and includes a few more recent observations. Searches of the web, back-referencing from other papers, and additional literature searches yielded ∼350 papers that are included in the reference list. Some additional papers that may be useful, but whose maps were not included in the catalogue, are referenced as well.

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ISO SWS/LWS Observations of Planetary Nebulae, S. Kwok, C.Y. Zhang, K. Volk, and Y. Su, University of Calgary.

The planetary nebulae H1–12, NGC 6790 and Vo–1 have been observed with the Infrared Space Observatory (ISO) Short and Long Wavelength Spectrometers (SWS and LWS). In all three cases, strong dust continua have been detected. A number of new forbidden lines, ranging from [Ar III] at 8.99 microns to [C II] at 157.74 microns have also been detected. The continuum levels are in general agreement with IRAS Point Source Catalog fluxes.

Simultaneous X-ray and Radio Observations of LS I+61º 303, Denis A. Leahy, University of Calgary, Fiona A. Harrison, California Institute of Technology, and Elizabeth Waltman, Naval Research Laboratory.

The unusual binary system LS I+61º 303 was observed twice for a total of 40 ks in a single binary orbit by the ASCA satellite, and monitored daily at two radio frequencies over the same orbit with the Green Bank Interferometer. During the first ASCA observation the source had a 1–10 keV luminosity of 3.9×10^{33} $(d/2.0\text{ kpc})^2$ erg s^{-1}. During the second the luminosity had decreased by $28 \pm 14\%$. During the first pointing the radio source was at a quiescent flux level of 27 mJy at 8 GHz and no variability was seen in the X-ray flux. However, during the second the radio flux was rising dramatically with an average value of 100 mJy and the X-ray flux was variable by ∼50% on timescales of ∼30 minutes. No pulsations are seen in either X-ray observation, with an upper limit on pulsed flux of ∼20%. The low X-ray luminosity and lack of observed pulsations indicate that accretion onto a neutron star surface is not the origin for the high-energy emission from LS I+61º 303. Rather, the X-rays may result from either: a) accreted matter which is stopped at the magnetosphere because the magnetospheric boundary is rotating at super-Keplerian rates, or b) a shock formed in the interaction of the dense wind of the Be star companion and a moderately young pulsar. We derive a required pulsar spin down luminosity of $\sim 10^{37}$ erg s^{-1} and argue that the shock model more easily explains the observed X-ray and radio observations.

The Structure of the Interstellar Medium in Cam OB1, David A. Lyder, Dominion Radio Astrophysical Observatory and University of Victoria.

A fully sampled, sensitive survey of the CO molecular gas in the Cam OB1 region recently taken with the Center for Astrophysics (CfA) 1.2-m telescope (Digel *et al.* 1996) reveals a rich structure relative to the original CfA survey (Dame *et al.* 1987). A Fourier analysis of the structure suggests that it follows a similar distribution of power with scale length to that seen in H I in the region. A structure tree analysis of a sample cloud in the region suggests it is similar to the Taurus star-forming region. The structure is hierarchical in nature and can be described with a Kolmogorov power spectrum.

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On the Blue Straggler Population of the Globular Cluster M55, Georgi I. Mandushev, Gregory G. Fahlman, and Harvey B. Richer, University of British Columbia, and Ian B. Thompson, The Observatories of the Carnegie Institution of Washington.

We have identified a large sample of 74 blue straggler stars (BSS) in the central region of the sparse, metal-poor, globular cluster M55 (NGC 6809). Most of them form a relatively narrow, well-defined sequence extending from ∼0.6 magnitude below the main-sequence turnoff (MSTO) to about 2 magnitudes brighter than the MSTO. Within the one core radius field that we observed, the BSS are more centrally concentrated than the MSTO and subgiant stars in the same magnitude range. About 15% of the BSS appear to form a secondary sequence ∼0.75 magnitude above the main blue straggler sequence. Artificial star tests and the fact that the stars are strongly concentrated towards the cluster centre suggest that at least some of them are binary BSS. Given the location and the small width of the blue straggler sequence, we argue that the BSS in M55 are born with helium-enriched cores, but not envelopes. We conclude that the observed blue straggler sequence is the equivalent of a core helium-enriched main sequence where the BSS spend most of their lives. Our observations are consistent with the assumption that the majority of the M55 blue stragglers are unmixed binary mergers or mass-transfer remnants.

Probing Protostellar Structure: NGC 2264G, B. C. Matthews and C. D. Wilson, McMaster University.

NGC 2264G is one of a number of protostellar sources identified to power an extensive outflow. Its outflow, although similar to that of the multiple source NGC 1333 IRAS4B, is much more developed (Lay *et al.* 1995). However, Ward-Thompson *et al.* (1995) have suggested that NGC 2264G could be even younger than the prototypical Class "0" source VLA 1623. Detection of the disk could serve to clarify the interpretation of the nature of NGC 2264G. We have observed this candidate Class "0" source with the OVRO interferometer in the $J = 1$–0 transitions of ^{13}CO and C^{18}O. Our maps reveal a single bright source at the position of NGC 2264G in ^{13}CO centred at 5.11 km s^{-1}. The C^{18}O maps, however, show two peaks on either side of the map centre and centred in velocity between 4.43 and 4.77 km s^{-1}.

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*Analyses of Delta Scuti Star*s, E. F. Milone, W. J. F. Wilson, D. J. I. Fry, and V. A. Fabro, University of Calgary.

Delta Scuti variables and their cousins (dwarf Cepheids, SX Phoenicis stars) are rapidly pulsating variables at the bottom of the Cepheid instability strip. They are dwarf or subgiant stars and so are not visible to as great distances as classical Cepheids, or even RR Lyrae stars, but they are very common. Therefore, an improvement in the determination of their luminosties will have useful consequences for distance determinations, especially in stellar ensembles that contain them. To that end, our program is aimed at refinement of the period-luminosity relation — or the establishment of a *P-L*-metallicity relation — for the objects. As a first step we are determining the Baade-Wesselink radii of several of them; from the radii we are exploring period-radius relations from which *P-L* relations may be derived, thus providing a useful distance indicator. Work by other investigators, through various methods, confirms the likelihood of a *P-R*-metallicity relation for the family of such stars. We have obtained Baade-Wesselink radii for three such stars, EH Librae, DY Herculis, and DY Pegasi, as a contribution towards the goal of establishing a *P-R* relation, and are observing (by means of optical and infrared observations from Rothney Astrophysical Observatory and radial velocity data from the Dominion Astrophysical Observatory) several others of differing properties. Most recently we have been observing the multi-period system AI CVn = 4 CVn.

The Low Redshift Lyman-α Forest, S. L. Morris, National Research Council, B. Jannuzi, National Optical Astronomy Observatories, and R. Weymann, Carnegie Observatories.

We present new Canada-France-Hawaii Telescope results on the relationship between low column density ($N_{H\,I} < 10^{-15}$ cm^{-2}) Lyman-α absorbers and galaxies in the redshift range from 0 to 0.8. The initial results indicate that huge sheets and filaments of material fill space, with galaxies embedded at intersections and high density clumps. Possibly unsurprisingly, one's impression of a universe of *island nebulae* separated by huge regions of nothingness is quite incorrect when such low-density material is considered.

Herzberg Institute of Astrophysics – Institut Herzberg d'Astrophysique, Donald C. Morton, National Research Council of Canada – Herzberg Institute of Astrophysics.

The National Research Council of Canada, through its Herzberg Institute of Astrophysics, provides astronomical facilities and the associated development of instrumentation, software and archives, for university researchers. The facilities include the CFHT, the JCMT, the Gemini telescopes, and in British Columbia the DAO optical telescopes and the DRAO synthesis telescope.

Le Conseil National de Recherches du Canada, par son Institut Herzberg d'Astrophysique, met à la disposition des chercheurs universitaires des installations astronomiques et le développement qui va de pair en instrumentation, logiciel et archives. Les installations comprennent le TCFH, le TJCM, les télescopes Gémini, et en Colombie-Britannique les télescopes optiques à DAO et le télescope à synthèse à DRAO.

Far-Infrared Observations of the Giant Planets with the Infrared Space Observatory, D. A. Naylor, University of Lethbridge, G. R. Davis, University of Saskatchewan, M. J. Griffin, P. G. Oldham and P. A. R. Ade, Queen Mary and Westfield College, B. M. Swinyard, Rutherford Appleton Laboratory, G. S. Orton, Jet Propulsion Laboratory, D. Gautier, Th. Encrenaz and E. Lellouch, *Observatoire de Paris*, S. B. Calcutt and P. G. J. Irwin, University of Oxford, Th. De Graauw, SRON, and M. Burgdorf, LWS Instrument Dedicated Team.

The Infrared Space Observatory (ISO), launched by the European Space Agency in November 1995, is an astronomical satellite operating at wavelengths from 2.5–240 μm with imaging, photometric and spectroscopic capabilities. One of the four payload instruments, the Long Wavelength Spectrometer (LWS), provides medium- and high-resolution spectroscopy over the spectral range 43–197 μm (Clegg *et al.* 1996; Swinyard *et al.* 1996). The authors comprise the ISO solar system team. We present some of the early results from observations of giant planets with the LWS (Davis *et al.* 1996; Encrenaz *et al.* 1996; Griffin *et al.* 1996). Portions of the spectra of Jupiter and Saturn obtained with the LWS are presented. The measurements were made with a spectral resolution of 0.29 μm from 43–90 μm and 0.6 mm from 90–197 μm. The observed Jovian spectrum between 55 and 90 μm is compared to an atmospheric radiative transfer model using nominal values for the constituent vertical concentration profiles. Ammonia absorption manifolds account for the observed absorption features, seen against the hydrogen continuum, from which an ammonia column abundance can be determined. The observed Saturnian spectrum between 43 and 197 μm is compared to theoretical models; absorption features from ammonia, phosphine and methane are clearly identified, from which column abundances of the species can be determined. Imminent high spectral resolution Fabry-Perot observations of the giant planets with the LWS should allow a determination of the vertical concentration profiles of such constituents.

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Physical Conditions in the Starburst Galaxy M83: Observations of C I and CO, Glen Petitpas and C. D. Wilson, McMaster University.

We present [C I] 492 GHz, CO $J = 4$–3, and CO $J = 3$–2 maps of the barred spiral galaxy M83 taken at the James Clerk Maxwell Telescope. M83 is believed to be undergoing a nuclear starburst, which should readily excite the higher-J CO emission and also possibly dissociate CO to form atomic carbon. The [C I] map covers an area of 20 × 20 arcseconds, while the CO $J = 4$–3 map covers 40 × 30 arcseconds. The integrated intensity and channel maps reveal a double-peaked structure that appears to be the result of a distorted ring of rotating molecular gas. The peak atomic carbon column density and the C to CO column density ratio in M83 are somewhat smaller than what is seen in the starburst galaxies M82 and NGC 253. The [C I]/CO $J = 4$–3 integrated intensity line ratios in M83 are uniform at the 2σ level and have an average value of 0.25 $\pm$0.03, similar to those found in the starburst galaxy NGC 253. In contrast, the CO ($J = 4$–3)/($J = 3$–2) integrated intensity line ratios vary substantially over the central region of M83.

The Supernova Remnant CTA1 — Putting Particle Acceleration Theories to the Test, S. Pineault, Université Laval, T. L. Landecker and C. Swerdlyk, National Research Council, and W. Reich, Max-Planck-Institut für Radioastronomie.

New radio observations of the supernova remnant (SNR) CTA1, obtained with the Dominion Radio Astrophysical Observatory Synthesis Telescope at 1420 MHz and 408 MHz and with the Effelsberg 100-m telescope at 1420 MHz, are presented. Angular resolution of the final maps is 1 arcminute and 3.5 arcminutes at 1420 MHz and 408 MHz respectively. From these and previous observations, we deduce an integrated spectral index of $\alpha = 0.57 \pm 0.006$ (where $S_\nu \propto \nu^{-\alpha}$), significantly steeper than previous estimates. In addition to the bright radio arcs visible to the south and east, the SNR has a very substantial extension to the northwest, interpreted as the breakout of the SNR blast wave into a medium of lower density. Faint emission is also present past the southern limb-brightened radio filaments. Although that could result simply from projection effects, we interpret it in terms of electrons diffusing upstream ahead of the shock front with a mean free path of order 0.02 pc. There is evidence for spatial variations in the spectral index distribution over the SNR, the diffuse emission to the northwest being generally of a steeper spectral index than emission associated with the brighter regions. A tentative explanation in the context of diffusive shock acceleration theory is given.

Gas Dynamics of the Outer Disk of the Milky Way, A. Razoumov and R. Ibata, University of British Columbia.

We use numerical gas-dynamic simulations to investigate the behaviour of the outer disk of the Milky Way. In particular, we are interested in the effect the Sagittarius dwarf galaxy produces on the gaseous component of the galactic disk. We constrain our models by recently-derived orbital and mass parameters of this dwarf galaxy. It is found that masses above $\sim 5 \times 10^9 \mathcal{M}_\odot$ produce a significant distortion to the structure of the galactic H I disk, although none of the models lead to a perturbation resembling the observed warp. We argue that encounters with dwarf elliptical galaxies will significantly affect the star formation history of the outer disk. Also, our study suggests that it might be possible to determine the merging rate of low surface brightness, gas-poor, dwarf galaxies of masses $10^9 \mathcal{M}_\odot$ onto giant spiral galaxies from careful analysis of observations of the structure of their H I disks.

DA530 — A Supernova Remnant in a Stellar Wind Bubble, D. Routledge, J. F. Vaneldik, and R. J. Smegal, University of Alberta, T. L. Landecker, National Research Council, and S. P. Reynolds, North Carolina State University.

The supernova remnant (SNR) DA530 (G93.3+6.9) is remarkable for its very regular shell structure and for the very high degree of linear polarization of its radio emission. We present radio continuum and H I observations of DA530 made with the DRAO Synthesis Telescope and X-ray observations made with ROSAT. The SNR lies within a shell of H I, clearly identifiable by its morphological resemblance to the radio continuum object. The systemic velocity of the associated H I (-14 km s^{-1}) places the SNR at a distance of about 2.7 kpc, implying a diameter of 21 pc. The X-ray emission from the SNR is extremely low. The ratio of X-ray to radio luminosity is the lowest of any known SNR. It appears that the supernova explosion that formed DA530 occurred in a region of very low density, possibly within a stellar-wind bubble.

The Molecular Outflows in NGC 1333, G. Sandell, Joint Astronomy Center, and Lewis B. G. Knee, National Research Council.

We present the results of CO (3–2) mapping, using the James Clerk Maxwell Telescope (JCMT), of the active star formation region immediately south of NGC 1333, supplemented by CO (1–0) mapping using the Onsala Space Observatory 20-m telescope. The spectral line maps provide the first clear overview of the complex cluster of overlapping molecular outflows associated with the Herbig-Haro objects and the far-infrared and (sub)millimetre sources in the region. At least eight molecular outflows are identified, for seven of which we can confidently identify the driving source. Among them are probable "Class 0" protostellar objects driving highly collimated CO jets. Two objects appear to drive outflows that are precessing. The nature and exciting source of the HH 12 complex is identified. All of the deeply embedded (sub)millimetre and/or outflow sources currently forming in NGC 1333 are probably binaries. There is a very close connection between the distribution of young objects, outflows, and the structure of the molecular cloud. A model of the very active NGC 1333 star formation region is proposed.

The Speckle-Spectroscopic Orbit of 12 Persei, C. D. Scarfe and D. J. Barlow, University of Victoria.

We have obtained a new series of radial velocities of the double-lined spectroscopic binary star 12 Persei, which has been resolved in recent years by speckle interferometry. We present a solution for the orbital elements from the speckle and radial velocity data simultaneously, and derive from that solution accurate values of the masses of the components and of the system's distance and angular momentum.

A Test of the Metallicity Dependence of the Cepheid Period-Luminosity Relation in the Near-Infrared and a New Distance to M31, T. M. Webb, D. L. Welch and C. D. Wilson, McMaster University, and P. B. Stetson, National Research Council.

We present new *JHK* photometry for previously discovered M31 Cepheids within the Baade and Swope fields I, III and IV. The data were obtained over six nights in August 1993 and three nights in October 1994 using the RedeyeN camera of CFHT in conditions of 0.65 arcsecond seeing. The Cepheids were chosen to be a subset of those studied by Freedman & Madore (1990). The correct star was identified by its variation, where multiple epoch observations were available, and by its position on the *JHK* colour-colour plane. The total absorption at *K* is a factor of 4 lower than for *I*, the longest wavelength in the Freedman & Madore study. We present an improved distance modulus estimate for M31 and an investigation of the dependence of the Cepheid infrared *P-L* relation on metal abundance. Theoretical predictions and empirical studies of the latter have, in the past, been contradictory, and the systematic errors affecting the calibration are expected to be much smaller in the infrared.

New Forbidden Components of Neutral Helium in the Optical Spectrum of Extreme Helium Stars, F. Wesemael, Université de Montréal, and A. Beauchamp, CAE Électronique Ltée.

We develop a simple criterion, based on the general properties of weakly excited forbidden components in neutral helium, to predict which forbidden components should be observable in the He I spectrum of extreme helium stars. On the basis of the criterion, we find that nearly a dozen such components should be visible. We then calculate detailed synthetic spectra for parameters representative of such objects. All the forbidden components predicted by our criterion are present in the synthetic spectra. Observation of the features in extreme helium stars will provide a valuable test of current theories of the broadening of neutral helium lines.

Atomic Carbon in Individual Molecular Clouds in M33, Christine Wilson, McMaster University.

The amount and distribution of atomic carbon is important for understanding the physical structure of molecular clouds, as well as the effect of star formation in changing that structure. I have detected [C I] emission from four individual giant molecular clouds in the Local Group spiral galaxy M33. A comparison of the data with published interferometric CO J = 1–0 measurements yields an average [C I]/CO ratio of 0.10 $\pm$0.03. The M33 line ratios are comparable to those observed in the starburst galaxies M82 and IC 342, and also in the LMC. The average line ratio is also similar to that observed in galactic molecular clouds. Despite very similar masses and metallicities, the [C I] emission is four times stronger in MC20 than in MC32. Such an increase in [C I] luminosity is likely caused by the presence of a nearby ($\leq$ 25 pc) H II region producing a photo-dissociation region on the surface of MC20. It is often expected that the size of the photo-dissociation region will be larger in low metallicity regions as a result of reduced self-shielding and shielding by dust. However, although the two NGC 604 clouds have metallicities comparable to the LMC, their [C I] luminosities are not enhanced relative to the two more metal-rich clouds in the sample. Competing factors such as a drop in the abundance of carbon may be complicating the picture. For three of the clouds the column density ratio N(C)/N(CO) is comparable to that observed in the Orion Bar, but somewhat lower than that observed in S140 or the starburst galaxies M82 and NGC 253. Since two of the clouds (MC32, NGC 604-4) are located at least 120 pc from the nearest H II region, such a result suggests that substantial [C I] column densities are present in all molecular clouds. Such [C I] could be produced either by ionization by the interstellar radiation field or by low density equilibrium chemistry. The column density ratio N(C I)/N(CO) is substantially lower for NGC 604-2, which is the cloud that is subject to the most intense ultraviolet radiation field. Unlike 30 Doradus in the LMC, where the [C I] emission is genuinely weak, the low ratio is the result of a relatively large derived CO column density, rather than a lack of [C I] emission.

Hubble Space Telescope Observations of Proto-Planetary Nebulae, C. Y. Zhang and S. Kwok, University of Calgary, and B. J. Hrivnak, Valparaiso University.

We present Hubble Space Telescope (HST) WFPC2 *V*-band images of two proto-planetary nebulae (PPN) IRAS 17150–3224 and IRAS 17245–3951. Besides the regular pipeline of the HST data reduction, the program "drizzle" is also used to improve the under-sampling problem of HST data and to enhance the spatial resolution. Both nebulae show a clear bipolar morphology with their respective central stars obscured by edge-on circumstellar disks. A series of ring-like structures can be seen in IRAS 17150–3224, similar to the rings observed in the well-known PPN AFGL 2688.

Dynamical Models of Dust Shells Around Asympototic Giant Branch Stars, Guojin Zhang and Sun Kwok, University of Calgary.

Results of a dynamical model of stellar outflow on the asymptotic giant branch (AGB) based on the mechanism of radiation pressure on grains have been obtained. The gas and dust outflows are treated as a two-component fluid and the coupled equations of motions and radiation transfer are solved self-consistently. The model results are compared with the energy distributions of optically-thick OH/IR stars on the AGB.

Education Session (theme "The Technological Revolution in Astronomy")

Oral Presentations

Planetscapes via Netscape, J. M. Matthews and D. Bilesky, University of British Columbia.

We have developed a special Netscape interface, dubbed *PLANET*, that enables first-year astronomy students to perform laboratory-style measurements on images and data for the terrestrial planets. For example, students measure crater densities and observe superposition of features on various parts of the Martian surface to estimate relative ages. The menu-driven framework is easily adaptable to a variety of web-based astronomy applications, without a great deal of expertise beyond basic HTML script.

Student Projects for a Small University or College, B. E. Martin, S. Strydhorst, T. Whyte, and D. VanderVelde, The King's University College, Edmonton.

Three research projects suitable for undergraduates at a small institution are presented. The projects were carried out as the major part of an Astronomical Methods course taught at The King's University College, Edmonton. The projects described are:

i. A Photometric Study of the SX Phoenicis Star AE Ursa Majoris (Shane Strydhorst). CCD photometry of the SX Phoenicis star AE Ursa Majoris was obtained at The King's University College Observatory during the winter of 1997 and confirms the main period of the star as 0.086020 day. The result compares well with data obtained by Marschall *et al.* at Gettysburg College, Pennsylvania. Times of maximum light were combined with data from Joner *et al.* at Brigham Young University, Utah, according to the ephemeris HJD(max) $= 2442062.5825 + 0.08601585\,E - 5.73107 \times 10^{-12} E^2$, in which the third term represents long term period changes in AE Uma. The Blazhko effect, a low amplitude beat frequency in the light curve, is also investigated.

ii. Educational Applications of Small Telescopes: Colour Magnitude Diagrams for the Open Clusters M36, M38 and M67 (D. VanderVelde). A small (0.2-m) telescope equipped with a CCD photometer at The King's University College Observatory was used to produce colour-magnitude diagrams in the *V* and *R* passbands for the bright northern open clusters M36, M38 and M67. From them a crude determination of the relative ages of the clusters was obtained. The project also illustrates the pedagogical potential afforded by very modest equipment when coupled with modern CCD detectors.

iii. Observing U Cephei With a Small Telescope (Travis Whyte). We have observed U Cep, an Algol-type eclipsing binary throughout the 1996/97 season using The King's University College Observatory 0.2-m telescope and CCD photometer. With the data obtained we were able to generate light curves in the *V, R,* and *I* filters and with them we established parameters for the system. The parameters were found through qualitative fits to the data using David Bradstreet's *Binary Maker* software.

Poster Papers

A Bench-Top Resolving Power Experiment, Keith Wolbaum and Peter A. Bergbusch, University of Regina.

The study of diffraction at a circular aperture is an almost obligatory part of any undergraduate experiment on diffraction and interference. However, the experimental connection between the phenomenon and the formation of an image by a telescope is rarely made. Astronomy students may confront the problem of resolving power while attempting to observe double stars visually through a telescope, but such observations are limited by the availability of suitably close double stars, differences in brightness and colour of the component stars, and atmospheric turbulence. It is possible for students to construct an extremely simple double star simulator (Maurer 1991) which can then be used to investigate the variation of resolving power with aperture or with wavelength, and even more realistic situations in which the component stars differ in brightness and colour. More sophisticated experiments involving the use of a CCD camera may be performed to study the effects of sampling in stellar images.

Reference

Maurer, A. 1991, Sky & Telescope, 82, 311

An Exercise in Self-Directed Exploration of Astronomical Data Bases, C. F. Brown, University of Manitoba.

Astronomy is about discovery, yet undergraduate students spend most of their time learning by rote what is already known. The exercise described here allows students to explore, with little or no restriction, the relationships between various attributes (columns) of any astronomical data base. The results yield many well-known relationships as well as some that are not so well known. Methods of acquiring data bases, analyzing the data and presenting the results are discussed. For more information, point your web browser to home.cc.umanitoba.ca/~cbrown/astrodb.htm.

ON THE MITHRAIC TAUROCTONY

by F. Graham Millar
Halifax Centre, RASC

(Received August 8, 1997; revised November 25, 1997)

I offer here some remarks upon "Astronomical Conceptions in Mithraic Iconography" by Chapman-Rietschi (1997). He has given a concise review of crucial references on Mithraism, not failing to mention early modern contributions. My comments are not directed at him, but at some of the accepted suppositions that he has passed along.

Mithraism was a Near Eastern religion of the stars, probably imported into the Roman Empire by soldiers recruited from the eastern frontier. Prevailingly, its adherents were soldiers of low rank and civilians of humble station. The sites of some four hundred Mithraic chapels have been found. Some statues from them bear inscriptions attesting wealthy donors. A uniform feature in the chapels was an altarpiece depicting the bull slaying — "the Tauroctony." Surviving examples have been sculptural reliefs in stone. Today it is agreed that the altarpieces represented a huge constellation comprising Perseus, Auriga, Taurus, Orion and Gemini.

Figure 1 is part of the star map given by Ulansey (1989, p. 53) for the area of the five constellations. The star chart is on a cylindrical projection tangent to the ecliptic, a projection that is virtually distortion

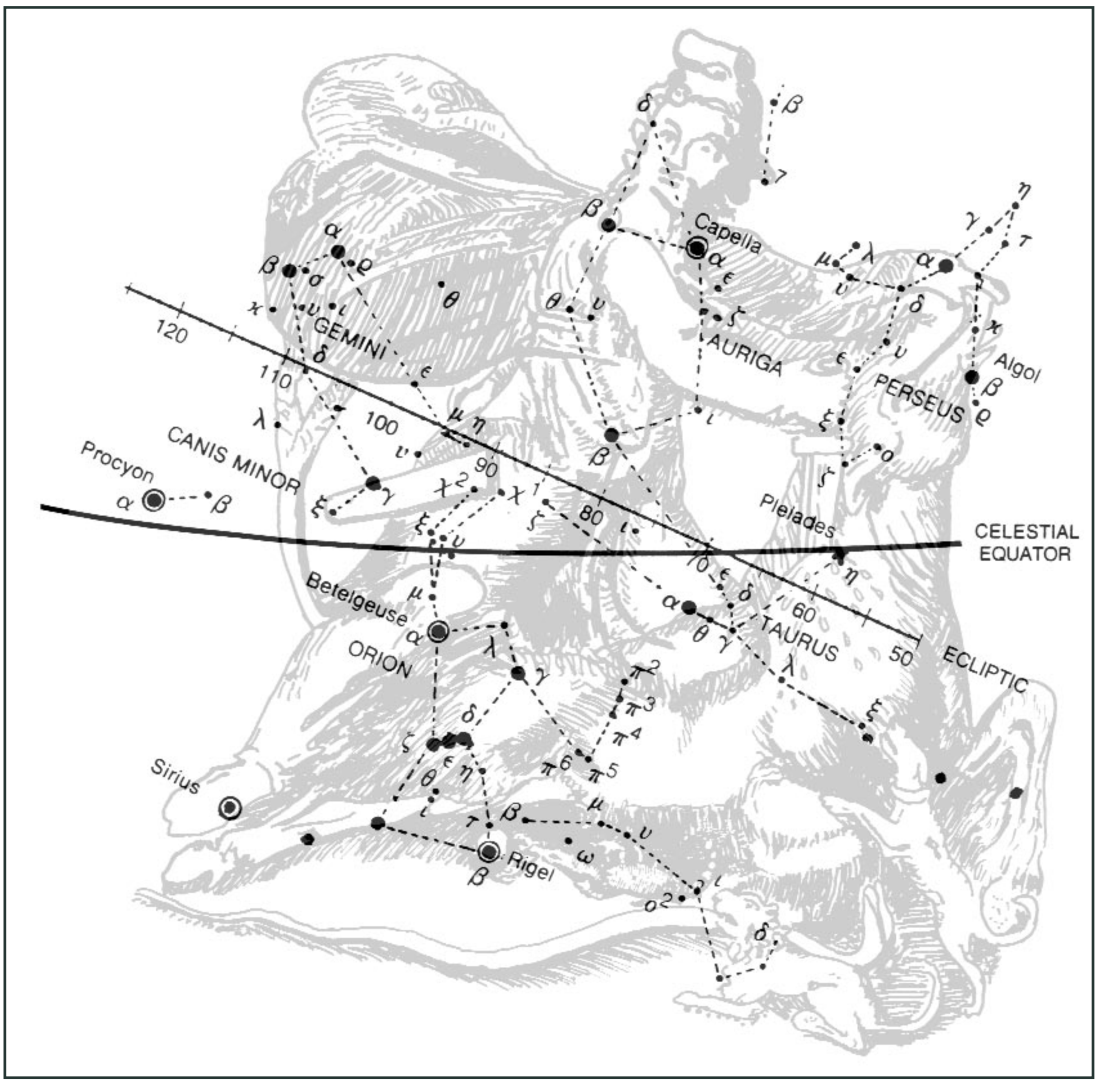

Fig. 1 — The constellation of the Tauroctony, comprised of Perseus, Auriga, Taurus, Orion and Gemini. The celestial equator is shown where it was about 2800 b.c.e.

free in the area of interest. Upon it I have sketched a typical tauroctony (Ulansey p.65), allowing some distortion but not more than between the original and another example (Ulansey p.17). The fit to the chart is good, although the hound leaping for the flowing blood is not represented in the stars. I make three points about the constellation:

1. On the altarpieces the bifurcated tail-brush is represented by ears of wheat. It falls on the modern constellation of Gemini, not Spica (the Ear) as Stark has said. As I propose here, the tail-brush was a predecessor to the Pleiades as an indicator of the seasons, by a couple of millennia or more. In the area of the Mediterranean and the Fertile Crescent, wheat is a winter crop, sown in autumn, reaped in spring. The rising and setting of the tail-brush signified seasons important in the culture of wheat. With precession considered, early in the Age of Taurus the astronomical events affecting the brush marked the times for ploughing, sowing and reaping, exactly as Hesiod, c.700 B.C.E., stated for the Pleiades in his ***Works and Days*** (Fraser 1983). The altarpieces, with the sword wound placed at the Pleiades, were made in the Roman era when the brush was obsolete as the seasonal indicator.

2. "[The Tauroctony] represents the state of the sky when the spring equinox was in Taurus."

Chapman-Rietschi (1997) citing Lajard.

Not so! Working with a planisphere, its window calculated for a latitude of 35° N and pivoted at the pole for 3500 B.C.E. — placing the equinox in Taurus — I found that only a smallish upper part of the Tauroctony was visible at the equinox, and then only for a few minutes before dawn. However, by midsummer the great constellation dominated the southern night sky. Its lower parts would begin their heliacal (dawn) settings as the autumnal equinox approached. Significantly, Rigel, the scrotum of the bull, would set heliacally soon after the heliacal rising of Spica. At this season the Sun would be entering Libra, which was anciently part of Scorpius, and so the scorpion's attack on the bull's scrotum is explained.

3. In the tableau of the altarpieces, the sword was thrust in at the position of the Pleiades. I challenge the theory that the religious sacrifice took place in spring at their heliacal rising; I believe it was enacted in late summer at the heliacal (dawn) setting of the Pleiades (earlier, Gemini). In the Near East in pagan times, the New Year festival was celebrated in late summer when the grasses had died and the noon Sun was getting lower. A tradition of the sacrifice, its meaning forgotten, remains to us in the bullfights, always conducted in summer. In the tableau, the hound leaping to lick the spurting blood was Canis Major, which rose heliacally in late summer, confirming for us that it was the season of sacrifice. The ritual assured the magical annihilation of the old year so that a fresh new year could take its place: a rebirth. By Roman times a sacrament of bread and wine had been substituted for the blood sacrifice, and the cultists who partook of it thereby assured their immortality.

Based mainly on contemporary concepts in the study of ancient astronomy, I have proposed here a few revisions to current views on Mithraism.

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Ulansey, David 1989, The Origins of the Mithraic Mysteries (Oxford University Press: New York and Oxford)

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F. GRAHAM MILLAR published his first paper in the Journal in 1936 and his most recent in 1995. He obtained a B.A. in mathematics and physics in 1933 and an M.A. in meteorology and geophysics in 1934, both from the University of Toronto. He was subsequently employed in Toronto for 16 years as a meteorologist at the Head Office of the Meteorological Service of Canada (as it was then called). Following that he worked for 23 years with the Defence Research Board, doing research on underwater sound and the statistical analysis of antisubmarine exercises. He finished his career as a scientific editor with the Defence Research Analysis Establishment, Ottawa. In retirement he studied modern astronomy and astrophysics in the graduate program at Saint Mary's University, but became interested in ancient astronomy and religion.

THE COMPOSITE OBSERVATIONAL-THEORETICAL HR DIAGRAM

by B. Cameron Reed
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College and university instructors facing textbook-adoption decisions for survey-level astronomy courses have a number of options from which to make their selection. Almost universally, texts aimed at such a market devote much of a chapter to exploring how astronomers' understanding of the characteristics and life cycles of stars is aided by Hertzsprung-Russell (HR) diagrams. The HR diagram is usually first presented as a synthesis of *observational data* (often in the form of a plot of absolute visual magnitude M_V or luminosity L versus B-V colour, spectral type or effective stellar surface temperature T). After that, interpretations are discussed in terms of a *theoretical* HR diagram which shows loci of constant stellar radius R in the (L, T) plane based on the Stefan-Boltzmann law,

$$\log\left(\frac{L_{\rm star}}{L_{\rm sun}}\right) = 2\log\left(\frac{R_{\rm star}}{R_{\rm sun}}\right) + 4\log\left(\frac{T_{\rm star}}{T_{\rm sun}}\right) \qquad (1)$$

By comparing observational and theoretical diagrams conveniently printed on the same or adjacent pages, students can come to understand why labels such as "red dwarf" or "yellow giant" are in fact literal descriptions of certain types of stars.

Despite the number of texts in print, however, one rarely sees a plot showing constant-radius lines overlaid on observational data so as to yield what one might refer to as a composite observational-theoretical HR diagram. Indeed, the co-ordinates commonly chosen in the two cases, (M_V, B-V) and ($\log L$, $\log T$), make direct comparisons awkward at best. The purpose of this note is to present and describe briefly the construction of such a composite diagram.

Two difficulties account for the lack of composite HR diagrams in popular texts. The first is that lines of constant total, or "bolometric," luminosity L do not transform into horizontal lines in the (M_V, B-V) plane because the amount of light a star emits at visual wavelengths relative to that over all other wavelengths depends on its effective temperature. Bolometric luminosity can be quantified in terms of absolute bolometric magnitude, which is related to absolute visual magnitude through a temperature-dependent bolometric correction BC. Specifically, the bolometric correction is defined to be the number of magnitudes that must be added to M_V to give $M_{\rm bol}$:

$$M_{\rm bol} = M_{\rm v} + BC(T)\,. \qquad (2)$$

Inasmuch as $M_{\rm bol}$ is intended to represent the stellar radiation emitted over all wavelengths rather than only that in the visual range, it is brighter than M_V. Bolometric corrections are thus inherently negative numbers. Bolometric luminosities are related to bolometric magnitudes via

$$M_{\rm bol}\,({\rm Sun}) = M_{\rm bol}\,({\rm star}) + 2.5\log\left(\frac{L_{star}}{L_{sun}}\right)\cdot \qquad (3)$$

The second difficulty is that the natural ordinate for theoretical HR diagrams, effective temperature, is non-linearly related to B-V colour.

As a consequence of such complications, loci of constant radius and luminosity transform into curved lines in the (M_V, B-V) plane. However, bolometric corrections and B-V colours for main sequence stars are sufficiently well-calibrated as functions of temperature that we can establish empirical relations to permit computation of (M_V, B-V) co-ordinates corresponding to given (L, T) or (R, T) values. Curves of constant L and R as functions of T can then be computed and overlaid on the (M_V, B-V) plane. That is the approach taken in what follows.

Figures 1(a) and 1(b) show B-V colours and bolometric corrections as functions of the common logarithm of effective surface temperature for O3-M8 main sequence stars as given on pages 137-138 and 150-151 of Lang (1992). They can be fitted empirically according to the relations

$$B - V = \begin{cases} C_1(\log T) + C_2 & (\log T \le 3.961) \\ C_3(\log T)^2 + C_4(\log T) + C_5 & (\log T > 3.961) \end{cases} \qquad (4)$$

and

$$BC = C_6(\log T)^4 + C_7(\log T)^3 + C_8(\log T)^2 + C_9(\log T) + C_{10}, \qquad (5)$$

where the coefficients C_1 through C_{10} are given in Table I.

To construct a line of constant luminosity in the (M_V, B-V) plane, one first chooses a value for $L_{\rm star}/L_{\rm Sun}$. For a range of temperatures one then computes colours and bolometric corrections via equations (4) and (5). For each temperature, equations (3) and (2) give corresponding bolometric and absolute visual magnitudes. Construction of a line of constant radius proceeds similarly; for a choice of $R_{\rm star}/R_{\rm Sun}$, bolometric corrections and colours are again computed for a range of temperatures. The results, in combination with equations (1) and (2), yield corresponding values of M_V. The only other variables are $T_{\rm Sun}$ and $M_{\rm bol}$(Sun). I adopt $T_{\rm Sun}$ = 5780 K and $M_{\rm bol}$(Sun) = + 4.75 (Lang 1992, p. 103).

An observational HR diagram overlaid with curves of constant L (dashed lines) and R (solid lines; both in terms of solar values) is shown in figure 2. The triangles represent some 240 nearby stars (d <22 pc) selected from the list given in Chapter 29 of Lang (1992), and the squares an approximately equal number of the apparently brightest stars (V <3.55) selected from Garrison and Beattie's list in the RASC ***Observer's Handbook***; variable stars have been excluded. The circled cross indicates the Sun. The horizontal bands across the top of the

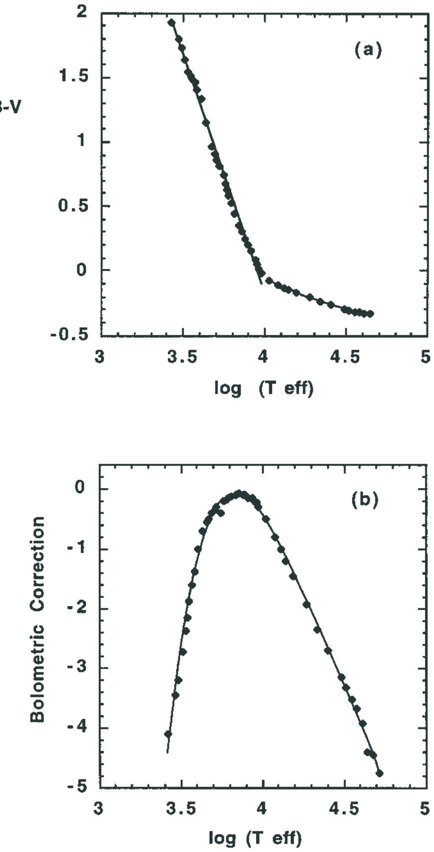

FIG. 1 - B-V colours (a) and bolometric corrections (b) as functions of the common logarithm of effective stellar surface temperature for O3-M8 main sequence stars. The curves are given by equations (3) and (4).

diagram indicate main sequence spectral types and effective temperatures.

Figure 2 makes clear a number of characteristics of stars, such as: (i) main-sequence luminosities and radii lie largely between 1/100 to 100 L_{Sun} and 0.1 to 10 R_{Sun}, respectively, (ii) the horizontal part of the giant branch lies right along 100 L_{Sun}, (iii) white dwarf stars are all about one hundred times smaller than the Sun and are definitely not all of "white" (i.e. T ≈ 10,000 K) temperature, and (iv) the brightest supergiants are about 1000 times the size of the Sun and nearly one million times as bright. The concave-upward shapes of loci of constant luminosity reflect the minimum in bolometric correction at around spectral type F0. For the bluest and reddest stars, bolometric corrections can reach several magnitudes.

The author would be happy to supply interested readers with copies of the observational HR diagram and overlays of lines of constant *R* and *L* lines from which slides or transparencies can be made. A limited number of copies of figure 2 with the points coloured according to the stars' wavelengths of brightest emission as given by Wien's law are also available.

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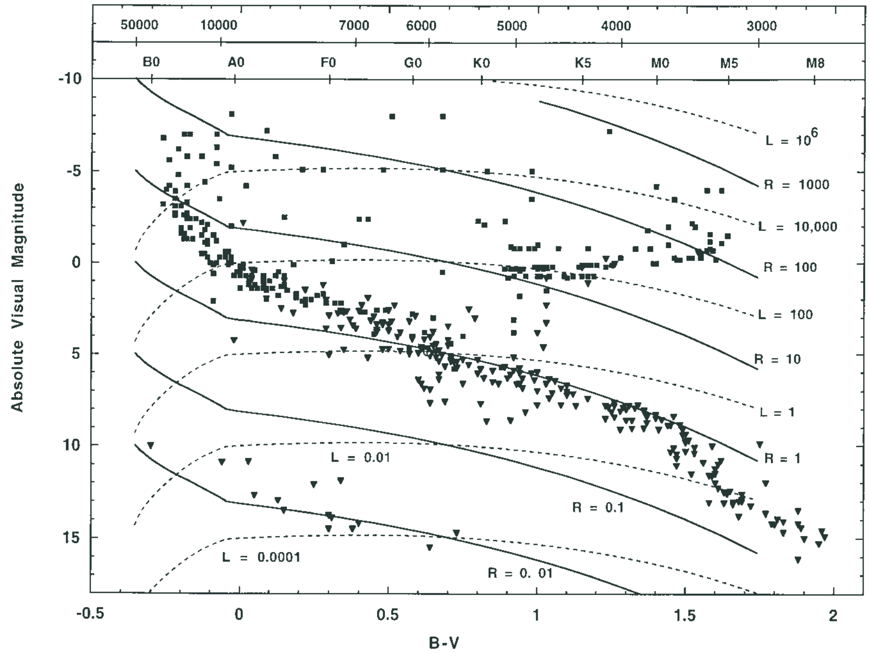

FIG. 2 - Composite observational-theoretical HR diagram. Triangles designate nearby stars (within 22 pc) and squares apparently bright stars (V < 3.55). Solid and dashed lines are respectively loci of constant radius and luminosity.

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TABLE I
Coefficients for Equations (4) and (5)

Coefficient	Value
C_1	-3.684
C_2	14.551
C_3	0.344
C_4	-3.402
C_5	8.037
C_6	-8.499
C_7	13.421
C_8	-8.131
C_9	-3.901
C_{10}	-0.438

CAMERON REED is currently Professor in the Department of Physics at Alma College, Alma, Michigan, where he teaches physics and astronomy. He earned his B.Sc. (1977) and Ph.D. (1984) from the University of Waterloo and his M.Sc. (1979) from Queen's University. His professional interests lie primarily in the study of galactic structure and in OB stars in particular. His other interests include data analysis and quantum physics.

ASTRONOMY IN THE PAN-CANADIAN SCIENCE PROJECT

by John R. Percy
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Abstract. The Pan-Canadian Science Project has developed a set of science learning outcomes that may be implemented in the schools in most of the provinces and territories of Canada. They include far more astronomy than ever before. The jurisdictions that transform such outcomes into curricula, and the teachers who deliver them to students, will need considerable advice and assistance. Amateur and professional astronomers, and astronomy educators can play a major role, especially if they work in partnership with governments, teachers, and other scientific and educational organizations.

Résumé. Le Projet Pancanadien en Sciences a développé une série de programmes d'instruction en sciences qui pourraient être adoptés par les écoles à travers presque tous les provinces et territoires du Canada. Ces programmes comprennent beaucoup plus d'astronomie qu'auparavant. Les autorités responsables pour la transformation de ces programmes en matière d'études, ainsi que les professeurs qui enseignent cette matière aux étudiants, auront besoin de bien des conseils et de l'aide. Les astronomes amateurs et professionnels et les spécialistes dans l'enseignement de l'astronomie peuvent jouer un rôle important, spécialement s'ils agissent de concert avec les gouvernements, les enseignants et les autres organisations scientifiques et éducationelles.
SEM

1. Introduction

On October 17, 1997, the Council of Ministers of Education, Canada (CMEC) released the *Common Framework of Science Learning Outcomes, K to 12*. The document is the product of the Pan-Canadian Science Project (PCSP). It defines the skills, attitudes, and knowledge, for students from kindergarten to grade 12, that contribute to scientific literacy. It is a remarkable example of inter-provincial co-operation in education. It will also have a profound impact on the teaching of astronomy in schools, if it is implemented in the provinces and territories of Canada. Every amateur and professional astronomer and astronomy educator should be aware of the project and its implications, and how they can help.

2. Background

The material in this section is taken (in some cases, *verbatim*) from the press release provided by the CMEC on October 17, 1997.

In February 1995, the CMEC adopted the Pan-Canadian Protocol for Collaboration on School Curriculum. They chose science as the first area of co-operation, in part because of the clear importance of science literacy and education for the health of our economy, our environment, our people, and our culture. School science curriculum reform was well underway in the U.S. (AAAS 1993, NRC 1996), as a result of heightened interest in math and science education on the part of the U.S. federal government. The governments in Canada have been rather slow to recognize the need to enhance and support science literacy and education on an ongoing basis. I hope that the PCSP is the first step in a new Canadian "science education initiative."

All Canadian jurisdictions except Quebec participated in the project. The project was based on a "lead jurisdiction" model. British Columbia was the lead anglophone jurisdiction, and Manitoba the lead francophone jurisdiction. A steering committee, comprising assistant deputy ministers responsible for curriculum, was responsible for overall direction and management. A project team, comprised of science consultants, worked with a group of expert teachers to develop the learning outcomes as directed by the steering committee. Education stakeholders (including me) were consulted at key project milestones.

The framework will be used as a basic reference whenever each participating jurisdiction revises its curriculum, in order to attain greater harmonization in programming between jurisdictions. That will certainly be helpful to students who move from one jurisdiction to another. It will also be helpful to organizations (such as the RASC) that are interested in supporting education on a national basis. Some jurisdictions (including Ontario) are already embarking on a curriculum revision process, while others plan to do so in the coming months or years. You can find out more about the CMEC and the PCSP from the Council of Ministers of Education, Canada, 252 Bloor Street West, Suite 5-200, Toronto, Ontario, M5S 1V5, e-mail cmec@cmec.ca, WWW: http://www.cmec.ca

3. The Common Framework

The purpose of the *Common Framework* is to develop science literacy in Canadian students. Science literacy is defined as "an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them" (CMEC 1997). It begins with a set of four foundation statements — related to (a) science, technology, society, and the environment (STSE), (b) skills, (c) knowledge, and (d) attitudes — that logically support the purpose. It is interesting that, within the brief foundation statement related to *knowledge*, Earth and space science are explicitly mentioned. The foundations are, of course, closely linked.

The format of the document therefore consists of about 200 pages of specific learning outcomes, grouped first by grade level, and then by subject — Earth and space science being one. In each case separate outcomes are listed under (a) STSE, (b) skills, and (c) knowledge. They are followed by "illustrative examples."

4. Astronomy in the *Common Framework*

In Ontario there is presently little or no compulsory astronomy in the school science curriculum, though many boards of education teach a "unit" or module on astronomy at about the grade 5 level. If and when the PCSP is implemented in Ontario and the other provinces, that will change radically.

Within the *Common Framework*, Earth and space science appears as a separate "strand" along with the traditional disciplines of biology, chemistry and physics. Astronomy appears explicitly at the grade 6, 9 and 11-12 level, and it would certainly be mentioned as part of "daily and seasonal changes" (grade 1). It could be used to illustrate topics, such as light and gravity, which appear in the physics strand. It could even be mentioned in life science units such as "matter and energy for life." Fittingly, the dominant image on the cover of the document is that of the planet Saturn.

The content of the units in the *Common Framework* is rather broad and vague. Presumably they will be made more specific in the provincial implementation process. In the grade 6 unit, for instance, there are five knowledge outcomes, involving the physical characteristics of the components of the solar system, Earth's rotation and revolution (day and night, seasons), phenomena involving the Moon (phases, eclipses, and tides), constellations, and a non-astronomical item dealing with the basic needs of astronauts in space.

At the grades 9 and 11-12 level, the knowledge outcomes are impossibly broad. One of the six outcomes at the grade 9 level is to "describe and classify the major components of the universe," followed, at the grade 11-12 level, by "compare and contrast a variety of theories for the origin of the universe." The implementers of such units will have to resist the temptation to make each unit a full survey course in astronomy. Research shows clearly that, in a traditional high school astronomy survey course, students retain virtually nothing (Sadler 1992, 1996). The best philosophy is "less is more" (Ahlgren 1996); it is better to teach a limited amount of material, and teach it well, than to try to teach everything.

In Ontario the first steps in the implementation of the K-8 units have taken place. The definition of the grade 6 astronomy unit may be determined, in part, by an astronomy "kit" that has been produced by the Science and Technology in Education Alliance (a network of partners from business, education, and government, in the Greater Toronto Area) in partnership with the Ontario Science Centre (OSC). Such kits would be circulated to the schools, and teachers would be trained in their use by the OSC as part of its extensive teacher development program (www.osc.on.ca).

The grade 6 unit, and probably the grade 9 unit, would be taken by all students, but the status of the grade 11-12 unit is not clear. Will it be part of a separate course in "Earth and Space Science?" Will the course be compulsory? If it is not, will it be required (or even accepted) for admission to universities or colleges?

5. How You can Help

- Find out more about the *Common Framework* document. You can request a copy through the CMEC address given earlier, or through the web site. The astronomy material is found on pages 164-165 (grade 6), 192-193 (grade 9) and 250-251 (grade 11-12).

- Find out who, in your province, is the contact person for the PCSP. In Ontario it is Denis McGowan at the Ministry of Education. Find out what the status of the implementation of the ***Common Framework*** is. In Ontario the K-8 section has been worked out in some detail and is awaiting approval from the Minister of Education. The status of the grade 9-12 material in Ontario is unclear, but it appears that the Ministry of Education will release an RFP (request for proposal) document, calling for proposals to convert the *Common Framework* outcomes into specific curriculum guidelines.

- Find out what other provinces are doing. It would be more efficient if there were some similarities between the astronomy material in the various provincial science curricula. It is always unfortunate to "re-invent the wheel."

- Make contact with other organizations that are involved in the implementation process, including professional development for teachers. They may include provincial science teachers' associations, university faculties of education and astronomy departments, science centres, and the like.

- Be prepared to support schools and teachers in the implementation of the astronomy material. Few teachers have any background and experience in astronomy. There is a great deal of resource material available, but many teachers are not familiar with it. For instance, check out the web site of the Astronomical Society of the Pacific (ASP) (www.aspsky.org) and its free quarterly Teachers' Newsletter. Also check out the "Teaching" section in the RASC *Observer's Handbook*. The ASP Project ASTRO prepares professional and amateur astronomers to work productively with teachers and their students, on an ongoing basis. The problem of sky watching — "the stars come out at night, the students don't" — can be helped by local amateur astronomers with telescopes.

- Share your experiences with other groups in Canada, such as RASC centres, and individual amateur and professional astronomers. You can do that through the ***Journal***, through education sessions at RASC General Assemblies, and through postings on your web site.

I thank Dr. Doug Hayhoe, Science Co-ordinator for the Etobicoke Board of Education, for his guidance and support of my efforts to expand and improve astronomy in the school science curriculum in Ontario.

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John Percy is a Professor of Astronomy at Erindale Campus, University of Toronto. He is President of the Astronomical Society of the Pacific and Past President of the IAU's Commission on Teaching of Astronomy. For 35 years he worked to bring more and better astronomy to Canadian schools, and the PCSP provides a means for him (and you) to do so.

Questions & Answers
Questions et reponses

Leonid Meteor Hazard?

I was asked an interesting question today by a co-worker who had been reading an article on the Leonid meteor storms of the past. What are the sizes of the particles and do they pose any threat to Earth-orbiting satellites?

Blair MacDonald
Halifax, Nova Scotia

There is a small, but significant, risk of a satellite being disabled during the 1998 Leonid storm. In terms of size, it is believed that the storm produces dust at least in the range from about 10^{-10} kg to (occasionally) ~1 kg. Brighter meteors are generally produced (in this shower) by objects with masses on the order of 10^{-4} kg. The mechanisms by which spacecraft are damaged by such high-speed objects (71 km s^{-1}) are not well understood, but it is believed that an object as small as 10^{-6} kg, and perhaps smaller, poses a serious threat. The overall hazard is not large, although it does suggest that one of the several hundred or so useful spacecraft could possibly be damaged by a strong Leonid storm.

Bob Hawkes
Mt. Allison University

A Call for Papers for the 1998 General Assembly

The General Assembly Planning Committee is inviting anyone interested in presenting a paper at the papers sessions to submit a notification of their wishes as early as possible.

The deadline is Friday, May 1, in order to meet publication deadlines, but we want to encourage all interested members to notify us of their wishes well before that date. Please note that papers will be allotted fifteen minutes each, including questions.

Prior to May 1 you should submit the following:

a) an abstract of your paper, to a maximum of 100 words, for inclusion in the program brochure;
b) a brief biographical sketch (maximum 100 words);
c) a slate of required audiovisual equipment for your paper.

This information should be sent to:

Gary Shearman
Chairman, 1998 GA Papers Sessions
1216 Clovelly Terrace
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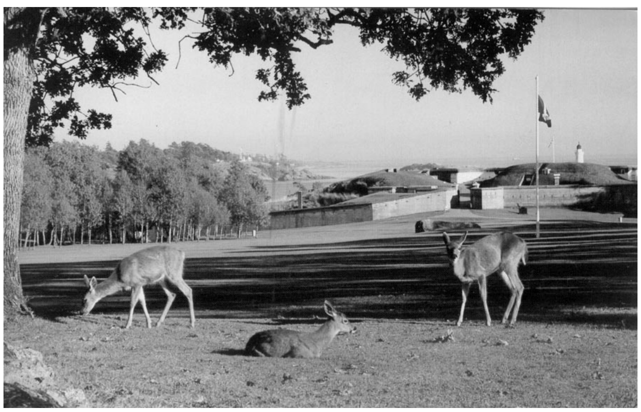
or e-mail to **shearman@freenet.victoria.bc.ca.**

Book Your Space for '98! An Invitation to the 1998 Victoria General Assembly

by Bill Almond and the Planning Committee, Victoria Centre

Have you begun to make your preparations for this year's General Assembly? You will not want to miss it because this year's GA is being held in a unique and special place, widely known as Lotusland, a.k.a. The Banana Belt, a.k.a. Victoria, which is beautiful British Columbia's capital on the southern tip of Vancouver Island. We try so hard not to blush when we say that!



One of the historic sites that will be visited is Fort Rodd Hill, which is also the site of the oldest lighthouse on Canada's Pacific coast.

The Victoria Centre extends a warm and enthusiastic welcome to all RASC members to enjoy the great assembly we are planning for you from June 18th to the 22nd. Arrangements for your stay are well under way; in fact, our planning committee has already put in many hours of work to make sure that nothing has been overlooked, and we are still hard at it! We have arranged some fine accommodations, thrown in some great meals, and allowed for lots of interesting and entertaining recreation time.

Some of you will most likely want to stay in Victoria for an extended vacation, because four days is nowhere near enough time to do and see all that there is to enjoy. With that in mind, when you arrive we will hand you a tourist package to help you find your way around Victoria and its attractions. Remember, book your accommodations early; by late June the tourist season is in full swing.

Interestingly, this GA will be unlike previous ones. How is that so? We wanted you to enjoy something different, something out of the ordinary, and in order to do that we chose a location that is definitely unconventional. We could have chosen a university; after all, that has long been the traditional choice. We thought it over and decided that you might enjoy something different, to "get away from it all," so we picked a location that is out of the city, surrounded by forest and lapped by the waters of the Pacific.

Location and Facilities

Imagine an idyllic rural setting, on the edge of the Pacific Ocean, surrounded by pines and cedars. The air is unpolluted and refreshing. Deer and a variety of wildlife abound. In the strait you will occasionally see killer whales and colonies of sea lions. This ideal place is called the Lester B. Pearson College of the Pacific, located on the extreme southern tip of Vancouver Island.

An artist's sketch of the campus of Pearson College.

This self-contained college has everything on campus that a GA needs. There is the Max Bell Auditorium, which will be the location for National Council meetings, the Annual Meeting, and the Helen Sawyer Hogg public lecture. All meals will be conveniently located in a large nearby dining room overlooking the water. Spare time and relaxation are also important, and the college offers a swimming pool and a splendid dark-site observatory. Smaller telescopes will be made available for your use, on a pad outside. So be sure to pack your swim suits and red flashlights!

General Assembly Dates and Registration

An e-mail registration package is now available, and snail mail packages will soon be arriving. On-campus registration opens at mid-day on Thursday, June 18, with departure time being Monday, June 22, after breakfast.

Transportation

Although Pearson College is on the outskirts of Victoria, it is by no means isolated and the city centre is easily reached by bus. There will be shuttle vehicles available to take you from the college to the nearest bus stop, and from there it is just a fifteen minute bus ride to local shopping centres, dining and liquor stores.

Accommodation

Five, large, two-story student residences offer comfortable accommodation for all our expected delegates and visitors. A vehicle will certainly be required if off-campus accommodation is desired, because of the college's location. Therefore, we encourage all delegates to sleep on campus. Overnight camping is not permitted on college grounds.

On-campus Dining

A spacious dining room with fully equipped kitchens will prepare delicious meals, and special needs also will be catered to. However, it should be noted that because of the college's location, there are no nearby restaurants within walking distance. Delegates should expect to take all their meals on campus.

Speakers

Our speaker for the keynote Helen Sawyer Hogg Public lecture is Dr. David Crampton of the Dominion Astrophysical Observatory (DAO). David and his team at the DAO were the designers and builders of the spectacularly successful Adaptive Optics Bonnette that has been instrumental in revolutionizing ground-based astronomy. Do CFHT images rival those of the Space Telescope? You are going to find out! David's audio-visual presentation will demonstrate his team's incredible results.

David Balam, of the Department of Physics and Astronomy at the University of Victoria, will deliver a timely description of the lurking killer rocks that threaten the Earth from their near-Earth orbits. David has used the Plaskett telescope at the DAO to upgrade the software and observational techniques he is using. David is currently doing more pioneering astrometric follow-up work on NEOs (near-Earth objects) than anyone else in the world.

Jack Newton, one of the RASC's premier amateurs and a pioneer of cold camera astrophotography and more lately amateur CCD imaging, will entertain us with a slide presentation of his achievements. Jack will let you into the secrets of good astrophotography. His home and observatory, on top of Matheson Mountain, are only a few kilometres from Pearson College, so you will not want to miss the fascinating tour we have arranged for you.

Doug George, our outgoing national president, is the featured speaker during the Sunday evening banquet. The title of his talk is "Adventures in Astronomy."

It has not yet been determined, but we are working on arrangements for a special, surprise speaker. We cannot say much right now, but the word is that it is all about extra-solar planets!

Tours

We have lined up some interesting tours of local attractions, including the renowned and historic Dominion Astrophysical Observatory on Telescope Hill north of Victoria. That is where the development team and workshops produced the fabulous instruments now used by the Canada-France-Hawaii Telescope.

Tours have been arranged to visit the home and observatory of Jack and Alice Newton, which are located on top of Mount Matheson. The organizing committee cannot guarantee the presence of a bright comet!

Other tours are planned to Fort Rodd Hill and its associated Fisgard Lighthouse. Fort Rodd Hill was an early British Royal Navy anchorage in 1848 that was further developed, in 1893, into a fort guarding the naval base at nearby Esquimalt. Fisgard Lighthouse is the oldest lighthouse on Canada's west coast.

Two evening tours have been arranged to Jack and Alice

Whale watching tours have been growing in popularity on Vancouver Island.

Gardeners will love Victoria as flowers can be found everywhere.

Newton's home on top of Matheson Mountain, in nearby East Sooke. Their dark-site home overlooks the Strait of Juan de Fuca and the snow-covered Olympic Mountains in Washington State. Built into the house is a complete observatory with a 5-metre dome and a 0.4-metre Meade LX200, replete with an office and warm room beneath it.

The Final Word

We think you will enjoy spending four days in the unusual surroundings of a small self-contained village in a beautiful setting. Pearson College normally supports a population of over 200 young students, along with a resident staff, but there are, of necessity, a few things to consider. First, it is located in a rural hobby farm location — but that does not mean that it is isolated. Within a short bus ride you will find all of the shopping you need, along with some good restaurants and liquor stores. Further, we encourage all delegates to use the accommodation and meals provided on campus, simply because of the convenience.

The provincial legislature building is just one of the beautiful buildings to be seen while visiting the city.

There will be plenty to keep you busy, with lots of fun thrown in — all of the usual good things you have come to expect from a GA. Friday night is party time. We have arranged a great wine and cheese party with lots of French wine, and we are following it with a comedy lineup you will love, including "Alice" of Winter Star Party fame!

Those delegates who can arrange to stay for a few extra days' vacation can enjoy all of Victoria's fabulous tourist attractions, such as Butchart Gardens. We look forward to sharing our beautiful island with you, and hope you leave with many happy memories.

To obtain a registration form for the 1998 General Assembly, including information about registration fees, tours, displays, accommodation and contests, please contact:

Frank B. Jones
1998 GA Registrar
247 Denison Road
Victoria BC V8S 4K2

or send an e-mail message to either **Frank Jones** at **Frank_Jones@bc.sympatico.ca** or **Bill Almond** at **fwalmond@islandnet.com.**

Lightwaves: Ten Things a Light Pollution Committee Can Do

by Bill Broderick, Chair, National Light Pollution Committee

1 Join the International Dark-sky Association (IDA) — individually or as a group. The IDA is the world leader in educating people and governments about good lighting and the need for better lighting practices. The larger its membership, the more effective it can be. Everyone who cares about the nighttime environment and dark skies should join and support the IDA.

2 Hold regular meetings of your committee. A committee does not function if it does not meet. Once a month is probably sufficient for general purposes, but if you get working on a specific project, once a month may not be enough. Remember, as you meet, so shall you accomplish.

3 Study the IDA information sheets — individually and at your meetings. They are obtainable on request from the IDA, and there are currently close to 120 of them. The National Light Pollution Committee of the RASC has compiled a handbook that includes most of the pertinent info sheets, but committees should have the complete set. Every member of the committee should have the opportunity to become knowledgeable about every aspect of the light pollution problem by studying the info sheets.

4 Write letters to local businesses which you feel are contributing to the light pollution problem. You can do that both as a committee and as individuals. Letters from individuals should be independently written — not form letters or copies. Avoid using a complaining tone; write from the position that light pollution is a problem in terms of both the environment and the economy — and present a solution. Explain how the business might benefit by using better lighting. That includes reduced costs, better public relations, and more responsible corporate citizenship.

5 Write letters to local newspapers about light pollution. Again, such letters can be sent not only from the committee but also from its members. They should also generally avoid a complaining tone (to avoid your being labeled as crank)! Try to present light pollution as a problem that needs to be corrected. Emphasize the benefits to be attained by switching to more responsible lighting.

6 Present "responsible lighting awards" to deserving recipients in your area or community. Not everyone uses only bad lighting; there are probably a number of businesses and other establishments that use excellent lighting. Search them out and give them the recognition they deserve. Presenting such awards gives you an opportunity to gain good publicity not only for such establishments but also for your committee and the cause of responsible lighting and dark skies.

7 Design a pamphlet about light pollution. A pamphlet can help you get your message across to many people. It is a great project for a sub-committee of your light pollution committee.

8 Design a display about light pollution. Inexpensive three-panel tabletop display boards are available from stationery and art-supply stores. Stick-on letters and graphics are also available. You can use your light pollution display on Astronomy Day and other occasions when you are promoting astronomy to the public. A light pollution display is an excellent focal point for distributing your light pollution pamphlet. Again, it is a great project for a sub-committee.

9 Offer to speak about light pollution before meetings of other groups and organizations in your community (Kiwanis, Rotary, chamber of commerce, business improvement association, ratepayers associations, church and school groups, *etc., etc.*). Not only will you make other people — people who may be able to help — aware of the problem of light pollution, but you will also hone your own presentation skills, for the day when you will be presenting to your municipal council or other government body. An excellent place to practice such presentations is at your light pollution committee meetings.

10 Draft a model light pollution by-law. Sooner or later your goal as a committee is to bring the problem of light pollution to the attention of your municipal council and to ask them to pass a by-law to regulate it. If you are successful in gaining their interest, they will want to see examples of what other communities have done (in Canada, so far, only Richmond Hill, Ontario, and Saanich, B.C., have by-laws). Every community seems to want to "invent the wheel" for itself, but if you can present them with a model of what you

feel is appropriate for your community, it may save them work (which is always appreciated) and you may end up getting some or all of what you want. After all, you are the experts on light pollution; your municipal council is not.

The Canadian Campaign For Dark Skies

The Canadian Campaign for Dark Skies was announced at the General Assembly in Kingston. The campaign is intended to unite the efforts of all concerned individuals, groups and organizations across Canada in working for the abatement of light pollution. Environmentalists, conservationists, naturalists — there are many groups that have as much reason to be concerned about light pollution as astronomers. All are invited to join with us in working for dark skies.

The National Light Pollution Committee's display at the Kingston General Assembly announcing the Canadian Campaign for Dark Skies.

The Canadian Campaign for Dark Skies is supported by the RASC, representing amateur astronomers, and the Canadian Astronomical Society, representing professional astronomers. The establishment of effective and viable Light Pollution Committees in major centres across Canada is a vital component of the campaign.

Important Addresses

The Canadian Campaign for Dark Skies
c/o Bill Broderick
R.R. #1, 2262 Shannon Road
Shannonville, Ontario, K0K 3A0
Telephone: (613) 396-6283
Fax: (613) 966-8038

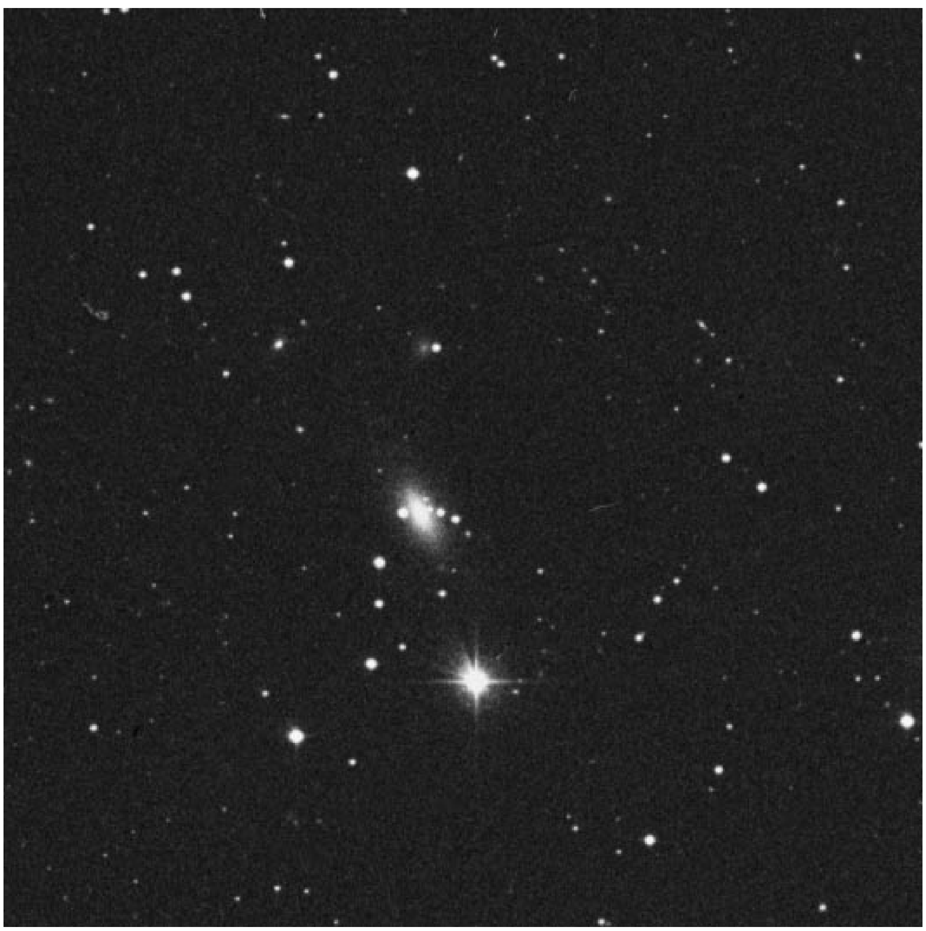
International Dark Sky Association
3545 North Stewart Avenue
Tucson, AZ 85716
U.S.A.
Telephone: (520) 293-3198
Fax: (520) 293-3192
Website: www.darksky.org

Bill Broderick keeps an eye on the light pollution situation from his observatory northeast of Belleville, Ontario. He enjoys retirement from the federal public service by pursuing a variety of interests, including several public advocacy issues in addition to light pollution. Bill is a member of the Kingston Centre, the Belleville Astronomy Club, and, of course, the International Dark-Sky Association.

Scenic Vistas: Trompe d'Oeil

by Mark Bratton, Montreal Centre (reprinted from Skyward*)*

I have never been one to plan an observing session. At best I might read an article about a particular object or group of objects that piques my interest and make a mental note to try to observe each at the earliest opportunity. Usually, at the beginning of an evening under the stars, I will select a page from *Uranometria*, target an object near a bright field star, and push off from there, taking baby steps through the cosmos as I follow groups and chains of stars from one field to the next, looking for interesting things along the way. By doing so, observing never becomes boring or predictable for me; the universe reveals secrets at its leisure. Such was the case the evening of April 1-2, 1995, a cool but not unpleasant spring evening. I had already located two moderately bright galaxies in Lynx and now turned my attention to the southwest corner of the constellation Leo, a region sprinkled with faint galaxies. I was looking to pick up Herschel objects for the Astronomical League's survey, a project I had been involved in for almost three years. NGC 2948 and NGC 2882 were found rather easily near the faint field stars 10 and 3 Leonis. Nothing special here, the galaxies were small and rather faint, quite representative of the deep sky quarry in this part of the sky. After observing NGC 2882, I moved my telescope about a degree east and south to an object designated NGC 2894, and came upon something that clearly was not typical.



NGC 2894, a galaxy in Leo. In this 15 arc-minute image from the Digitized Sky Survey[1], north is up.

A small, bright galaxy was visible in the field. At a magnification of 146× it was much extended WSW–ENE with a fuzzy core and a sharp, stellar nucleus. What intrigued me were the bright extensions. Faint sparkles were strung along its envelope, looking for all the world like bright H II regions. My first thought was, "Why isn't this little jewel in the guidebooks?" For here, clearly, was an extraordinary little galaxy, small yet revealing subtle structure. I increased the magnification to 272× in an effort to resolve further detail, but the results were rather ambiguous. The sparkles seemed to be stellar in nature, but I could not be sure. I fished out my 4.7 mm Meade eyepiece and placed it in the focuser. The telescope's magnification was now 405× and the field was considerably reduced. I had to set my reflector a little ahead of the galaxy and then watch it as it quickly drifted across the field of view. After a moment, it became apparent what I was looking at.

I had a galaxy all right, but a rather pedestrian one after all. The faint sparkles were stars of our own Milky Way, a tight pair of magnitude 14 stars west of the galaxy's core and a solitary magnitude 12 star due east. The galaxy itself was a fuzzy little ball of light with a sharp, stellar nucleus, its edges extending on either side to just contact the faint field stars.

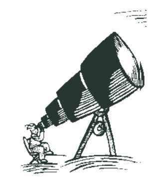
The possibility existed that one of the stars might be a supernova, and when I returned to Montreal I consulted *The Deep Sky Field Guide to Uranometria 2000.0*. The listing for NGC 2894 indicated that it was an Sa type spiral, magnitude 12.4, measuring 2.1×1.0 arcminutes in size, elongated in position angle 27°. There was no mention of any stars in the field. Next I consulted the Centre library's copy of the *New General Catalogue* and here, in the remarks section, was the notation that two or three faint stars were involved with the galaxy.

So the mystery was solved. A chance alignment of a few faint stars in our galaxy and a remote system of stars far beyond our own combined to create something extraordinary.

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

[1]Based on photographic data of the National Geographic Society — Palomar Observatory Sky Survey (NGS-POSS) obtained using the Oschin Telescope on Palomar Mountain. The NGS-POSS was funded by a grant from the National Geographic Society to the California Institute of Technology. The plates were processed into the present compressed digital form with their permission. The Digitized Sky Survey was produced at the Space Telescope Science Institute under US Government grant NAG W-2166. Copyright (c) 1994, Association of Universities for Research in Astronomy, Inc. All rights reserved.

Ask Gazer



Dear Gazer:

I just inherited one of those small, nifty Quackstar telescopes from my eccentric aunt. My problem arises because there is a clause in her will that says that I can only keep it if I sell all of my other telescopes. Is a Quackstar so good that I could use it as my only scope? I already have what I consider to be a good telescope, but now I have the executor on my case to make up my mind between selling it, or keeping it and selling my other scope. What do you think I should do?

Anxious in Athabasca

Dear Anxious:

I was wondering how long it would take before I received a question on Quackstars. I must admit that I have never looked through one myself, but there appears to be sufficient evidence that, apart from their compact size, they are not all that they are cracked up to be. I know that within the Halifax Centre there is a confirmed case of one observing session where there were two Quackstars as well as two 250-mm Odyssey telescopes, both stopped down to the aperture of the Quackstar. The two Odyssey telescopes gave much better views of details on Jupiter, including one transitting shadow that was very clear in the Odysseys and almost nonexistent in the Quackstars. Given such results, I suspect that it would be a considerable challenge to use a Quackstar for a more daunting task such as counting the globulars around M87.

I once (early 1990s) looked through about five years' worth of ads in *Sky & Telescope* and found that about ten percent of them were from people who were trying to sell Quackstars at close-to-new prices. The question that I raised then was, "Do Quackstars constitute ten percent of all new telescopes sold?" If so, then one might expect them to constitute ten percent of the used scope market. While it is nice to imagine that fraction of amateur astronomers has enough money to spend on a Quackstar, my suspicion is that the percentage of new sales is much less that ten percent. Additionally, if Quackstars are such an exceptional instrument one would expect that very few owners would be willing to part with them, making them very hard to find on the second-hand market.

My advice to you would be to keep your current scope and sell the Quackstar. Even if you sell it at a fire sale price, you can use the money to either get a few more accessories for your current scope, or, if you have come to like the portability of the Quackstar, to get another small spotting scope in the same size range.

Dear Gazer:

The last few issues of the Journal *have contained a lot of items about solar system debris, such as meteorites, asteroids, comets,* Jovian *moons, etc. Does JRASC now stand for the* Journal of Rocks, Asteroids, Satellites and Comets? *As an avid deep-sky observer and having just gotten a newer, larger scope, I find that there is little to read of interest for me.*

Deep-sky Dude in Dawson

Dear Deep-sky Dude:

No need for concern. While there may have been a bit more focus than usual on solar system bodies, your irritation is caused by something far more serious. You are showing all of the symptoms of an untreated case of amateur aperture fever (AAF), which afflicts many amateur astronomers at least once in their lifetime. AAF is caused by being infected by the parasitic bacteria *Spendimaximus bigamirrorcus*. The main symptoms are an overwhelming desire to purchase telescopes of increasing size, dissatisfaction with all of their existing eyepieces, increased irritation at all forms of light pollution, and the inability to tolerate viewing or reading about solar system objects. Oddly enough, astrophotographers seldom show these symptoms. Instead, possibly because of some common genetic trait, the disease manifests itself in them by a desire for faster films and a fondness for handling dry ice. In advanced cases, patients have been known to switch entirely to using CCD cameras.

Like chicken pox, one person in an observing group usually gets the infection first and it then rapidly spreads to their fellow observers. The disease usually runs its course when the first person to be affected either ends up with a telescope that is so large that it is unmanageable or when they have run out of money. When the other infected members of the group see the fate that will befall them, it appears as though a yet-to-be-isolated hormone is released, which kills off the remaining parasites. It also appears that certain combinations of sounds can trigger the release of the hormone, as there have been documented cases of patients who were cured after a discussion with their spouse who had been reviewing their bank statement. There is no known drug that can cure the ailment, and as you are in a very isolated area, you may have to simply let it run its course, or try to find someone to talk to who was recently cured. That may be enough to trip the hormone release. Fortunately, relapses are very rare and mostly seem to occur in those who have recently come into a large amount of money from an inheritance or a lottery.

Gazer is a member of the Halifax Centre who wishes to remain anonymous. Gazer's true identity is known only to the current and past editors of Nova Notes, *the Halifax Centre's newsletter. Questions to Gazer will be forwarded if sent to either editor, or by sending e-mail to gazer@rasc.ca.*

At the Eyepiece

March Challenges

by Alan Whitman, Okanagan Centre

My spring equinox tour begins in the mid-evening zenith with the globular cluster that is probably the easiest object on the *Observer's Handbook* Deep-Sky Challenge Objects list. The tour ends low in the south in the March pre-dawn sky with the toughest object on the Messier list, a galaxy that is as challenging from Canada as the easiest Challenge Object.

NGC 2419 is the Milky Way's most distant globular cluster, about 200,000 light years from Earth. The globular's interest lies in its distance — it is about as far away as the Small Magellanic Cloud. Some older references like Burnham's *Celestial Handbook* call it "The Intergalactic Wanderer," a romantic image indeed. However, the title is almost certainly wrong given our current knowledge of dark matter and its great contribution to our Galaxy's gravitational field.

NGC 2419 is one of the most compact globulars, concentration class II, appearing about 2′ in diameter in amateur instruments. My 20-cm Newtonian picked up the cluster at 61×. It was faint at magnitude 10.4, but it was unmistakably a globular in the eyepiece. There are no reports of anyone resolving its 17th magnitude stars visually — Lord Rosse could not do so with his 1.8-m metal mirror last century in Ireland.

NGC 2419 is the Milky Way's most distant known globular cluster. (Digitized Sky Survey Image[1])

The distant globular is in the obscure constellation Lynx. Don't let that throw you. The way to handle recently created constellations like Lynx is to ignore their unfortunate creation and work from the nearest prominent star. You will find your quarry a mere seven degrees north of Castor. While NGC 2419 is comparable to M83 in difficulty, it is actually easier to see than some Finest NGC Objects, notably IC 289 and NGC 6888.

Castor is one of the finest multiple stars. Components A (magnitude 2.0) and B (magnitude 2.8) are currently 3″.7 apart, so if you cannot separate them you can safely record the night's seeing conditions as poor. Unfortunately, poor seeing is quite common in north temperate latitudes at this time of year owing to the turbulence caused by wind shear aloft, especially that associated with the jet stream. (For that reason, most of the observations mentioned in this article were at low or medium power.)

Castor was the first gravitationally bound binary system to be announced by William Herschel in 1803. The pair were

NGC 2903, in the "Sickle" of Leo, is a showpiece spring galaxy. (Digitized Sky Survey Image[1])

at their minimum separation of 1″.8 in 1965, but my logbooks record two occasions in 1962 when my 60-mm refractor managed to elongate and notch the A and B components at the correct position angle. The small refractor also revealed the 9th magnitude C component some 73" distant. Each of Castor's resolvable stars is a spectroscopic binary. So α Geminorum is a rather interesting multiple star with six components.

The magnitude 8.9 galaxy NGC 2903 in the "Sickle" of Leo is rated as a showpiece object by Alan Dyer, a rating earned by only 11 of Messier's galaxies and 10 of the Finest NGC galaxies. The elongated Sb spiral is a large 11′×5′ oval with a bright core. The galaxy yielded easily to the 60-mm refractor. The dark lane southwest of the star-like nucleus was visible at moderate power in the late Peter Kuzel's 45-cm Dobsonian from a 900-metre high ridge east of Kelowna on a club observing night in March 1985, when we enjoyed superb transparency. Phil Harrington says that telescopes in the 30-cm range may reveal the brightest H II region, designated NGC 2905, 1′ northeast of the nucleus. Please send me an e-mail message if you can see NGC 2905 or any of the other H II regions and star clouds that Harrington suggests may be visible with large apertures on the face of NGC 2903.

The star γ Leonis is on just about anyone's list of the sky's finest double stars. Separated by 4″.4, the golden pair shine at magnitudes 2.1 and 3.4. Some authors have ascribed a greenish or reddish tinge to the fainter star — such perceptions probably arose in the eye of the observer or in the chromatic aberration of his 19th century refractor.

Only 50′ east of γ Leonis lies an attractive pair of almost touching galaxies: the round, 1′-diameter, elliptical galaxy NGC 3226 is magnitude 11.4, and the elongated 3′x 1′ spiral NGC 3227 is magnitude 10.8. My only view of them was with the Prince George club's 0.6-m Cassegrain at 120×. Walter Scott Houston found that NGC 3227 was easy in his 10-cm Clark refractor at 95×.

M96, a large 6′×4′, magnitude 9.2, Sb spiral with a bright core, anchors a group of galaxies in the belly of the Lion. M95 (magnitude 9.7) is in the same low power field of view, only 42′ to the west. It looks round (3′) with a bright central condensation in my 20-cm reflector at 61×. Harrington writes that the largest amateur telescopes will increase the apparent size to 5′ and show hints of the barred-spiral structure that is visible on photographs. The galaxy would then look like the Greek letter theta (θ), which is Robert Burnham's description of the photographic appearance.

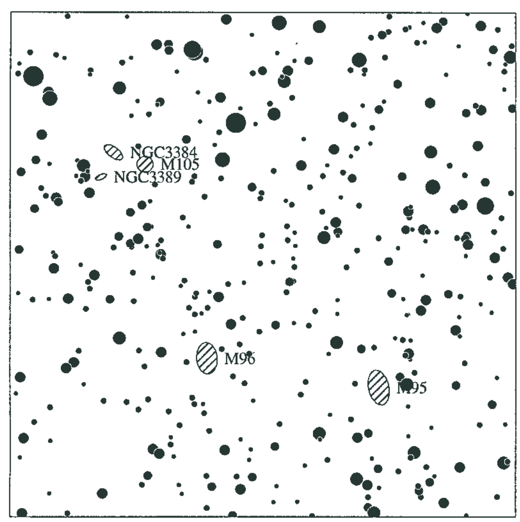
The elliptical galaxy M105 lies 48′ NNE of M96. M105 has two companions, NGC 3384 and NGC 3389, and the three form a small triangle about 8′ to 10′ on a side. The triangle plus M96 will fit into my 20-cm equatorial's 30× field of view, but M95 won't quite squeeze in. M105 is magnitude 9.3 and spherical (2′) with a bright centre. Magnitude 10.0 NGC 3384 is 4′×2′, but may visually look nearly round. Edge-on spiral NGC 3389 was just a very faint (magnitude 11.8) featureless blur with the 20-cm telescope.

Within three degrees of M96, five additional members of the galaxy group are plotted on Tirion's *Sky Atlas 2000.0*. Their NGC numbers are 3338, 3367, 3377, 3412, and 3433. *Sky & Telescope's* Alan MacRobert found NGC 3377 and NGC 3412 without any difficulty with his 15-cm reflector at 70×, but found NGC 3367 to be very difficult. NGC 3433 may require a 25-cm aperture. See the table for the magnitudes of the five galaxies and for Dreyer's coded descriptions. No decode table is provided as it is assumed that the serious observers who might tackle them will have access to the lists of abbreviations provided in books such as *NGC 2000.0* and Burnham's *Celestial Handbook*. (The abbreviations are quite intuitive and generally mean what one suspects they mean.)

Halfway between ϑ Leonis and ι Leonis there is a trio of Sb galaxies in the same low power field: M65, M66, and NGC 3628. The two Messier objects are only 21′ apart and Dyer ranks both as showpieces. I called both "easy" when I found them in 1964 with the 60-mm refractor at 10×. But, like Messier's small refractors, mine missed NGC 3628 at both 10x and 55×.

M65 is very elongated (7′.8×1′.6), is at magnitude 9.3, and has a bright nucleus. Harrington says that it displays a dark lane on its eastern rim (the side facing M66), visible with only a 15-cm aperture. While the dust lane is prominent on most photographs of M65, I have no record of having observed it. Send me an e-mail message if you have!

M66 is the brightest of the three at magnitude 9.0 and is



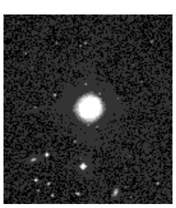
A 2° field near the Messier galaxy grouping that includes M95, M96, and M105. Stars to near magnitude 14 are shown. (Chart prepared by Dave Lane)

The dimensions of objects are from Burnham's *Celestial Handbook* since Burnham gives the apparent visual size, which is much more useful to the visual observer than are the much larger sizes measured on astrophotos. The magnitudes are from *NGC 2000.0*, as are the celestial co-ordinates:

	R.A.(2000)	Dec.(2000)	Remarks
NGC 2419	$07^h 38^m.1$	+38° 53´	
α Gem	$07^h 34^m.6$	+31° 53´	Castor
NGC 2903	$09^h 32^m.2$	+21° 30´	
γ Leo	$10^h 20^m.0$	+19° 51´	Algieba
NGC 3226	$10^h 23^m.4$	+19° 54´	
NGC 3227	$10^h 23^m.5$	+19° 52´	
M96	$10^h 46^m.8$	+11° 49´	
M95	$10^h 44^m.0$	+11° 42´	
M105	$10^h 47^m.8$	+12° 35´	
NGC 3384	$10^h 48^m.3$	+12° 38´	
NGC 3389	$10^h 48^m.5$	+12° 32´	
NGC 3338	$10^h 42^m.1$	+13° 45´	mag 10.8 F,cL,E,vgbM
NGC 3367	$10^h 46^m.6$	+13° 45´	mag 11.5 pB,cL,iR,vglbM
NGC 3377	$10^h 47^m.7$	+13° 59´	mag 10.2 vB,cL,lE,svmbMBN
NGC 3412	$10^h 50^m.9$	+13° 25´	mag 10.6 B,S,lE,smbMN
NGC 3433	$10^h 52^m.1$	+10° 09´	mag 12 phot. vF,vL,R,vgbM
M65	$11^h 18^m.9$	+13° 05´	
M66	$11^h 20^m.2$	+12° 59´	
NGC 3628	$11^h 20^m.3$	+13° 36´	
τ Leo	$11^h 27^m.9$	+02° 51´	
83 Leo	$11^h 26^m.8$	+03°01´	
NGC 3115	$10^h 05^m.2$	–07° 43´	
NGC 3242	$10^h 24^m.8$	–18° 38´	
M83	$13^h 37^m.0$	–29° 52´	

elongated (8´.0×2´.5). The 20-cm reflector shows a bright star-like nucleus at 61×. Burnham compares the southeastern spiral arm to a "crab's claw," a very apt analogy to the photographic appearance. One of the spiral arms is visible at 120× with the 0.6-m Cassegrain, but my notes state that it is "the longer spiral arm," which would be the arm closest to M65 not Burnham's "crab's claw." Harrington reports seeing the latter with his 33-cm Dobsonian.

The edge-on galaxy NGC 3628 is 12´×2´, is at magnitude 9.5, and displays a little mottling with the 20-cm Newtonian at 61x. An equatorial dust lane was barely visible at 120× and 225× with the 0.6-m reflector on a night with excellent transparency but only fair seeing. (In comparison viewing a few minutes later, the equatorial dust lane of the famous edge-on spiral NGC 4565 was easily visible near its nucleus.) At the next New Moon, with better seeing, I called NGC 3628's dark lane "easy" at 120×.

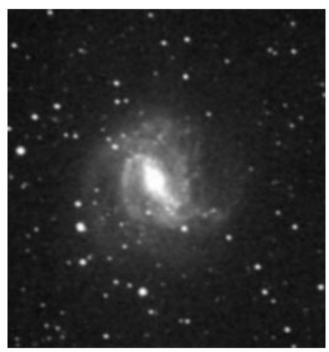


The "Ghost of Jupiter" planetary nebula (NGC 3242 in Hydra). (Digitized Sky Survey Image[1])

Lemon-yellow and pale blue τ Leonis is one of the sky's prettiest double stars. Its 5th and 7th magnitude components are separated by a wide 1´.5, so use your lowest power. I normally do not observe optical doubles, but τ Leonis is so attractive that I make an exception for it several times each spring. A true binary, 83 Leonis, lies in the same field. Its stars are 29" apart. One is pale yellow and magnitude 6.5, and the other is greenish-tinged and a magnitude fainter.

One of the most attractive elliptical galaxies is NGC 3115 in Sextans, near λ Hydrae. The magnitude 9.2 Spindle Galaxy measures 4´x1´ and has a high surface brightness. As it is one of the most appropriately named objects in the sky, further description is not necessary. A 75-mm refractor can find it.

Our fourth showpiece deep-sky object is NGC 3242 in Hydra. Any observer who wonders why Herschel coined the metaphorical term "planetary nebula" need only look at this example. Known as "The Ghost of Jupiter," it has a uniformly illuminated, oval (40"×35"), pale blue disk. It is one of the brightest planetaries at magnitude 8.6. The object is so easy to find that my first view of it was during Full Moon! Walter Scott Houston said that a 15-cm telescope would reveal the 11th magnitude central star, but Burnham implies that a 25-cm aperture is needed. James Mullaney suggests that the central star is variable. Variability, in combination with NGC 3242's remarkable surface brightness (eight times that of the Ring Nebula), may make the central star much more difficult than magnitude 11 sounds.



Visible from Canada, M83 (in Hydra) is a spectacular object for those who venture south to such venues as Florida's Winter Star Party where this CCD image was taken. (Image by Ram Krishnan, Dave Lane, and Greg Palman using a prototype CCD camera of Ram's own design and construction)

M83 might seem like an object for later in the season, but both Mark Kaye and Richard Huziak recently made the point that the early morning hours are the best time to hunt for difficult objects. Most house lights, porch lights, and headlights are off in the predawn hours, resulting in significantly darker skies in many populated areas. When Spica culminates, it is time to search for M83 nineteen degrees farther south. The magnitude 7.6 glow, spread over a 10´×8´ face-on Sc spiral, is the toughest Messier object to detect from Canada. (Most sources list the galaxy as being of about 8th magnitude. In *NGC 2000.0* the magnitude of M83 is given as 7.6 and I have used that source. But in a few sources the magnitude

[1]Based on photographic data of the National Geographic Society — Palomar Observatory Sky Survey (NGS-POSS) obtained using the Oschin Telescope on Palomar Mountain. The NGS-POSS was funded by a grant from the National Geographic Society to the California Institute of Technology. The plates were processed into the present compressed digital form with their permission. The Digitized Sky Survey was produced at the Space Telescope Science Institute under US Government grant NAG W-2166.

is given as 10.1, which seems very pessimistic. Perhaps someone measured the small central core at magnitude 10.1 and failed to integrate properly the glow from the three magnificent spiral arms. That would be like determining the magnitude of a great comet by measuring its pseudo-nucleus while ignoring its coma.)

From Canada you cannot hope to do much more than find M83. However, it is one of the most impressive galaxies south of the celestial equator, so remember to re-observe it when you have a chance at a southern U.S. star party or while on a subtropical vacation. Part of the hobby's attraction is the joy of the successful hunt. You have to plan; you have to observe objects again and again until, on some night of excellent transparency and/or seeing, you discern detail that was never revealed to you before; and sometimes you have to travel to see objects normally hidden from you.

Alan Whitman lives in a dark rural subdivision whose residents voted against the scourge of streetlights many years ago. He will divulge the location of his Okanagan amateur astronomer's paradise in exchange for detailed observing reports suitable for use in this column. His e-mail address is awhitman@vip.net.

Answers to the Pop Quiz - How did you do?

Answers:

1. Zefram Cochrane.
2. Quadrotriticale.
3. Time travel.
4. The Borg.
5. The Ferengi Rules of Acquisition.
6. Torek Nor.
7. Transparent aluminum.
8. Intrepid class.
9. The batlh. (bat-leth)
10. The Alpha Quadrant and the Gamma Quadrant.
11. Positronic.
12. The laws of physics.
13. Dilithium crystals.
14. The Federation and the Borg.
15. The Vidians
16. Talaxian.
17. The duotronic circuit and the M5 computer.
18. Rachel Garrett.
19. gagh
20. Grand Nagus.
21. The *Botany Bay.*
22. Nanites.
23. The Khitomer Accords.
24. Admiral Alidar Jarok

The Mystery of K 3–35

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

Recently I related my summer activities to you. I wrote of spending my summer trying to do research, and its culmination in an observing proposal to the Very Large Array radio telescope in New Mexico. Despite my fears, expressed to you at the time, I did submit the observing proposal. Now I am waiting.

And I am thinking about doing research. How can I do research while teaching at a small, remote college? I think, "Research is not restricted to science or scientists or people with Ph.D.s. Any time you set out to learn something or to gather information, you are doing research. When you look up a word in the dictionary, you are doing very simple research."

So I tell myself, "You don't have to be at a university or observatory to be able to do research. Research can be done anywhere, like in Fort McMurray." But I have doubts. "When you are at a university, there are people with common interests to share your ideas. Research ideas come your way. That doesn't happen in a small college."

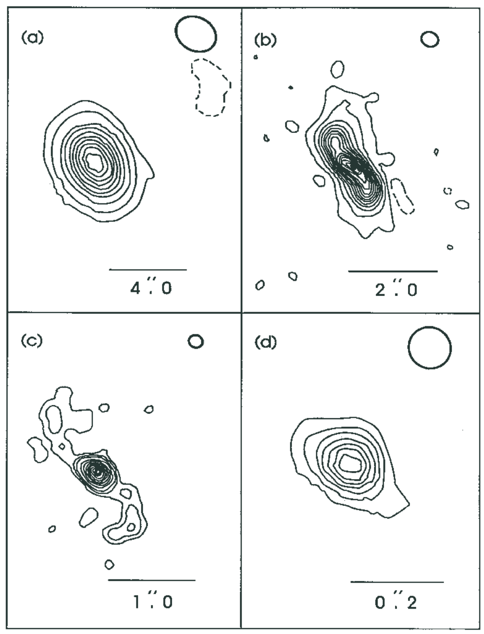


Fig. 1 — Contour plots of radio continuum images of K 3–35 at wavelengths of 20, 6, 2 and 1.4 cm (1.5, 5, 15 and 22 GHz). The contours are lines of constant intensity, with a linear spacing. The shape of the telescope's beam is shown by the ellipse in the top right corner, and the image scale is shown by the horizontal line below the image.

When I was halfway to depression, a research paper arrived in the mail. Strangely, I was among the authors. How could that be? I don't recall doing any research, here, in Fort McMurray. The mailing address on the paper, below my name, was "University Transfer Division, College of New Caledonia, Prince George, B.C." Perhaps part of me is still in Prince George, living at the Prince George Astronomical Observatory, doing research. Could part of me have been left behind in Prince George when I left last year? Has anyone seen me there? Check the basement at the observatory. Check behind the furnace. Look for empty *Oh Henry* bar wrappers.

The title of the mystery paper contained the name of an old friend, K 3–35. I first encountered K 3–35 while analyzing Very Large Array radio data during the first years of my graduate work at the University of Calgary. Back then, K 3–35 looked like a mistake, a side lobe, some bad data, a piece of lint on the hard drive. It was too small to show much detail, even at sub-arcsecond resolution. Yet, it was clearly elongated with three distinct emission peaks, the strongest being at the geometrical centre. I went to the library to scan the journals for similar images.

That is the good part about doing research at a university. You can go to the library and look for almost anything. In Fort McMurray I can also go to the library, but the only scientific references to be found are *Scientific American* and *Discover* Magazine.

At the U. of C. library, many years ago, I found an almost perfect match to the image of K 3–35: a galaxy. But K 3–35 could not be a galaxy. Galaxies are generally not visible a few degrees from the galactic centre, even with a radio telescope. The object was intriguing, but I was blinded by 50 compact planetary nebulae awaiting processing, so I did not pursue my discovery.

Five years later I observed K 3–35 again, this time for much longer in order to obtain an image with greater dynamic range. I also observed it at four wavelengths to obtain images at various optical depths and resolutions: 20, 6, 2 and 1.4 cm. At 20 cm wavelength (figure 1a) K 3–35 looks like an unresolved elliptical blob (basically because it is). At 6 cm (figure 1b) it still looks like a little, nearly edge-on, galaxy with a bright core. At 2 cm (figure 1c) it looks like two faint propeller blades attached to a bright core. At the time, its appearance at 2 cm reminded me of a seahorse. Unfortunately, the tail of a seahorse is curled in the same direction as the snout, whereas the tail of K 3–35 is curled away from the snout. Moreover, the snout of K 3–35 looks more like the beak of a duck with fat lips. I was not alone to recognize the shape of a seahorse in the contour image of K 3–35; one out of four secretaries in the Department of Physics and Astronomy at The University of Calgary also saw the seahorse. Despite that, and to the relief of my supervisor, I abandoned the name *Seahorse Nebula*.

At 1.4 cm (figure 1d) K 3–35 looks like a tiny, elongated, unresolved blob. I had no idea what K 3–35 was. In my thesis I dedicated a chapter to the strange object, wherein I concluded that I didn't know what it was.

Five years later in 1993, while teaching physics at the College of New Caledonia in Prince George, B.C., I published a paper in *Astronomy and Astrophysics* entitled "Detailed Radio Morphology of the Compact Nebula K 3–35," wherein I concluded that I didn't know what K 3–35 was. Five years after that, while teaching physics at Keyano College in Fort McMurray, I received a paper on "The Nature and Structure of the Emission Line Nebula K 3–35," wherein the authors concluded that they don't know what it is. My name was among the authors, and I wasn't sure why.

I pulled out my old publication and reread it. I read the mystery paper. After seven years of teaching undergraduate physics, mathematics and computer science, I was pleasantly surprised that I could still follow the jargon and understand the astrophysics. Just like riding a bicycle. It wasn't a bad paper. A little too long, perhaps, but so were my own publications, so was my thesis, and so was my last trip to Edmonton.

I read the paper again, generated three typed pages of comments, and asked a few meaningful questions. Just like riding a bicycle. I forwarded my comments to the first author, who thanked me, and then swore me to secrecy until the paper was accepted for publication in the *Monthly Notices of the Royal Astronomical Society*.

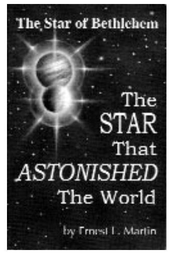
Who are those other authors? Why am I involved? Where did the paper originate? Where does the rain fall mainly on the plain? To you it must remain a mystery, at least for a little while.

For me, the incident revitalized my enthusiasm for research. From a small, remote college in a small, remote town, I can talk with scientists anywhere in the world. We can exchange ideas, data, and publications as easily as if we shared an office (wherein the speed of sound is tens of centimetres per hour). In the words of an old friend, Mark Shegelski at the University of Northern British Columbia, "We are only as remote as we believe ourselves to be."

Orla Aaquist is the physics instructor at Keyano College in Fort McMurray. His rather varied career has included periods as an undergraduate and graduate student at the University of Alberta (B.Sc., M.Sc., Ph.D.) and Queen's University (B.Ed.), a high school teacher of physics and mathematics in Toronto, and a "telescope instructor" at the Calgary Centennial Planetarium. His hobbies include writing serious songs, bad poetry, and the occasional humorous (albeit warped) science essay. He is also the first author on several published research papers written after receiving his doctorate. If asked nicely, he will play the guitar and sing astronomy songs of his own composition. He claims to be one of the first people (if not the first) to have won the prestigious RASC song contest. He was the editor of PeGAsuS *from 1992 until 1996, and he is still a regular contributor.*

Reviews of Publications
Critiques d'ouvrages

The Star That Astonished the World



by Ernest L. Martin, pages 280 + iv; 21 cm × 14 cm, Associates for Scriptural Knowledge Publications, P.O. Box 25000, Portland, Oregon, 97298, 1996. Price US$14.95 paperback. (ISBN 0-945657-87-0)

Despite the development of a vast literature on the Star of Bethlehem, there have been only a few books devoted to the subject. For several years now *The Star of Bethlehem Mystery* (J. M. Dent & Sons Ltd., 1979) by David Hughes has been — despite its deficiencies — a standard reference book on "everything you wanted to know about the Star of Bethlehem but were afraid to ask." Ernest Martin published a similar type of book at about the same time; it was entitled *The Birth of Christ Recalculated*. *The Star That Astonished the World* is a new edition of that earlier publication, with a reorganization of its contents and a new presentation of the author's arguments.

The basic premise of Martin's book is that there is enough information available from the archaeological and historical records, as well as from the biblical accounts in the New Testament, to formulate a self-consistent sequence of events that fits the incidents associated with the birth of Jesus of Nazareth. In doing so the author adopts a chronology for the reign of Herod the Great that moves the date of Herod's death to 1 B.C., a few years later than most accepted estimates. The point of such an exercise is to reconcile statements about the birth of Jesus given in the New Testament book of Luke with available historical facts. A later date for the death of Herod would permit the census of Quirinius to have occurred in 3 or 2 B.C., the latter being the 25th year of the reign of Caesar Augustus as *emperor* of Rome, when the Roman senate bestowed upon him the prestigious title Pater Patriae (Father of the Country). In that event the census of Quirinius could have been undertaken as part of an exercise to obtain an oath of allegiance to Augustus from all citizens of the Roman empire, including those in Judaea. One of several problems attached to such an interpretation is that it implies that Quintilius Varus was governor of Syria on two occasions, one of which, by necessity, coincided with the period immediately prior to the death of Herod when he presided at the trial of Herod's heir Antipater. Martin has found a nifty solution for that problem through his deciphering of a partial inscription found on a stone (the lapis tiburtinis) found near Tivoli, which is located about 20 miles east of Rome adjacent to a villa that was maintained by Varus. It is Martin's contention that the inscription can be interpreted as indicating that Varus was indeed twice governor of Syria, possibly in 2 B.C. as well as during the period 6–4 B.C.

Martin's chronology for the reign of Herod the Great is not entirely new. It is similar to one originally proposed by W. E. Filmer in 1966. In similar fashion it is subject to the same criticism of Filmer's chronology put forward by Timothy Barnes in 1968; the latter is based upon historical arguments as well as evidence from coins. Martin is correct in pointing out that one must exercise a great deal of caution when considering the written historical evidence, since versions of the original manuscripts available today exhibit some evidence for alteration from the originals. However, he then appears to neglect his own advice when advocating his chronology and sometimes seems to place an undue amount faith in documents of dubious historical value. Much is made of the statements in Luke, for example, although there is no mention of the Star by Luke and his use of angels to herald the birth of Jesus is sufficient to make most skeptics wary of the other statements in his testament.

I was first attracted to this book by the rather controversial opinions that were generated by the earlier volume. Martin's hypothesis concerning the birth date of Jesus, for example, was the subject of a rather scathing attack by Douglas Johnson in an article that appeared in *The Planetarian* in 1981. Despite such criticism, many planetariums subsequently revised their Christmas Star shows in order to present solutions to the Star of Bethlehem mystery more in line with Martin's views, in the process relegating the triple conjunction hypothesis to the wastebasket. The Griffith Planetarium was one of those that adopted Martin's chronology as the basis for its revised Christmas Star shows. Thus, when John Mosley of the Griffith Observatory reviewed *The Star That Astonished the World* in the June 1996 issue of *The Planetarian*, I was determined to obtain a copy to establish my own views on Martin's hypothesis.

The book itself is a colourful paperback with large-type pages that make it easy to read. The material is also organized in a manner that seems to flow naturally for the reader. The contents are filled with all of the standard ideas one finds in the literature on the Star of Bethlehem, although they are discussed primarily from the point of view of the author. The presentation is therefore decidedly one-sided and the knowledgeable reader will find the lack of a balanced approach rather tiresome. Martin refers to the period associated with the birth of Jesus as "That Dark Decade in History," for example, although an historian would undoubtedly argue that the time period in question is no more obscure than any other. There are fewer historical clues available for identifying the mythical King Arthur. And, if it was indeed such a "dark decade," the reader must find it rather amusing that Martin is still able to establish the exact date and hour for the birth of Jesus from the scant clues available. (David Hughes goes to the same trouble in his own book, by the way, and that also detracts from the arguments presented there.)

Although the review of *The Star That Astonished the World* published by John Mosley is quite complimentary, I found myself in disagreement with his favourable opinion of the treatise. Martin reaches several conclusions that are not fully justified by the available evidence. Some are so tenuous that alternate views simply scream from between the lines of the page. The book does contain a very detailed critique of the various historical arguments that have been put forward in attempts to identify the time period associated with the Star of Bethlehem. I would therefore recommend it as required reading material for those seeking to establish their own views on the Star. However, I suspect that specialists in ancient history or sky lore would disagree with some of the book's contents, as well as finding it sometimes frustrating to read. Indeed, Martin's choice of a publisher seems to imply that the manuscript did not get a particularly good review from the scholars normally used by the big name book publishers.

I hesitate to recommend this book for anyone seeking to get an overview of the general academic problems associated with the identification of the Star of Bethlehem. There are other sources that provide a more general overview without going into excessive detail for the various historical arguments. Likewise, Martin's identification of September 11th, 3 B.C., for the birth date is not without its difficulties and one can find equally (if not more) appropriate symbolism associated with the triple conjunction of 7 B.C. The subject area of the book is, however, one that has attracted the interest of numerous generations of scholars and deep thinkers, and the continued popularity of annual Christmas Star shows at many planetariums attests to the longevity of the mystery. If *The Star That Astonished the World* were more balanced in its approach, it might make an excellent addition to existing reference sources on the Star of Bethlehem. If you do decide to purchase it, be aware that you may find the author's criticism of alternate scholarly ideas a bit tedious.

David G. Turner

David Turner is the editor of the Journal *and a professor of astronomy and physics at Saint Mary's University. For several years prior to joining the faculty of Saint Mary's he taught astronomy and directed the Doran Planetarium at Laurentian University, where he developed his current interest in the Star of Bethlehem mystery.*

Obituary
Necrologie

Photograph courtesy of the Department of Archives and Special Collections, University of Manitoba.

B. Franklyn Shinn (1911–1997), long-time member of the Winnipeg Centre — and in later years the Victoria Centre — of the RASC, passed away on October 22, 1997. Born in Wales, Frank Shinn moved to Canada with his parents after World War I and developed a strong interest in music. A graduate of England's Royal Academy of Music and the London College of Music, he spent the greater portion of his life as a church organist and choir director in Winnipeg and, upon retirement, in Nanaimo, and as owner and director of his father's Shinn Conservatory of Music. He served as an instructor in the air force during World War II and built his own radio-controlled aircraft. He was an active photographer and boater, and was an expert in the design and construction of telescope optics and explanatory models for the orbits of comets and binary stars. He worked in the late 1960s initially as Assistant Director at the new Planetarium of the Manitoba Museum of Man and Nature, but later became its Director. In commemoration of the 500th anniversary of the birth of Copernicus, the Polish Societies in 1973 undertook to finance a heliostat at the Planetarium, for which the design and construction was largely the responsibility of Frank Shinn. His work producing a 32-cm mirror for Jack Newton was made into a film documentary.

Frank Shinn joined the Winnipeg Centre in 1954 and became a very active member of its executive. He developed and edited the Centre's newsletter, organized observing nights in city parks, presented talks at meetings, served as Centre President (1963–66), and played a vital role with his wife Florence in hosting the RASC General Assemblies in Winnipeg in 1966 and 1974. He was involved as an observer for the Moonwatch program in the late 1950s, contributed observations of meteors and variable stars in the 1960s as a member of the AAVSO, and later joined in expeditions to observe lunar occultations. He served as editor and frequent contributor to the *National Newsletter* during the period 1978–80 following a move to Vancouver Island, and later continued his involvement with the *Newsletter* as a member of its editorial staff. Even in retirement in Nanaimo he retained his boundless enthusiasm for the RASC, serving as a councillor for the Victoria Centre and working with the British Columbia Parks Service to give astronomy demonstrations at provincial campgrounds. He received the RASC's Service Award in 1972, and was constantly regarded as a highly valued member of the Society.

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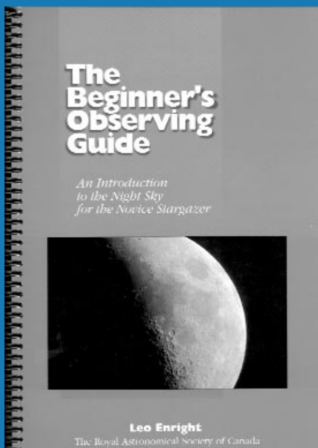

The Beginner's Observing Guide

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

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

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

Looking Up:

A History of the Royal Astronomical Society of Canada

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

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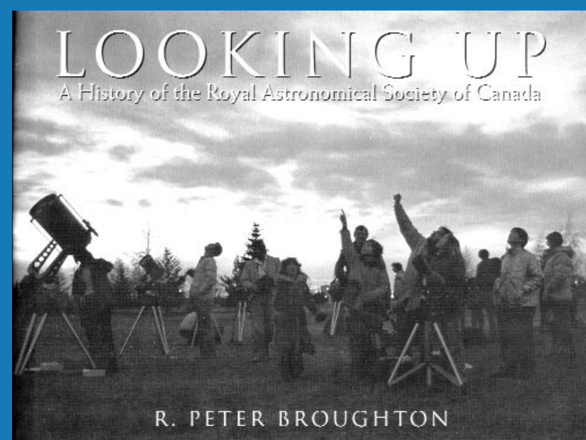

Observers Calendar — 1998

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

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