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# Journal

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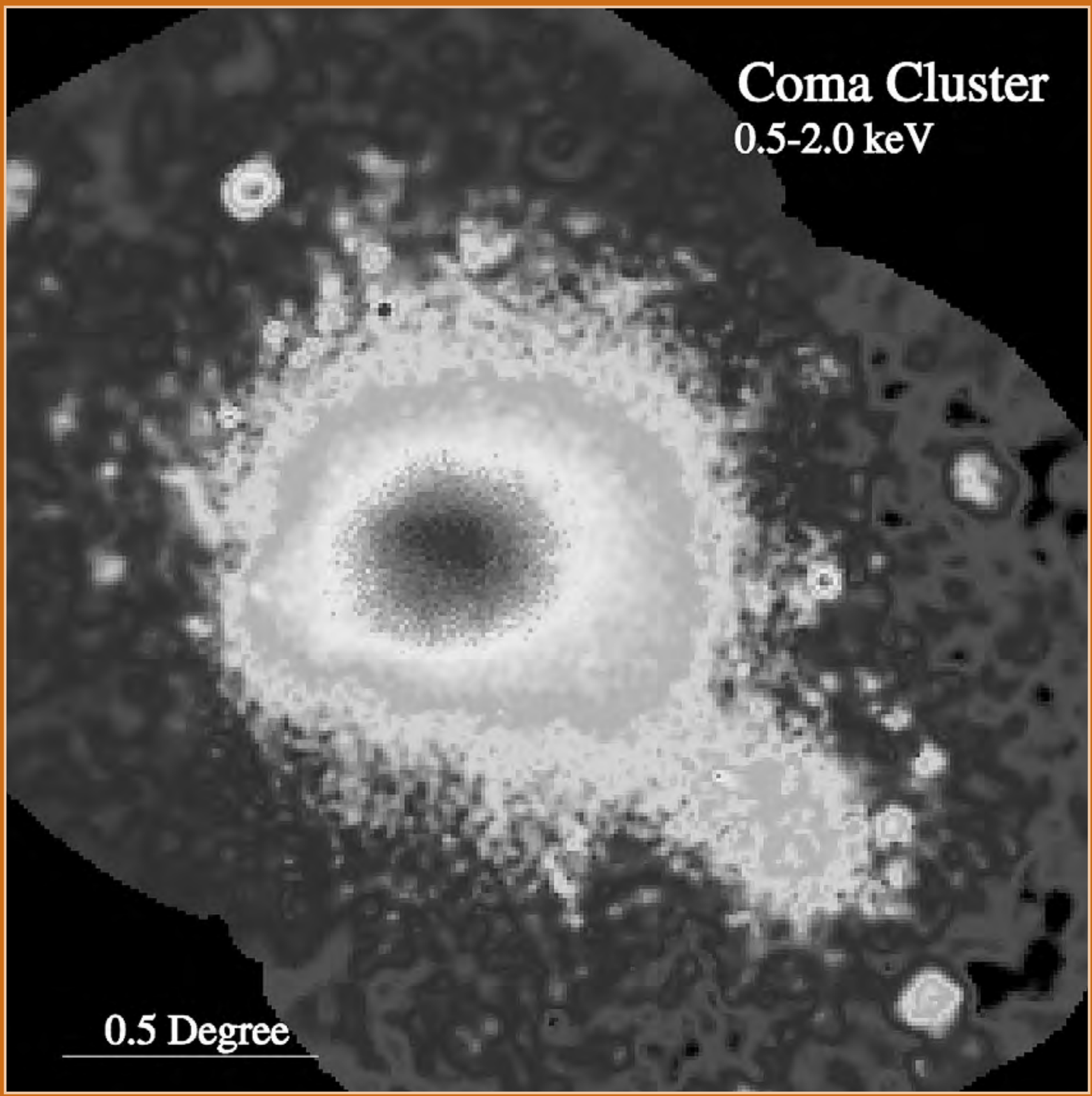


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Journal

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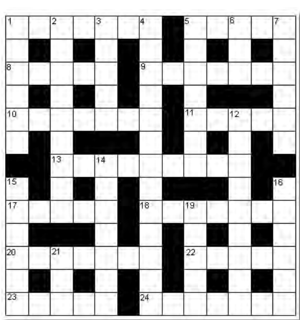

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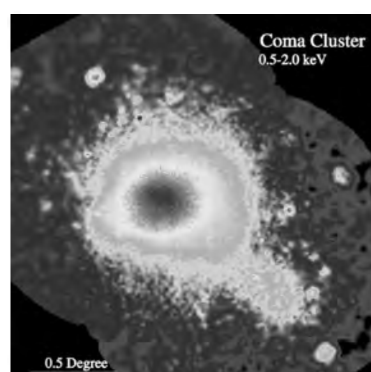



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# President's Corner

*by Rajiv Gupta (gupta@interchange.ubc.ca)*

The *Observer's Handbook* is probably the most important contribution the Society makes to the astronomical community at large. Its users include amateur and professional astronomers across the globe. The *Handbook* is generally regarded as the "bible" for serious amateur astronomers, an accomplishment that the Society is very proud of. As I write this column, the 2003 edition, my 3rd as editor, is nearing completion. With this modest amount of experience under my belt, I'd like to share my perspective on the, as I see it, five ingredients that make this 95-year-old publication the tremendous success it is.

The success of the *Handbook* is largely the result of the skill and dedication of its editors over the years. It's first four editors, who also happen to have been presidents of the Society, were C.A. Chant (49 editions), Ruth Northcott (13 editions), John Percy (11 editions), and Roy Bishop (19 editions). (Frank Hogg and Ruth Northcott also served as assistant editors for 13 and 6 editions respectively.) My predecessor Roy Bishop brought us the *Handbook* as we now know it, reorganizing and expanding the small pocket book that C.A. Chant had conceived in 1906. The progression continues: the 2003 edition will be the first to break the 300-page mark.

Perhaps one of you reading this column will at some point in the future be asked to serve as *Handbook* editor. If so, you will surely regard the request to join the above elite group of individuals as a tremendous honour, just as I did when Doug

Bob Garrison presenting the Chant Award to Roy Bishop. (Photo: Clair Perry)


## Journal

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





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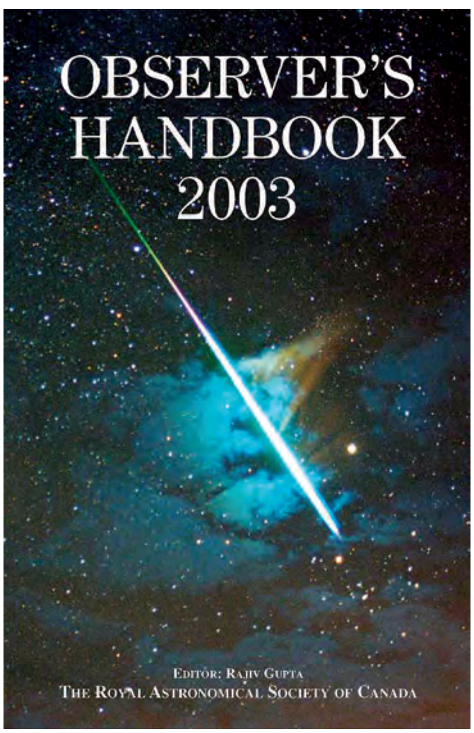
George (who was then chair of the Nominating Committee) telephoned me almost three years ago.

The real success of the modern *Handbook* stems not from the efforts of its editor, but rather the expertise and long-term commitment of its contributors. Roughly two-thirds of the current contributors are members of the Society and reside in Canada. The Society can be justifiably proud to have so many members who are world experts in their respective branches of astronomy. These "home-grown" contributors define the *Handbook* as a truly Canadian product, one of Canada's oldest scientific publications. Following the great Canadian tradition of open borders and open thinking, we also welcome contributions from expert non-Canadians, which further elevates the stature of the *Handbook*. All contributors, no matter where they reside, think of their participation as a privilege rather than a chore; 11 of the 39 world experts who contributed to the 2002 edition have been doing so for 20 or more years. For the record holder it was the 34th edition. When both editors and contributors last as long as they do, something is being done right!

In my brief tenure as editor, I have added a third category of participation in the *Handbook*: editorial assistance. Knowing that I could not put together edition after edition almost single-handedly as my predecessors had done, I formed a little "editorial team" with Betty Robinson as copy editor and James Edgar as proofreader. It is this assistance that has allowed me to assume the multiple roles I currently occupy within the Society. The longevity of the current editor will likely be correlated with that of the editorial assistants.

A fourth player in the production of the current *Handbook* is the computer, which plays a tremendous role in not only the layout and design of the publication and also the generation of the data that appears therein. Most of the year-specific data and diagrams that appear in the *Handbook* are now automatically generated with a few keyboard strokes, and therefore much of the tedium is now relieved.

Finally, there is you, the reader. As good as the *Handbook* is, there will always be room for improvement. Suggestions from readers on content that should be added or other changes that might be made are always welcome. At the 2002 *Starfest* star party, our first vice-president Peter Jedicke asked *Sky & Telescope* editor-in-chief Rick Feinberg, who gave a wide-ranging talk on the history of 20th-century astronomy and prospects for the 21st century, why it took until the 1970's for the Dobsonian telescope to be invented. His reply was that sometimes great ideas just involve looking at things from a new perspective; John Dobson was the first to realize that an expensive equatorial mount was simply not needed for visual observing. As you read the next edition of the *Handbook*, please spin it around and relay to me any insights the new viewing angle yields.




It just keeps getting better! The 2003 Observer's Handbook.

Previous and current editors of the Observer's Handbook (from left): John Percy, Roy Bishop, and Rajiv Gupta. (Photo: James Edgar)

# Editorial

*by Wayne Barkhouse, Editor-in-Chief (editor@rasc.ca)*

One of the fringe benefits of pursuing a career in the sciences is the opportunity to travel and work abroad. On August 5 of this year, I left the University of Toronto to pursue a postdoctoral research position at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts. The primary goal of my new job is to work on the Chandra Multiwavelength Project (ChaMP), concentrating on the optical follow-up aspect of the project.

ChaMP is a multi-wavelength survey (from radio to X-rays) of serendipitous sources discovered by the Chandra X-ray satellite (`hea-www.harvard.edu/CHAMP/`). Chandra, named after the famous astrophysicist Subrahmanyan Chandrasekhar, is currently NASA's most sensitive X-ray satellite, having the remarkable ability to resolve details as small as one arcsecond. This characteristic allows one to accurately pin down the position of X-ray sources on the sky. Positional information of this type can be used by other observatories to help facilitate the gathering of observations of a particular source in other parts of the electromagnetic spectrum (radio, optical, *etc.*).

The advantage of observing the same object at multiple wavelengths can be great. A recent demonstration of this point is the observations taken of Centaurus A (`chandra.harvard.edu/photo/2002/0157/index.html`). Combined optical, radio, and X-ray measurements have shaken previous beliefs that this galaxy's bizarre appearance is due strictly to a merger with another galaxy. Evidence now suggests that a gigantic explosion had taken place millions of years ago, triggering the formation of new stars.

ChaMP will use multi-wavelength observations to investigate the properties of Active Galactic Nuclei (AGNs), galaxy groups and clusters, as well as "normal" stars. Some X-ray-bright but optically-faint AGNs, for example, may be very bright in the infrared if they are enshrouded by dust. Clearly, data collected in one wavelength region alone would make it difficult to fully understand the "big picture."

Eventually, datasets of this type will be made publicly available and will no doubt be part of the National Virtual Observatory (a repository of astronomical data, allowing users to cross-correlate observations from multiple telescopes covering different wavelengths: See: `www.us-vo.org`). Observations like these help pry open the door to a better understanding of the Universe around us.

Everyone had a grand time at the GA. An excellent barbecue, and a happy bunch of people. See more photos from this year's GA beginning on page 221 (Photo: Clair Perry)

# Correspondence
## Correspondance

### MILLENNIUM TELESCOPE

Dear Sir,

I enjoyed reading about the Regina Centre Millennium Telescope project in the June issue of the *JRASC* and the success of the Regina Centre setting this up. I'm a former member of the Regina Astronomical Society, 1953/1959, and am now a life member of the RASC Victoria Centre living in Courtenay on Vancouver Island. Technically, the dome was not built by the Regina Centre. The Regina Astronomical Society was not affiliated with the RASC at that time, although many of the members also belonged to the RASC. The dome and observatory was largely built through the efforts of John V. Hodges and it was mainly through his efforts that the job got done. I was a young student at the time the dome was completed and I helped John in a minor way with the fabrication of the shutters in his basement workshop. The RAS Observatory was officially opened in 1955 by the late Dr. Peter M. Millman. It was then behind Regina College and later moved to the Broad Street location because the College needed the location for parking and further development.
Congratulations to the Regina Centre on your fine new facility.

*Ed Majden — former member of the RAS*
*RASC Victoria Centre, Courtenay office*

### CANADA-WIDE SCIENCE FAIR 2002

Dear Sir,

I would like to thank you and the rest of the Royal Astronomical Society of Canada for your generous sponsorship at National Science Fair. The award that you offer each year to the science fair is really appreciated by "young astronomers" like me. It encourages us to continue in the astronomical sciences and maybe become ourselves astronomers in the future.
The fact to have my work recognized by great societies like yours, gives me more energy and confidence to accomplish future astronomy projects. Furthermore, the membership to your organization gives me the possibility to have access to resources that might allow me to find ideas for the next science fair.
I hope you will continue participating to the National Science Fair so that other people can benefit from the same encouragement and opportunities as I did.

Best regards
*Jonathan Massey-Allard,*
*Kingston, Ontario*

# News Notes
## En Manchettes

### MORE CANADIAN ASTEROIDS

The International Astronomical Union's Minor Planet Center based at the Harvard-Smithsonian Center for Astrophysics has recently named an asteroid after Dr. J. E. Hesser of Canada's National Research Council (NRC). The asteroid was discovered on August 13, 1997, by David Balam of the University of Victoria, using NRC's 1.8m Plaskett telescope in Victoria, British Columbia. Dr. Hesser is acting Director General of the NRC Herzberg Institute of Astrophysics (NRC-HIA).

Also finding his name amongst the main belt asteroids is geologist Dr. E. Cloutis of the University of Manitoba (minor planet 6081). Saint Mary's University has also been 'given' an asteroid (minor planet 6898) by Carolyn Shoemaker in recognition of the 200$^{th}$ anniversary of its founding.

### EXPANDED COLLECTION

The National Meteorite Collection of Canada has recently grown in size with the acquisition of the Christopher E. Spratt Meteorite and Tektite Collection.

This acquisition, as explained by Dr. Richard Herd, who is Curator of the National Collection, was by Deed of Gift. The collection was independently evaluated, and then certified as Canadian Cultural Property at the June 19-21, 2002 meeting of the Canadian Cultural Property Export Review Board.

"While the Spratt collection may not be the most extensive private collection in Canada, it is of outstanding cultural significance because of its composition, and because it is a well-documented and well-organized collection that can readily be added to the National Meteorite Collection of Canada" Herd says. The Spratt collection contains specimens from over 400 meteorites and constitutes some 800 samples. "The addition of the Spratt collection to the National Meteorite Collection of Canada adds 76 meteorites previously unrepresented, raising the overall representation of worldwide meteorites to about 1100" Herd explains. The National Collection now contains over 2700 meteorite fragments.

### TUCSON HONOUR

Canadian astronomer and past president of the RASC, Dr. R. Garrison (University of Toronto) was recently honoured at a special meeting held in Tucson. The meeting in Tucson addressed the topic of "probing the personalities of stars and galaxies". The meeting was organized by Chris Corbally (Vatican Observatory) and Richard Gray (Appalachian State University), both of whom are former graduate students of Garrison, and held at the Arizona Inn. The scientific papers at the meeting highlighted Garrison's work on spectral classification.

Garrison's present work (in collaboration with Corbally and Gray) is the "Nstars Project", which has set out to produce precise spectral types of 3600 dwarf and giant stars cooler than M0 within 40 parsecs from the Sun. The "Nstar Project" forms part of a broader NASA mission to search for planets around nearby stars.

### COMETARY HONOURS

The 2002 Edgar Wilson Award for the discovery of comets by amateur astronomers are now in, and among the list of five award winners is Saskatchewan native Vance Petriew (President of the RASC Regina Centre). Petriew has been given his award for the visual discovery of comet P/2001 Q2. Seven other amateur astronomers from Japan and the United States were also given awards for their cometary discoveries. Petriew has also been honoured for his cometary discovery at the Saskatchewan Provincial Legislature by Buckley Belanger, Minister of Northern Affairs.

### SAINT MARY'S BICENTENNIAL STAMP

The Honourable John Manley, Deputy Prime Minister and Minister responsible for Canada Post, recently visited Saint Mary's University to unveil the artwork for a postage stamp to mark the institution's 200$^{th}$ Anniversary.

The design of the stamp is by Semaphor Design Company of Halifax. Steven Slipp, design principal of Semaphor, has many stamps to his credit: Bishop Charles Inglis (1987), Lunenburg Academy (1995), and the $1 Loon and $2 Polar Bear high value definitives in 1998. Stamps in the 2002 university series were commissioned to show an image of a significant building from the individual university's campus, its coat of arms and a vignette illustrating an activity. The Saint Mary's stamp depicts an aerial view of the McNally Building and the Science Building, by local photographer James Steeves. In the upper background, a second image shows graduate student Louise Edwards (now at the University of Victoria) at the telescope of the Reverend M.W. Burke-Gaffney Observatory. Three institutions that were honoured in the stamp series are the University of Manitoba in Winnipeg, Université Laval in Quebec City, and the University of Trinity College in Toronto.

Saint Mary's University is the oldest English-speaking University in Canada


The new Canada Post Stamp commemorating the 200th anniversary of Saint Mary's University.

instituted by the Roman Catholic Church. Founded by the Reverend Edmund Burke in 1802, the institution was incorporated in 1841 and received permanent degree-granting powers in 1852. Although it struggled for survival throughout the 19th century, its reputation as a liberal arts institution was firmly established under the direction of the Christian Brothers of Ireland, who began operating the school in 1913.

By 1940, when the Jesuits succeeded the Christian Brothers as administrators and professors, a number of new instructional programs had been initiated, most notably the Faculty of Commerce, which was among the very first of its kind in Canada. Under the Jesuits, the college initiated courses in continuing education, purchased Atlantic Canada's first computer, and added engineering and science programs.

On the technical philatelical side, Ashton Potter printed the stamp on Tullis Russell coated paper using 5-colour lithography. Measuring 44.5 mm $\times$35.3 mm, the stamp has general tagging on four sides and is perforated at 13+. The cancellation of the Official First Day cover is Halifax, Nova Scotia. Stamps and Official First Day covers will be available at participating post offices, or by mail order from the National Philatelic Centre. From Canada and the USA call toll-free:1-800-565-4362 and from other countries call: (902) 863-6550. Stamp information may also be found on Canada Post's Web site at: `www.canadapost.ca`

# Astronomical Events Recorded in the Medieval Anglo-Saxon Chronicles

by Robert A. Egler (robert_egler@ncsu.edu)

The records that are collectively known as *The Anglo-Saxon Chronicles* [1] were the work of various anonymous monastic scribes from the ninth century to 1154. Sometime in the ninth century, earlier dates and events, both historical and biblical, were added to the chronicles. *The Anglo-Saxon Chronicles* is actually the compilation of 4 principal works known as the Ā, C, D, and E chronicles (along with several fragments). The Chronicles are primarily concerned with recording the yearly civil and ecclesiastical events and vary considerably in the detail recorded by the different scribes over the course of the centuries. Considering the constant low-level warfare that characterized the early medieval period, and which is well recorded in the chronicles, it is surprising that the scribes recorded astronomical events at all. Nonetheless, for some years the records do mention astronomical events, or at least events that are likely to have been astronomical. The dates given in the chronicles, however, including years, month, and date (if recorded at all), cannot always be taken at face value. Changes in the accepted start of the year over the time period covered by the chronicles (varying from Christmas to March), as well as somewhat less-than-rigorous attention to the calendar and the common use of the ecclesiastical calendar of Saint Days, can sometimes lead to uncertainty in the actual date of the event recorded.

My attempt here was to examine the chronicles and note any astronomical references. The monks who wrote the chronicles were not astronomers, nor was the purpose of the chronicles to record astronomical phenomena; therefore the events of astronomical interest recorded were those that could be clearly seen and were sufficiently unusual to warrant note. These are principally solar and lunar eclipses and the appearance of comets, although there are some references to what appear to have been aurorae, and a small number that seem to refer to some type of astronomical or atmospheric phenomena, which, owing to the language used in description, cannot be clearly identified.

After I noted the astronomical phenomena in the chronicles, I attempted to correlate the description with an actual, identifiable event. When the event was clearly an eclipse, solar or lunar, I determined the circumstances of eclipses of the given year, starting at the date given (if any), and searched for an eclipse of the appropriate type that would have been visible from approximately Cambridge, England.[2]

Records of comets presented more difficulty. I confined the search to known periodic comets. The descriptions of comets sometimes indicate an extremely bright apparition, stretching from horizon to horizon. Today we rarely, if ever, see comets that appear this bright, but it is not possible to know how much of this description is the result of the standard medieval exaggeration.

The following is a list of all passages in *The Anglo-Saxon Chronicles* that appear to reference astronomical phenomena, with occasional accompanying text that seems related (principally events that the scribe appears to feel were related). After each is the date and description of the event that best agrees with the chronicle passage noted, where such an event was identifiable. In some cases, as noted, I was not able to identify the event described in the chronicles. Additionally, there are a number of both solar and lunar eclipses in this time period that would have been visible but that were not recorded by the chroniclers.

**AD 538 "The sun darkened on February 16th from dawn until nine in the morning"[3]**

Partial eclipse of the Sun, (76%) February 15, AD 538.

**AD 540 "The sun darkened on June 20th, and the stars showed fully nearly half an hour past nine in the morning."**

Partial eclipse of the Sun (75%) June 20th, AD 540.

**AD 604 "The sun darkened on May 3rd. In the same year there was much pestilence on the island of Britain."**

There was a partial eclipse of the Sun (55%) on March 10, AD 601, and another (58%) December 26, AD 604, however I cannot find a solar eclipse that would have been visible from England on the date specified, May 3, 604. Note that the chronicles were not started until approximately AD 800, so this event would have had to be recorded in the chronicles from any earlier record. Apparently the earlier record was incorrect as to the date, or the date was incorrectly copied into the chronicles.

**AD 678 "There appeared the star called a comet in August, and it shown for three months each morning like a beam of the sun"**

Halley's comet would have been at a distance from the Earth of 26.4 AU, approximately 1.4 times the distance of the famous apparition of 1066, so this comet may be Halley.

**AD 729 "Two comets appeared, and the same year Osric passed away, who was king for eleven years..."**

I was unable to find any known periodic comets that would have been bright enough to be seen in this year.

**AD 733 "...the sun darkened. Acca was driven from the Bishopric."**

Near total (97%) eclipse of the Sun on September 14, 733.

**AD 734 "The moon was as though drenched in blood. Archbishop Tatwine passed away, and also Bede..."**

The total eclipse of the Moon, January 24, 734, is a likely candidate for this reference. The well-known effect of refraction of sunlight as it passes through the Earth's atmosphere giving the Moon a coppery tint during a total lunar eclipse is the probable explanation for this and other descriptions of a "blood-coloured" Moon.

**AD 776 "Men saw Christ's red cross in the heavens after sunset..."**

I suspect that this event was an atmospheric effect, refraction of sunlight onto clouds perhaps. A sun pillar is another possibility.[4]

**AD 800 "The moon was darkened during the second hour of the night of January 16th..."**

Partial eclipse of the Moon (83%) January 15, 800. There was also a partial eclipse of the Sun (53%) on June 26 of this year, but no mention is made of this event.

**AD 802 "The moon darkened at dawn on May 21st. Beornmod was hallowed Bishop of Rochester the same year."**

Total eclipse of the Moon, May 21, 802, maximum eclipse would have been about 05:00 local time, ending about 07:30. Since sunrise on this date at Cambridge would have been at approximately 04:00, the Moon would have set while eclipsed.

**AD 806 "The moon darkened on September 1st...also in the same year, on June 4th, the sign of the cross was shown on the moon, Wednesday at dawn."**

There was a total eclipse of the Moon on both March 8th and September 1 of 806. We can only wonder why the scribe recorded only one of them. I can find no specific cause for the sign of the cross appearing on the Moon in June.

**AD 809 "The sun darkened at the beginning of the fifth hour of the day on Tuesday, July 16, the 29th day of the moon."**

Partial eclipse of the Sun (59%), July 16, 809, first contact was at 9:13 AM.

**AD 829 "The moon darkened on Christmas eve."**

Total eclipse of the Moon starting just before midnight on December 24, 829.

**AD 879 "...A gang of Vikings gathered and occupied Fulham, by the Themes. The same year, the sun darkened for one hour one day."**

I find a total eclipse of the Sun on October 29, 878, and a partial eclipse of the Sun (67%) on March 14, 880, but no solar eclipse visible from England in 879. I suspect the eclipse noted here was the total eclipse of 878.

**AD 891 "...the same year, after Easter, during the Rogation days or before, the star appeared which men call in Latin cometa, some men say in English that is a hairy star, because long beams stand out, sometimes on one side, sometimes on every side."**

I could not find any periodic comet that would have been clearly visible. Halley's comet would have had a closest approach to Earth of approximately 33.5 AU. Interestingly, there is no mention of the partial solar eclipse (83%) on August 8th of that year.

**AD 904 "The moon darkened." (This brief sentence was the entire chronicle entry for this year.)**

Total eclipse of the Moon, June 1, 904.

**AD 905 "A comet appeared on October 20th."**

I could not find any periodic comet that would have been clearly visible. Of the comets I examined, this year Halley's comet was the closest, at a minimum distance of approximately 27.0 AU.

**AD 927 "Fiery lights appeared in the north part of the sky, and Sihtric died."**

The description of the "fire" and the direction of north lead me to believe that this event was the observation of the Aurora Borealis, which is often red.[5]

**AD 995 "The comet appeared, that is, the long haired star. Archbishop**

**Sigeric passed away..."**

Halley's comet reached a minimum distance from the Earth of 7.3 AU this year, half the distance of its closet approach in 1066, making Halley the prime candidate for this chronicle entry. The reference to the "long haired star," frequently noted in the chronicles, actually gives us our common name of "comet." *Aster kometes* is Greek for "hairy star."

**1066 "Then it happened that all through England such a sign in the heavens was seen as no man had seen before. Some men said it was the star comet, that some men call the long-haired star. It appeared first on the eve of Letania Minor, April 24$^{th}$, and shown all seven nights."**

Possibly the most famous apparition of Halley's comet, this event was recorded on the Bayeux Tapestry commemorating the Battle of Hastings in 1066.

**1078 "The moon darkened three nights before Candlemas..."**

Candlemas is celebrated on February 2$^{nd}$. In the late evening of January 30, 1078, there was a total eclipse of the Moon.

**1097 "Then after Michaelmas, October 4$^{th}$, there appeared a rare star, shining in the evening, and soon sinking to its setting. It was seen in the southwest, and the beam of light which stood out from it seemed very long, shining in the southeast. Nearly all the week it appeared this way. Many men supposed it was a comet."**

Michaelmas is celebrated on September 29. Comet West would have been just above the western horizon at sunset, but at a distance of 511 AU it clearly was not the object observed. I could not identify any other periodic comet would have been in the correct location, or visible at or near this date.

**1104 "This year the first day of Pentecost was June 5$^{th}$, and on the Tuesday after appeared four circles around the sun at midday, white in hue, each interwoven with the other, as though painted. All who saw it were filled with wonder, for they remembered nothing like it before."**

This event seems likely to be the result of ice in the upper atmosphere, causing multiple solar haloes. Such multiple haloes are not common, but do occur. *The Audubon Society Field Guide to North American Weather* shows a photograph of multiple solar haloes that fits the description very well.[6]

**1106 "The first week of Lent, on Friday February 16, there appeared in the evening an unusual star, and for a long time thereafter it was seen each evening, shining for awhile. The star appeared in the southwest, it seemed little and dark but the light which stood out from it was very bright, and a beam so immense that it seemed to be shining in the northeast.**

**On the night of the morning which was Cena Domini, that is the Thursday before Easter, two moons were seen in the heavens before day, one in the east and the other in the west, both full..."**

The first of these clearly refers to a comet. Comet Linear C/1999 S4 was located near the horizon in the west southwest, however it was at a distance of 498 AU, which would make it extremely unlikely to be the comet described as so bright its tail reached to the northeast.

The second reference is likely to have been a sun pillar or similar atmospheric phenomenon.[7] The full Moon would be setting in the west at sunrise, and the Sun would be just below the horizon in the east. I suspect that the "full Moon" in the east was a reflection of the Sun of some type.

**1110 "On the fifteenth night of the month of May, the moon appeared, shining brightly. Then little by little its light waned, so that as soon as it was night it was so fully quenched that neither light nor circle nor anything at all of it was seen, and so it stayed for full nigh a day. ...it was on the same day 14 nights old."**

A total eclipse of the Moon occurred on May 5, 1110, most likely this eclipse was the event described, with an incorrect date recorded. While the entire eclipse would have taken just a little over 5 hours, it certainly would not have lasted "full nigh a day".

**1114 "This year toward the end of May was seen a rare star with a long beam of light shining for many nights."**

I am unable to find a period comet bright enough to have been seen in this year.

**1117 "...and on the night of December 11$^{th}$ the moon was long into the night as though all bloody, and after it was darkened."**

The total eclipse of the Moon, December 11, 1117, is the likely cause of the "blood" coloured Moon this year.

**1121 "The moon darkened on the eve of April 5$^{th}$, that was the 14$^{th}$ day of the moon."**

Total eclipse of the Moon, April 4, 1121.

**1131 "After Christmas on Sunday night, at the time of first sleep, were the heavens in the north all as though they were burning fire, such as they never were before. That was January 11$^{th}$. The same year was such death among livestock as never before in the memory of men over all England."**

This description is quite similar to the chronicle entry of AD 927, and is also likely to have been an Aurora Borealis.[8]

**1140 "In the spring, the sun darkened, about noon of the day,**

**when people ate, and people lit candles to eat by. That was March 20th, and people wondered greatly at it.”**

A near-total eclipse of the Sun (98%) occurred on March 20, 1140. The eclipse would have started at about 14:00 local that day, and been maximum at 15:12.

## Conclusion

Medieval chroniclers are known for their tendency to exaggerate, especially when they refer to numbers involved or killed in any particular battle, however the investigation of the astronomical events recorded in *The Anglo-Saxon Chronicles* shows that with only two exceptions (AD 879 and 1110) the chronicles’ record of eclipses is reasonably accurate for those the scribes recorded. There were, however, a number of eclipses, not all of which I mention, that would have been visible from England during this time period that were not recorded.

The chronicle references to events that were likely aurorae or atmospheric effects are noteworthy in that the chroniclers did not usually ascribe any supernatural causes or effects to the phenomena, but usually recorded their observations such that it is was possible for me to arrive at probable, although not definitive, explanations.

The identification of possible comets to match those recorded is difficult for the most part, with no certainty of identification being possible except for the well-documented apparition of Halley’s comet in 1066. There are several possibilities for this lack of identification: chief cause is likely that I examined only the possibility of a small number (8) of known periodic comets. Of course, the possibility exists that the unidentified comets may have been one-time visitors, or comets with very long periods. Perhaps someone with more comet orbit experience will take a look at the comet records and may yet identify these references.

## Notes

1. Savage, Anne (Translator), *The Anglo-Saxon Chronicles*, Barnes and Noble, 2000
2. Latitude 52° north, Longitude 0.1° west, approximately the position of Cambridge.
3 This, and all calendar entries, is taken from Savage (2000).
4. Ludlum, David, *The Audubon Society Field Guide to North American Weather*, Alfred A. Knopf, 1991. p. 554. Two photographs of sun pillars are shown on plates 345 and 346.
5. Ludlum, David, *Op. Cit.*, p. 548. Aurorae can be clearly red, as shown in the photos on plates 361 and 362. At the latitude of England, aurorae would be infrequent but not unknown.
6. Ludlum, David, *Op. Cit.*, p. 551. The usual solar halo is at 22°, however haloes can also appear at 9°, 18°, 20°, 24°, and 35°. A photograph of multiple solar haloes is shown on plate 338.
7. Ludlum, David, *Op. Cit.*, p 554
8. Ludlum, David, *Op. Cit.*, p 548

*An Unattached Member of the RASC since 1985, Robert Egler teaches solar system astronomy at North Carolina State University. His professional projects have been on applications of astronomy to navigation, and include work on the satellite orbits of the GPS system. He has had a long-time interest in medieval English history. A former professional firefighter, he resigned from the fire department to study either astronomy or history, and astronomy won.*

# Simple Planning Tools for Budding Astrophotographers

*by Brady Johnson (bradydjohnson@rogers.com)*

One of the keys to successful astrophotography is deciding what pictures you'll be taking *before* you pack up your equipment and head out the door. Planning is crucial because many factors already conspire to eat up your valuable time in the field — all reducing your chances of a successful outing.

So don't make the mistake of going out and *then* trying to decide what to shoot and what lens to use. Instead, plan your general composition (how you want the picture to lay out) and the lens you need to get it — well in advance.

With a few simple tools, pre-planning your shots is easy. For my routine I use a planisphere, a star chart, and overlays that show me the exact area of sky that each of my camera lenses will capture. With these tools I create a shot list consisting of primary targets in each of north, south, east, and west directions. If I can't shoot my number one choice because of interference from clouds or light pollution *etc.*, my shot list gives me alternative targets to go after.

The image of NGC 7000 — the North America Nebula — shows the result of one of my pre-planned compositions. I chose to use a 135-mm lens with my ST8 CCD camera because I wanted to include Deneb in the composition.

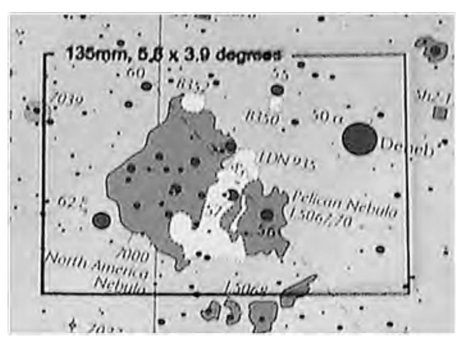
As you can see, the actual image closely matches the preview version, which shows NGC 7000 framed by the field of view indicator (FOVI) for my 135-mm lens. I find that being able to create such accurate previews is indispensable for planning purposes. In this article I'll describe the general steps I take to plan a session, and show you how to make your own set of star chart overlays.

The North America and Pelican nebulae in Cygnus. This hydrogen-alpha image was obtained with an ST8 CCD camera and a 135-mm Pentax SMC lens. The composition was planned in advance using a field-of-view overlay and a star chart (inset).

## Using the Planisphere

I always start out with a planisphere. The planisphere is a wonderful device. It shows what constellations will be well positioned for any day of the year, right down to the hour. The utility of this tool for planning is obvious. Just dial in the date and time scheduled for a session, then consult the planisphere to see which constellations will be well positioned (*i.e.*, highest in the sky) that evening.

It's a bit like using a crystal ball to see into the future, except that a planisphere really works! I just wish there was a version that would show what the sky c*onditions* would be like on any given evening, too!




## Using the Star Chart and Overlays

Once you've identified some suitable constellations, the next step is to look them up in a star chart. The chart will reveal a choice of photographic targets within each constellation. Now begins the process of choosing what to shoot and what lens to use to shoot it.

The selection process is much simpler with a set of FOVIs to use in conjunction with your chart. As you can see from Figure 1, FOVIs are nothing more than rectangles drawn on transparency paper. When you lay them on top of a page of your star chart, you get an instant view of what your camera lens will capture if it's pointed at that particular region of sky.

If you make a FOVI for each of your camera lenses, you can quickly switch among your indicators to see which lens gives you the most pleasing composition. When you're done, you know just what lens you need and exactly where to point it to get the picture you want.

## How to Make a FOVI

Construction of a FOVI is simple. It involves just a bit of math and some familiarity with a calculator. Specifically, you'll need to know how to use the *arctan* function on your calculator, but don't worry about that. You don't even need to know what an *arctan* is to make your own set of FOVIs.

Let's begin by listing the information you need to start with. You need:

1. A list of the focal lengths of each camera lens in your selection. If you use a zoom lens, treat each zoom setting marked on the lens barrel as a separate lens, and make a FOVI for each one.

2. The dimensions of the *image area* for your camera. If you're using a 35-mm format film camera, the values you need to know are $x$ = 36 mm and $y$ = 24 mm. If you're using a CCD camera, just look up the width and height dimensions of your CCD imaging chip in your owner's manual.

3. The *image scale* of your star chart. The image scale is a value that expresses how much sky your chart covers in some distance, like a centimetre or an inch. If your chart consists of separate pages, the image scale is probably written on each page. If the chart comes in a book, the image scale will be noted somewhere in the preliminary pages. Look for expressions like "*8.2 mm per degree*" or "*4 degrees per inch*." When you find it, write down your image scale for use later.

Next we'll take these different bits of information and use them to determine the dimensions of our FOVIs. We'll do the calculations in two simple steps. In the first, we will calculate the field of view for a given camera lens and camera type. The result will give us width and height measurements of the field of view in *degrees*. In the second step we'll convert the degree values into linear units (*i.e.*, millimetres or inches). This calculation will make it easy for us to draw the field of view as a rectangle on transparency paper using a pen and ruler.

### Calculating Field of View

Let's determine the width, $w$, and the height, $h$, for the field of view of a 200-mm lens on a standard 35-mm format camera. I'll use my personal star chart, *Sky Atlas 2000, Deluxe Edition*, which has an image scale of 8.2 mm per degree. We know that the width of the image area on film, $x$, is equal to 36 mm, and that the focal length of our lens, $F$, is equal to 200 mm. So,

$$w = 2 \times \arctan ( x / ( 2 \times F ) )$$

$$w = 2 \times \arctan ( 36 / ( 2 \times 200 ) )$$

$$w = 10.3°$$

To solve this formula with your calculator, begin by selecting the "Degrees" mode. Then, just divide 36 by 400, press the *arctan* button, and multiply your result by 2. That's it. The number you have is the width of the field of view of a 200 mm lens, expressed in degrees.[1]

Before we convert the result to a linear value, let's do the same calculation for the height.

$$h = 2 \times \arctan ( y / ( 2 \times F ) )$$

$$h = 2 \times \arctan ( 24 / ( 2 \times 200 ) )$$

$$h = 6.9°$$

It's exactly the same formula, but 24 has been substituted for 36. Completing the calculations and rounding, we get $w$ = 10.3° and $h$ = 6.9°. Next, we convert $w$ and $h$ into linear units so that we can draw rectangles for use with our sky chart.

### Determining the FOVI Rectangle Dimensions

This step is even easier than the last. Just multiply $w$ by the *image scale*, and then do the same for $h$. This calculation will give us the length of the sides of our rectangle. Recall that the *image scale* for this example is 8.2 mm per degree. Therefore,

$w \times$ image scale = width of FOVI in millimetres

10.3° × 8.2 mm per degree = 85.5 millimetres

Doing the same for $h$, we get 56.6 mm. That's it.

Now we can draw the FOVI for the 200-mm lens. On transparency paper, draw a rectangle with sides of 86 and 57 millimetres (3.3 by 2.25 inches). Put the transparency on top of your chart, and the rectangle shows you the exact area of sky a 200-mm lens will capture. You

[1] If the number you see isn't the same as the one in the example, then it's likely that your calculator works a little differently. If need be, consult your operator's manual to determine the correct sequence for doing the above calculation. Note, too, that the results in these examples are rounded to one decimal point.

can move the FOVI around and experiment to get different compositions until you get just the one you want. Neat, huh?


A star chart and a planisphere — two indispensable tools for preparing for an astrophotography session. Shown here are *Sky Atlas 2000, Deluxe Ed.*, by Tirion and Sinnot, and a *Miller* Planisphere.

## FOVIs with Your Computer

There are a couple of ways to make FOVIs with your computer, too. For example, some planetarium programs will let you set the screen size to a particular field of view. If you know the field of view for your camera lenses, you can just enter that information and print the window.

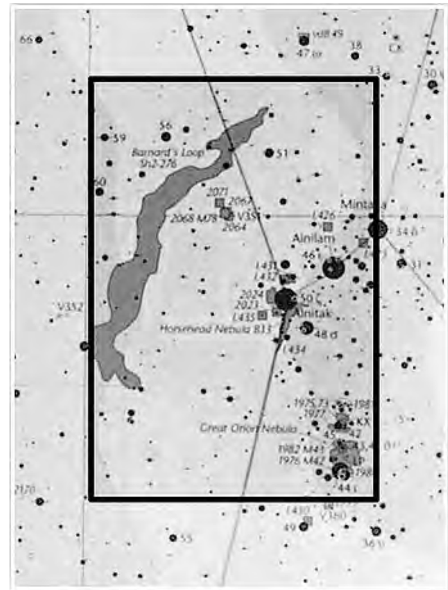
Other programs have FOVIs built right in. *TheSky*, from *Software Bisque*, is an example. You just provide it with the focal length of your lens and the type of camera you use (film or CCD), and it will display a FOVI on the screen for you. Incidentally, I use the FOVIs in *TheSky* all the time when I'm *taking* images. But for *planning* my shots, I still prefer to use FOVI overlays with my star chart.

Finally, you can use your computer to draw your FOVIs, giving them a crisp, professional look. But whether you draw them by hand or print them with a computer, I suggest you clearly label your FOVIs, especially if you use your camera lenses with both film and CCD cameras.

## FOVIs Really Work!

I simply can't overstate the utility of FOVIs for pre-planning my shots. But a large part of their utility is in keeping me focused on my objectives. I use FOVIs to select only one primary target for a given photography session. When I head out the door, I know exactly what I'm going to shoot, and I stay focused on coming home with an excellent result.

But beyond this, FOVIs are fun to use, too. I often spend an hour or two poring over the pages of my star chart, looking for targets for upcoming photography sessions. As I switch among FOVIs, I try to imagine what the different results would look like. The anticipation in itself is very rewarding. In fact, for me, planning my sessions is now a big part of the fun of doing astrophotography.




Here is how the FOVI we just constructed would look on a page of *Sky Atlas 2000*. The field of view, which is centred near Alnitak in the belt of Orion, would include the Horsehead, the Great Orion Nebula, and Barnard's Loop in its entirety. This composition would make a stunning image given a long enough exposure.

*Brady Johnson has been interested in astronomy since he was a child growing up in Alberta. Today, Brady has a passion for wide-field astrophotography using ordinary camera lenses attached to his automated CCD imaging system. Brady is a V.P. and regular speaker at the Kitchener/Waterloo Centre of the RASC.*

# Henry Norris Russell

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

H.N. Russell,
Dean of American Astronomers
(1877 – 1957)

Henry .N. Russell, born 125 years ago on October 25, is perhaps the most celebrated and influential American astronomer to date. He is best known for co-introducing the Hertzsprung-Russell diagram of stellar luminosity vs. temperature (more about this later), but he had many other accomplishments. He was born in 1877 to privileged parents in Oyster Bay, New York, but spent most of his life in Princeton, New Jersey. (His father was a Presbyterian minister from Canada!) He received a good education at Princeton ("with extraordinary honour"), spent a little time as a Research Assistant at Cambridge University, then returned to Princeton as an instructor. He rose through the academic ranks, eventually becoming Director of the Observatory in 1912, a post he held for 35 years. He also had strong connections with Mount Wilson Observatory, through annual visits beginning in 1921. He remained active following his official retirement, passing away in 1957 at the age of 79.

Russell is best known for his work on stellar evolution, notably his observation that stellar luminosity (absolute magnitude) tends to be correlated to spectral type (temperature, colour index, or some related quantity). In order to draw this conclusion, it was necessary to measure accurate distances to the stars, to convert their apparent magnitudes to absolute magnitudes. This work was conducted in part during his stay at Cambridge University. In 1913, Russell published the first diagram showing this correlation. It turned out that Ejnar Hertzsprung (1873–1967) had earlier noticed a similar correlation involving the apparent magnitudes of stars within the same cluster (all having the same nominal distance from Earth). The graphical expression of this rule is called the Hertzsprung-Russell (HR) diagram and continues to be an important tool for investigating star clusters. (See `library.thinkquest.org/12713/noframes/hrdiagrm.html`.) The principal grouping of stars on the HR diagram forms a band called the "Main Sequence" stretching from the "bright blue" corner at the upper left down to the "dim red" corner at the lower right. Of course, all good rules have important exceptions. It was soon discovered that, while most stars (including the Sun) lie within the Main Sequence, there are groups of stars in outlying regions of the diagram that represent red giant stars on the one hand (large, bright, cool, red stars) and white dwarfs on the other hand (small, dim, hot, white stars). Russell's first stab at describing stellar evolution had stars moving along the Main Sequence during their lives; however, the discovery that nuclear fusion powers stars compelled astrophysicists to realize that stars evolve in a completely different way, spending most of their life at a spot within the Main Sequence, then quickly moving out of this band into the outlying regions.

Russell confirmed the discovery by Cecilia Payne-Gaposchkin (1900–1979) that hydrogen is by far the must abundant element in stars. (Interestingly, he initially disparaged the idea when she showed him the results of her investigations.) Russell's interests were broader than astronomy: he made a significant contribution to atomic physics (Russell-Saunders coupling). His strong theoretical interests transformed astronomy, incorporating the new (at the time) concepts of atomic physics into the study of the vastness of the cosmos. Russell and two Princeton colleagues published a trend-setting astronomy textbook in 1927 with this emphasis.

Among his many scientific distinctions, Russell received the Gold Medal of the Royal Astronomical Society (1921). The American Academy of Arts and Sciences awarded Russell the Rumsford Prize in 1925. (Canadian John Stanley Plaskett received this in 1930.) The Astronomical Society of the Pacific awarded Russell the Bruce Medal in 1925. (Also received by Simon Newcomb in 1898 and John Plaskett in 1932.) On the occasion of his retirement, the American Astronomical Society set up the Henry Norris Russell Lectureship and asked Russell to be the first recipient in 1946.

(Canadian astronomer Sidney van den Bergh received this honour in 1990.)

At various times in his career, Russell was President of the American Astronomical Society, the American Association for the Advancement of Science, and the American Philosophical Society. He published 241 papers overall, including one on the navigation of airplanes, a small defence science project for the U.S. government in World War I. He has a lunar crater, a Martian crater, and an asteroid (1762) named after him. The Russell-Vogt "Theorem" states, in its most stripped-down form, "the properties of a star are determined primarily by its mass."

In all aspects of his life, both professional and private, he was an energetic and enthusiastic man. For example, he would get carried away in his graduate-level lectures, going far beyond the allotted time (with the consent of his audience, one hopes!). There is a recent biography of Russell by David H. DeVorkin: "Henry Norris Russell: Dean of American Astronomers" (Princeton University Press, 2000). I have not read it, but there have been favourable reviews in *Sky & Telescope* and *Physics Today*, and it has been endorsed by Patrick Moore, Owen Gingerich, and David Levy.

*David Chapman is a Life Member of the RASC and a past President of the Halifax Centre. At the RASC General Assembly in Montreal, he was inducted into the RASD: the Royal Astronomical Society of Daves, which (among other things) entitles him to sign his postings to RASCals Listserver as "Dave XVII". By day, he is Acting Chief Scientist at Defence R&D Canada–Atlantic. Visit his astronomy page at* `www3.ns.sympatico.ca/dave.chapman/astronomy_page`.

## Second Light

# Heating Cooling Flows

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

In the late 1980s, searching for the gas associated with 'cooling flows' in clusters of galaxies was big business. A cooling flow is just what the name implies — a flow of gas from the outer reaches of a cluster towards the centre as it radiates away its energy. Searches for this gas went on for years, and massive amounts of telescope time were expended on them, but nothing more than about one percent of what was predicted, based on the X-ray data, was ever found. Now, Marcus Brüggen of the International University Bremen in Germany and Christian Kaiser of Southampton University in Britain think they can explain why the cold gas is nowhere to be found (see the July 18 issue of *Nature*). It is being reheated by the active galactic nuclei that exist at the centres of most clusters.

Clusters of galaxies (see Figure 1a) are a clear case in which what you see is not all that's there. At visible wavelengths, clusters are concentrations of galaxies in the sky, but there still appears to be a lot of empty space between the galaxies. We know, based on studies of the motions of the galaxies by Fritz Zwicky in the 1930's and later by Vera Rubin, that they are moving too fast to remain in a coherent cluster unless there is a lot more unseen mass — this was the first indication of 'dark matter'.

Much of the baryonic mass (*i.e.*, not dark matter) associated with galaxy clusters does not reside in the galaxies themselves, but rather exists as a huge bath of X-ray emitting plasma in which the galaxies swim (see Fig 1b). In fact, the temperature and distribution of this gas can be used to infer the total mass of the cluster, under some simplifying assumptions, because the temperature is related in a rather straightforward way to all of the mass — including the dark matter. Using Earth-orbiting X-ray satellites, astronomers determined that many clusters seemed to have a peak in the X-ray 'surface brightness' (the number of photons emitted per unit area) at their centres, and that this was associated with a drop in the entropy of the gas. Entropy can be thought of in this context as a measure of the portion of the energy that is available to support the gas against gravitational collapse.

By emitting X-rays, the gas cools from its equilibrium temperature of a few million degrees Kelvin. If it gets cold enough, it should fall to the centre of the cluster, a position that often is occupied by a huge elliptical galaxy, which is referred to as a type cD, for centrally dominant. The logical inference was that the cD galaxies grew so large as a result of the cooling flow, and therefore we should be able to see traces of the gas in and around those galaxies. But, however hard astronomers looked, they could not find the gas in any form. The first searches were for atomic hydrogen at about 100 K. When those failed, there were searches for traces of the very cold molecular gas out of which new stars form, and for evidence of new stars. Nothing was found.

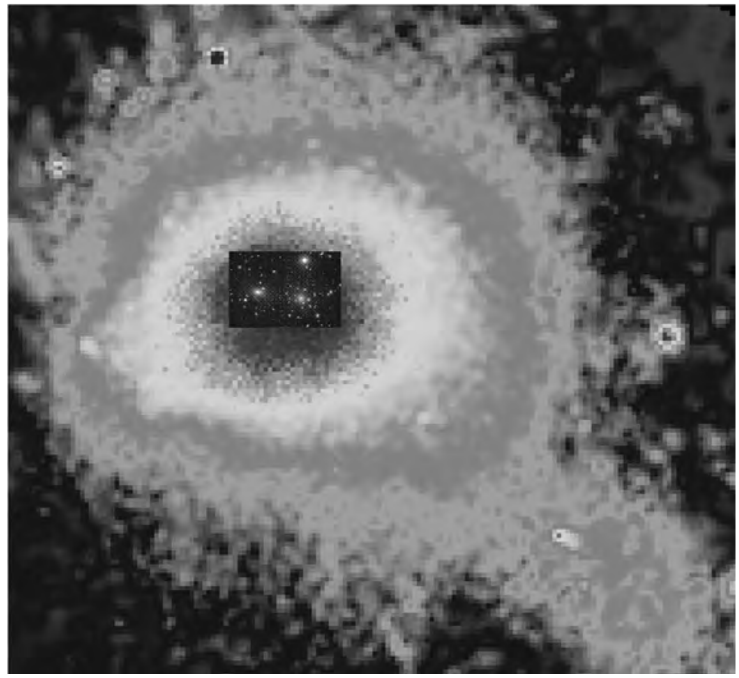


Figure 1(a)

Figure 1(b)

Figure 1(a) An optical image of the central region of the Coma cluster. Figure 1(b) The X-ray emitting part of the cluster extends far beyond the optical core, which is shown as an insert. The galaxies themselves are a small portion of the total cluster, and swim through a sea of hot, thin plasma.

After about a decade of negative results, people started looking for mechanisms to reheat the gas, but this is tricky to reconcile with a peak in X-ray emission and a drop in entropy. For example, if you simply dump a lot of heat in the centre of the cluster and let convection distribute it through the gas, you would have the highest entropy at the centre, which is opposite to what is observed.

Brüggen and Kaiser reasoned that because active galactic nuclei, which are supermassive black holes into which gas is falling, drive strong outflows like radio jets, there might be sufficient energy put back into the gas to reheat it without violating the restriction on the entropy. They set out to model the system, to see if this is what happens. They found that the critical heating occurred with small bubbles of hot gas, rather than with the huge jets that give rise to the massive radio-emitting lobes around some AGN. The smaller bubble structures would input heat more gently, and be more abundant than the larger jets.

Heat is spread more gently by these bubbles because they are not crashing supersonically through the surrounding gas, but rather they bubble up from the centre, just like bubbles rising in a lake (and for exactly the same reason). The gas inside the bubble is hotter than the surrounding medium and therefore at a lower density, so there is a buoyancy force pushing them out from the centre of the cluster. The model shows that the bubbles can stop the cooling flow while depositing very little entropy near the centre of the cluster. Brüggen and Kaiser suggest that a feedback loop might develop in which a cooling flow feeds gas into the supermassive black hole at the centre of a cD galaxy, which then interrupts the flow by its occasional input of energy and turns off the cooling flow for several hundred million years. Once the energy put in by the bubbles has dissipated throughout the gas, a cooling flow could develop briefly, then turn itself off with the next energy injection by the black hole.

Was all that telescope time devoted to looking for cooling flow wasted? Not at all! Once again, not seeing what we expected has led ultimately to a much deeper understanding of the physics of gas in clusters of galaxies than we would have achieved if we had simply seen what we expected to see.

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

## DAYLIGHT SAVING TIME; IS IT COMING?

A year ago the proposal to introduce 'daylight saving' into Canada was laughed out of the House of Commons, but it looks now as though we may have it after all. A bill has passed the United States Senate and, it is said, is likely to be accepted by the House of Representatives and the President, providing for the change in the clocks. There is a great agitation going on in the United States in favor of the proposal and Canadian newspapers also are advocating it. It is not a new thing. In 1907 a pamphlet entitled "The Waste of Daylight" was published in England by a man named Willett, but the subject was discussed many years before — by Benjamin Franklin, indeed.

To many the suggestion to move on the clock and use the sunlight appears ridiculous. Why not get up earlier? But we are simply slaves to the clock, and if by advancing the hands one hour we shall automatically rise earlier and do our work by daylight instead of taking much of the night for it, by all means let us do it.

Early in the war, Germany adopted daylight saving and since then the following countries have done the same — Italy, Portugal, Sweden, Norway, Denmark, Holland, Belgium, Austria and Australia and, perhaps, others. At the present time when we are so short of coal and electric energy the scheme of daylight saving is a real conservation measure.

by C. A. Chant,
from *Journal*, Vol. 12, pp. 123*ff*, March, 1918

# Research Papers
## Articles de recherche

### CANADIAN THESIS ABSTRACTS

*Compiled by Melvin Blake (blake@ddo.astro.utoronto.ca)*

*Gravitational Lensing of Polarized Sources* by Christopher R. Burns (burns@astro.utoronto.ca), University of Toronto, Ph.D.

In the past couple of decades, gravitational lensing has gone from being a theoretical possibility to an observational test of general relativity to a method for determining cosmological parameters. Being the only direct and independent way to measure the mass of cosmological objects, it is by far the most promising method of pinning down the value of the density parameter ($\Omega_o$), and directly measuring the mass-to-light ratio of the universe at both small and large scales.

As promising as it is, gravitational lensing is hampered by the lack of knowledge of the intrinsic morphology of the sources being lensed. In the strong-lensing regime, one is aided by the fact that the distant source is multiply-imaged. Each image is a different, highly distorted view of the same source and therefore must reproduce the same morphology when the lens is theoretically removed and therefore gives us the extra constraints needed to gain this knowledge. However, strong lensing is much less likely, and probes smaller length scales, than weak lensing. One therefore needs another way to determine the intrinsic morphology of the source. One way is to use the polarization of the source.

Like wavelength, polarization is an intrinsic property of the photon, which is not altered by gravitational potentials. The path of the photon will be deflected and the image of a source formed by an ensemble of photons will be distorted due to differential bending, yet the polarization of the source remains intact. Polarization therefore gives us a window into the source plane that we can use to constrain the amount of weak and strong gravitational lensing.

This thesis will examine the effects of gravitational lensing on polarized sources in the strong- and weak-lensing regimes. The theory of the gravitational lens and its role in cosmology will be presented as well as general considerations of cosmological observations in a non-homogeneous universe. Next, the theoretical predictions of the effects of gravitational lensing, both strong and weak, on polarized sources will be presented. Finally, this theoretical framework will be applied to several astronomical objects that produce polarized radiation.

*The Red-Sequence Cluster Survey* by Michael Gladders (gladders@astro.utoronto.ca), University of Toronto, Ph.D.

The Red-Sequence Cluster Survey (RCS), consisting of 100 square degrees of imaging in the Rc and z´filters, is the largest moderately-deep imaging survey currently being carried out. The primary goal of the survey is to identify a large sample of galaxy clusters over a broad redshift and mass range, suitable for a number of studies focused in the areas of cosmology and galaxy evolution.

Critical to the success of the RCS has been the development of a new method for finding galaxy clusters. This method solves the problem of projection that has plagued previous deep optical cluster searches. A detailed justification for the method in the context of current knowledge of galaxy clusters is given, as well as a detailed description of the cluster-finding algorithm. It is argued that this method, in conjunction with the imaging now available with large-format cameras on moderate-sized telescopes, represents by far the most efficient method for detecting galaxy clusters to at least redshift one.

The survey strategy of the RCS is described, as is the data processing pipeline. A cluster catalog based on an analysis of the first two complete survey patches (of twenty-two) is also given. This catalog is analyzed using photometric methods to produce an estimate of the redshift evolution of the cluster-mass spectrum, $N(M,z)$. Combined with detailed modeling of the RCS cluster selection functions, and large scale n-body simulations from the literature, the measured $N(M,z)$ shows that it is possible to measure cluster masses using only photometric data. Eventually, a similar analysis using the entire RCS sample will provide strong constraints on the matter density of the universe, $\Omega_M$, and the normalization of the cosmological power spectrum, $\sigma_8$.

A detailed description of a newly discovered RCS cluster, RCS J02254-0002, is also given. RCS J0224-0002 is likely the single most striking strong-lensing cluster ever discovered, and some of the potential of such systems is described. A quick description of five other strong-lensing systems discovered in the RCS is provided; together these systems represent a major new sample of strong-lensing clusters.

This thesis concludes with a summary of much of the other work being done with RCS data and an indication of some of the followup currently planned or in progress. We also briefly describe plans for RCS-2, and argue that cluster surveys at $z < 1$ using X-rays or the SZ effect are inefficient in comparison with optical surveys in light of these planned data.

## OUTREACH: WHY YOU SHOULD DO IT, AND HOW TO SUCCEED


By John R. Percy

*Department of Astronomy & Astrophysics, University of Toronto*

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Astronomers can learn and pursue their profession or hobby in isolation. They can also share it with others through education and outreach. The terms Education and Outreach are sometimes used interchangeably, or are used to refer to formal and informal education, or to school and public education, respectively. The two are related: science education in the schools is strongly affected by the many channels for public education — notably the mass media; public understanding and appreciation of science begins in school. Hereafter, I will use the term Education and Public Outreach (initialism E/PO), which is widely used in the US where there is lots of money from government and private sources to support it.

E/PO is essential to attract and train the next generation of professional and amateur astronomers. We do not expect every student to become a professional astronomer, but we want to ensure that those who do are well prepared. Amateur astronomy also needs to attract young people, especially women, minorities, and other under-served groups. E/PO is also essential to promote public awareness, understanding, and appreciation of astronomy — most Canadian astronomy is supported by taxpayers. Astronomy is also an excellent vehicle for increasing science literacy in general, and science literacy is increasingly important for the health of our economy, our environment, our bodies and minds, and even our culture. E/PO (if done effectively) can present a positive image of astronomy, astronomers, and their institutions. As the following list shows, astronomy is useful for many reasons, and should be an integral part of our education system, and our culture!

- Astronomy is deeply-rooted in almost every culture, as a result of its practical applications, and its philosophical implications.

- Among the scientific revolutions of history, astronomy stands out. In the recent lists of "the hundred most influential people of the millennium", a handful of astronomers were always included.

- Astronomy has obvious practical applications: timekeeping; calendars; daily, seasonal, and long-term changes in weather; navigation; the effect of solar radiation, tides, and impacts of asteroids and comets with the earth.

- Astronomy has advanced the physical sciences by providing the ultimate physical laboratory — the Universe — in which scientists encounter environments far more extreme than anything on Earth. It has advanced the geological sciences by providing examples of planets and moons in a variety of environments, with a variety of properties.

- Astronomical calculations have spurred the development of branches of mathematics such as trigonometry, logarithms, and calculus; now they drive the development of computers: astronomers use a large fraction of all the supercomputer time in the world.

- Astronomy has led to other technological advances, such as low-noise radio receivers, detectors ranging from photographic emulsions to electronic cameras, and image-processing techniques now used routinely in, for example, medicine and remote sensing. Its knowledge is essential as humankind enters the era of space exploration.

- Astronomy, by its nature, requires observations from different latitudes and longitudes, and thus fosters international co-operation. It also requires observations over many years, decades, and centuries, thus linking generations and cultures of different times.

- Astronomy reveals our cosmic roots, and our place in time and space. It deals with the origins of the Universe, galaxies, stars, planets, and the atoms and molecules of life — perhaps even life itself. It addresses one of the most fundamental questions of all — are we alone in the Universe?

- Astronomy promotes environmental awareness, through images taken of our fragile planet from space, and through the realization that we may be alone in the Universe.

- Astronomy reveals a Universe that is vast, varied, and beautiful — the beauty of the night sky, the spectacle of an eclipse, the excitement of a black hole. Astronomy thus illustrates the fact that science has cultural as well as economic value. It has inspired artists and poets through the ages.

- Astronomy harnesses curiosity, imagination, and a sense of shared exploration and discovery (I think Doug Cunningham was the first to put this so eloquently).

- Astronomy provides an example of an alternative approach to "the scientific method" — observation, simulation, and theory — in contrast to the usual experiment and theory approach.

- Astronomy, if properly taught, can promote rational thinking, and an understanding of the nature of science, through examples drawn from the history of science, and from present issues such as pseudo-science.

- Astronomy, in the classroom, can be used to illustrate many concepts of physics, such as gravitation, light, and spectra.

- Astronomy, by introducing students to the size and age of objects in the Universe, gives students experience in thinking more abstractly about scales of time, distance, and size.

- Astronomy is the ultimate interdisciplinary subject, and "integrative approach" and "cross-curricular connections" are increasingly important concepts in modern school curriculum development.

- Astronomy attracts young people to science and technology, and hence to careers in these fields.

- Astronomy can promote and increase public awareness, understanding, and appreciation of science and technology among people of all ages.

- Astronomy is an enjoyable, inexpensive hobby for millions of people.

Finally, you should consider doing education and outreach because it is deeply rewarding and satisfying. You are sharing your passion with people who, by and large, are thirsting for it, and appreciate it.

Because astronomy has so many facets and dimensions, there are many different reasons why students and the public might want to learn about it. There are also many different venues, other than school and university classrooms: planetariums and science centres; astronomy clubs; newspapers, magazines, and books; TV and radio; the Internet; on hikes and at camps (Fraknoi 2001). All of these provide opportunities for astronomers to work with other educators and communicators in an enjoyable and effective way.

### Forms of Education and Outreach

The many forms of E/PO can be illustrated by the remarkable work done by the RASC, its Centres and members, and by other astronomy clubs; they bring their knowledge, their enthusiasm, and their telescopes to Canadians, young and old, across the country. This work includes the following: hundreds of public lectures each year, with attendances of up to several hundred people; over two hundred "star parties" given by the RASC alone, with attendances up to two thousand people; network and cable TV and radio programs and interviews; newspaper and magazine articles and interviews; open houses at observatories and planetariums; exhibits and displays; Astronomy Day and other special events; school visits and star parties; Web sites; publications such as the *Observer's Handbook* and *The Beginner's Observing Guide*. Many RASC E/PO activities are done in partnership with other organizations — astronomical and otherwise. I estimate that the RASC reaches 400,000 Canadians each year!

Professional astronomers, graduate and undergraduate students also engage in E/PO activities of many kinds. Most university astronomy departments have public lectures and open houses (especially on Astronomy Day), and provide advice and assistance to teachers, students, and the public. Some of these activities are done through programs such as the award-winning Let's Talk Science. It's especially important to expose undergraduate students to E/PO as an exciting activity and possible career.

### The Canadian Astronomy E/PO Initiative

In 2001, the Canadian Astronomical Society (CASCA), in partnership with the RASC and other organizations, embarked on a major E/PO initiative. This was motivated by several developments: (1) the report of a Long-Range Planning Panel for astronomy in Canada; (2) the appearance of astronomy in the school science curricula in many provinces; (3) heightened interest in and concern about science literacy and education; (4) two decades of E/PO experience in the US, funded by NASA, the National Science Foundation, and other organizations; (5) the availability of (modest) federal and provincial funding support for science E/PO in Canada.

The initiative is administered by CASCA and its Education Committee, with input from an Advisory Board, including representatives of the RASC and other partners. With limited funding, the initiative must be selective, and designed to provide maximum leverage; it will be targeted through educators (broadly defined) to young people in schools and youth groups, but organized in such a way that anyone interested in astronomy can benefit. The centrepiece will be a Canadian astronomy education Web site, with information and resources that are directly relevant to the needs of the target audiences; some of those needs are described elsewhere in this article. The Web site will support the E/PO activities of professional and amateur astronomers, graduate and undergraduate students, educators at all levels, in all settings. Workshops will be organized to help educators — teachers, youth group leaders, and astronomers — make use of the resources, *i.e.*, to implement a "train the trainers" approach. This will be done through a "network and nodes" structure, spanning the country, and by partnering with other like-minded organizations. The emphasis will be on identifying and disseminating exemplary existing material; new material will be developed only if necessary.

### Needs Surveys

As part of the Canadian astronomy E/PO initiative, we have carried out small surveys among three participant populations: RASC Centres, Grade Nine teachers, and Science Consultants.

RASC Centres interested in starting or expanding their E/PO activities, and presumably other astronomy clubs, requested the following, in descending order of priority: (1) a Canadian astronomy education Web site; (2) curriculum-related materials, activities, and resources; (3) information on effective teaching and learning of astronomy; (4) information on sky events and phenomena; (5) images, slides, posters; (6) workshops on education and outreach; and (7) "templates" for school visits.

Astronomy is now a compulsory part of the grade nine science curriculum in Ontario and many other provinces. Teachers have little or no background in astronomy, and need as much support as they can get. They request, in descending order of priority, the following curriculum-linked items: (1) student activities; (2) audio-visual materials; (3) on-line resources; (4) guides to the implementation of the curriculum; (5) astronomy guest speakers; (6) regional workshops; (7) opportunities for field trips; and (8) software.

Science Consultants for school boards had very similar requests: (1) regional workshops; (2) on-line resources; (3) background information about curriculum topics — videos, for instance; the curriculum now includes several difficult topics such as the origin and evolution of planetary systems, the life cycles of stars, and the origin and evolution of the Universe; (4) astronomy guest speakers; and (5) information about sky events, and school star parties, if possible.

These suggestions will be very helpful to the Canadian astronomy community in developing its national E/PO initiative. A Canadian astronomy education Web site is a high priority. It must be selective, listing and linking to materials that are relevant and exemplary. Teachers especially do not need "yet another Web site"; they need a site that is curriculum-relevant and user-friendly; it must be "steak, not sizzle".

### What People Know about Astronomy

Those who embark upon astronomy E/PO are amazed at the apparent breadth of peoples' interest, especially among young children. Many people know quite a bit about astronomy, but much of it is deeply incorrect. Indeed, Professor Neil Comins (2001) has written a whole book about astronomy misconceptions, and has a list of over 1700 of them on his Web site. Comins (1998) has also divided these misconceptions into at least 16 classes. Some are truly conceptual in nature ("seasonal changes in temperature are due to the changing distance of the Earth from the Sun") but others are due to such causes as language ("weightlessness" indicating that there is no gravity in space), incomplete observations ("the Moon is only visible at night"), religious belief ("creationism") and popular culture ("UFOs are alien spacecraft"). One way to become aware of misconceptions is to read the literature. Another is to talk in depth with students and the public. And, astronomy instructors know that another way is to read the bizarre answers that students often give on exams!

### Why Do People Acquire Misconceptions?

Faulty knowledge of astronomy can be ascribed to deficiencies in science education. Those who are knowledgeable about astronomy sometimes find it difficult to understand why others are less knowledgeable. In fact, the learning of science is not a trivial process; it occupies the efforts of hundreds of education researchers worldwide. And remember that teaching and learning are two different things; only a small fraction of teaching actually results in learning!

### How People Learn

It is commonly believed that learning can occur through listening to lectures, and reading textbooks. The brain is thus filled, as an empty glass is filled with water. Learning is a much more complex process than that. There are a number of theories of learning, each of which highlights one or more aspect of this complex process.

Bruner's Constructivist Theory emphasizes that learning is an active process in which learners construct new ideas or concepts, based on their current and past knowledge; this current knowledge may not agree with accepted scientific understanding! Constructivism therefore implies that, for learning to occur, the students' minds must be engaged; "hands-on" activities are not sufficient. Piaget's Developmental Theory pointed out, many decades ago, that learners' ability to construct new knowledge depended on their stage of cognitive development; for instance, students much younger than 12 years old are unlikely to be able to develop an understanding of the cause of Moon phases. Vygotsky's Social Development Theory emphasizes the role of social interaction in the development of cognition; in fact, group learning is increasingly used in universities — especially in professional faculties. Gardner's Multiple Intelligences Theory suggests that there are seven different forms of intelligence that each individual possesses in varying degrees: linguistic, musical, logical-mathematical, spatial, body-kinesthetic, intrapersonal (insight), and interpersonal (social); naturistic (an appreciation of nature) has been suggested as an eighth intelligence. All of these can be used, to a greater or lesser extent, in the teaching of science. For more information about these and other learning theories, see the Web site listed under "Resources" below. Effective teaching and learning should incorporate as many of these theories as are appropriate. And teachers should always be on the lookout for misconceptions, and for incomplete or ineffective learning.

Students learn more effectively when they are interested in the subject matter, and learn less effectively when they are bored. Astronomy can be an intrinsically interesting subject — having a visiting astronomer in the classroom adds interest and variety. It also reminds the students that science is a human endeavour.

In summary: educators know a great deal about effective teaching and learning of astronomy (the problem is in implementing this knowledge):

- Students form new concepts by building on old ones; their minds are not blank slates.
- Students (and many teachers) have deeply-rooted misconceptions about astronomical topics; many of these are based on even deeper misconceptions about topics such as light and gravity.
- Most students have difficulty visualizing three-dimensional concepts, or concepts involving different "frames of references" — Moon phases, for instance.
- Concepts must be introduced in logical order, and at the right stage of cognitive development.
- Teachers at all levels over-estimate what their students learn.
- Inquiry-based teaching, including hands-on activities, discussion of patterns, possible explanations, and predictions, are the most effective way of teaching; lecturing is the least effective way.
- Teaching more astronomy should give way to teaching it better.
- Expertise in astronomy does not guarantee expertise in teaching it; university professors (who normally receive no training in teaching) are the ultimate amateurs.
- All teaching should be subject to research, evaluation, and improvement.

Teachers can also benefit from astronomers in the classroom. Few teachers have any background in astronomy, or astronomy teaching. In fact, they tend to have the same misconceptions as do students and the public. They need and deserve our support. Remember, though, that they are education professionals who understand effective teaching and learning, so we can learn much from them.

## Astronomers in the Classroom

If you are visiting a classroom or youth group (or even if you are giving a public lecture), there are a few basic issues that you should keep in mind. One is to ask, "why am I visiting this classroom?" or, "why am I giving this public lecture?" Is it to inform, inspire, or entertain? Or all three? Another interesting question is what your audience expects you to be like; what is their stereotypical image of an astronomer? For a classroom visit, you could ask the teacher to ask the students to draw a picture of you the day before your visit. You may be surprised and amused by the result! When you actually appear in the classroom, introduce yourself, and tell the audience a little about your background and your passion for astronomy. In a public lecture, the introducer may give some of this information, but it does not hurt to establish a personal human link with your audience right from the start.

This leads to a second kind of audience involvement: the question period. In a grade 6 class, I can spend an hour, just answering questions. And the questions rarely have anything to do with day and night, seasons, and Moon phases! Often, I ask the teacher to take a few minutes on the day before my visit and get each student to write down one question that they would ask an astronomer. This develops their writing skills and also allows each student to participate in the discussion — not just the most assertive ones. I can quickly sort these questions before the question period. I can also take the questions home with me and put the answers on the FAQ page of my Web site (see Resources). Another good source of answers to FAQs is Dickinson (1993).

Adults also ask questions; in my experience, the older the adult, the more (and the more interesting) their questions (Percy & Krstovic 2001)!

Many class visits are a once-only affair; the astronomer drops in and out, never to be seen again. There are advantages to multiple visits: the class gets to know the astronomer; the astronomer and the teacher have an opportunity to learn from each other. Project ASTRO is a project of the Astronomical Society of the Pacific, funded in part by the US National Science Foundation. It has several functions: supporting ongoing partnerships between teachers and amateur and professional astronomers; emphasizing the sharing of enthusiasm; reaching out to underserved groups; and involving families and community groups through Family ASTRO. Project ASTRO produced a wealth of material for astronomer-teacher partnerships, including several dozen hands-on activities that have been well tested; see the Resource section below. Among the favourites are:

`www.astrosociety.org/education/astro/act1/astronomer.html` (Picture an Astronomer)
`www.aspsky.org/education/tnl/01/01.html` (Invent an Alien)

www.nthelp.com/eer/HOAtpss.html (Toilet Paper Solar System)
www.aspsky.org/education/tnl/23/23.html#activity (Creating Craters)

### The School Curriculum

If you are visiting a classroom in elementary or secondary school, you should be aware that there is a curriculum to cover, and the teacher may want you to help. Canada does not have a national curriculum but, in the area of the sciences, there is the Pan-Canadian Science Project (Percy 1998), and the curriculum in most provinces is aligned with this. Dodd (2002) has published an excellent summary of the place of astronomy in the Canadian curriculum (K-12) in this *Journal*. Generally, grade 1 introduces the daily and seasonal cycles. Grade 6 introduces the physical characteristics of the objects in the Solar System, and the causes of the changes that we see from earth as a result of the movements of these objects; it also introduces space science and technology. Grade 9 introduces a deeper understanding of the Solar System and the Universe, and of space science and technology; investigations into the appearance and motions of visible celestial objects; and an appreciation of Canadians' contributions to space and astronomy. The Ontario grade-9 astronomy/space unit also includes three advanced topics: theories of the origin and evolution of the Solar System; the life cycles of the stars; and theories of the origin and evolution of the Universe. These topics were to be included in a grade 11/12 course, but were "dropped down" when the grade 11/12 course did not materialize in this province. These advanced topics make the unit extra-challenging for both teachers and students. A grade-12 course in Earth and Planetary Science was eventually developed in Ontario (without the more astrophysical topics), but it is not clear how many schools will offer this course.

At the high-school level, courses in Ontario are divided into "academic" and "applied", the former being more theoretical, and the latter being more practical. Astronomy, of course, naturally divides into the theoretical and the practical. Many amateur astronomers' interests — telescopes, instruments, computers, the night sky — are ideally suited for the applied courses.

The curriculum specifies more than just content. To quote the Ontario grade-9 and -10 science curriculum (Queen's Printer for Ontario 1999): "*The overall aim of the secondary science program is to ensure scientific literacy for every secondary-school graduate*" (my italics). The secondary-science program, from grade-9 through grade-12, is designed to achieve this aim by promoting and meeting three overall goals for every student:

- to understand the basic concepts of science;
- to develop the skills, strategies, and habits of mind required for scientific inquiry;
- to relate science to technology, society, and the environment."

While your classroom visit may convey concepts in astronomy, it can also illustrate how astronomers work and think (skills, strategies, and habits of mind), and how astronomy relates to technology (telescopes and computers), society (the many uses of astronomy mentioned above), and the environment (the night sky, and the loss thereof due to light pollution). Your presentation may introduce students to the beauty of the cosmos, and your enthusiasm may leave students with a very positive attitude to our science. This may be more important than any content that you convey.

### Youth Groups

Youth groups such as Guides and Scouts have astronomy in almost every level of their programs. The purposes, however, may be different from those of the school curriculum: in Guides, one purpose is to introduce girls to science as an interest and a career; in Scouts, much of the emphasis is on practical outdoor astronomy. Since these youth groups normally meet in the evening, they are an ideal venue for introducing astronomy.

### Adult Learners

Not all learning ceases with graduation; there are millions of lifelong learners in Canada. J. Miller (2001) has made some interesting observations about who makes use of "informal" (out-of-school) learning in astronomy: males; people with children; people with education (especially science education); people with an established interest in science, especially astronomy. As I have recently pointed out (Percy & Krstovic 2001), later-life learners are an especially receptive and satisfying audience.

### Giving a Good Presentation

Whether you are giving a class or youth group presentation, or a public lecture, there are certain "golden rules" for giving a good presentation:

- Plan ahead: if you are visiting a classroom, talk with the teacher; if you are giving a public lecture, find out about the audience, and check out the lecture room.
- Don't worry if you are nervous: most people are (or should be); but try to be enthusiastic and lively!
- Make sure that all parts of the text and images on your visuals are actually visible (large font, appropriate colour), whether you are using slides, overheads, or PowerPoint; also, make sure that your voice is audible, especially if there are seniors in the audience; use a microphone (or speak loudly) if necessary.

- Organize your presentation! Start at a very basic level; divide your presentation into manageable segments (seven minutes is a typical attention span); summarize the segments, and summarize the presentation as a whole.

- Be clear and concise: avoid unnecessary jargon; define any new terms, and keep them to a minimum; this is especially important if there are ESL (English as a Second Language) students in the group.

- Use analogies and other examples from everyday life; use demonstrations and hands-on activities, especially in the classroom.

- Know how much time you have, and keep to it; rehearse, rehearse, rehearse!

Some of these same rules apply if you are participating in a star party and answering questions at your telescope. Remember that most of your viewers will be unfamiliar with astronomical terminology, and with the 3D geometry that produces the effects you see in moon phases, the moons of Jupiter, and the rings of Saturn. There is no better way to learn how to explain things simply and vividly than to read an article or book by Terence Dickinson!

### Partnerships, Networks, and Nodes

The Canadian astronomy E/PO initiative will succeed if members of the astronomical and educational communities work together, as partners. That means professional and amateur astronomers, and educators of all kinds. Every partner has something to offer. Good partnerships are based on communication and respect.

We envision a structure in which astronomy education resources are identified (and created only if necessary), and disseminated through a national network in many ways. A Web site will be useful, but is not always sufficient. A related need would be for workshops to "train the trainers" in all parts of the country. This can be accomplished through a system of "nodes".

Nodes may be located in major cities, and/or any centre where there is astronomical activity. The nodes are made up of members of the local astronomical and educational community. In 2002, we re-established the Greater Toronto Area node. It includes representatives of two universities, the RASC, the Ontario Science Centre and Royal Ontario Museum, the Canadian Space Resource Centre, the Toronto District School Board, and a science journalist or two. Two activities were: (1) to organize a one-day workshop for teachers on Astronomy Day 2002, and (2) to organize a series of star parties across the GTA to see the array of five naked-eye planets in April-May 2002. In Montreal, there are plans to organize a node on the Project ASTRO model (see Resources below). Other informal nodes undoubtedly exist. We welcome suggestions about such a partner/network/node structure.

### Resources

**ACTUA (Hands-On Science and Technology for Youth):**
`www.planetactua.com`
**Canadian Careers in Astronomy:**
`www.hia.nrc.ca/STAFF/jpv/carr/careers.html`
**Ontario Curriculum:**
`www.edu.gov.on.ca/eng/document/curricul/secondary/science/scieful.html`
**Frequently Asked Questions:**
`www.utm.utoronto.ca/~astro/astrofaq.htm`
**Guide and Scout Astronomy:**
`www.utm.utoronto.ca/~astro/guidescout.htm`
**Hands-On Activities - General:**
`www.astrosociety.org/education/activities/activities.html`
**Hands-On Activities - Exemplary Pedagogical:**
`www.learner.org/teacherslab/pup/`
**Learning Theories:**
`www.funderstanding.com/about_learning.cfm`
**Let's Talk Science:**
`www.letstalkscience.uwo.ca`
**Long-Range Plan for Astronomy in Canada:**
`www.casca.ca/lrp/`
**Misconceptions:**
`www.umephy.maine.edu/ncomins/` and
`www.badastronomy.com/bad/misc/`
**Misconceptions: On-Line Questionnaire:**
`www.oise.utoronto.ca/~ewoodruff`
**NASA Picture of the Day:**
`antwrp.gsfc.nasa.gov/apod/`
**Project ASTRO, Family ASTRO:**
`www.astrosociety.org/education/astro/project\_astro.html`
**Public Speaking Tips:**
`www.toastmasters.org/tips.asp`
**Sky Information On-Line:**
`www.astronomy-watch.com/home.htm`

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## References

Comins, N.F. 1998, in New Trends in Astronomy Teaching, ed. L. Gouguenheim,

D. McNally & J.R. Percy (Cambridge UP: Cambridge), 118

Comins, N.F. 2001, Heavenly Errors (Columbia UP: New York)

Dickinson, T. 1993, From the Big Bang to Planet X (Camden House: New York)

Dodd, W. 2002, JRASC, 96, 114

Fraknoi, A. 2001, in Amateur-Professional Partnerships in Astronomy, ed. J.R. Percy & J.B. Wilson, ASP Conf. Ser. 220, 243

Miller, J.D. 2000, The Acquisition of Scientific Information about Astrophysics and the Universe, paper presented at the 2000 conference of the International Planetarium Society, Montreal PQ

Percy, J.R. 1998, JRASC, 92, 38

Percy, J.R., & Krstovic, M. 2001, JRASC, 95, 205

Queen's Printer for Ontario 1999, The Ontario Curriculum: Grades 9 and 10: Science



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# Astronomy Week/Day 2002 at the Kingston Centre

*by Kim Hay, Astronomy Day Co-ordinator (kimhay@kingston.net)*

Team work; that is what it is all about. We had a great team this year to help make this year's Astronomy Week/Day (April 15-21) a great success.

Eight Kingston Centre members set up their scopes at Murney Park, both at noon and at night to bring the sky a little closer to those who wished to stop by. We also supplied handouts on the Sun, and star maps of the upcoming planetary alignment. Though there was some cloud and rain, most of the week held clear.

Astronomy Day was held at the local Frontenac Mall. We had members (Hank Bartlett, Laura Gagné, and Mike Earl from Ottawa) and their telescopes set up outside showing the Sun, Jupiter, Mercury, and Venus.

Inside the mall we had six display tables with many interesting contributions from Centre members: Leo Enright displayed astrophotographs and posters: Peggy Hurley showed a painting of an aurora, which she did herself: Kim Hay brought along many different posters: and Hank Bartlett brought his moveable solar system, posters, and his galactic "friend," CSAR. We even had some interesting models to display; Don Mastrianni loaned us his model of the Hubble Space Telescope, and Kevin Kell loaned us his lunar-lander model. We also had a childrens' table set up and many youngsters stopped by to make playdough aliens, do word searches, and take home lunar projects.

Astronomy Day at the Frontenac Mall (all photos courtesy of Kevin Kell and Kim Hay).

We also had an Earth theme with Bill Broderick lending us his display of meteorites, which included samples from Canyon Diablo, Pallasite, a brecchia sample from Sudbury, and an Octahedrite slice showing the Widmanstatten pattern. Susan Gagnon made a wonderful poster of Canada's meteor impact sites. From the Queen's University Geology Department (thank you to Mark Badham) there was a selection of rock cores.

The 24-inch Venor Telescope, 10-inch A.V. Douglas Telescope, and the 4-inch Voyager Telescope.

There was also a StarLab portable planetarium (owned and operated by Theodore Micholias (`www.geminispace.com`)), which attracted a crowd of both young and old, with over 100 people in the six 20-minute shows that were put on.

There were several telescopes on display, including an inexpensive drugstore type to show people what features to avoid when purchasing a first telescope.

We also had a display from members of the Mars Society. It was a great opportunity to show the model of the Analog Rover Experimental System (ARES) to members of the public. The ARES team is a group of about 50 people from Ontario that is collaborating to build a prototype of a Mars exploration vehicle. Theirs will be one of over 20 entries in a competition being sponsored by the Mars Society. For more information visit (`www.engsoc.queensu.ca/ares`). There was also a model of the Devon Island Flashline Mars Arctic Research Station. T-shirts, memberships, and Mars globe balls were also available. If you wish to know more about the Mars Society visit `www.marssociety.ca`.

Our day did not end there. We went to the public observing area, Murney Tower, and set up our new 24-inch telescope (the Robert Venor Telescope). Here we had first light, with over 100 people, both public and members, showing up to view the magnificent sights. There were several other telescopes set up to let the public view the night sky. Though the day was clear and cool, the night brought out the clouds: Murphy's Law #1, when there is new astronomical equipment about, clouds will appear. We did manage to see the Moon and Jupiter through the Venor Telescope, and other interesting galactic wonders were seen in the other telescopes. For more information on the new telescope, visit the Kingston Centre's Web site: `www.rasc.ca/kingston`.

I thank everyone who helped out, those who showed up and spent some time with us, those with mighty muscles to help us put our displays together and tear them down, and those who created works of art, posters, and models. It helped us show that astronomy has many different forms.

From the feedback I have received from the mall liaison person, we did just that. They want us to come back again later in the year. That is a fantastic feeling. This is what it is all about — team work — to be able to achieve the presentation of our hobby to the public, and have them take a few moments and look up into the night sky, and say "Wow!"


Mars Society display with layouts of the Rover, Space Hut on Devin Island, and the poster display.

*Kim Hay has just recently moved to Yarker, Ontario, Dark Sky Country to enjoy the night skies and new house with Kevin and their family of cats. Kim is also involved with the RASC as National Secretary, and at the local level as the Public Relations Coordinator and Light Pollution Committee chair. Other hobbies are gardening, and amateur ham radio (VA3KDH).*

# Canada-Wide Science Fair 2002

*by Frederick R. Smith, National Awards Committee (frsmith@morgan.ucs.mun.ca)*

## National Awards Committee

Once again it was a great pleasure to be a judge for the RASC Awards in a Canada Wide Science Fair. The CWSF2002 was held May 11–19 at the University of Saskatchewan in Saskatoon. Over 200 judges evaluated 340 projects during a two-day period. The first day of judging was for medals in the various divisions and the second day was for "Special Awards" offered by donors such as the RASC. There are many Special Awards but students could nominate themselves for a maximum of seven, based on the nature of their projects and the criteria for the awards. There were four Junior, two Intermediate, and two Senior nominations for the RASC Awards.

Award for Excellence
in Astronomy
Sponsored by the
Royal Astronomical Society
of Canada
$200 and a 1-year membership
in the RASC

The Senior project, submitted by Élise Solomon, Est du Québec, was entitled "L'ultime destin." It dealt with the structure of the Universe and the amount of mass that determines whether the Universe is open, closed, or flat, as well as the possible outcomes based on values above or below the critical value.

Sarah Ball, Western Newfoundland, submitted the winning Intermediate project, "Mars 2002," in which she used a combination of Visual Basic and Adobe


Jonathan Massey-Allard won the Junior Award of Excellence in Astronomy at the 2002 Canada-Wide Science Fair for his project "Une Classification Céleste."


The 2002 Intermediate Award was presented to Sarah Ball for her project "Mars 2002."

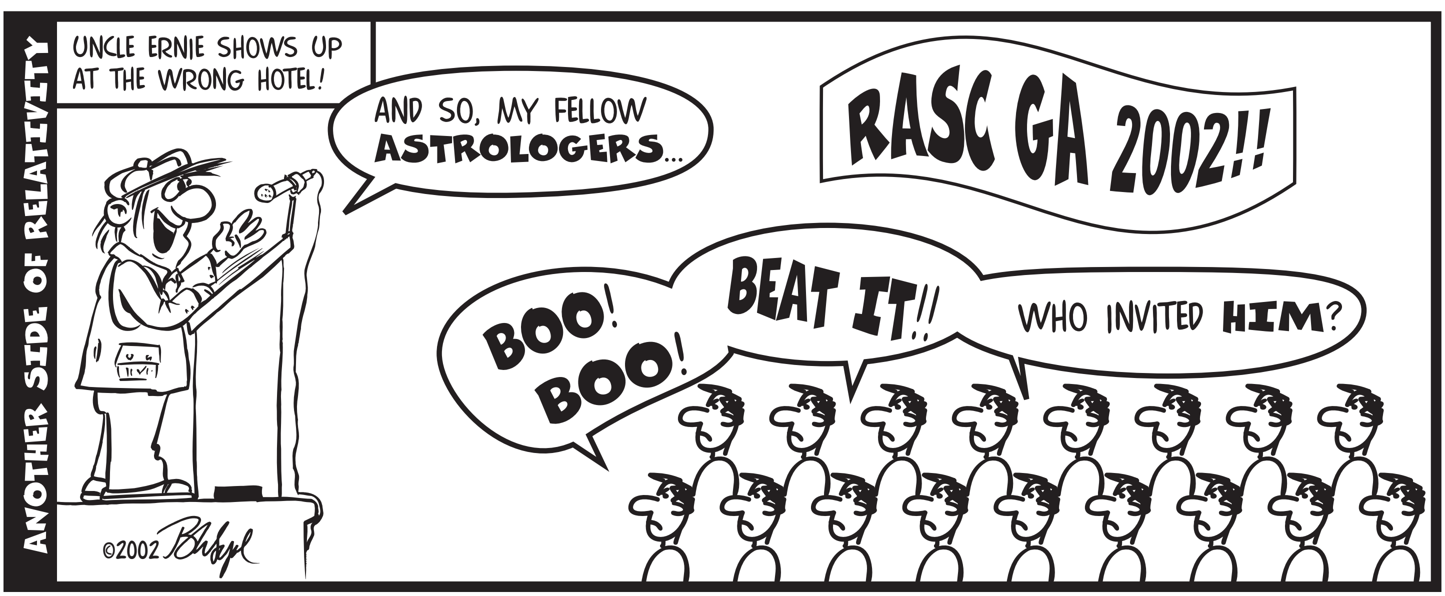
Photoshop to produce a computer program to teach astronomy to elementary-school students. The project dealt only with Mars but work on the other components of the Solar System is in progress.


The Senior Award was presented to Élise Solomon for her project "L'ultime destin."

The Junior winner was Jonathan Massey-Allard, from Frontenac, Lennox and Addington, who wrote a computer program, "Une classification céleste," that classifies stars by their spectra. His program can analyze a star's spectrum and classify the star in the OBAFGKM system.

All the students judged were very knowledgeable and enthusiastic. In fact, it was not possible to stop judging after the designated 20 minutes because they wanted to keep talking about their projects and discuss their future plans. Judging is tiring but very rewarding; the kids are great. It was a pleasure to represent the RASC National Awards Committee at CWSF 2002 and I am looking forward to next year's CWSF, which will be held in Calgary.

The 2004 Canada Wide Science Fair will be held in St. John's, a little over a month before the RASC GA, which will also be held in St. John's. For more information about CWSF 2004 or RASC GA 2004 contact Fred Smith, Office of the Dean of Science, Memorial University, St. John's NF A1B 3X7 or `frsmith@mun.ca`.



# Moonrock & *Roll*

*by Bruce McCurdy (bmccurdy@telusplanet.net)*

> *"The moon cradle's rocking and rocking*
> *as a cloud and a cloud go by*
> *silently rocking and rocking*
> *the moon cradle out in the sky."*
>
> — Loreena McKennitt "Moon Cradle"

The invention of the telescope triggered an explosion of astronomical discovery. Within months of constructing his first "spyglass" in 1609, Galileo resolved the Milky Way into countless individual stars, discovered the moons of Jupiter, the phases of Venus, and the rings of Saturn (although he couldn't discern their true nature). Galileo also methodically observed the Moon, noting craters and mountains and proving conclusively that it was anything but the perfectly smooth sphere envisioned by Aristotle.

But Galileo didn't do it all. Doubtless his was a singular intellect; his fame, however, more resembles a singularity, a gravitational well whose accretion disc has swallowed whole the discoveries of some of his contemporaries. In some circles, he is often credited with the invention of the telescope itself. Indeed, Galileo was not the first to use a telescope even for astronomical purposes, a common misperception that was perpetuated in this column a while back. The man who seems to have been the first telescopic astronomer is a particular victim of Galileo's reputation, namely the English mathematician, scientist, and philosopher Thomas Harriot. While he may have been something of a scientific dilettante, Harriot dabbled on the cutting edge of the New Astronomy. He is considered by at least one noted historian to have been the first to observe sunspots (Koestler 1959), before quickly turning his crude "trunke" towards the much safer Moon. Likely the first telescopic visual observer of Earth's only satellite, Harriot was certainly the first to sketch an eyepiece view on July 26, 1609. A couple of years later, on a page of notes referring to this earlier sketch, Harriot observed:

> "1611 Decemb. 14th... I noted that the darker partes of [Sinus Roris and Mare Frigoris] were nerer the edge then is described." (Whitaker 1989)

Harriot was thus the first person to observe the peculiar effect known as lunar libration. As with the rest of Harriot's firsts, this discovery is commonly attributed to Galileo, who did attempt the first crude physical explanation of this phenomenon.

Lunar libration was one of the most subtle of these early telescopic discoveries. Ironically, a telescope is not required to observe this effect. It seems early astronomers took for granted that the exact same side of the Moon was always fixed towards Earth, a widely accepted inaccuracy to this day. But the careful moonwatcher who makes a series of observations over a period of time can note shifts in position of major features, whether using a telescope, binoculars, or the naked eye.

It is true that the Moon rotates on its axis exactly once per orbit around Earth, but this orbit is irregular enough to make the Moon appear to rock back and forth, up and down, in a slow, hypnotic dance, precariously balanced on its central coordinates. Indeed, the very word *libration* stems from the Latin word for balance (as does the constellation Libra, the Scales). Although it tends to be glossed over in recent astronomical texts, libration was one of the visible effects of lunar orbital mechanics that received the attention of many of the greatest astronomers and mathematicians of the 17th and 18th centuries. According to one historical account, "This is a complicated subject; nevertheless some attempt had to be made to come to terms with it, since the Moon's librations enter inextricably into all observations of the lunar features, most especially those in the neighbourhood of the limbs." (Sheehan & Dobbins, 2001) Isaac Newton correctly explained the principles of all three of the optical librations in his *Principia Mathematica*. J.D. Cassini, perhaps better known for his observations of Saturn, deduced the three laws of lunar rotation, and J.L. Lagrange solved the complex lunar orbit to an extraordinarily complete degree.

There are two significant types of libration that will receive most of our attention here. The first is called *optical libration of longitude*, which is the apparent shifting of the Moon in the east-west dimension. The Moon has a strongly elliptical orbit, in fact the most eccentric of any major satellite in the solar system. At closest approach to Earth (*perigee*) it can be as much as 12 percent closer than at its most distant point (*apogee*). In accordance with Kepler's Second Law of orbital motion, the closer to Earth it is, the faster its orbital speed. However, Cassini's First Law states that the Moon rotates on its own axis at a constant speed.

By definition, the Moon exhibits zero libration of longitude when it is at either perigee or apogee (*the line of apsides*). Midway between the two, however, the terrestrial observer can see as much as 7°54′ beyond the eastern and western limbs (Rükl 1991). The effect is fairly pronounced between four and ten days after perigee on the eastern limb (*i.e.* lunar east, or celestial west), and the same interval before perigee on the western.

Libration of longitude can be observed with the unaided eye, or more easily with binoculars, by following the position of Mare Crisium (the Sea of Crises). The only major mare that is disconnected from the others, Crisium is the large, dark, circular feature situated near the E.N.E. limb of the Moon. Conveniently, it is in sunlight when the Moon is most easily seen in the evening hours, from roughly the three-day-old crescent phase to three-days-after-full phase. Over that two-week period, Crisium can be seen to shift to one of its extremes, where its eastern edge nearly "touches" the lunar limb, or where it appears fully its own diameter removed from it.

The second significant wobble is the *optical libration of latitude*. The Moon's orbit is tilted to the ecliptic, the plane of the Earth and Sun, by just over five degrees (5° 8′ 43.4″). Furthermore, the Moon's poles are inclined to the ecliptic by a further degree and a half (1° 32′ 32.7″), and the planes of these effects are aligned in such a way that the two tilts are always added together, as described by Cassini's Second and Third Laws (Meeus 1997). The net effect is that the lunar poles tilt an apparent 6° 50′ toward, then away from, Earth during each orbit.

Each month the Moon crosses the ecliptic at two points called *nodes*. By definition, there is zero libration of latitude when the Moon is crossing either of the nodes.

Libration of latitude can be tracked by observing Harriot's example, Mare Frigoris (the Sea of Cold), the long narrow mare that some see as the rabbit's ears, alternately nod towards and away from the northern limb.

The combined result of these two effects means that, while at any given moment an observer can see no more than 50% of the lunar globe, over time some 59% of the surface can be observed. 41% is always visible, an equal amount completely out of view, while the remaining 18% rocks back and forth into our line of sight. This is analogous to the celestial sphere visible from a high latitude: circumpolar stars that never set, an equal circle of anti-circumpolar stars that never rise, and a middle zone whose stars are best seen during particular seasons. The well-organized observer can take advantage of those times.

One thing to bear in mind is that the best region visible on the Moon at a certain time depends on the combination of librations of both latitude and longitude. If the Moon is a few days past perigee and is well south of the ecliptic, this is an ideal time to look at the northeastern quadrant. One can see a sliver of the "far side," in the so-called libratory zone. As these regions are at best situated on the limb, they are still very difficult to observe due to foreshortening. However, it is equally important to realize that nearside features near the limb are more favourably shifted towards the observer, and are much more easily seen at gibbous phases during times of favourable libration. Again using the celestial sphere as an analog, imagine taking a southern vacation. The instinctive response is to peer at the very southern horizon for new stars and constellations, but perhaps the best advantage is to reexamine areas which are low in the observer's home sky but are now higher and much better seen.

Librations are measured by the amount of displacement of the mean centre of the lunar disk from the apparent centre (Meeus 1991). For example, a libration of 6° south, 2° west, would place the crater Herschel, whose own coordinates are 6°S., 2°W., at the apparent centre of lunar disk. The SSW limb would be favourably rotated towards Earth. Sometimes librations are shown as a net displacement figure with a position angle, measured from north through lunar west (celestial east).

It must be pointed out that although both types of libration occur in monthly cycles, we are not referring to exactly the same "month" in both instances. Whereas the Moon itself makes a complete orbit against the background sky in about 27 days 8 hours (*sidereal month*), the cycle from one ascending node to the next (*draconic month*) is about three hours shorter at 27 days 5 hours, while the period between perigees (*anomalistic month*) is about five hours longer at 27 days 13 hours. This eight-hour difference between the draconic and anomalistic month means that libration angles change slightly from one month to the next. In general, the short term patterns are consistent enough that the current libration will be almost exactly opposite in 14 days, meaning a feature poorly tilted on the morning terminator will in a fortnight be favourably situated on the evening terminator. Also, a libration at a given phase (*e.g.* full Moon) will be approximately opposite in six months.

A full and fabulously complex cycle of librations occurs over a period of six years, three days. That this period equals exactly one third of a Saros cycle is no fluke. This 18-year-plus-10-day periodicity familiar to eclipse-chasers consists of almost exactly 242 draconic and 239 anomalistic months, meaning that the two will go in and out of phase with each other three times in a Saros. Looked at another way, the lunar nodes gradually retrograde westward along the ecliptic, completing a full circuit in 18.6 years (*regression of the nodes*). Meanwhile, the semi-major axis of the Moon's orbit advances eastward, completing its cycle in 8.85 years (*advance of perigee*). In an 18-year Saros period, therefore, the line of apsides will have completed roughly two laps in one direction, and the nodes one lap in the other.

Finally, and perhaps most importantly, we must remember that the time for the Moon to go through its phases (*synodic month*) is significantly longer than any of the others at 29.5 days. This is because after a month, the Moon has to go through approximately one twelfth of its next orbit to again line up with the Sun. A libratory zone may be very favourably angled towards Earth, but it will still be tough to see if it is on the unlit portion of the Moon! This is a direct effect of Earth's orbit around the Sun; for lunar nearside features the patient observer will get a chance within a few months to peek at the same region under favourable lighting conditions, but the libratory zones themselves may not be available for up to six years. (Westfall 2000)

Other types of observationally insignificant libration have also been measured. *Diurnal libration* (in longitude) is an effect of parallax that can theoretically be seen near moonrise and moonset, as observers on opposite sides of Earth see the Moon from slightly different angles. Librations are calculated from a geocentric perspective; however the observer's topocentric position can be a full Earth radius to either side, allowing a slightly more favourable view of that limb of the Moon that is furthest from the horizon. This effect is small, however, about one degree in total, and is most noticeable when the Moon is near the horizon and poorly seen. A similar shift occurs in latitude that can more accurately be described as a bias than a libration, as it is fully dependent on the observer's terrestrial latitude. An observer stationed in the far north (say, Edmonton, Alberta) will always get a better view of the Moon's north polar region than the south at otherwise similarly favourable librations. Finally, there is a *physical libration* — an actual wobble of the Moon itself due to gravitational irregularities — that amounts to only half a second of arc, far beyond the "scope" of any amateur.

Galileo, Newton, Cassini, Lagrange. All of these worthies have been immortalized by a crater named in their honour on the lunar nearside; all except poor Thomas Harriot whose contributions seem to be permanently lost in the glare of his famous contemporary, Galileo. Harriot's own crater is buried deep on the far side of the Moon, ironically beyond observation even at the most favourable of librations.

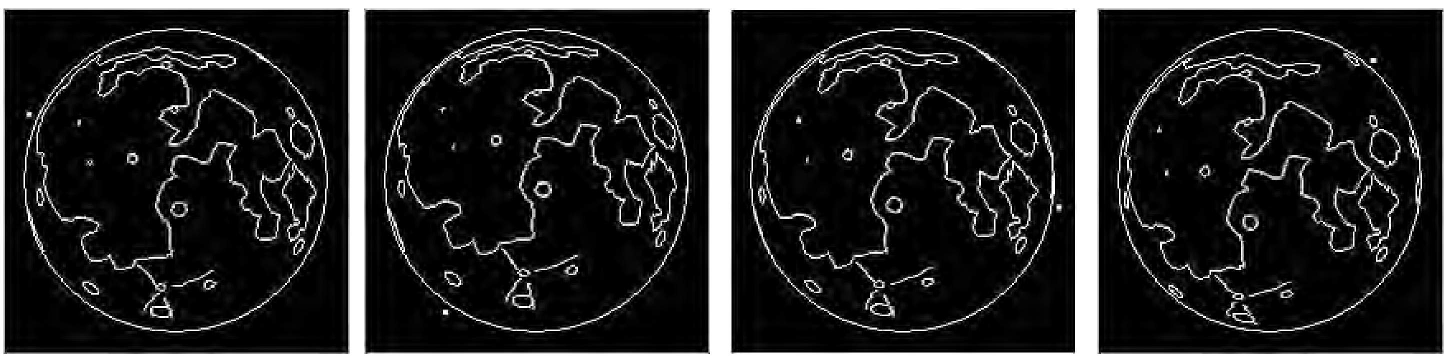


Fig. 1(a) Fig. 1(b) Fig. 1(c) Fig. 1(d)

**About the Figures**

The elusive libratory zones best reveal themselves at Full Moon, when the terminator effectively encircles the Earth-facing side resulting in low lighting levels on all limbs. The above figures demonstrate librations, indicated by the white dot, at three-month intervals starting in November 2002. (all dates UTC)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2002/11/20/01:32 | Lib: | 2.6° | PA: | 55° | (N: | 1.5 | E: | –2.1) |
| 2003/02/16/23:51 | Lib: | 7.5° | PA: | 144° | (N: | –6.1 | E: | –4.4) |
| 2003/05/16/03:36 | Lib: | 0.9° | PA: | 263° | (N: | –0.1 | E: | 0.9) |
| 2003/08/12/04:47 | Lib: | 7.8° | PA: | 327° | (N: | 6.6 | E: | 4.3) |

The librations of February and August 2003 are significant and will allow good opportunities to view the SW and NE libratory zones respectively (note the relative positions of Mare Crisium). In November 2002 and particularly May 2003 librations are minimal, affording a much poorer opportunity to view the NW and E libratory zones. The N/S libration of only 0.1° in May 2003 indicates the Full Moon is extremely close to a node, resulting in a total lunar eclipse.

The figures have been provided courtesy of Alister Ling and his Lunar Calculator program, which provides much useful information for lunar observers including librations. Shareware version available at RASC Edmonton Centre Web site at `www.edmontonrasc.com/software/software.html#1`.

## References

Koestler, A. 1984, The Sleepwalkers: A History of Man's Changing Vision of the Universe, (Penguin: New York), 436

Ling, A. 2001, Lunar Calculator 1.53, `www.edmontonrasc.com/software/software.html#1`

Meeus, J. 1997, Mathematical Astronomy Morsels (Willmann-Bell Inc.: Richmond), 29

Meeus, J. 1991, Astronomical Algorithms (Willmann-Bell Inc.: Richmond), 341

Rükl, A. 1991, Hamlyn Atlas of the Moon (Paul Hamlyn Publishing: London), 8

Sheehan, W.P., & Dobbins, T.A. 2001, Epic Moon: A History of Lunar Exploration in the Age of the Telescope (Willmann-Bell Inc.: Richmond), 30

Westfall, J.E. 2000, Atlas of the Lunar Terminator (Cambridge University Press: Cambridge), 9

Whitaker, E.A. 1989, in The General History of Astronomy, Vol. 2: Planetary astronomy from the Renaissance to the Rise of Astrophysics; Part A: Tycho Brahe to Newton, ed. R. Taton and C. Wilson (Cambridge University Press: Cambridge), 120

## Acknowledgement

The assistance of Alister Ling is gratefully acknowledged.

*Bruce McCurdy is the Education Development Coordinator of the Sky Scan Science Awareness Project, a program bringing radio astronomy to Alberta junior high students. A national representative of the Edmonton Centre, he was recently named the RASC's Astronomy Day National Coordinator. In the past half-Saros this committed lunatic has observed every named feature on the lunar nearside, but under 50% of possible targets within the libratory zones.*

# Royal Astronomical Society of Canada National Awards — Call for Nominations

The RASC sponsors several national awards. Their purpose is to recognize Society members for outstanding service to the RASC as well as excellence in all aspects of amateur astronomy. Members are encouraged to nominate candidates for these awards. The Awards Committee reviews all nominations and puts forward outstanding candidates to National Council for approval. Successful nominees are invited to attend the General Assembly the following summer to receive their awards.

**Nominations for all four awards must be received at the National Office by December 31st, 2002 to be considered.**

**Service Award**
The Service Award is presented to members who have performed outstanding service to a Centre or to the National Society over an extended period of time. The nominee must have been a member in good standing for at least 10 consecutive years prior to nomination. The service performed should have had a major, constructive impact on the Centre or Society, requiring a very substantial and continued commitment on the part of the nominee over a period of at least 10 years.

When submitting a nominee to the Awards committee, the nominating Centre (or individual if the nominee is an unattached member) must provide a statement establishing the suitability of the candidate.

**Chant Medal**
The Chant Medal was created in 1940 and is named for Prof. C.A. Chant. It is awarded to an amateur astronomer who has carried out a significant and original project that has contributed to the science of astronomy. The nomination of a Centre member should be submitted by the Centre itself.

**Ken Chilton Prize**
The Ken Chilton Prize was established in 1977 and is named after Hamilton Centre member Ken Chilton. It is awarded to a member resident in Canada in recognition of a significant piece of astronomical work carried out or published during the year. Any member can submit a nomination for consideration.

**Simon Newcomb Award**
The Simon Newcomb Award is intended to encourage members of the Royal Astronomical Society of Canada to write on the topic of astronomy, either for the Society or the general public, and to recognize the best published works through an annual award. Any member is eligible for the award. Nominations can be submitted by a member, a group of members, or by a Centre.

More information about these awards can be found in the RASC manual at the RASC web site. If you have any questions about the Society's awards, please contact the undersigned via email (attwood@istar.ca) or through the National Office.

Please submit nominations to:

Robert F. Garrison
Chairman - Awards Committee
garrison@astro.utoronto.ca
or by mail to:
RASC National Office
136 Dupont Street
Toronto ON  M5R 1V2

# Triumphs in Triangulum

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

One of the advantages of doing this column is the opportunity it affords me to regularly review the observing records that I have maintained for fifteen years. For each installment, I try to create a coherent article made up of observations that are often spread over many years. While studying my records I become aware of regions of the sky that I have spent many hours exploring and of others where much work remains to be done. The subject of this month's column, the constellation Triangulum, is a region that I have only occasionally visited down through the years, though I would expect to spend much more quiet time exploring this region in the future.

Located away from the plane of the Milky Way, Triangulum is galaxy country for observers with small telescopes and the objects in this region of the sky seem to fall into two main categories: relatively nearby, low-redshift dwarf galaxies and higher-redshift, more-massive galaxies that shine relatively brightly despite being hundreds of millions of light years away from our own Milky Way.

Two of the most curious objects in this region of the sky are the double elliptical galaxies NGC 750 and NGC 751. I first observed this pair under dark New Brunswick skies back in 1991, though at the time I was unable to resolve them into separate objects. Core to core, the galaxies are separated by only 27 arcseconds in declination. The following year, I observed this pair again from Mount Sutton and, in my 8-inch Schmidt-Cassegrain at 161×, I was at least able to detect a slight brightness difference between the two components, though resolution escaped me once again. The two galaxies are redshifted by 5171 and 5152 km s$^{-1}$, implying a distance of almost 230 million light years. I'd be interested in hearing from observers who are able to succeed where I have failed in resolving this pair.

NGC 780 is a galaxy with a redshift similar to NGC 750/751, though at magnitude +14.6, it is considerably fainter. In 1995 from Sutton, this galaxy appeared as a hazy, poorly-defined patch of light that was nevertheless fairly easy to pick up in my 15-inch reflector. Oval in form, it is oriented north/south and a little brighter to the middle. Two magnitude +15 field stars, one due south and the other located in the northeast, seem to merge with the galaxy making it look larger than it is.

The distant spiral galaxy NGC 890 is a little easier to observe as it features a bright core and a mottled, relatively well-defined outer envelope. Set against a fairly rich background of faint stars, it is preceded by a magnitude +9 field star.

The tiny galaxy NGC 684 is a tough challenge for smaller telescopes, though in 1995 I had an excellent view of this edge-on streak of light with my 15-inch reflector at Sutton. The edges of this galaxy are well defined and the major axis is oriented due east/west with a brighter core being visible.

Nearby is NGC 670, quite similar in size to the preceding, though its orientation is almost due north/south. At 272×, only a very gradual brightening to the middle was observed in this well-defined oval of light. These three galaxies have similar redshifts, implying a distance in the neighbourhood of 160 million light years.

As mentioned earlier, not all the galaxies in Triangulum are at chillingly remote distances; the interesting pair NGC 672 and IC 1727 being a case in point. NGC 672 is a relatively bright object, which should not pose too many problems for the small telescope user. Although its light is rather diffuse, this galaxy is bright, large and much extended, oriented east-northeast/west-southwest, brighter along its major axis though no bright core is visible. IC 1727 will pose a challenge, however, as I found it quite faint in my 15-inch reflector; only the core, a low-surface-brightness patch of light oriented northwest/southeast was detected. With redshifts measured at 421 km s$^{-1}$ for NGC 672 and 338 km s$^{-1}$ for IC 1727, this pair of galaxies is located about 17-million light years distant.

Immediately southeast of this pair is the coarse open cluster Collinder 21, a grouping of about 15 magnitude +8 and fainter stars arranged in a semi-circle that is quite isolated from surrounding field stars. Just north of the cluster is the very faint galaxy IC 1731, visible in my 15-inch reflector as a hazy patch of light best seen with averted vision. The galaxy appeared a little brighter to the middle and the edges were poorly defined.

Located on the outskirts of the remote galaxy cluster Abell 262, NGC 688 appears as a moderately-bright galaxy in my 15-inch reflector, very gradually extended northwest/southeast. Moderately condensed to the middle, at 146×, a faint stellar core is occasionally visible. At 272×, this core is well seen, though the galaxy itself starts to fade. NGC 784 is a bright, though ethereal galaxy, quite large and much elongated in a north/south direction. Contained within a magnitude +12 triangle of field stars, the galaxy is brighter along its major axis, though no core is visible. The texture of the main envelope is slightly mottled, suggesting that this galaxy may be nearby. Indeed it is, as its redshift is only 198 km $s^{-1}$, the lowest of any galaxy discussed in the present article.

Another low-redshift galaxy is the challenging dwarf spiral NGC 925. Though plotted on *SkyAtlas 2000.0*, this low-surface-brightness galaxy is a tough catch in a small telescope. In the Fortier-Widdop 12.5-inch reflector at Woolly Woods, this galaxy appears as a very faint haze slightly extended in a north-northwest/south-southeast direction. This is a misleading impression caused by faint field stars, however, as the weak-spiral structure is extended more along an east/west axis.

Much easier to observe in the Fortier-Widdop telescope is the remote galaxy NGC 777. Small, well condensed and pretty much round, this E1 elliptical galaxy is well defined at its extremities and forms a triangle with two magnitude +8 field stars.

Though small in size (the constellation ranks 78$^{th}$ in total area), Triangulum is an interesting area of the sky that offers many challenges to the serious observer. The constellation is well placed in northern skies as the chill weather of winter approaches.

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

# GA 2002

# RASC Award Citations

At the 2002 RASC General Assembly in Montreal, three national RASC awards were announced and presented to the individuals (or stand-ins) named below. The citations appearing below have been extracted from the email correspondence of the Awards Committee.

### Chant Medal: Roy Bishop, Halifax Centre

We are pleased to nominate Dr. Roy Bishop for the RASC's Chant Medal. We think that this award is particularly appropriate in this year, 2001, since Roy has just completed a nineteen-year tenure as editor of the *Observer's Handbook*.

An amateur astronomer resident in Canada, Roy has completed work with the *Observer's Handbook* that is original enough to make him eminently qualified for the Chant Medal. During his tenure as editor, he oversaw an enormous growth in the size and quality of the *Handbook*. In particular, his essay *Orbital Motion*, which has been revised over later editions, reflects the thinking of a man who struggles for a deeper understanding of those physical principles that appear to govern us. Very few people have even attempted to explain gravitation in terms that the public can understand, and we believe that Roy's treatment has added significantly to the ability of many people to understand the world and universe in which they live. The orbital motion article is just one example of Roy's originality of thought: the sections he wrote on Optics and Observing, Telescope Parameters, Binocular Performance, Filters, and others, have allowed thousands of professional and amateur astronomers to understand these aspects of the heavens in greater depth.

For over 19 years, the *Observer's Handbook* was a true labor of love from the writing desk at Maktomkus Observatory, a structure on the roof of his Avonport, Nova Scotia home. From this site he has conducted an observational program that has now stretched over three decades. His 16-inch telescope, which he designed himself, is a work of art as much as an accurate scientific tool. (See *Sky and Telescope*, May 1996, page 85)

In addition to his research directed toward the sky, Roy has done considerable research on the effects of celestial bodies on Earth, specifically the tides. From his home he can observe the ebb and flow of the tides of the Minas Basin, whose range can exceed 50 feet, the greatest on Earth. Among his popular writings, the pamphlet *The Bay of Fundy's Minas Basin: Highest Tides in the World* is an excellent popular essay on the subject of tides.

Dr. Bishop's research on important $18^{th}$ and $19^{th}$ century observatories in eastern Canada has led to their being recognized as important to the history of our country: observatories and people who otherwise would have been completely forgotten. His interest in the birthplace of Isaac Newton led to his visit to Woolsthorpe Manor, and to his taking a unique photo of the house precisely at the time when a double rainbow arched over its roof. This was no accident, and the story is typical of the way Roy takes clever advantage of situations. With his wife, Gertrude, he visited the house during a drizzle. After he drove off, he noticed clearing to the west and hurried back, hoping that he would catch the rainbow. His photograph appeared on British postage stamps and in many other places, a tribute both to a British physicist of a previous century and a Canadian astrophysicist who produced the remarkable photograph. Roy has also taken many remarkable photographs of eclipses, planetary alignments, atmospheric effects, and other testaments to the beauty of the sky.

A respected teacher, naturalist, physicist, and astronomer, and a remarkable human being, Roy Bishop is, in our opinion, precisely the kind of person, and has precisely the kind of achievements, that make him worthy of the Society's Chant medal, and we are honoured to so nominate him.

### Ken Chilton Prize: Vance Petriew, Regina Centre

The Awards Committee moves that the 2001 Ken Chilton Prize be awarded to Vance Petriew of the Regina Centre for his discovery Comet C/2001 Q2 on August 18, 2001. Mr. Petriew becomes the third Canadian amateur astronomer to discover a comet visually from Canada.

### Simon Newcomb Award: David Levy, Montreal and Kingston Centres

I would like to nominate David Levy for the Simon Newcomb award for 2002, under the category, "history of exemplary writing."

David's knowledge, enthusiasm and talent for telling a story has[*sic*] made him an ideal promoter of astronomy. He represents what many would consider the ideal amateur astronomer, and someone that our society should celebrate.

From observing guides and research papers to biographies, David's works are a pleasure to read.

[These remarks, prepared by Susan Gagnon of the Kingston Centre, prefaced an extensive list of books, magazine, articles, and columns written by David Levy.]

# Okanagan Centre
# Astronomy Contest

*by Guy Mackie (guy.m@shaw.ca)*

In the spring of 2002, the Okanagan Centre members challenged grade 7 to 9 students at six middle schools in the Okanagan region to write an essay on "Why I Am Interested in Astronomy." The winner of the essay contest would receive a 4.5-inch Dobsonian reflector donated by former Okanagan Centre president Ron Bell of Bellstar telescopes. John and Susanne Kidner of astronomy retailer Perceptor added to the prize with the donation of a 20-mm Skywatcher Plössl eyepiece. The Okanagan Centre members donated a Telrad to round out the full beginner-telescope package ready to give to the young writer of the best essay. The OC members targeted middle-school students because we felt that at that age-group, many students are reaching the point in their lives where they are starting to make decisions that will affect the rest of their lives. We also felt it would be a benefit for them to consider astronomy and its allied sciences as one of the many possible life interests they could choose from.

Soon after the deadline of May 24th, the essay judges, Traci Shuster, Jim Fisher, Jim Tisdale, and Guy Mackie, began sorting through the many entries from hopeful students. A consensus was quickly reached that the prize-winning essay was the one submitted by 12-year-old, grade-7 student of K.L.O. Middle School, Stephanie Fromberg. The contest judges could not overlook the fine efforts of the runners-up Christina Shaak (Constable Neil Bruce Middle School), Raminder Saini, and Jessica Wolfe-Leeming (both of Glenrosa Middle School), who along with Stephanie were awarded membership in the RASC for one year, paid for by the Okanagan members.

Winner of the Okanagan Centre Astronomy Contest, Stephanie Fromberg.

It was a pleasure to award the Bellstar telescope to Stephanie at the year-end assembly of her school. She was loudly applauded by her peers and congratulated by the Okanagan Centre members who attended the assembly. After a few directions on how to use and maintain the scope, Stephanie proudly carried off her new key to the door of astronomical exploration.

The members of the Okanagan Centre would like to express their gratitude to the contest sponsors, Bellstar and Perceptor, and to School District 23 for facilitating the contest, to middle school teachers for encouraging the appreciation of astronomy, and most importantly to the many students who dedicated time and effort to enter the contest. There is no higher education than Astronomy!

Why I Am Interested in Astronomy
By Stephanie Fromberg
K.L.O. Middle School
Grade: Seven
Age: 12

There is a whole other life outside of ours that many take a liking to — we call them Astronomers. I have often looked out the window and thought to myself, "I wonder what it's like up there?" I guess I'll never make it to the Moon, but I still love spending time making out the constellations and seeking out the shooting stars. I, myself, find the stars and planets a fascinating trip, literally out of this world. When I was younger, I got the privilege of looking at the moon through a huge telescope, which was an experience I remember very clearly that stunned me. Most humans are interested only in their own planet. A small percentage of people are interested in the world outside of Earth. I recently heard that a giant meteor would hit the Earth in about 900 years. I read that it would probably end life on Earth. I, myself, can't imagine a universe without human or animal life. What would it be like? I suppose I won't be alive 900 years from now to see it or solve the BIG problem. By that year I'm sure scientists will know how to stop it.

When we started studying Astronomy in science class I strived to learn all I could about the planets and moons. Astronomy in my mind is the most interesting science because of all the history and beauty behind it all. People love to say that they saw aliens or UFOs because of all the instant popularity they gain. I am personally not interested at all in these "alien hunts." What interests me is how amazing it is to know that there are 8 other known planets surrounding us.

Sometimes I think that I want to donate my life to science and in particular astronomy. It is so simple to list the 9 "known" planets and feel proud because you memorized 9 words. Imagine, though, that you actually discovered a planet or constellation or galaxy. There are many believers in the "we've learned all we have to learn" type. But I say this is nonsense! There are millions of other facts out there to learn — that keeps life interesting.

We as humans of this millennium should feel very grateful that people like Galileo found out that Earth is not the centre of the galaxy. I am proud of all the scientists out there who tried or did change the way we see the world, literally.

Astronomy is the oldest science and it dates back to the caveman days when they would draw on their cave walls about what they saw outside their caves in the sky. I mean who doesn't like sleeping under the night sky? Cavemen did it and so do I!

Things like why the Big Dipper and the Little Dipper both have seven stars interest me. If I had a telescope I could do diagrams of what I see. I could do speeches about galaxies to younger kids. Although I am only twelve, I CAN make a difference in our world. Hey, who knows, maybe I will discover the next planet. We might not know about lots of other planets! There is so much to learn and only our own lifetime to learn it!

There are many other subjects linked to Astronomy. You could be interested in chemistry, physics, medicine, religion, world history, geology and even anthropology! I mean, if you are religious you can study the birth of Christ by looking at the stars.

I hope to be an astronomer who will make a difference in this universe. You might just say "I have my head in the stars." But I am willing to give my life to a study that interests me very deeply.

— Stephanie Fromberg

*Guy Mackie is president of the Okanagan Centre of the Royal Astronomical Society of Canada. He enjoys observing "Old Light" with his 12.5-inch telescope and then sketching and writing descriptions of what he sees. Always a bit of a daydreamer, Guy was pleased to discover at an early age that it was possible to dream at night as well, without being asleep.*

# Building a Simple Mirror Cell

*by Paul Moffat (paulmoffat@mindspring.com)*

Figure 1 depicts a mirror cell for a 17.5-inch mirror. This cell is constructed with 1× 1-inch steel tubing, in the shape of a "Y," welded in the centre, and having "feet," which are plates at the ends to attach to the tube.

The mirror floats on a 9-point suspension, formed by the 3 triangular plates. Those plates are made from $^{3}/_{8}$-inch aluminum, and each has 3 points of contact with the mirror. $^{3}/_{8}$-inch bolts that go into a shallow drill hole on each plate act as adjusting screws for collimation. A nut was welded on the mirror side of each cross bar, to receive the bolts. The felt pads that touch the mirror have some silicone adhesive applied to keep the plates from rotating while being transported.

I found some $^{1}/_{4} \times 5$-inch screws that were fully threaded and used a "coupling nut" as an attachment for the retainer pad. This retainer is free to slide up and down through the slot in the edge-retaining bar that rises vertically from the tubing frame. That bar is $^{1}/_{8} \times 2$-inch steel, and rises above the mirror face.

The pads are round, hard, felt self-stick-on "protectors," which I purchased at Wal-Mart. When being set up, the retainers are loosened to allow alignment, and when the mirror is correctly positioned, the retainer screws are carefully tightened – just enough to keep everything in place. With this cell, I have been able to transport my telescope several times (80 miles to a dark site), and when set-up, the mirrors are in perfect alignment.

Figure 1. Mirror cell of a 17.5-inch mirror.

Figure 2. Just seen at the outside of the cell is a front retainer screw.

*Paul Moffat joined the RASC Winnipeg Centre in 1965, and learned about observational astronomy under Frank Shinn. He has built several telescopes including an 82-mm refractor and a 45-cm Newtonian. Paul has worked at the Manitoba Museum of Man and Nature Planetarium, chased eclipses with Jack Newton, and designed the Glenlea Observatory in Winnipeg. Paul moved to the USA in 1995, and joined the Escambia Amateur Astronomical Association. He is currently an RASC member.*

# Reviews of Publications
## Critiques d'ouvrages

**From Galaxies to Turbines: Science, Technology and the Parsons Family**, by W. G. Scaife, pages xiii + 579, 16cm ×24 cm, Institute of Physics Publishing Ltd, 2000. Price $45.00 US, hardcover (ISBN 0-7503-0582-7)

In *From Galaxies to Turbines*, Garret Scaife follows the history of the Parsons family, from their first settlement in Ireland in the late 16th century to the death of Charles Parsons in 1931. It was under the reign of Queen Elizabeth in 1620, that Sir Laurence Parsons was granted 1,277 acres of land, which included the town of Birr in County Offaly, Ireland (roughly 140 kilometres west of Dublin). The royal grant allowed the Parsons family to take possession of the town of Birr, which was later to be known as Parsonstown. The property is still held by the Parsons family, under the 7th Earl of Rosse. Although much of the early part of the book chronicles the lives of the Parsons family, the book focuses primarily on two members: William Parsons, the 3rd Earl of Rosse, and his inventor son, Charles Parsons.

William Parsons, born in 1800, graduated from Magdalen College Oxford in 1822 with first-class honours in mathematics. Parsons' telescope building experiments began with the purchase of a number of small mirrors, a few inches in diameter. Being dissatisfied with those mirrors, Parsons soon began casting his own mirrors, beginning with one that was six inches in diameter. It was during this period that Parsons started his metallurgical study to establish the best ratio of tin and copper to produce a mirror with the best optical performance. That required the building of a small foundry on the grounds of Birr castle. By 1830 Parsons had built a 24-inch telescope of a composite design, with the reflecting surface made of strips of bronze that were soldered together. A machine of his own design was developed to grind and polish it and other mirrors that Parsons had built. In 1831 he was elected to the Royal Society, partly as a result of his published papers in telescope making.

Infected with a good case of telescope fever, Parsons then set to build a 36-inch diameter telescope. Parsons' attempts to build the larger mirror through his composite designs failed, however, and he was forced to return to building a mirror from one large casting. That required the building of a larger foundry, workshops, and most importantly, a large annealing oven. It took Parsons until 1839 to cast a perfect 36-inch disk in one piece. The mirror had a thickness of 3.75 inches and weighed $1\frac{1}{4}$ tons. Unfortunately for Parsons, French scientist Leon Foucault did not develop his knife-edge test until 1859. To figure the mirror, Parsons would periodically roll the horizontally mounted mirror out of the workshop and up to a tower on his castle, where he could view the mirror from platforms perched at different floors on the tower. The completed mirror, with a 27-foot focal length, was mounted outdoors on very large wooden *A*-frame of an altazimuthal design. Because of its enormous size, several servants were required to position and track the telescope.

Although Parsons initiated a program of methodical experimentation between 1826 and 1839 to build his 36-inch telescope, no attempt was made to actually use his telescope to study the sky in any systematic fashion. Almost immediately, Parsons set out to build a telescope 72 inches in diameter with a focal length of 54 feet. For the larger telescope, Parsons had to build an even larger foundry, with separate furnaces that could simultaneously heat three crucibles of molten bronze. A crane was installed to allow each of the $\frac{1}{2}$-ton crucibles to be moved over to the mould. Each crucible required 10 hours to pre-heat and a further 16 hours to melt its bronze charge, but only seconds were available to Parsons to pour all of the metal. After pouring, the mould, weighing over 4 tons, was pushed into the annealing oven. A six-week annealing period followed, with the interior of the oven initially heated to 900 degrees Fahrenheit. Peat from the bogs surrounding Birr castle was used to fuel both the foundry furnaces and the annealing oven. The fuel had to be ordered almost a year in advance, since it could only be harvested during the summer when it could be dried. Five attempts were made to cast the mirrors between 1839 and 1842, resulting in only two usable mirror blanks. A new grinding and polishing machine was built for the giant mirrors. The first mirror was cast with slightly less tin in the bronze than intended and it fractured during the grinding process. The second mirror, which Parsons took great pains to cast with the right proportions of tin and copper, required two months of continuous grinding to figure.

As a result of the size and weight of the mirror and the 46-foot-long tube of the telescope, two giant masonry walls, each 70 feet long and 50 feet tall were constructed on a north-south alignment. By 1844 the mirror was given its final polishing and figuring. It was supported on a universal joint, which allowed the mirror to swivel from 15 degrees above the southern horizon to an almost vertical position. Through a system of ropes and pulleys and two tons of counterweights, the telescope could be raised in altitude with just a "few" servants. Unfortunately, the telescope could only track in azimuth for no more that 30 minutes on either side of the meridian because of the restricted field of view imposed by the walls. Interestingly, no finder scope was ever mounted on the telescope. Instead a "low-powered" eyepiece was used that "gave a field of view of 31 arc minutes with a magnification of 216 times." To ease observing, a maneuverable gallery was built, which could carry up to 12 persons. It was often required, as such was the attraction of the "Leviathan of Parsonstown" that noblemen and scientists (such as Sir George Airy, John Herschel, and renowned optician Sir Howard Grubb), came from far and wide to view through what was then the largest telescope in the world.

Within a month of finishing the telescope, Parsons made a new discovery with his instrument. Over several nights of observations, Parsons was able to make out and sketch in great detail the spiral arms of the "nebula" M51. At a June 1845 meeting of the British Association for the Advancement of Science, Parsons passed his sketch around to the praise of those who were in attendance. From Parsons' sketch alone, the "nebula" was soon dubbed the "Whirlpool Nebula." Over the next few years many more drawings and descriptions were made by Parsons, along with his assistants and visitors, of nebulae and countless globular clusters, which for the first time were resolved into individual stars. A detailed study of the Moon was also carried out. It is interesting to note that the "Leviathan" was not to be surpassed in size until the construction of the 73-inch reflector of the Dominion Astrophysical Observatory in Victoria, British Columbia, in 1918, nearly 74 years later.

The following sections of the book detail the life of William Parsons' youngest child, Charles Parsons. Born in 1854, Charles was encouraged to make use of his father's workshops, and to try his hand with the machinery within. It was about that time that young Charles Parsons made many little toy cars, boats, and submarines from strings, wire, wood, sealing wax, and rubber bands. It was to foreshadow his later life, when after university Charles joined the firm of Clarke & Chapman as an engineer. At that firm Charles applied himself to the application of steam to generate electricity. During that period, rotational power for an electrical generator was produced through the use of piston-powered steam engines. The pulsating effects of the steam-driven generator greatly reduced the life of very expensive light bulbs. Seeing an opportunity, Charles set to work to develop a practical steam turbine, which, when coupled to a generator, could produce a very consistent electrical output at much-reduced maintenance and noise level. In 1877, at the age of 23, Charles' work was significantly developed that a patent was taken out in his name, and again another patent in 1877. By 1889, over 250 small turbines had been build and sold. Charles felt, however, that if the steam turbine were to compete with the now highly developed stationary steam engines, a considerable amount of research was necessary. Unfortunately, his partners at Clarke & Chapman did not agree. Thus, in November of 1889, Charles set up his own works in Newcastle.

Under the name of CA Parsons and Co., Charles Parsons set upon the methodical research that was necessary to develop steam turbines of significant size to compete with the steam engines of that time. Business was going sufficiently well for Charles that in 1894 he established the Marine Steam Turbine Company solely to develop and market steam turbines for the propulsion of boats. One of the first tasks of Parsons was to build a ship, named *Turbinia*, specifically to study the effects of steam turbine-driven propulsion. As a result of a famous publicity ploy in 1897, during a royal procession to celebrate Queen Victoria's Jubilee, the *Times* reported that *Turbinia*, with a "*deliberate disregard of authority…contrived to give herself an effective advertisement by steaming at astonishing speed between the lines… patrol boats which attempted to check her adventurous and lawless proceedings were distanced in a twinkling…*" The ploy worked, since after that *Turbinia*, with a top speed of 34 knots, was known as the fastest boat in the world. From that time on, orders for marine turbines came in from navies around the world.

In 1925, Sir Charles Parsons was able to help out an old family friend, Romney Grubb, son of Sir Howard Grubb, whose company was forced into liquidation. The new, reformed company, the Sir Howard Grubb, Parsons and Co., was able to prosper as a scientific instrument manufacturer until 1984 (shortly after it had built the 4.2-metre William Herschel telescope). At the age of 76, in 1931, Charles Parsons passed away while on a trip to the West Indies. At the time of his death, a 74-inch reflector was under construction at Grubb-Parsons for the David Dunlap Observatory in Toronto. As a result of the death of Parsons, Dr. Charles Chant of the University of Toronto chose instead to have the 12-inch thick, 5,000-pound mirror cast at Corning Glass Works in the United States, and then sent the mirror blank to Grubb-Parsons to be ground and polished. Up until then, the 74-inch reflector was the largest telescope ever built in Europe, and the second largest in the world. To this day it is still the largest telescope in Canada.

*From Galaxies to Turbines* is a well-researched book, detailing the lives of the Parsons family until the early 20$^{th}$ century. Many of the trials and tribulations that William Parsons and Charles Parsons experienced are brought to life with excerpts from letters between members of the Parsons family. Unfortunately, for the astronomy fan, only the first six chapters of the book's twenty-three chapters are spent detailing the life of William Parsons and the development of his giant telescopes. Scaife goes to great depths in detailing the metallurgical and mechanical aspects of the telescopes, but the astronomical discoveries made by William Parsons are scarcely discussed. Scaife then spends the rest of the book concentrating on the technical aspects of Charles' turbine design. That should be of no surprise since Scaife was previously a power station engineer, has written extensively on turbine generators, and was a lecturer in mechanical engineering. At times his writing style can be dry, but the book is beautifully illustrated throughout. A short explanation of fluid mechanics is provided in the appendix of the book to help the lay reader. For those who have an interest in either the development of the Leviathan of Parsonstown, or in the development of steam turbine technology in the late 19th century, this book would be a welcome edition to your collection.

Although not mentioned in the book, the original 72-inch telescope was dismantled in 1914 after falling into ruin. The mirror was sent to London's Science Museum, where it can still be seen. In 1996, the 7$^{th}$ Earle of Rosse started a restoration project, and in 1999 a new 76-inch glass mirror was installed. Currently the telescope is in working order and can be seen as part of a tour of Birr castle. More information on Birr Castle can be found at `www.birrcastle.com/`.

Vincent Chan

*Vincent Chan is currently an Assistant Professor in the Department of Mechanical Engineering at Ryerson Polytechnic University in Toronto. He teaches and is engaged in research in the area of manufacturing processes. Vincent is an avid ATMer and a member of the Toronto Centre of the RASC.*

**Cosmic Discoveries**, by David H. Levy with Wendee Wallach-Levy, pages 232 + xvi, 15.5 cm × 23.5 cm, Prometheus Books, 2001. Price $28 US, hardcover (ISBN 1–57392–931–X).

It is difficult to imagine what people thought of the night sky prior to the era covering the last 400 years of astronomical enlightenment. Generally the heavens were thought to be static and forever unchanging, so one wonders what Tycho Brahe thought when he discovered a bright new star one night in 1572. David and Wendee (Wallach) Levy provide insights into that and much more in their recent book *Cosmic Discoveries*. Written in a very fresh and open style, the book captivated me with its liveliness, so much so that at times I was sure it had a pulse!

David and Wendee offer a collection of essays on many of the famous people in astronomy, and on a few others whose names may be unfamiliar to us. If finding Pluto or Neptune assures immortality to their discoverers, then surely being the first to find a planet orbiting another star would do so for its discoverers, Geoffrey Marcy and Paul Butler. The Levys rightly thought so, and so they included these two among the other greats in the book.

One facet of the book I found very appealing was that the authors very obviously went to great pains to bring us fresh views of history. Clearly avoided are the many factoids that seem to have been reiterated so often in the literature that they are precariously close to becoming cliche.

Arthur Stanley Eddington, for example, is not treated as a footnote to Einstein's Theory of Relativity. Instead, his 1919 trip to South America to view a total eclipse of the Sun — to obtain evidence that starlight is indeed bent by the Sun's mass, as predicted by Einstein — is lushly described. At times we enjoy Eddington himself speaking to us directly through his logbook. The essay reads like a Clancy novel: Will the stars of Taurus appear to be deflected as their light passes the Sun? Too little? None? Or, how about twice the deflection predicted by Einstein? (The last was put forward by Edwin Cottingham, who accompanied Eddington on the journey. Quipped England's then Astronomer Royal, Sir Frank Dyson, "Then Eddington will go mad, and you will have to come home alone!") The trip was a success; starlight at the Sun's limb was deflected by the predicted 1.75 seconds of arc. That sort of discovery is of course the theme of the book. David Levy knows well the thrill of such discoveries and throughout the book never fails to highlight the human end of science. In Eddington's case, the Levys round out the trip with some verse by Eddington, summing the journey up himself; in part:

*"Oh leave the Wise our measures to collate*
*One thing at least is certain, LIGHT has WEIGHT*
*One thing is certain, and the rest debate*
*Light-rays, when near the Sun, DO NOT GO STRAIGHT."*

Another example of useful history in *Cosmic Discoveries* is the section on Charles Messier. About him we usually hear only of his famous list of objects that look like, but are not, comets. Instead we are transported to the dirty streets of Paris where we learn a great deal about the man and his life's work. I was very intrigued to learn of the bizarre treatment that Messier received from his employer when he reacquired Halley's Comet: he was forbidden to announce that he had found it for several months! When he was finally permitted to make an announcement, the comet was by then returning to the outer reaches of the solar system. The lateness of the announcement created considerable ridicule for Messier among other astronomers.

Overall, the book deals with the non-esoteric or highly technical end of astronomy, but I was a bit surprised to see very little mention of the history of spectroscopy. The addition of spectroscopy to observational astronomy opened a floodgate of new finds and still does to this day. The term "redshift," which is mentioned in the essay on Edwin Hubble, is a direct result of spectroscopy and is a key to our understanding of the universe. Although Annie Jump Cannon and others related to the field are mentioned several times throughout the book, I felt that they should have been more thoroughly discussed in a dedicated chapter.

*Cosmic Discoveries* should be an easy read for almost any person. The overall balance is not perfect, but a beginner or anyone unfamiliar with the history of astronomy will not find any parts of the book too difficult to understand. I noticed one or two oddly worded or incorrect statements, and in other places there are explanations (or lack of explanations!) of concepts that might have been more clearly explained, but they are minor. Overall, the book will leave its readers enlightened, not mystified.

For almost every person portrayed in *Cosmic Discoveries*, David and Wendee have also included trivial — yet very interesting — snapshots of their lives that I found myself looking forward to with anticipation in each essay. It made the book much more personal, and the end result was very gratifying. With each snapshot I was reminded that this is not a book to be studied intensely as a canon of astronomical history, but one to be enjoyed on a Sunday afternoon while sitting in the sun. To that end it served very well and the openness of the book will draw many others to the same conclusion. I highly recommend it.

Thomas Kovacs

*Thomas Kovacs is a very active observer who lives in Haliburton, Ontario. He also teaches astronomy and gives tours of the night sky to visitors at the new Haliburton Forest Observatory:*
*(*`www.haliburtonforest.com`*).*

**The Composition of Kepler's Astronomia Nova**, by James R. Voelkel, pages x + 308, 16 cm × 24 cm. Princeton University Press, 2001. Price $49.50 US, hardcover (ISBN 0-691-00738-1)

In the title of *The Composition of Kepler's Astronomia Nova* there is a hint regarding the nature of the book, but it is not until the Conclusion that we learn that the word "Composition" is a deliberate play on words that James R. Voelkel uses because his book is partly a consideration of the content of the *Astronomia Nova* but also an argument to explain the format that Kepler used for the book in which two of his laws were announced to the world.

Voelkel's text is nicely organized. In the introduction he tells us in great detail what he intends to demonstrate in the book. Then in Part I he covers the period from Kepler's life as a student under Maestlin at the University of Tubingen to the time he started research with Tycho Brahe. Part II covers the period of collaboration with Tycho, the political situation after Tycho's death, and the publication of the *Astronomia Nova*. In the Conclusion Voelkel summarizes his argument and could have added one more phrase, *quod erat demonstrandum*.

*The Composition of Kepler's Astronomia Nova* considers only those parts of Kepler's life that relate to his research. Much time is devoted to his correspondence with Maestlin, Longomontanus, Tengnagel, and others and to the problems he encountered with the family of Tycho over the inheritance and title to Tycho's data. Voelkel shows how Kepler used his correspondence with David Fabricius to develop his arguments in the *Astronomia Nova* and how those letters shaped the final form of the work.

The *Astronomia Nova* was written in a narrative form that was very unusual. But why would Kepler present his ideas to the world in such a fashion? Voelkel counters the argument (e.g. by Koestler) that Kepler's writing was that of a "sleep-walker" and develops the argument that Kepler wrote the *Astronomia Nova* in narrative form and included details of his many failures and dead ends in anticipation of its readers' responses. He knew there would be great objection to his use of Tycho's data to overturn the current (including Tycho's) understanding of the universe. Kepler's ideas were innovative and he had to counter the objections of astronomers who would view with great suspicion the introduction of physics into astronomy. The new ideas were complex and difficult to follow, and the *Astronomia Nova* was meant to appeal to a varied audience and to introduce the new concepts in a way that would generate the least trouble. Voelkel makes it clear that the style of the *Astronomia Nova* can only be understood in the context in which it was written, and supplies ample evidence to support his thesis.

*The Composition of Kepler's Astronomia Nova* is an "academic" book for the serious student of Kepler's work and for students of the history and philosophy of science. It has extensive notes to each chapter, a general index, and an "index of correspondence." Readers who have had exposure to Kepler's *Mysterium Cosmographicum* and *Astronomia Nova* would get a lot more from Voelkel's book, but the reverse is also true. It may be the author's style or just the nature of the material he is writing about, but some parts of the book are easy to read and others require several readings. It is certainly an important contribution to our understanding of Kepler, and the author presents a good argument.

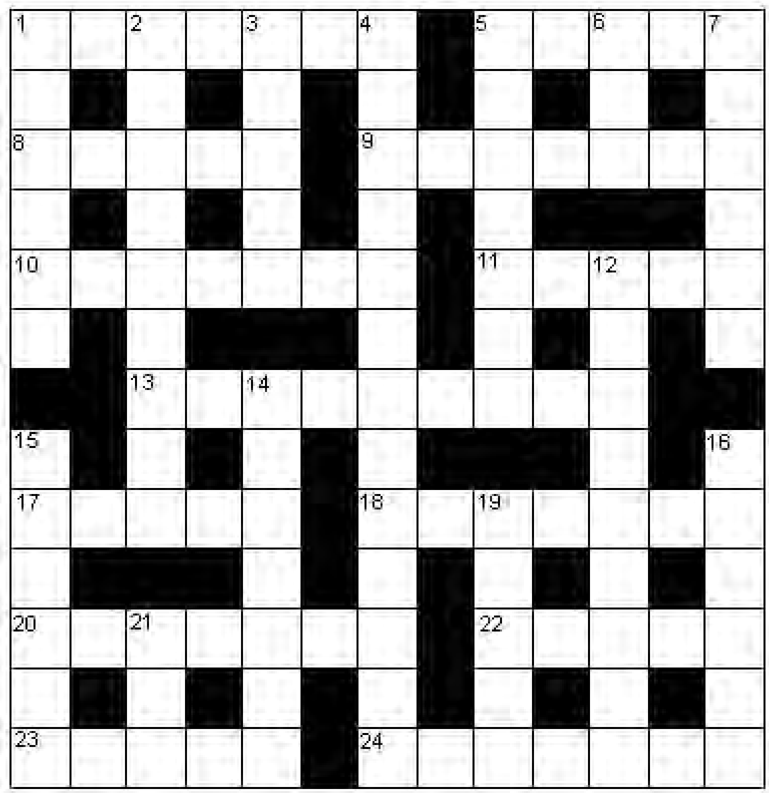
James R. Voelkel is Capabilities Manager of the History of Recent Science and Technology web project located at the Dibner Institute for the History of Science and Technology in Cambridge, Massachusetts. He is also the author of *Johannes Kepler and the New Astronomy*.

Frederick R. Smith

*Frederick R. Smith is a professor in the Faculty of Science of Memorial University of Newfoundland, where he teaches introductory stellar astronomy and astrophysics.*

# Astrocryptic

*by Curt Nason, Moncton Centre*



## ACROSS

1. After backsetting periodic error correction, he leads us to the King (7)
5. Beginning seven o'clock Universal Time, Hydra appears in this direction (5)
8. Roman is confused by the constellation, as a rule (5)
9 Eddington and Vogt somehow solve how a star progresses over the HR diagram (7)
10. Wrong angle in extraterrestrial view of Greene's stringy universe (7)
11. Leo, Leo Minor and family supposedly precede the fall (5)
13. Component of Martian soil labeled index 10 or other (4,5)
17. Star becomes apparent in the Meade nebula filter (5)
18. Southern sky creature seen in recent Auriga images (7)
20. Opens to adjust camera aperture by root two (3,4)
22. 19th century comet last seen back in Mare Orientale, I believe (5)
23. Nominal requirement of the RASD (5)
24. I'll return in code to show what galaxies may do (7)

## DOWN

1. Objective shape produces cone around 5 to 10 mm in diameter (6)
2. Average helium-lithium on either side of the Sun (9)
3. The Spanish celestial altar was located around Jupiter (5)
4. In small Schmidt-Cass scope Pictor unravels Doppler shift measurement (13)
5. Crops destroyed before eleven had belonged to Orion's nemesis (7)
6. You be Venus soundly in the stellar magnitude system (1,1,1)
7. Sphere rotates as poetic Venus (6)
12. Mid-sixties highlight after Ike saw himself returning, say (5-4)
14. Editor Barkhouse initially spun around and circled Earth (7)
15. The first name in periodic comets turns dome toward North Dakota (6)
16. A rainstorm to the east scuttles the European launcher (6)
19. Prestigious prize giver observed Leo rising around the head of Bootes after nine (5)
21. TeleVue reflects part of the extreme ultraviolet (1,1,1)

# GA 2002

## PHOTO GALLERY

A collection of images from the 2002 General Assembly (GA) held in Montréal, Quebec


Bob Garrison arrives in style. (Photo: Clair Perry)

Mark Bratton getting us started. (Photo: Clair Perry)

David Levy autographing copies of his recent book. (Photo: Clair Perry)

John Percy making a point. (Photo: Clair Perry)

# GA 2002 PHOTO GALLERY

Getting together at Bronfman Hall. (photo: James Edgar)

Bob Garrison (left) presenting the Simon Newcomb Award to David Levy. (Photo: Clair Perry)

Everyone had a great time at the banquet. (Photo: Ken Saumure)

A beautiful view of Royal Victoria College. (Photo: James Edgar)

The power of the executive: Rajiv Gupta, Bob Garrison, and Bonnie Bird. (Photo: James Edgar)

Special thanks to photographers, Ken Saumure, Clair Perry, and James Edgar for capturing so many great moments at this year's GA!

Right: Dr. Paul Hodge takes time for a smile.
(Photo: Clair Perry)

Bonnie, Peter, and Rajiv talking about forming a band?
(Photo: Clair Perry)

Dave Lane (Halifax) and Stan Runge (Winnipeg) are just good buddies - really!
(Photo: James Edgar)

More good times at the banquet. (Photo: Ken Saumure)

# GA 2002 PHOTO GALLERY

Michael Watson on decoupling. (Photo: James Edgar)

Even MORE great times at the banquet! (Photo: Ken Saumure)


Lee Beck and Glenn Hawley at the I.K. Williamson Observatory hospitality room. (Photo: James Edgar)

"Yes, we are the host committee - what's your complaint?" (Photo: Clair Perry)

Right: Time for a break: (sitting) Jim Crombie, Jim Tisdale, (standing) Ted Bronson, Clair Perry. (Photo: Clair Perry)

## See you next year!

# THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

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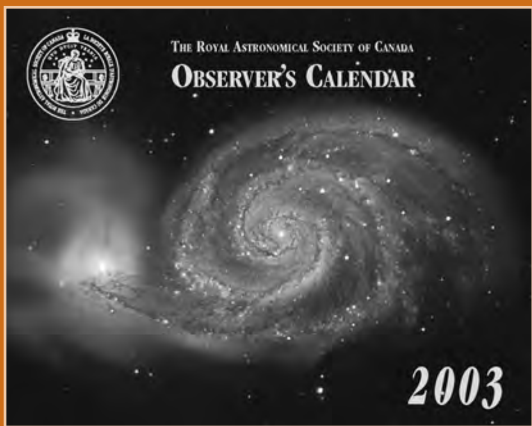


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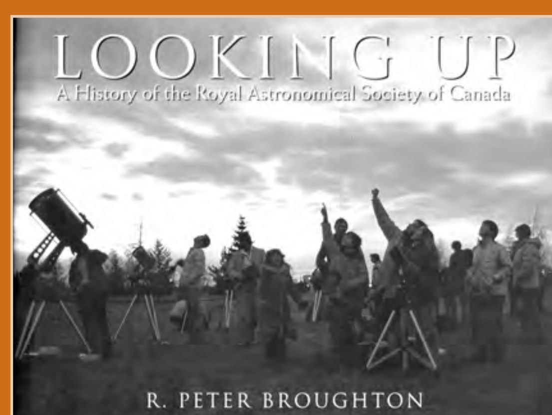


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