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Journal

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Journal

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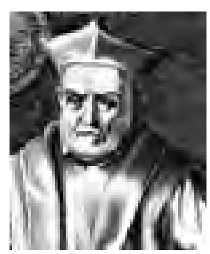

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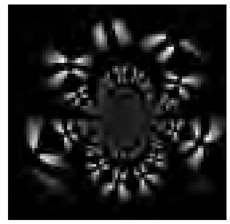

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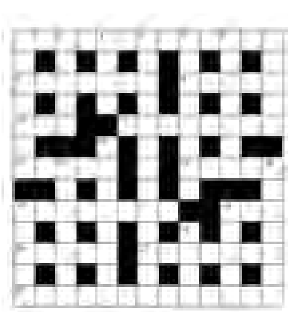

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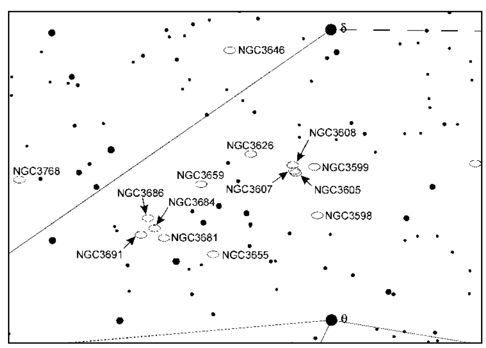

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From the Editor

by David Turner

Our present system of keeping track of the year count is attributed to Dionysius Exiguus (literally, Denis Little), a scholarly Byzantine monk who was abbot of Rome. Dionysius, while updating the Easter tables in 533 AD, proposed a year count separate from the standard Roman system of AUC (ab urbe condita, from the founding of Rome), in particular one dating from the birth of Jesus. Dionysius's system placed 1 AD (ab incarnatione Domini, from the incarnation of the Lord, or anno Domini, in the year of our Lord) as the year immediately following the birth of Jesus in Bethlehem. It was not until a few centuries later, however, that the system gained general acceptance.

The basis for the reckoning used by Dionysius is a statement attributed to Titius Flavius Clement of Alexandria in about 200 AD that Jesus was born in the 28th year following the first census ordered by Augustus Caesar. The first Roman *taxation* in the reign of Augustus was apparently carried out in 726 AUC according to an inscription on the Roman Temple Augusteum in Ankara, Turkey. Clement's date therefore corresponds roughly to 754 AUC, or perhaps earlier, depending upon when the census was ordered that preceded the taxation. The year 754 AUC corresponds to the year 1 AD in our current system.

Much has been made of the fact that there was no "year zero" in Dionysius's year count, but such criticism tends to ignore the cultural differences that separate present times from those of two thousand years ago. Although the numeral "zero" was not used in that era, it was almost certainly not considered essential either. A newborn baby would likely have been referred to at that time as being "in its first year," whereas today we would specify the exact age to the nearest month or week. Following the first anniversary of its birth, a child might have been referred to as being "in its second year," and not as "a one-year-old," as we would put it today. Thus, the year 1 AD *did* correspond to the first year in the life of Jesus, according to Dionysius.

This year, 2000 AD, represents the two thousandth year from the birth of Jesus according to the original method of reckoning. The year is therefore a milestone of sorts. It is, however, *not* "the start of a new millennium," or "the beginning of a new century," or "the beginning of a new decade." For that we must wait until next year, 2001 AD. Is there some reason why media types seem unable to count to 1000, 100, or 10, or was the hype surrounding the end of 1999 simply evidence for an international decline in educational standards? And what is "Y2K" supposed to mean? The symbol for year is normally "a" for annum or "yr" for year, not "Y," and the mathematical symbol for one thousand is "k" not "K," with the unit of measurement also being specified — as in kg (for kilograms), km (for kilometres), and kpc (for kiloparsecs). In the case of 2000 AD, the normal abbreviation would therefore be 2 ka AD (where "ka" is a kiloannum = 1000

Journal

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

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years), or 2 ka CE (common era) for secular usage.

A statement by Randy Attwood in his "President's Corner" for December gives the false impression that recent delays in the mailing of the *Journal* to RASC members are often tied to delays in the printing or distribution of the *Journal*. In fact, on a number of occasions the delays have occurred because of delays in the printing or distribution of *SkyNews*, not the *Journal*. The meshing of two completely separate production schedules is clearly not without its problems, but it is not correct to place the blame entirely on the *Journal* production.

The production schedule for the *Journal* is rather ambitious in some respects. Every two months the production team attempts to meet three separate deadlines: one for receipt of material, one for completion of editing, and one for proofreading. On occasion two of the deadlines fall on the same date or are closely adjacent, which makes it difficult for unpaid volunteers to meet all of the demands of a tight production schedule in their "spare" time! All editors at one time or another make regular appeals for volunteers who can "assist with all types of editing and production responsibilities." Given the uncertain status of future membership on both the editorial and production teams for the *Journal*, it is time to reiterate such an appeal to all Society members. The *Journal* needs you! Can you help in any way?

If you would like to volunteer your services, please contact Pat Kelly, Dave Lane, or me at the E-mail addresses indicated on the *Journal* banner.

President's Corner

by J. Randy Attwood (attwood@istar.ca)

I hope everyone survived the switchover from 1999 to 2000. Of course astronomically, the event meant nothing, but it was interesting to watch midnight slowly move around the world during the day of December 31st.

There was one amusing outcome to all of it. During the first week of January I received a telephone call from a researcher at *Maclean's* magazine. The banner on the front page of their first issue in January was causing problems with some of their readers. The banner read "First Issue of the 21st Century." The researcher said she was calling on behalf of the editor and was wondering what the official RASC statement was on all of it. I told her that there had been discussion about it for the past year or so among our members and in the public domain, and asked her if *Maclean's* had missed the debate. Anyway, my vote was that *Maclean's* was wrong and their angry readers were right, but that the discussion ended a long time ago and to most people it really did not matter.

An astronomical event that took place the week before Christmas was even more amusing. On December 22nd the Full Moon occurred on the same day as the Moon's closest perigee (distance to the Earth) of 1999. In addition, it all happened on the winter solstice. One would expect larger tides than normal on such a day, but that's about it. Well, it must have been a slow news day and the media got hold of the story. Media contacts for astronomy stories were busy all day doing interviews trying to explain that it was not all that noteworthy and that, contrary to what some were saying, if people were to drive that night, they should still turn on their headlights.

In southern Ontario it was a cool, clear evening and many people saw what looked to me to be a normal December Full Moon. For days afterward, friends described to me what they saw and told me they were convinced that the Moon was brighter than normal, and of course it had to be closer than usual because when it was close to the horizon it looked huge.

By the way, the December perigee distance was 356,653 km, while the farthest perigee in 1999 took place in September at 369,818 km — a difference of only 13,165 km or a difference of 3.5%, not a difference easily detectable by the human eye. I guess the only way you could tell would be if you could look at the December and September Full Moons at the same time.

In RASC news: if you look on the last page of this issue of the *Journal*, you will see that the 23 Centres represent all but two provinces — New Brunswick and Prince Edward Island. One objective I set for myself when I became President was to approach amateur astronomy groups in those two provinces to see if any of them were interested in becoming RASC Centres. In November I visited two amateur astronomy groups in P.E.I. and the same month talked on the telephone with several groups in New Brunswick. I am pleased to report to members that progress is well underway; I hope in the near future that all ten provinces will have RASC Centres.

Apart from our members in the provinces, we have members in the territories — I want to send best wishes to our one member in the Yukon Territory and four members in the Northwest Territories. We do not have any Nunavut members — yet.

We have many members outside of Canada, so to all members in Canada and around the world, clear skies!

News Notes
En Manchettes

STELLAR DEATH-FLARES MAY POINT TO SUPERMASSIVE BLACK HOLES

Supermassive black holes appear to be lurking in the centre of many, if not most, galaxies. Since the black holes themselves emit almost no radiation, direct detection is very difficult. Recent observations of the orbital speeds of stars in the cores of nearby galaxies, however, imply, through celestial mechanics, that the central masses of the galaxies are consistent with the presence of black holes containing the equivalent of millions or even billions of Suns.

John Magorrian of the Canadian Institute for Theoretical Astrophysics (CITA) and Scott Tremaine of Princeton University have now proposed a new method for the detection and possible confirmation of such gravitational monsters (October 21, 1999 issue of the *Monthly Notices of the Royal Astronomical Society*). As normal stars orbit closer and closer to a black hole, they become tidally disrupted and their outer atmospheres are torn off. Some of the debris is ejected, but a portion remains bound to the black hole. As it falls toward the black hole, the debris should emit a brilliant and characteristic flare, which, like a celestial distress signal, would reveal the black hole's presence. Such flares would last from a few months to a year, and would emit mostly extreme ultraviolet and soft X-ray radiation. The visible (V-band) luminosity of each flare is predicted to be about a billion times the brightness of the Sun, and would be even greater in the ultraviolet (U-band). There the flare should appear about four times brighter than the entire galaxy.

Magorrian and Tremaine began their research by modelling the rate at which tidal disruption of stars should occur. They found that the highest disruption rates occur in fainter galaxies, since the density of stars in space is greater near their cores than in brighter galaxies. On average a star in a galaxy like M32 (the small E2 elliptical companion to M31, the Andromeda Galaxy) should be tidally disrupted and should produce a flare about once every 4,000 years. In a larger spiral galaxy like M31 itself, the rate is estimated to be much lower, about one flare every 50,000 years. The difference is attributed to two effects. First, larger galaxies have a lower density of stars in the space near their core. Their expected central black holes are also typically larger, so that they often swallow a star whole before it has a chance to send out a flare.

With such low rates of occurrence, one would expect to wait a very long time before seeing such an event. The chances greatly increase however, the further one looks out into space, where one sees more galaxies. Out to a redshift of $z = 0.3$, Magorrian and Tremaine estimate that observers should witness about one flare per year for every ten square degrees of sky. (A redshift of $z = 0.3$ means that the expansion of the universe has caused wavelengths of light to be stretched — "Doppler shifted" — 30 percent towards the long wavelength end of the spectrum.) With the known expansion rate of the universe (the Hubble Constant), such a redshift corresponds to a distance of 4 to 6 billion light years.

To confirm the predictions of Magorrian and Tremaine, observations must now catch up with theory. The next challenge will be to observe such flares, with their predicted characteristics.

CANADIAN TOP TEN

In a similar fashion to what is done regularly at a rock and roll station, the Canadian Astronomical Society (CASCA) has compiled a selection of the ten greatest "hits" in Canadian astronomy over the last one hundred years. The Society admits that the list is not exhaustive, but should give a sense of the enormous contribution Canada has make to the field. Here is the list, arranged in chronological order.

1918 The Dominion Astrophysical Observatory's 1.83-m telescope begins operation in Victoria. At the time, the DAO telescope was the largest in the world. The observatory has made major contributions to our understanding of such things as binary stars, interstellar gas, and galactic dynamics.

1935 The David Dunlap Observatory, with its 1.88-m telescope, opens just north of Toronto. The "74-inch" telescope is still the largest in Canada. The event signalled the beginning of major Canadian university involvement in astronomy. Helen Sawyer Hogg conducted her pivotal research on variable stars in globular clusters using observations gathered with this venerable instrument. Ian Shelton was an Observatory employee working as resident observer for the University of Toronto Southern Observatory when he made his historic discovery of Supernova 1987A, the first supernova in three hundred years to be detected with the unaided eye (although the actual discovery images were photographs).

1946 The Solar Activity Index is invented. Canadian astrophysicists initiate a continuous 10-cm Solar Flux Monitoring programme with a small radio telescope located just south of Ottawa. The resulting index is now considered one of the standard indicators of solar activity.

1951 The Canadian Impact Crater Programme was initiated. Today the hazard of asteroid and cometary impact is taken very seriously, and the pioneering efforts of Canadians such as C. S. Beals are well recognized.

1960–66 The Dominion Radio Astrophysical Observatory (DRAO) and the Algonquin Radio Observatory (ARO) both opened circa 1960. Over the subsequent six years the main radio dishes of the two observatories were the first to discover complex molecules in space, which ushered in the field of interstellar chemistry.

1967 The first successful very long baseline interferometry experiments were completed in Canada using the radio dishes of the DRAO and the ARO, with Canadians being the first to link such distant radio telescopes in that fashion. Interferometric techniques produce an instrument that has the resolving power of a telescope with an aperture equivalent to the distance between the radio dishes. Today the technique is one of the most powerful tools used in radio astronomy, capable of resolution better than a thousandth of an arcsecond.

1978 The first centre for professional astronomy in French Canada was begun with the opening of the Observatoire du Mont Mégantic (OMM). Members of the Observatory have become leaders in such areas as the structure of white dwarf stars and the dynamics of galaxies.

1979 The Canada-France-Hawaii Telescope (CFHT) saw first light. Currently the instrument is used frequently with a new high-resolution camera, invented by Canadian astronomers and engineers, that rivals the resolving power of the *Hubble Space Telescope*. Canadian astronomers also used the telescope for pioneering spectroscopic techniques now used to detect extra-solar planets.

1985 The Canadian Institute for Theoretical Astrophysics (CITA) opens. The institute is the first national centre devoted to theoretical work in astrophysics. Its contributions have ranged from the successful prediction and confirmation of the existence of a vast reservoir of comets lying beyond the orbits of Neptune and Pluto, to models of galaxy formation.

1975–99 Canadians lead the world in efforts to find the ages of the oldest stars in the Milky Way. Such information is critical for work in areas such as the understanding of stellar evolution to finding the age of the universe.

THE CREATION OF URANUS AND NEPTUNE

The planets Uranus and Neptune present something of an enigma. According to the currently accepted understanding of planetary formation, the two planets should simply not be there. When the solar system was forming, the amount of dust and gas at such distances from the Sun (19–30 A.U.) would have been far too low for the two planets to achieve their present form.

Edward Thommes and Martin Duncan of Queen's University, along with Harold Levinson of the Southwestern Research Institute in Boulder, Colorado, have now provided a possible explanation for this planetary puzzle (December 9th issue of *Nature*). Their computer modelling suggests that Uranus and Neptune were probably formed in the same neighbourhood as Jupiter and Saturn (5–10 A.U. from the Sun), where the density of gas and dust was much higher.

After Uranus and Neptune were formed, the much more massive planets Jupiter and Saturn may have then gravitationally evicted the two to the outskirts of the early solar system. Numerous close encounters between the infant planets would have resulted in the less massive ones being bumped into different orbits. Initially the two banished planets would have had chaotic orbits. Gravitational interactions with numerous smaller bodies in the early outer solar system would have pacified their motions, however, and slowly moved them even further outward, eventually settling both into their current stable orbits. According to the computer simulations, such an unstable period would have lasted only a few hundred thousand years.

Luck may have also played an important role. Only half of the computer trials succeeded in moving Uranus and Neptune into their current locations. The model also successfully reproduces the Kuiper belt, the zone of small icy bodies lying beyond the orbit of Neptune in the outer disk of the solar system.

THE SKY IS THE LIMIT IN AMATEUR-PROFESSIONAL COLLABORATIONS

The 1999 Toronto General Assembly marked the first joint meeting of the Astronomical Society of the Pacific (ASP), the Royal Astronomical Society of Canada (RASC), and the American Association of Variable Star Observers (AAVSO). An important symposium on Professional-Amateur Collaboration was held as part of the event, with almost 200 professional and amateur astronomers and educators from five continents attending.

The first session highlighted the work of the AAVSO. Over the years the AAVSO has built a large data base of amateur observations of variable stars (both by eye and by photometric measurement). Such systematic work is of great value in professional studies. Currently amateurs can work with equipment that would have been the envy of professionals not that long ago, as international amateurs proved in subsequent presentations, including one on the "Center for Backyard Astrophysics" program led by Joseph Patterson.

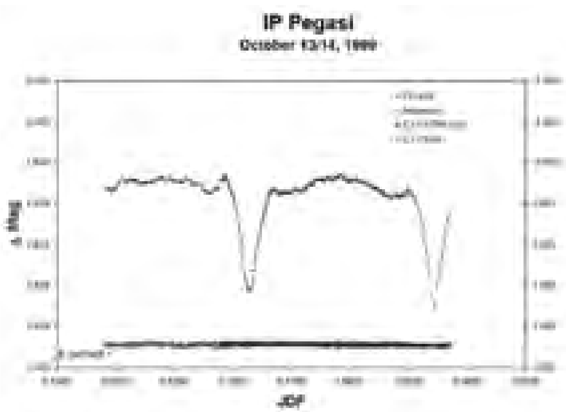
Amateur research activity now encompasses the entire gamut of astronomy, from sky surveys of various sorts to follow-up observations of gamma-ray bursters. As recently featured in *Sky & Telescope* magazine, Ottawa's own Paul Boltwood has pushed amateur CCD imaging to magnitude 23 with a 0.4m telescope in his Ottawa backyard.

Near the end of the symposium, a panel on "What Motivates Amateur Astronomers?" featuring Andreas Gada, Al Stern, and Tom Williams, estimated that the number of "master" amateur astronomers in North America is about equal to the number of professional astronomers. The total number of astronomical hobbyists is perhaps 50 times larger. Today the opportunity for upward mobility in astronomical research exists, in part as a result of instrumentation, but also because of the interest and enthusiasm of hobbyists. The symposium highlighted what is possible when members of the astronomical community at all levels put their efforts and ideas together.

CANADA GETS AN ASTRONOMICAL BACKYARD

The international "Centre for Backyard

Astrophysics” (CBA) has now officially taken root in Canada. The Alberta section



of the CBA operates near Edmonton, and is run by Brian Martin of King’s University College from the college’s observatory (web site: `www.kingsu.ab.ca/~brian/astro/cba_alta/html/cba_alta_index.html`) and by Rick Iwanika at his private observatory. Existing and planned telescopes are in the 0.25 to 0.5 metre class, and feature robotic control based on designs of U.S. amateur Mel Bartels, and detectors including Cookbook Camera 245’s, also of amateur design. Observing mainly the rapid variations of close binary stars (see one in action on the website), these small instruments are already doing important work on stellar evolution.

The accompanying light curve shows several hours of observation of the binary IP Pegasi from King’s College Observatory and with data from nearby amateur Marc Anderson. The two data sets merge seamlessly, illustrating the good precision attained with each instrument. A contact point is given on the CBA-Canada web site for those who may wish to move astrophysics into their own backyards.

DEVON OBSERVATORY UPDATE

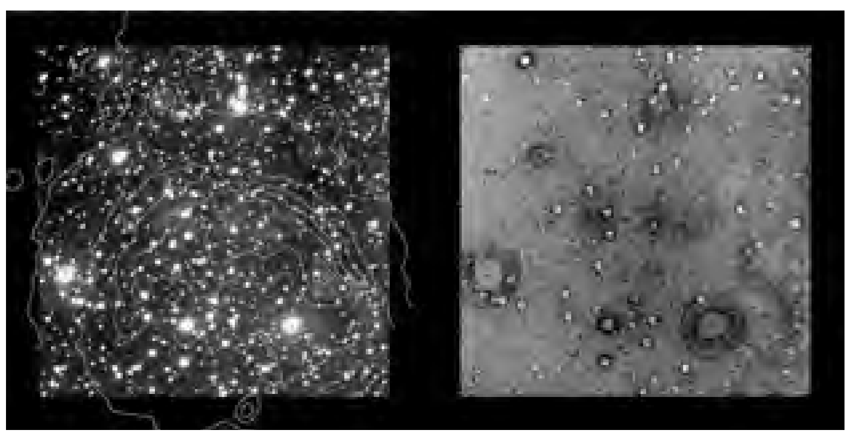
The Devon Observatory of the University of Alberta, which is located southwest of Edmonton, has recently been given a new mission. With a focal reducer system, the 0.5m Cassegrain telescope is now being used at its prime focus for detection of faint emission-line nebulosity over a nearly half-degree field. Such emission originates mainly from galactic objects such as

The King’s University College Observatory is a modest research site geared to undergraduate research. The observatory is located 25 km east of the centre of Edmonton.

supernova remnants and H II (ionized hydrogen) regions. Master’s degree student Tyler Foster has worked in both the radio and optical wavelength bands, and can now claim the first optical detection of emission from the H II region NRAO 655, as illustrated here.

As well, a deep field of the region of the nearby supernova remnant 3C434.1 region reveals new atomic hydrogen emission nebulosity, seen for the first time. Foster is investigating the possible links between the two objects using data gathered at many wavelengths, including those obtained with the refurbished Devon telescope.

The telescope at The Iwanika Observatory, which is presently a 10-inch f/4.5, will eventually operate as a semi-robotic 18-inch f/5.



Left: A deep optical image (the sum of twenty-two 600 second exposures) of NRAO655 in the H-alpha emission line (656 nm). The contours are brightness temperatures at a frequency of 1420 MHz in a radio image from the DRAO. Right: The same optical emission line image with stars removed and inverted to highlight the nebulosity. The emission features are dark, while the square and circular halos around the stars are image artifacts.

Feature Articles
Articles de Fond

The November 15th Transit of Mercury

by Chris Malicki, Toronto Centre (kmalicki@idirect.com)

One of the most dramatic astronomical events is a total eclipse of the Sun, where the disk of the Moon totally covers the Sun and, for a few splendid minutes, the outer atmosphere, or corona of our local star becomes visible. Two other large objects can also pass between the Sun and Earth, namely the inner planets Mercury and Venus. The last transit of Venus occurred in the year 1882, and there is probably no person living today who witnessed it. Mercury, on the other hand, transits the Sun approximately 13 times per century.

My wife Liz and I had already experienced eight total and three annular eclipses of the Sun, but never a transit. So, when I received the 1999 edition of the *Observer's Handbook* a year ago, and saw that a transit of Mercury would occur on November 15, I decided that we would have to see it. The only problem was that the event was visible primarily from the Pacific Ocean and late in the afternoon in the western portion of North America. Our home in Mississauga would witness the transit under an extremely low Sun just before sunset, with a difficult horizon. The only option was to travel west. We wanted to stay in Canada and drive there and back in one day (we have to work, after all). The obvious choice was Point Pelee National Park near Windsor. There, the Sun would be four degrees higher during the transit, and we had a perfect southwest horizon looking above Lake Erie as the Sun sank. It would be a race with the sunset to see it.

The shadow of Mercury is visible as a small black dot very close to the limb of the Sun as marked by the arrow (photo taken at 16:45 EST using a Celestron 8-inch telescope, Celestron solar filter, and Kodak Gold 100 print film).

On the morning of November 15, as we drove from Mississauga, the sky was completely overcast. It was pouring rain in London, and we were disheartened. As we approached Chatham, less than 100 km from Pt. Pelee, however, the sky began to clear in the west. Clouds later began to roll in, but fortunately a large clear area moved towards the western sky where the Sun was to be visible in the late afternoon. We were located at the southern tip of Point Pelee National Park in Lake Erie, at latitude 42° N, longitude 82° 32′ W. We were the southernmost observers on mainland Canada, and possibly all of Canada, to observe the event, (unless one of the 230 residents of Pelee Island was watching). Two members of the Niagara Centre RASC, Denis and Darrell, began to set up telescopes near our car, and declared that the sky would be clear for the event. They were right. I set up my Celestron 8-inch telescope and solar filter, and observed at 71× and 133×.

Ten minutes before Mercury touched the Sun's limb, the Sun entered a large clear area of the sky, and stayed in it with only a few minor clouds passing by until sunset. Four minutes after the predicted external ingress (Mercury touching the Sun's limb), I was able to spot a dark indentation in the predicted place near the north pole of the Sun. The planet rapidly entered the Sun's disk and separated from the edge of the Sun as a distinct "black drop" at 4:22:36 p.m. For the next glorious 40 minutes we could see the planet move its way across the extreme northeast potion of the Sun. The disk of Mercury was very obvious and was much blacker than the *very* numerous and large sunspots. We were able to follow Mercury on the solar disk until 5:00 p.m., only minutes before sunset, when it was halfway off the edge of the Sun's disk. It was a wonderful event to witness, especially with the uncertain November weather. We certainly were ecstatic to see our first, and hopefully not last our last, transit.

Chris Malicki is a medical doctor, family physician, and emergency physician at the Trillium Health Centre in Mississauga. He earned a B.Sc. in biochemisty in 1972, and his medical degree in 1976, both at the University of Toronto. He has been interested in astronomy since Grade 6 when his brother pointed out the belt of Orion to him. During the next fifteen years he explored the sky with binoculars, followed and charted the movement of planets, and learned the constellations. He purchased a Celestron-8 in 1979, and since then has observed ~1600 deep sky objects. He joined the Toronto Centre in 1978 in order the join their eclipse expedition to Manitoba, and has been a member ever since. His current astronomical passion is chasing eclipses, but he also loves observing deep sky objects. He also enjoys hiking the Bruce Trail, philately (especially eclipse stamps), canoeing, and the piano. His teenage daughter Adrianna (19) and son Greg (17) accompanied him and his wife on three of their eclipse expeditions.

THE 1924 TRANSIT OF MERCURY

Although the early part of Wednesday, the 7th of May, 1924, looked unfavourable for viewing the transit of Mercury, the afternoon became all that the most eager votary of astronomical science could desire. I shall give my own meagre experiences in connection with the event.

A four-inch refractor was used in the observations. Thinking that the transit might be capable of being projected on a screen, I secured a circular piece of cardboard, about 14 inches in diameter, cut a hole in its centre, and fastened it to the telescope, so that the image of the Sun projected on another piece of card would have as much contrast as possible.

By using the telescope in this manner, I totally lost the earlier part, or commencement, of the transit. Although I had found the point where the planet was likely to make its entrance on the Sun, I could see nothing, although I watched, not only that point, but all parts of the circumference of the Sun's image, very carefully for some minutes both before the time the transit was due to commence, and also afterwards. I do not understand why I could not see the planet. Having seen nothing for nearly ten minutes, I altered my method, and affixed a "sun-glass" to the eyepiece. I now saw the planet well upon the disk of the Sun, near the eastern limb — a little to the right of the bottom of the image as viewed in the inverting refractor. The planet was there, a tiny black spot upon the disk of the Sun, which was otherwise apparently unmarked, except by a double sunspot above and to the left in the telescopic field of view.

The planet kept creeping forward in an upward and left hand direction during the period it was visible, or until about 8:05, daylight saving time, when a dense cloud drew over the Sun, and by that time the orb had sunk behind the chimneys and roofs which girded the western horizon.

The transit was witnessed by members of my own family, and some other friends, to all of whom it was an object of distinct interest.

I tried to locate the planet with the help of a field glass magnifying about four and one-half diameters, but could not detect it. When using the field glass, I looked through only one of its tubes, holding the coloured sun-glass before its eyepiece while making the observation.

I also made the same experiment with the finder of the telescope, which magnified, possibly, eight or nine diameters. Very faintly could I observe through it the planet.

After about 7:30 p.m., when the strength of the Sun was noticeably failing, I viewed its disk without the aid of a coloured glass. Sometimes the Sun was struggling through clouds — these began to make their appearance at about this time, but some of them were faint and filmy — and at other times the Sun was free and bright in the late afternoon sky. There was no difficulty in viewing the transit thus, without any coloured glass to reduce the brightness of the Sun's rays at all. The Sun then shone with a lustrous splendour, and on its face was the tiny black dot, the image of the planet. The Sun's rays during the last half-hour of the phenomenon were just such as did not inconvenience the eye by either their intensity of glare, or their heat.

Perhaps the most striking feature of the transit was the sudden revelation of the exceeding smallness of the planet when on the Sun's broad face. I had expected a much larger object, and was disappointed in finding that the visitor to the Sun was so manifestly tiny. Most of the time I used a magnifying power of sixty to one hundred diameters. Even with such optical aid, the spectacle was none too striking. Still it was an event not to be missed, and was welcome to those who love to contemplate the mysteries of the skies.

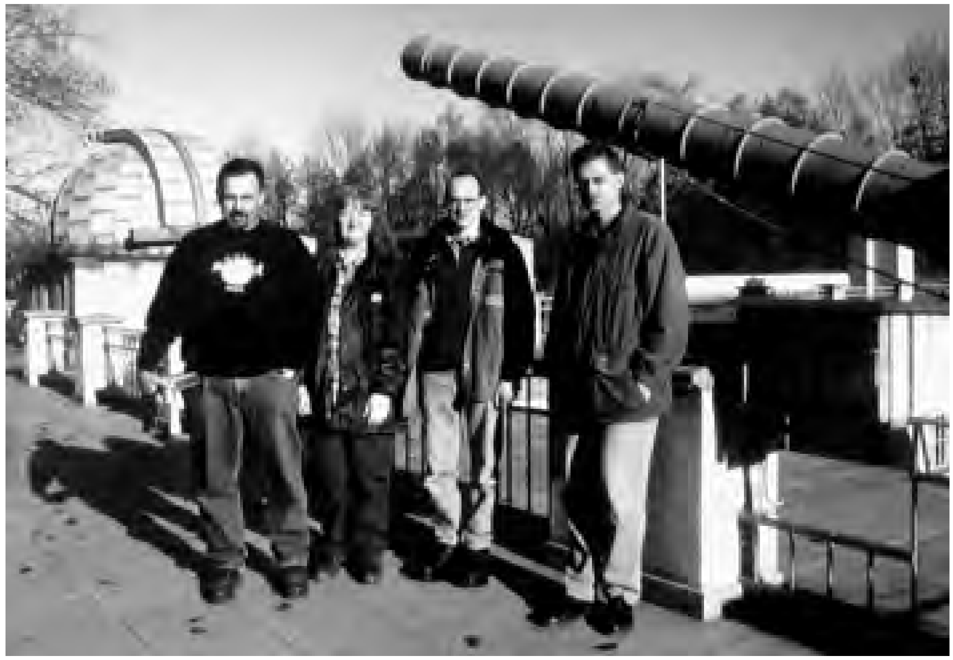
by Albert R. Hassard,
from *Journal*, Vol. 18, pp. 199–200, May, 1924

For the Love of Meteors

by Cathy L. Hall, Kingston Centre (chall@cyberus.ca)

November 17/18, 1999

High in the mountains above Malaga, Spain, far above the beaches of the Costa Del Sol, eight meteor observers from several continents were treated to a memorable display of Leonid meteors. The group included Jürgen Rendtel, Manuela Trenn, Rainer Arlt, Sirko Molau, and Ralf Koschack from Germany, Robert Lunsford from California, and Pierre Martin and myself from Canada. Further east, another group of Canadians, Les MacDonald, Joe Dafoe, and Gwen Hoover, observed from northern Cyprus. Over the course of more than five hours that night, those of us in southern Spain recorded an incredible number of meteors, with most of us seeing between 1,000 and 2,000 Leonids. The group in Cyprus was hindered by cloud, but was still delighted with the Leonids' performance.



Left to right: Robert Lundsford of San Diego, California (IMO Secretary-General and AMS Visual Program Co-ordinator), the author, Pierre Martin of Orleans, Ontario (Ottawa Centre's Meteor Co-ordinator), and Sirko Molau of Aachen, Germany (IMO Video Commission Director). The photo was taken at the Berlin Observatory prior to flying to southern Spain to observe the Leonids.

It was a beautiful display in the mountains over Malaga. The meteors and comets I have seen over the years have always been very personal things. I like to enjoy them alone, if possible. So, while the other observers in our group huddled in the lee of a hillside by some old Spanish ruins, I set up my sleeping bag and cameras in the middle of an open field a fair distance away. A strong wind was blowing, and it was cool, but not cold. Far below me in the east, I could see about half a dozen tiny Spanish towns, all sparkling orange in the dark. From north to south there was a low line of mountains, dark against the horizon. It was absolutely beautiful. I turned on my radio, and the lively popular tunes of the European music scene kept me moving to a soft beat, and tapping my toes to the meteors. My favourite song was a beautiful Irish piece I had never heard before — "Just My Imagination," with the female voices of a group called the Cranberries. It wafted over the Spanish mountains as the Leonids started to fall.

The earliest Leonid meteors were a pale orange in colour — fast, delicate, and with trains. The visual effect they gave, while falling over the orange lights of the Spanish towns, was almost beyond words. The rate started to pick up at about 1:30 UT, and it was as if the meteors built to a delicate, rising crescendo over the next half hour. The wind blew, and the meteors fell over the mountains. Most of the meteors by now were a pale white in colour. Leo was well up in the sky, and the radiant, the point from which the meteors originated, became quite evident, as many tiny faint meteors started to fall. I saw a beautiful point meteor, coming right out of the Lion. I think the most meteors I saw in any given second would have been about six or seven — tiny, faint, most with trains, falling silently out of the sickle. It was exquisite and delicate, like soft notes on a flute. There would be a brief lull, followed by another tiny burst of delicate meteors.

Just after the time of maximum, which occurred about 2:00 UT, the rate gradually eased back, and the meteors did not come as frequently. Leo started to move closer to the hillside where the other observers were huddled. I was pleased that I had not heard them during the night, as their noise would have spoiled the tranquillity of such a beautiful experience.

Later, when the rates were much more subdued, the average brightness picked up. Although I was concentrating on visual observing, I did run some cameras over the evening, using several different types of film — P1600, tungsten 320T, and Ektachrome Infrared EIR. Although my results were modest, it was interesting to see the different appearance of the same meteor on all three films.

It was, however, the visual aspect of this particular Leonid shower that was so beautiful, not the technical aspect. The mountains, overlooking the little Spanish towns with the meteors gently slipping out of the sky, were just wonderful, and the melody of that song and the 1999 Leonids are still imprinted on my brain.

Prelude

Amateur meteor observing in Canada goes back many years, and has had a long and interesting history in the RASC. The professional meteor observers, such as Dr. Peter Millman, inspired many amateurs to become involved. The study of meteors was, and continues to be, one of the few fields in astronomy where the amateur can still make valuable contributions to science without requiring a lot of equipment. It is also perhaps the best area of amateur astronomy for beginning observers — it teaches them how to observe and find their way around the sky without optical aids.

How did some of us get involved in such an interesting pursuit? I was eleven years old when I saw my first meteor, from my parents' driveway. It was 1964 and we lived in the town of Alliston, Ontario, where my father was posted with the air force at Camp Borden. We moved to Ottawa soon afterwards, but I did not become aware of any local astronomy groups, so for the next four years I recorded meteors on my own, all plotted and recorded on a set of index cards. I would not go to bed at night until I had recorded at least one meteor, satellite, or weather balloon, duly plotted. For years I telephoned the Dominion Observatory to ask the names of the satellites I had seen. They were never able to help me, and they never once told me about the astronomy group that met next door in one of their own buildings.

I finally linked up with the Ottawa Centre around 1968, through a member of the astronomy club at my high school, Alan Miller, a quick-footed redhead and telescope maker extraordinaire. It was through Alan that I started attending the RASC meetings, and through him that our school club was invited to observe at the "Quiet Site," a radio-quiet observing site owned by the Defence Research Board and used by the Ottawa Centre's amateur meteor observers.

Who were the observers back then? At the time I joined the Ottawa group, the co-ordinator was Les MacDonald. The other observers included Ken Hewitt-White, Steve Craig, Dave Paterson, Chris Martin, Peter MacKinnon, Lindsey Davis, Sylvia Wake, and others, perhaps fifteen different observers in all. The core of the group had been started back around 1962 by Les MacDonald, Joe Dafoe, and Brian Houlihan.

It was an interesting time when I started going out meteor observing to the Quiet Site. The Centre had banned females from using the telescope at their small domed facility in town, as a result of an indiscretion on the part of one of the male observers and his lady friend. In consequence, females entering the group at that time had to work twice as hard to prove to the male-dominated observing core that they were even half as interested in astronomy. That was, however, not a problem. In the early 1970s, female meteor observers dominated the Ottawa amateur group for several years.

For those of you who have never heard of the famous Quiet Site or our meteor observing coffins, I will describe them. Owing to the cold Ottawa winters, the group decided to make some sort of observing shelter. The professionals (Dr. Millman and group) had been using a set of eight individual wooden enclosures, nicknamed "coffins" by us all, each with warm air piped in for the observers' comfort. One person sat in the middle of the eight coffins, which were arranged like spokes in a wheel, and recorded the meteor observations of the others.

Our amateur group decided on a single pie-shaped unit that would hold eight people, feet towards the middle. That way, the group saved on the cost of plywood, and we could put a single heater in the middle, down by everybody's feet. The eight people were all inclined, as if sitting in lawnchairs, so that all faced a different compass point, and the centre of the field of view was about 50 to 60 degrees above the horizon. The coffins were designed by Les MacDonald, our meteor co-ordinator, and were quite cozy. They were later wired so that one could record the observations by microphone onto a large tape recorder set up in a warm-up trailer about 20 metres away. As an added touch, the guys set up stereo speakers so everyone could listen to music wafting over the fields while they were observing. There were many wonderful nights spent listening to Joan Baez and the strains of "The Lady Came from Baltimore"...

We had great times out at Quiet Site — many of us grew up there. At the end of the school year, we would have a book-burning party down by the Ottawa River, where we would collect hundreds of feet of extension cord so that we could run the big music speakers down to the water. We saw many deer and fawns at the site, and it was common for bats to swoop down over our heads while observing. During school holidays, we would camp out there. There were also many star parties held by the Ottawa Centre, with people bringing telescopes and enjoying hot chocolate and hot dogs. I saw my first comet there one night — Comet Heck-Sause — through Ken Hewitt-White's telescope "Big Bertha."

The group had an excellent training regime set up, mainly as a result of the efforts of Les MacDonald. He taught us how to find our way around the sky, the brightnesses of the stars used for judging meteor magnitudes, and how to distinguish the various meteor showers. Some of us plotted meteors as well, on charts that the National Research Council had made for the International Geophysical Year. What Les also made us do, though, was learn the various Arabic or other names of the stars. That way we got to know the sky even better. On quiet nights, we often played an astronomical word game to keep us alert. The first person would give an astronomical name or word, such as the name Aldebaran. The next person would have to give an astronomical word starting with the last letter of the current word, in this case "n." The game would go around the coffins until we tired of it, or hit too many cases of "z" or "x." It was great fun!

In those days we recorded meteors in 10-minute periods, synchronized to the Universal Time signal. We spoke our individual names onto the group tape recorder with each meteor, so that, if necessary, the individual data could be separated from the group counts. The meteor co-ordinator would transcribe the group tape after the observing session, usually the following day. Many nights we would have four or five observers in the coffins, and for major showers the coffins would be full, plus there would be other observers nearby in lawn chairs.

What were some of the highlights over the years? I suppose that my favourite nights back then were December 13/14, 1971, and December 14/15, 1974. In 1971 I set the Ottawa Centre's observing record for the longest observing time without a break — 8 hours, 40 minutes, during the Geminid meteor shower. In 1974 I set a new record, jointly with Doug Welch, observing 9 hours, 30 minutes without moving. It was warmer that year though, about −12˚C as compared to −15˚C in 1971. The Geminids have always been my favourite shower — bright meteors and lots of trains. It is so beautiful that you just do not notice the cold!

I also remember the unusual meteors that I have seen over the years. One night at the Quiet Site, I saw a beautiful yellow-gold meteor that travelled across the sky, flared, died, and then exploded — and you could see four individual golden pieces falling down. It was exquisite. I remember several very long, slow, red meteors that traversed the sky just above the trees — what I always referred to as "down in the weeds." I very rarely see colour in meteors, so it is always a special treat when something like that happens.

I also remember the wolves. One cold winter night, when Les and four of us women were out observing, I heard wolf howls in the distance. We turned down the radio and yes, the others heard it too: yapping and howling. Later in the evening we heard it again, but from a different direction and closer. Still later the howls were back, and much closer, but that was the last of their serenade.

Where are those Ottawa meteor observers now? Well, Les MacDonald teaches political science at a university in Ottawa. Joe Dafoe is the owner of several nature stores, also in Ottawa. Ken Hewitt-White, at one time Director of the H. R. MacMillan Planetarium in Vancouver, now works freelance for television and planetariums from his home in British Columbia. Alan Miller is in telecommunications in Belgium. Lindsey Davis is a professional astronomer working at Kitt Peak in Arizona. Sylvia Wake-Hood is a software engineer in California. Peter MacKinnon is an economic advisor to Canada, over in Britain. Doug Welch is a renowned astronomer working on the age of the universe, and travels the world in that pursuit. The rest of us are in assorted, more mundane careers. Many members of the former crew are not active in meteor observing any more, and some of us have taken breaks from it and are back!

Meteor Groups Today

It is now the year 2000, and we are entering another century. What meteor groups do Canadians belong to now, and what resources are available? Canada's amateurs have an excellent resource in the new generation of Canadian meteor professionals. We have Peter Brown in London, Ontario, Robert Hawkes in New Brunswick, and Martin Beech in Regina. There are others as well, but those are the names with which most of us are familiar. There is also a wonderful effort on the part of some of the older and more experienced astronomers in Canada to forge ties with the current amateur meteor community. Foremost in the effort is Jeremy Tatum of Victoria, who has helped co-ordinate a number of amateurs who are interested in fireballs.

Canada also has the Meteorite and Impacts Advisory Committee (MIAC). Many of the meteor researchers belong to the group, but it also encompasses many of Canada's meteorite experts, such as Richard Herd of Ottawa, and Alan Hildebrand of Calgary. The committee also has the continued expertise of Ian Halliday, one of Canada's foremost meteor researchers. Several noted RASC members donate their time as well — Damien Lemay of Rimouski, Quebec, and Gary Dymond of St. John's, Newfoundland. MIAC collects fireball reports from across Canada in an attempt to track down possible meteorite falls. The primary interest of MIAC, however, is in the geological aspects of meteor science. In other words, our amateur meteor observers are interested in observing meteors, whereas MIAC is interested in studying impacts and meteorites. The two are complementary, of course, but there is a difference.

Many decades ago the RASC had "National Co-ordinators," who attempted to co-ordinate amateur observations in various fields, including meteors, and to act as a liaison with the professionals. The program was disbanded after the 1960s. Nowadays, most amateur meteor observers in Canada have joined one of the North American or international organizations that specialize in the observation and study of meteors.

The oldest such group is the American Meteor Society (AMS), founded in 1911 by Charles Olivier. Although originally "American" in the United States sense, over the years the society has acquired much more of a North American identity, with many observers in Canada. Dr. Olivier's original goal was to organize a joint effort between amateur and professional astronomers for the purpose of conducting visual observations of meteor showers and sporadic, *i.e.* non-shower, meteors. In the late 1970s, the leadership of the AMS passed to David Meisel, and the headquarters of the society moved to Genesee, New York. The activities of the society were expanded to include more radio meteor studies. Nowadays, the activities of the AMS span a wide variety of fields, from visual to radio to spectroscopy. There are even several Canadians on the volunteer operations staff, myself, as well as Ed Majden from Courtney, British Columbia.

In 1988 the International Meteor Organization (IMO) was founded in response to a need for international co-operation in amateur meteor work. The IMO's main objectives are "to encourage, support, and co-ordinate meteor observing, to improve the quality of amateur observations, to disseminate observations and results to other amateurs and professionals, and to make global analyses of observations received world-wide." The IMO, in spite of its fairly recent existence, has revolutionized amateur meteor observing. It has standardized the way most visual meteor observations are now done, so that observations from countries all around the globe can be combined into a computer data base, and observations of both meteor showers and sporadic meteor activity can be analyzed on a global basis. (The main changes in the standardization of observing technique relate to individual as opposed to group counts, the timing of meteors to the minute, and more precise estimations of the limiting visual magnitudes of individuals.) Such data are a great resource for both meteor professionals and amateurs.

The other meteor organization of note for Canadians is the North American Meteor Network (NAMN). It was founded in 1995 by Mark Davis of South Carolina and George Zay of California, and was initially a completely Internet-based organization. More so than the other meteor organizations, its purpose is to help new people get involved in visual meteor observing, and to teach them how to have fun and to contribute to a worthwhile scientific cause. Basically, NAMN provides a user-friendly interface to the type of observations done by the IMO. NAMN has a complete observing guide on its website, as well as star charts and other useful information for new observers. The monthly meteor newsletter *NAMN Notes* is available via E-mail and on their website. The group runs a very informative E-mail list, maintained by Lew Gramer, where meteor observers and new people of all ages are welcome to discuss meteor topics and to ask questions of all kinds. The NAMN, besides being probably the most active group on the

WEB RESOURCES FOR METEORS AND METEORITES

Where to find out information on meteor observing:

North American Meteor Network: `web.infoave.net/~meteorobs` includes an observing guide and star charts for beginners, and a monthly on-line newsletter with information on what showers are currently visible.

American Meteor Society: `www.amsmeteors.org` includes meteor shower basics, answers to frequently asked questions, and also information on radio and spectroscopic observation of meteors.

International Meteor Organization: `www.imo.net` includes info on visual, photographic, video and radio observations, some excellent meteor software, and a neat computer simulation of a meteor storm called MetSim.

Where to get further info on major and minor showers: Gary Kronk's Comets and Meteor Showers: `comets.amsmeteors.org` includes historical information, and a special education corner with on-line movies of comets, meteors, and asteroids.

Where to find out what your sky will look like on any given night: Your Sky, an interactive planetarium on the web (`www.fourmilab.ch/yoursky`). Excellent, recommended easier to view for beginners if you delete deep sky objects, constellation boundaries, star names, and codes, set stars to magnitude 4.0, and adjust colour to your preference.

Where to find out what satellites you will see while meteor observing: `www.heavens-above.com` gives daily predictions for where in the sky to look to see the brighter satellites, and what their names are.

Where to learn all about meteorites and impacts: Meteorite and Impacts Advisory Committee to the Canadian Space Agency: `wwwdsa.uqac.uquebec.ca/~mhiggins/MIAC.`

Where to see meteorite samples up close: The Meteorite Market: `www.alaska.net/~meteor,` a great source of information on learning about different types of meteorites, with lots of colour pictures and information on various falls.

Where to view various astronomical movies, including the Peakskill fireball: `image.gsfc.nasa.gov/poetry/movies/movies.html` has an incredible selection of online movies and animations from NASA and elsewhere, on all aspects of astronomy.

Where to find books on meteors to further your knowledge: Knollwood Books: `www.meteorite.com/knollbks.htm.`

continent, is also the only meteor organization with no fees of any kind.

Some of the great publications available from these groups

1. *Meteor Trails*, the newsletter published by the AMS, American Meteor Society, is available for US$8 for the year, and is called "associate membership." To receive the newsletter, send a money order payable to "AMS" to Karl Simmons, AMS Treasurer, 3859 Woodland Heights, Callahan, FL 32011, U.S.A.

2. *WGN*, the bimonthly publication of the IMO, the International Meteor Organization, is available as part of membership in the IMO, which is US$25. Send a money order payable to "Mr. Robert Lunsford," to Mr. Robert Lunsford, 161 Vance Street, Chula Vista, CA 91910, U.S.A.

3. *NAMN Notes*, the monthly newsletter of NAMN, the North American Meteor Network, is available free of charge. If you wish to have it E-mailed to you, please drop a note to Mr. Mark Davis at MeteorObs@charleston.net. It is also posted on the NAMN website.

To communicate or ask questions of the amateur meteor observers around the continent and world-wide

Join the NAMN meteor Email list, which is administered by Lew Gramer, the Internet Co-ordinator of NAMN. Send a note to Lew at owner-meteorobs@jovian.com to join or just to post your own question. We have active list participants in such diverse locations as California, Vancouver Island, Beijing, Australia, Slovenia, and the slopes of Mt. Etna!

Join a weekly meteor Internet Relay Chat (IRC) session. They are held every Monday evening, starting at 8:00 PM EST, and every Saturday morning, starting at 11:00 AM EST. To attend, download a copy of one of the many IRC client programs. *mIRC* is a good one for Windows computers, as is *IRCle* for Macintosh computers. Both are available as try-to-buy shareware on the Internet. Once you have an IRC client on your computer, connect to the server on DALnet known as irc.dal.net and enter the IRC command for joining our meteor chat session: /join #meteorobs.

Who are the RASC meteor observers?

Who are the amateur meteor observers across Canada and the RASC right now? That is a difficult question. I am aware of some of you through the RASC E-mail list, but the participants on that list represent only a very small percentage of the observers across Canada, and only those with Internet access.

I am aware of several meteor amateurs in Quebec, several in the Maritimes, a couple in Ontario, at least one in Saskatoon, some in Edmonton, and a couple in British Columbia. The RASC has about 3500 members, though, and I would like to put together a list of those members who would like to find out more about meteor observing, and would like to keep in touch with other amateurs, or at least be advised personally of interesting meteor events coming up! I expect many of you may be interested in visual observing, but if your meteor interests are related to photography, video, radio, or spectroscopy, I would also like to find out who you are!

Please drop me a note and introduce yourself! My address is: 2604 Draper Avenue, Apt. 1211, Ottawa, Ontario, K2H 9B1, Email: chall@cyberus.ca, telephone: (613)–828–8807.

Conclusion

Visual meteor observing is one of the very few fields left in astronomy where the amateur can truly make a difference, and can contribute a great deal to worthwhile science. No fancy equipment is needed — no telescope, no computer — just the unaided eye and a willingness to enjoy the night sky!

It is an ideal pursuit for both young and old alike. Meteor observing provides a wonderful opportunity to learn about the heavens, the constellations, and the brightnesses and the names of the stars. It is a great way to introduce kids to astronomy as well, to teach them about the wonders and the legends of the night sky, and to show them what a wonderful resource we will lose if light pollution keeps encroaching outwards from our cities.

So, as we enter the new century, with all of its constantly changing technology, never forget that astronomy still needs actual observers — those people who love going out under a dark country sky and observing — with just their own eyes! Clear Skies and Many Meteors to All!

Cathy Hall has been observing meteors with the RASC since 1968, and is currently a member of the International Meteor Organization, co-author of the monthly newsletter of the North American Meteor Network, and one of the Assistant Visual Program Co-ordinators for the American Meteor Society. She lives in Ottawa, Ontario.

Observing Geostationary Satellites

by Richard Huziak, Saskatoon Centre (huziak@sedsystems.ca), reprinted from Saskatoon Skies

As of June 12, 1999, 791 geosynchronous satellites could be found sitting in orbit above the Earth's equator. Almost every day, a new launch puts yet another satellite into the tiny remaining gaps between the satellites already there. Some quick math shows that there are 2.20 satellites per degree (791 satellites divided by 360°). Geosynchronous space is indeed a crowded place!

Geosynchronous orbit is located about 35,800 km above the Earth's equator, in a region of space known as the Clarke Belt. A satellite at that distance revolves around the earth exactly one time every 24 hours, so despite travelling at over 4,600 kilometres per hour (1.3 km s^{-1}), the satellite appears to be locked directly above one point on the Earth's surface. (The Clarke Belt is named for the noted science fiction author Arthur C. Clarke, who first wrote about the properties of geosynchronous satellites.) Geosynchronous satellites thus become very valuable to their owners, since the satellite can broadcast and receive 24 hours a day, unlike satellites in a low orbit that can generally be seen above the horizon for 16 minutes or less out of each 96-minute orbit. Geosynchronous satellites are used daily for overseas and long distance telephone calls and data transmission, television broadcasting, weather monitoring, Earth resources imaging, and for spook stuff — spying! (the United States, Russia, NATO, and others use geosynchronous satellites to look for the contrails from intercontinental ballistic missiles, *etc.*)

The exact orbits of such satellites fall into two main categories: *geosynchronous* and *geostationary*. Most people who think about such satellites imagine them to be in a truly circular orbit around the Earth. In that mode, the satellite is *geostationary*. But it is not easy to maintain such an orbit since it requires very precise speed matching during launch, and then a lot of fuel consumption to keep the satellite there in the presence of constantly changing gravitational tugs from the Moon and the Sun. Expending limited fuel to tweak the orbit to keep it perfect takes a lot of "housekeeping" on the controller's part, and reduces the useful life of the satellite, since the amount of fuel is limited.

To avoid such a scenario, most satellites are *geosynchronous*, and appear to do a small figure-eight dance about a point in space. The figure-eight is actually a slight oscillation or wobble that keeps the satellite almost above the same point and saves fuel, but the tradeoff is that the ground station has to have a tracking antenna to receive signals. Some satellites oscillate as much as 4° north and south of the equator. A typical antenna beam width is about half a degree. With so many satellites spaced that closely together, electronic interference becomes a concern. That is generally overcome by having side-by-side satellites transmit in different frequency bands and at different polarizations.

Note that the "satellites" that we see with the unaided eye are generally not satellites at all. They are mostly expended rocket bodies. Except for very low orbit satellites (generally spy satellites!), satellites are too small, and thus too dim, to see with just your eyes. Using a telescope, however, changes the situation as a consequence of the increased light-gathering ability. It is rare that a night goes by where I do not see several satellites cross the fields of the variable stars or galaxies that I observe. One hundred times further out into space is where one finds the "geosyncs," but despite their extreme distances they might be seen with a modest telescope. That is a consequence of some fortunate circumstances: the satellites we are looking for are generally very large (often the size of a train boxcar), sunlight illuminates their bodies, antennae, and solar panels virtually head on, and they appear as stationary objects when viewed with an untracked telescope (see Figure 1).

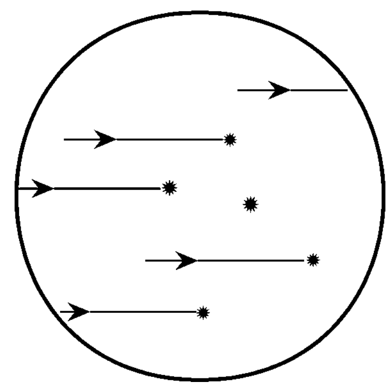


Fig. 1. In an untracked telescope when viewed at high power, geosynchronous satellites stay fixed in the eyepiece as the stars float by!

I have seen photographic exposures of several hours duration taken of such satellites with an untracked tripod-mounted telephoto lens, but how faint are they really? Could they be spotted visually? Well, the answer is, "Yes!". My first view of a geosynchronous satellite was on the evening of July 6, 1999. Doing some basic math (see Figure 2 and the Table) showed me where in the sky to look. From 52° N latitude I would have to set my telescope to look at a declination of −7°25′. I took out my copy of *Uranometria,* found an easily located asterism at that declination, and pointed the 12.5-inch reflector to that part of the sky. There shone a thirteenth magnitude satellite, dead steady in the field as the other stars moved by! Scanning the telescope left and right, between Earth

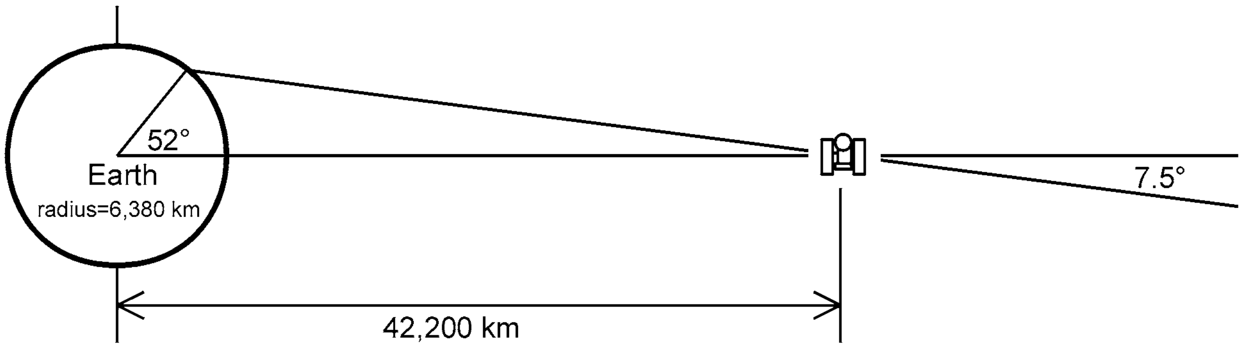


Fig. 2. The geometry of geosynchronous satellites visible from Saskatoon. The figure is to scale (except for the size of the satellite).

longitudes of about 102˚ and 107˚ west, I found three other satellites, all between magnitudes 13 and 13.5, each a degree or two from the last! Chances are that one of the satellites is Canada's *Anik C1*, although I could not identify it for certain.

In the next few days I showed these little gems to several other observers: Al Hartridge, Darrell Chatfield, and Andrew Krochko. We were all amazed at how the satellites stayed fixed in a high power field while the distant stars whizzed by! Anyone with a telescope having an aperture of 8-inches or larger can find the satellites with a bit of luck! Over the next few months, I hope to map, photograph and identify all the geosynchronous satellites visible from Saskatoon!

Richard Huziak has been observing the sky for 32 years. What keeps his observing schedule fresh is thinking of new and unusual observations to attempt, such as the challenge of observing geosynchronous satellites. His main interests lie in deep-sky observing, with a goal towards observing all of the objects in the New General Catalogue *before he dies (and it will certainly take that long!), and variable star observing, with over 12,500 estimates being provided to the American Association of Variable Star Observers. In addition, Rick observes for the International Meteor Organization counting meteors, for the International Occultation Timing Association observing asteroid occultations, and for the Noctilucent Cloud Can/Am Network. He also provides dozen of astronomy presentations and star nights to school camps throughout the year. He is often heard saying, "I might be able to get some sleep next week — but right now, I hear the sky calling!" Rick is currently the Saskatoon Centre's newsletter editor. And, once and for all to end the rumours, yes, he has seen the Horsehead Nebula in a 4-inch scope!*

Table

The declination of the Clarke Belt for various latitudes. For northern observers, the declination is negative. For southern observers, the declination is positive.

Latitude (°)	Declination (°)
0	0.0
5	0.9
10	1.8
15	2.6
20	3.4
25	4.2
30	5.0
35	5.7
40	6.3
45	6.8
50	7.3
55	7.7
60	8.1
65	8.3
70	8.5

Astronomy Day - April 8th, 2000

This year Astronomy Week is April 3rd through April 9th and International Astronomy Day is Saturday, April 8th. This international event is held each year between mid-April and mid-May on the Saturday closest to the first quarter Moon. It provides a forum for amateur astronomy enthusiasts to promote the science of astronomy to the general public. Since 1973, International Astronomy Day has generated a wide range of public interest in amateur and professional astronomy. The media are sensitized to the event and enhance public awareness. During Astronomy Week many groups setup demonstrations, hold lectures and present slide shows in shopping malls, schools, museums and other public venues. The evenings are an ideal time to host local star parties. This is a fantastic opportunity for your Centre members to be involved in this annual exposé of our interests in astronomy.

A section of the National RASC web site (www.rasc.ca) has been setup to provide background information, contact names and numbers and suggestions for organizing this exciting event. Should you need any information please contact Peter Williams.

J. Peter Williams
Astronomy Day Coordinator
E-mail: jpw@iqs.net

La Météorite de St-Robert

par Christine Kulyk, clkulyk@kos.net

La Météorite de St-Robert,
In '94 it scorched the air
And thundered over Québec, there,
As pieces scattered everywhere.

This visiteur d'une autre terre
Announced itself with beaucoup flair
As folks were startled by the glare
And curious cows did stop and stare.

Dans le chemin de Forcier-père
A clever lad, avec son frère,
Became the first to proudly bear
A meteorite from St-Robert.

Soon newshounds came from everywhere
To photograph their treasure rare,
And scientists with savoir-faire
Were stepping through the fields with care.

Though much was found, they still declare
There must be fragments yet to snare.
La Météorite de St-Robert —
Un jour, on trouvera une pièce, j'espère!

Christine Kulyk has been an RASC member off-and-on since the late 1960s, when she joined the Montreal Centre as a teenager. A native Montrealer, she attended McGill University, where she majored in Physics and Mathematics, then moved to Edmonton, where she graduated from the University of Alberta with a B.Ed. and a B.A. in English. She served as Treasurer of the Edmonton Centre for several years. After spending a few years in Toronto, she moved to Kingston nearly ten years ago and joined the Kingston Centre, where she has been a past President and Vice-President. She is a full-time freelance writer and editor, currently Assistant Editor of SkyNews *and a Researcher/Writer for* Equinox.

Calendrical Conundrums and Cosmic Chaos

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

The production cycle for the *Journal* compels me to submit my first year 2000 column by the beginning of December 1999. On my part, writing the column requires some faith that the world will not turn topsy-turvy in the meantime as a consequence of the well-exposed "Y2K Problem." It seems appropriate to herald this very special New Year with a calendar topic. How about a quiz in two parts? The quiz concerns the sequence of numbers:

1904, 1908, 1912… 1992, 1996, 2000, 2004, 2008… 2088, 2092, 2096.

The questions are:
a) What is special about the sequence?
b) Which number is peculiar?
If this were a proper quiz, there would be a deadline and prizes. I would then have to find a new subject for this issue, however! So… take a minute to ponder before reading on, as I will reveal everything here.

* * *

The numbers above are — of course — a sequence of leap years, uniformly separated by four years and each divisible by four. (There are no points for that, since you already knew it was a calendar puzzle.) What makes the sequence special is that it is the longest regular sequence of leap years since the Gregorian calendar was introduced in 1582. It is particularly long because of the appearance in the list of a special year, which most of you have already guessed is the year 2000. (Again, there are no points for wild guesses: you must know the reason.) The year 2000 is special not simply because it is the middle entry; it is special because it appears through the application of a seldom-used rule of the Gregorian calendar: the "400-year" rule.

Most people know the familiar "4-year" rule for determining leap years in the Julian calendar: if a year is divisible by four, it is a leap year, having an extra day in the year, that day being February 29. For reasons that will be explained below, however, the Julian calendar has too many leap years, and needed to be refined. The solution provided by the Gregorian calendar is to have no leap day in century years (the "100-year" rule) unless the year is also divisible by 400, in which case there is a leap day (the "400-year" rule). With the new rules, the years 1700, 1800, 1900, and 2100 are not leap years, but the years 1600 and 2000 are leap years. Even with the new rules, it turns out that between 1901 and 2099 the convoluted Gregorian rules identify the same leap years as the simple Julian rule! It is no wonder that so few people know — or care — about such calendrical trivia.

German astronomer Christopher Clavius (1538–1612), Jesuit advisor to Pope Gregory XIII on the calendar reform of 1582.

Pope Gregory XIII, with good advice from astronomers such as Christopher Clavius, introduced the reformed calendar in 1582, with most of the Roman Catholic world following suit. Not surprisingly acceptance occurred more slowly in the Protestant world, despite the assurance from distinguished Protestant scientists that the calendar reform had a sound astronomical basis. Great Britain and its Dominions (including the American and Canadian colonies) did not adopt the Gregorian calendar until 1752. Many other countries did not convert until much later, some only this century! Some Eastern Orthodox churches still operate according to the Julian calendar. It is a long and complex story, and revolves around determining a correct date for Easter, which is why the churches have had so much to say about the calendar. A good history of the problem can be found in David Duncan's *Calendar: Humanity's Struggle to Determine a True and Accurate Year* (Avon, New York, 1998). (There is a move afoot to resolve the Easter differences between the Eastern and Western Churches, whereby the date of Easter would be calculated by a mutually acceptable astronomically accurate formula, while the two churches retain their separate calendars. But that is another story for another column.)

The point about this digression is that February 29, 2000 is the very first "400-year" leap day for all of the countries that adopted the Gregorian calendar after 1600. Before you dismiss it as arcane trivia, ask why this particular date is one of the dates of interest for Y2K compliance testers. Up until fairly recently, some date-sensitive software — including some produced by a large monopolistic firm that will remain nameless — incorrectly followed February 28, 2000 with March 1, 2000. One explanation could be that some programmers knew about the "4-year" rule and the "100-year" rule, but skipped class on the day the professor covered the "400-year" rule. They would have been better off with the Julian calendar rules, at least until 2100!

I hear people asking, "So, where's the astronomy?" (Actually, the loudest voice is that of our overworked and under-appreciated Editor. He gets that way, sometimes.) The astronomy resides in the length of the year (the time cycle that defines the seasons) and the length of the day (the rotation period of the Earth). If the length of the year were an integer number of days, there would be no need for leap years. The Tropical Year (equinox to equinox) is 365.242190 days long, just under 365¼ days. Accounting for the extra fraction of a day in one complete year has caused all of the trouble, as calendars cannot cope with fractional days, only whole days. The Egyptian calendar counted a whole number of 365 days per year, but that calendar quickly became out of step with the seasons: the equinoxes and solstices steadily arrived later and later on the calendar, about one day for every four years elapsed.

At this point it must be emphasized that having a calendar synchronized with the Sun is only convenient if there is an annual cycle of seasons. Migratory and agricultural peoples alike are governed by such a cycle, for the seasons modulate food gathering and production. As I have argued before, if the Earth's rotational axis were not tilted, any given day would be more-or-less like every other day, and it would be a very boring existence indeed. Mind you, without seasons we could choose any old calendar we liked!

The Julian year, which adds a leap day every four years, was the first attempt at accommodating the fractional nature of the true Tropical Year. On average the Julian year is 365.25 days long, which slightly overestimates the Tropical Year, but takes longer to get out step than the Egyptian year. This information is summarized in the Table, along with data from some other year types. The "Century Rule" year has never been used (except by dozing programmers). Rather, it is a notional year that is a halfway step between the Julian year and the Gregorian year. There have been several proposals to extend the leap year concept to refine the approximation, but it is evident that they will not be needed for quite some time (if they are needed at all).

All this fuss over a fraction of a day! Would it not have been simpler for the Creator to have constructed a more harmonious solar system? Here's one: a year of 360 days (orbital motion of one degree per day) with a month of 30 days (instead of 29 days and change) made up of three ten-day weeks. (Here is the plan: work six days and have a four-day weekend!) To have names for all of the days, we would need to make Uranus, Neptune, and Pluto obvious naked-eye planets. (I know, the whole idea is goofy.)

In all seriousness, even if one could set up such a scheme, there is no guarantee that it would run smoothly, at least if the laws of physics are in effect. It is commonly believed that the motions of the planets cycle as regularly as a clockwork mechanism, but that is not true. That it has been approximately true over historical time is a consequence of the overwhelming dominance of the Sun, the largest gravitational attractor. If we ignore small corrections attributable to the effects of general relativity, non-spherical masses, and non-rigid bodies, the dynamics of the solar system (or any planetary system) are governed by one simple law: the acceleration of a given body towards a second body is proportional to the second body's mass and inversely proportional to the square of the distance between the bodies. For a system of several bodies, one simply adds vector-wise the accelerations induced on a given body by all the other gravitating bodies.

For a two-body system, the equations of motion solve nicely and result in the well-known analytical solutions for hyperbolic, parabolic, and elliptical orbits. Except in very special circumstances, the solutions for n bodies with $n > 2$ are not solvable, and are not periodic. Such a system is inherently chaotic in nature, despite the fact that its dynamical evolution

Table

The Lengths of the Tropical Year and Several Calendrical Approximations

Year Type	Length (days)	Expanded Fraction	Error	Years to Gain or Lose One Day
Egyptian	365	365	$-5^h\,49^m$	4
Julian	365.25	365 + ¼	$+0^h\,11^m\,15^s$	128
"Century Rule"	365.24	365 + ¼ − 1/100	$-0^h\,3^m\,9^s$	457
Gregorian	365.2425	365 + ¼ − 1/100 + 1/400	$+0^h\,0^m\,27^s$	3226
Tropical	365.24219			

is deterministic and based on a simple law. In practice such equations can be evaluated numerically on a computer. Computer simulations of the solar system that are run for elapsed times of millions of years show that the current state of affairs is not stable, and the orbits of the planets — including Earth — can vary considerably from what they are now, both in the past and in the future. The current clock-like revolution of the Earth is a temporary state. A solar system designer trying to establish a metronomic year with a whole number of days would be hard-pressed to come up with a scheme of physics that maintains the beat.

Those interested in finding out more about the fascinating subject of chaos in the solar system could surf to `geosys.mit.edu/~solar/text/short.html`, or simply type "chaos in the solar system" into your favourite Internet search engine and follow the several links.

So, on Leap Day 2000, pour a glass of your favourite beverage and drink a toast to a unique day. Reflect on the simple laws of physics and how they manifest themselves, not in clockwork planetary systems, but in the awesome complexity of (mildly) chaotic motion.

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

Second Light

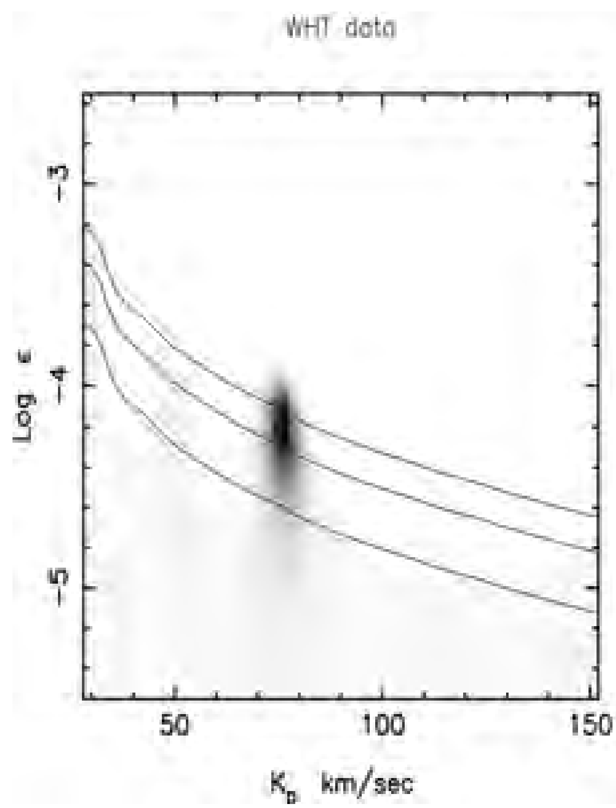
Detecting Other Planets

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

The last four years have brought us the discovery of planets orbiting 27 solar-type stars, starting with the landmark work of Michel Mayor and Didier Queloz in 1995 (see 23 November 1995 issue of *Nature*). All but one of those planets have been discovered by detecting the periodic shifts of spectral lines of the parent star that result as the star and the planet orbit their mutual centre of gravity. One planet was recently seen transiting the face of its parent star, and now Andrew Cameron and colleagues at the University of St. Andrews in Scotland have — they think — seen starlight reflected off the atmosphere of the planet around Tau Boötis (see 16 December 1999 issue of *Nature*).

As a star and planet orbit their mutual centre of mass, the much more massive star appears to simply "wobble" a little about the orbital centre of mass, while the planet describes its more-or-less regular orbit about the star. Think of the analogy of the Sun and Jupiter — we speak of Jupiter orbiting the Sun, because Jupiter is the body that moves the most, but in fact the Sun performs a tiny orbit as well. The orbit is considerably smaller than the dimensions of the Sun, so it is not readily apparent from simple observations. If Jupiter were closer to the Sun, however, the Sun's wobble would be larger in speed and Jupiter would complete its orbit about the Sun in much less time than the 12 years it takes at present. All of the extra-solar planets discovered using the Doppler wobble technique are much closer to their parent stars than Jupiter is to the Sun, and many are closer than Mercury is to the Sun, though they are all giant planets and therefore presumably look something like Jupiter.

The wobble produces a motion of the centre of mass of the star relative to the centre of mass of the planetary system that results in a shift in the observed positions of lines in the spectrum of the star. The shift is tiny and difficult to measure, but it can be detected. Such a Doppler shift is the same basic phenomenon that explains why the pitch of sirens drops as an ambulance or police car goes by. As the source of



The residual velocities of the starlight reflected from the planet in the Tau Boötis system are shown against the unknown ratio of planet light to starlight (epsilon). The dashed lines show confidence intervals, with the dark blob of the planet lying between the 95% and 99% levels.

the sound (or light) approaches us, the pitch (frequency) is increased — a blue shift. When the source is going away, the pitch drops, which is called a red shift. By knowing the pitch (frequency) of the source when it is at rest, its velocity along the line of sight can be calculated readily, because the shift is proportional to the velocity as a fraction of the velocity of propagation of the wave (either sound or light).

But measurement of Doppler shifts is an indirect method of finding planets. To see them directly requires different techniques. The planet around Tau Boötis orbits only four million miles (6.3 million kilometres) from the star, so its orbital velocity is very high, which is critical for the technique employed by Cameron *et al*. What they have done is a very complicated bit of data processing, based upon one good assumption and one straightforward piece of physics. The assumption is that the star's rotation period is locked to the planet's orbital period. That is important because, to us, seen directly, the star's spectral lines are smeared out by its rotation. The lines arising in gas on the side of the star rotating towards us are blue shifted, while the lines coming from gas on the opposite side of the star are red shifted. When the star's rotation is locked to the planet's "year," however, the lines in the light reflected off the planet's atmosphere do not show such smearing. In a sense, the light is more concentrated in the lines reflected from the planet, thereby making the planet easier to see.

That's not all, though. Cameron had to produce an accurate template of what Tau Boötis's spectrum should look like, and subtract that from each of the 580 individual observations. He then combined the results from about 2300 spectral lines in each spectrum to produce a resultant signal that can be distinguished from the starlight in "velocity space" (see the figure). While it looks convincing, though, the statistical significance of the detection is not high; there is about a 5% chance that the detection is false.

Under the assumption that the detection is real, Cameron can use the observed rotational velocity and the known orbital period to determine the inclination of the orbit and the mass of the planet (eight Jupiter masses). From the further assumption that the planet's albedo (the amount of incident light it reflects) is similar to that of the planet Jupiter, they infer that its radius is about 1.6–1.8 times that of Jupiter. Such a large radius is apparently in conflict with current theoretical expectations (see *News & Views* by Adam Burrows and Roger Angel in the 16 December issue of *Nature*). Moreover, the planet appears to be bluer than expected. Given the uncertainties in both theory and observation, though, only a few brave souls are in a hurry to rewrite the theory.

The second method of detecting planets directly does not actually track their light, but the absence of light. If the planet's orbital plane lies fairly close to the line of sight to us, then during part of its orbit the planet will pass in front of the star, blocking some of the starlight. The closer the planet is to the star, the more light will be blocked. The reduction in observed light from the star is at most a few percent, but with CCD cameras that is fairly easy to measure.

The detection by two groups of the transit of a planet across of the face of the star HD 209458 is more definitive than Cameron's result, in terms of demonstrating that the Doppler shifts seen in the star's light do indeed indicate the presence of a planet (papers by Charbonneau et al. and Henry *et al*. reporting the observations are in press with the *Astrophysical Journal Letters*). The planet's radius as determined by the dimming of the star's light is more in line with theoretical expectations, according to Burrows and Angel. Readers will need to decide for themselves if it is more exciting to see possible light from another planet, or the definite absence of light. In the long run, we will learn new things about planets from both types of observations. We are now moving away from the "butterfly collecting" phase of studying extra-solar planets, towards the stage where we can begin to ask important questions about their true nature.

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.*

Call For Papers

The General Assembly of the Royal Astronomical Society of Canada
June 30 - July 2, Winnipeg, Manitoba, Canada

The General Assembly of the Royal Astronomical Society of Canada is held annually to discuss the business and direction of the Society. For full details, see `www.rasc.ca/ga2000`. As a part of this gathering, it is traditional to hold paper sessions at which members of the Society and other interested participants may present interesting aspects of their endeavours in the field of astronomy.

This year GA2000 will be held in Winnipeg on the grounds of the University of Manitoba, near the confluence of the Red and Assiniboine Rivers. The Assembly is open to members of the RASC, and interested non-members of the astronomical community. Accommodation and other facilities are available at the University of Manitoba. Paper sessions will be held in the morning and afternoon of Saturday, July 1st. A CCD imaging seminar will be held in the morning of Sunday July 2. Individual presentations will be limited to 15 minutes with an additional 5 minutes for questions and set-up. Presentations may be made using overhead slides, photographic slides, or computer presentations (an LCD projector and laptop computer will be available). A connection to the Internet may be available if there is sufficient demand. Presentation time at the CCD seminar is limited to four to six speakers with 20 to 30 minutes each. Those participants with computer presentations may bring their material on floppy disk, CD, or Zip disk (100 MB). Download over the Internet or by e-mail can be arranged.

We are also pleased to announce that Steve Edberg of the Jet Propulsion Laboratory will be one of the keynote speakers. Other speakers are being planned.

Suggested topics for the general paper presentations include:
· Recent observational works, including visual, photographic or electronic studies including
    · Eclipses
    · Variable stars
    · Studies of asteroids, especially their brightness variations and positions
    · Nebulae, clusters, galaxies and other deep sky objects
    · Planetary studies
    · Comets
    · Exotic subjects such as quasars
· Topics in the history of Canadian or international astronomy
· Equipment design and observational innovation
· New software
· Data reduction techniques
· Education and public awareness of astronomy
· Meteorites and meteors
· Dark sky promotion

Suggested topics for the CCD Seminar include:
· Data reduction and processing
· Innovative studies
· High resolution observations
· Equipment and observational aids

Prizes will be awarded for the best papers.

Abstracts for the paper and CCD sessions should be sent to

Jay Anderson
189 Kingsway Avenue
Winnipeg, MB
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THE 1999 ANNUAL MEETING OF THE METEORITE AND IMPACTS ADVISORY COMMITTEE (MIAC)

by Alan R. Hildebrand

University of Calgary

The Meteorite and Impacts Advisory Committee (MIAC) to the Canadian Space Agency/Comité consultatif sur les météorites et les impacts (CCMI) de l'Agence spatiale canadienne met in Edmonton, Alberta, for its annual meeting on Saturday, October 23, 1999. The Research Subcommittee met on the previous Friday afternoon, with a viewing of the University of Alberta's meteorite collection on Friday morning. This remarkable collection, the second largest in Canada, was amassed in large part by Dr. Robert Folinsbee, formerly professor and head of the then Department of Geology at the University of Alberta, who pursued meteorites vigorously during the 1960s. His efforts led to the accumulation of hundreds of kilograms of material from the Bruderheim, Alberta, fall of March 4, 1960, and the Allende, Chihuahua, Mexico fall of February 8, 1969. Meteorites, or fragments thereof, were also recovered from three other falls: Peace River, Alberta, March 31, 1963; Revelstoke, British Columbia, March 31, 1965; and Vilna, Alberta, February 5, 1967. The material from those three falls was recovered largely or completely on the basis of eyewitness reports of the fireballs. (Many have erroneously stated that finding meteorites solely on the basis of eyewitness accounts is not possible, although it often is not easy.) Dr. Folinsbee was honoured by MIAC/CCMI for his work in meteoritics at a banquet held Friday evening.

The entire meeting was organized by Dr. Dorian Smith, Department of Earth and Atmospheric Sciences, and Dr. Douglas Hube, Department of Physics, of the University of Alberta. All agreed that they had set a new standard that would be hard to top. The *pièce de résistance* was each banquet diner receiving a small individual meteorite from the Bruderheim fall as a place setting gift. The meeting also featured two well-attended public talks. On Thursday evening, Dr. Paul Chodas of the Jet Propulsion Laboratory at the California Institute of Technology presented "The Impact Threat and Public Perception," concerning the magnitude of the current impact hazard from asteroids and comets. On Saturday evening, Dr. Alan Hildebrand of the Department of Geology and Geophysics at the University of Calgary presented "The Comet that Killed the Dinosaurs," concerning the Chicxulub impact on the Yucatán Peninsula of Mexico that drove much of terrestrial life extinct sixty-five million years ago.

The abstracts that follow illustrate the broad spectrum of interests of the committee, whose members are a mixture of amateur and professional researchers. The first abstract by Dr. Ronald Cavell was a guest presentation to advertise the opportunity presented by the Canadian Light Source for sample analysis.

ABSTRACTS OF PAPERS PRESENTED AT THE 1999 ANNUAL MEETING OF THE MIAC/CCMI HELD IN EDMONTON, ALBERTA, OCTOBER 23, 1999

The Synchrotron X-Ray SpectroMicroprobe at the Canadian Light Source, Ronald G. Cavell, University of Alberta.

The development of intense, high quality X-rays from advanced (3rd generation) synchrotron sources during the past ten years, coupled with the ability to focus X-rays into sub-micron spot sizes, has revolutionized the elemental analysis of complex and heterogeneous materials. Those capabilities are embodied in the X-Ray SpectroMicroprobe, a device that provides the capability for excitation of small areas of material with focused X-rays in order to measure X-ray absorption and/or X-ray emission spectra of the material. X-ray absorption and emission spectroscopy identifies the chemical species, reveals the valence state of that species, and can be used to probe the local structure surrounding the excited element, even at extremely low concentration levels. The technique succeeds because of the specificity and sensitivity of the elemental response; each element has a unique response to the X-ray excitation process that is overall very efficient. Other elements present in the sample do not interfere significantly with the measurement. The ability to select the energy of the exciting X-ray, because the source is fully tunable, provides sensitivity control. Focus is now possible to sub-micron dimensions, thus detailed compositional variations can be readily determined for individual grains and particles (or for small areas of a heterogeneous structure) to provide the information commonly required for petrological or mineralogical studies. In contrast to the electron microprobe, the X-Ray SpectroMicroprobe technique is more sensitive, less destructive, and requires minimal sample preparation, and the sample is not inserted into a vacuum chamber. The Canadian Light Source (CLS), the largest scientific project to be undertaken in Canada in the past three decades, is now underway, and is to become operational in 2004. This world-class, third generation, synchrotron facility will provide a high brightness source for an X-ray microprobe facility that is presently being planned by the author. The synchrotron facility and the microprobe capabilities are described here.

Amateur Meteor Detection Video and Spectroscopy Experiments, Edward Majden, Courtenay, British Columbia.

A short VHS video presentation illustrates a Sandia All-sky Camera mounted on the roof of the author's backyard observatory in Courtenay, British Columbia. A number of dual-station fireball detections were recorded, as well as one three-station fireball. The latter part of the tape depicts meteors recorded with a surplus 2nd generation MCP image intensifier fitted with a Canon f/1.4 camera with a 50 mm lens, a 600 grooves mm^{-1} Bausch & Lomb replica transmission grating recording on a Hi8 video camera, and a standard VHS recorder. Several zero-order meteor images were secured along with three 1st order meteor spectra. Two of the spectra are of Perseids that show the forbidden line of oxygen at 557.7 nm trailing the main spectrum.

A New Canadian Astronomical Meteor Radar Facility, P. Brown, K. J. Ellis, J. Jones, A. R. Webster and M. Campbell, UWO Meteor Group, University of Western Ontario.

Some of the earliest radar observations in the world were conducted in Canada at the National Research Council during 1940s under the direction of P. M. Millman. Since the closing of the Springhill Meteor Observatory in 1987, however, no modern radar facility for the astronomical observation of meteors has been in operation in Canada. Indeed, the only continuously operating meteor patrol radar currently concentrating on astronomical observations is the Advanced Meteor Orbit Radar (AMOR) in New Zealand. As part of the International Leonid observation program in 1998, a novel, triple-frequency radar was purchased. The radar was initially deployed in Australia's Northern Territory, where it successfully observed the 1998 Leonid shower (Bayaraa *et al.* 1999). A permanent facility has now been established for the radar system near London, Ontario, for regular, on-going, astronomical observations. The unique aspect of the system is its ability to detect meteor echoes at three frequencies simultaneously. Such a novel observing method has led to new insights into the issues of initial train radii of radar meteors, a topic central to the measurement of meteor flux at Earth. All three radar systems have interferometric capability, permitting the range, azimuth, and elevation of each meteor echo to be automatically logged for further analysis. Initial results of the system are presented, including daily measurements of shower activity, the sporadic complex, and early velocity measurements. Results from ongoing projects, such as the precise measurement of sporadic flux and variation in activity of the sporadic meteor sources, physical measurement and modeling of initial trail radii of meteors measured, as well as corrected velocity distributions for the sporadic complex, are discussed. Plans to upgrade the system to allow calculation in the year 2000 of several thousand individual meteor orbits per day are also given.

Further Research on Possible Ejecta from the Sudbury Impact Event in the Gunflint Formation of Northwestern Ontario, Makoto Okamoto, Kyushu International University, Stephen A. Kissin, Lakehead University, Bill Addision and Greg Brumpton, Thunder Bay, Ontario.

Previous studies revealed that the Gunflint lapilli tuff unit, located in the Kamistiquia Gorge near Thunder Bay, Ontario, is unlikely to represent an ejecta layer from the Sudbury impact event. Euhedral zircons extracted from the lapilli tuff unit have yielded a date of 1878 ±2 Ma, presumably the age of sedimentation based on a volcanic source for the zircons, too old to be associated with the Sudbury event at 1836 ±14 Ma. However, a distinct ash layer, approximately 100 metres stratigraphically higher in the section, has recently been discovered and investigated. A gray ash layer 11.5-cm thick is exposed in two locations on the southern side of the Kaministiquia Gorge. The layer is comprised mostly of friable illite and montmorillonite, but separation of particulate fractions revealed the presence of lithic fragments, mudball lapilli, crystal fragments, and green spherules with a glassy appearance. The latter were found to be glauconite, however, which also occurs as amygdules in Gunflint lavas that appear to comprise the majority of lithic fragments. The crystal fragments are mostly potassium feldspar, containing minor quartz, calcite, and various other minerals. Analyses of samples taken at various intervals in the layer, as well as of the enclosing shales at one of the locations, revealed the presence of anomalous Ir (1.9 ppb), as well as other PGEs and Au. On the other hand, the chalcophiles Co, Cr, and Ni are significantly depleted in the ash layer relative to the enclosing shales. A strong enrichment in Zr suggests the presence of zircons, which so far have not been separated. Zircons should again provide opportunities for dating the material, as well as investigation for shock features. To date, however, the evidence is in favour of a volcanic source for the ash layers, including detritus from lower units within the Gunflint Formation, as well as a felsic contribution as manifested in potassium feldspar clasts.

Making the Most of a Meteorite Collection — An Application of Multi MIMSY 2000, a Collections Database Management System, Dorian G. W. Smith and Jim Whittome, University of Alberta.

The University of Alberta Meteorite Collection came into being as a result of the far-sighted aggressive collecting of the Bruderheim fall in 1960. Every effort was made to recover as many of the more than 300 scattered individuals as possible for scientific examination. Specimens were subsequently distributed internationally to top laboratories for investigation. In 1964 the fall and recovery of the Peace River meteorite added further specimens to the collection, and then, in 1969, about 200 specimens were acquired from the Allende, Mexico, fall. Together, these mainstays of the collection provided an excellent trading base, and many samples were exchanged for other meteorites in collections and museums around the world. Collections are of limited use if they cannot be conveniently accessed. Because of limited resources, this important collection has not been easily accessible to the scientific community, greatly reducing its usefulness. Today's databases offer opportunities to alleviate problems of collections access. To this end, the Meteorite Collection adopted Multi MIMSY 2000, an Oracle-based, relational database management system. This application is designed with flexible data entry, update, query, and reporting capabilities to meet the needs of all collection types. In the case of the Meteorite Collection, four different "views," or screen customizations, have been created for the collection categories of meteorites, tektites, impact materials, and false meteorite-like objects ("meteorwrongs"). Each view has been tailored to include fields unique to that category, help messages, and pop-up lists of terminology. Additional modules allow for the recording of activities as well as reference information associated with the collection. The application also provides multimedia capabilities (imaging, audio, and video). To date, the Meteorite Collection has integrated images and audio. Images are displayed in both "thumbnail" and full screen formats (640×480 pixels). The audio component is used to give the pronunciation of names and terms, which may be particularly useful to non-specialists. The database is accessible on campus via the Local Area Network (LAN). However, to achieve greater access to the collection, a web interface has recently been designed. That allows access to selected areas of the database from anywhere in the world, while preserving the security of sensitive information. The facility will be of increasing future use in distance and computer-assisted learning since, once established, the site can be referenced in web- and CD-based courses developed and used anywhere. We have worked part time for about a year and a half on the database, and have now entered basic information and acquired images for nearly all of our specimens. Much work remains to be done, but the usefulness of the collection will increase continually as that work is completed.

The 1998 International Leonid Expedition, P. Brown, M. Campbell, J. Jones, and A. R. Webster, University of Western Ontario, R. Hawkes, A. LeBlanc, and I. Murray, Mount Allison University, K. Ellis, Communications Research Center, Maj. R. Correll, U.S. Air Force and N.A.S.A., Col. S. P. Worden, Lt.Col. M. Bedard, Lt.Col. D. Jewell, Lt. T. Montague, Maj. J. Thorne, and Maj. B. Tilton, U.S. Air Force, P. Gural, SAIC, Ltd., D. Babcock and R. Worsfold, York University, M. Connors, Athabasca University, A. R. Hildebrand, University of Calgary, S. Molau and J. Rendtel, International Meteor Organization, Maj. R. Sponder, Department of National Defence, Ottawa, T. Baayraa, D. Batmunkh, and B. Bekhtur, Mongolian Academy of Sciences, K. G. Garradd and R. H. McNaught, Australia, and M. Beech, University of Regina.

Results are presented for the 1998 Leonid meteor shower, based upon observations from sites in Mongolia and Australia using electro-optical, multi-frequency radar, and visual techniques. Some results from the Canadian light curve experiment on NASA's 1998 Leonid MAC (airborne campaign) are also presented. The flux profile of the shower using each of the techniques for the days nearest the maximum are presented and discussed. While the most impressive visual meteors occurred on November 16 prior to the anticipated maximum, the peak flux for particles detected by the radar and electro-optical equipment (10^{-5} to 10^{-9} kg) occurred during the interval 19^h to 22^h UT November 17, at approximately the time of the predicted maximum. The electro-optical data suggest that at peak flux about 0.01 Leonid meteoroids (greater than a mass of 4×10^{-8} kg) would strike a one square kilometre surface per hour, for a surface perpendicular to the Leonid radiant. Analysis of beginning heights and trail lengths was used to estimate the presence of a volatile component in the Leonid meteoroids. The precise dual station electro-optical observations indicated that most Leonid meteors begin in the region from 100 to 130 km, with none above 145 km. Less precise single station observations show the presence of higher Leonids, and it is not clear if the difference in the two height distributions is attributable to a bias imposed by the need for a common intersection area for dual-station detection. Only the brightest Leonid meteors had distinct flares on their light curves, which we interpret as meaning that most Leonid meteoroids are dustballs that have disintegrated into their constituent grains prior to meteor ablation. The light curves are inconsistent with a single body compact structure. Several individual Leonid meteors provided more direct evidence for a fragmented dustball structure. An estimate of the fraction of incident Leonids detected as a function of radar frequency is also given, and compared to the correction factors computed on the basis of the height distribution of the electro-optical Leonid meteor population. Plans for the 1999 Leonids are outlined briefly.

Hydrocarbon Potential of the Steen River Impact Structure, Alberta, Canada, Alan R. Hildebrand, Robert R. Stewart, and Michael Mazur, University of Calgary, Mark Pilkington and Richard A. F. Grieve, Geological Survey of Canada, Don Hladiuk and Armin Schafer, Gulf Canada Resources Ltd., and Dean Sinnott, Sunoma Energy.

The ~25-km diameter Steen River impact structure (59° 30 ′ N, 117° 38 ′ W) is the remnant of the largest known impact crater in the Western Canadian Sedimentary Basin (WCSB). The eroded crater lies buried under ~200 metres of cover with no surface expression necessitating geophysical and drilling projects for its exploration. The terrain is predominantly poorly drained taiga, necessitating winter operation for most exploration and production activities. The crater rim hosts production of $\sim 3 \times 10^7$ $ft^3\ d^{-1}$ from Slave Point gas wells (as of March 1999) and seasonal petroleum production of ~1200 barrels of oil per day from the Keg River Formation. The crater marks the northeastern limit of gas production infrastructure in Alberta. Although Steen River was discovered more than thirty years ago with documented evidence of shock metamorphism, little has been published about it in the open literature. Examination of chips from a second well extends the range of known shock evidence and reveals an intracrater breccia unit lying on the margin of the central uplift. Hydrocarbon exploration companies have acquired more than one hundred two-dimensional seismic reflection profiles over the impact structure, and one three-dimensional seismic survey has been executed over the northwest corner of the crater rim. Approximately fifty wells have been drilled in and near the crater, providing generally good control for the coherent seismic data. All known hydrocarbon reservoirs occur in structural closures formed by the rim deformation. Industry seismic data outline parts of the rim uplift in some detail, but most profiles record only chaotic reflectors interior to it. Mapping the impact structure's interior structures has been attempted with magnetic- and gravity-field surveys. The crater's central structures create large-amplitude and concentric anomalies. Gravity surveys reveal central anomalies with a maximum value of ~3 mGals; a positive anomaly of up to ~0.5 mGal is found associated with the rim uplift. A total of ~2,000 gravity stations have now been acquired over the crater. Interpretation of the gravity data is complicated by the high regional gradients (17 mGal decreasing northwestwards across the impact structure), with superimposed regional anomalies of 10 to 20 km scale. The rim uplift, down-slumped blocks, and the central uplift are well to poorly delineated by available seismic, well, and potential-field data. Well 16-19 at ~9 km radius preserves the inverted stratigraphy of the overturned flap lying on the inner down-slumped blocks, and establishes a minimum structural downdrop of ~0.6 km. Reflection seismic data usually do not reveal the down-slumped blocks, but occasionally provide vague images, and a slump zone at least 3 km wide is indicated. Wells and seismic profiles reveal an irregular, faulted, crater perimeter with rim uplift of up to ~100 m. The central structural uplift has a radius of ~3 km, based on well control and magnetic-field anomalies, and is located off centre. The uplift is displaced eastwards of the rim-uplift-defined centre, and the magnitude of down slumping is greater on the west side, based on a limited understanding of the slumped blocks. That indicates an oblique impact from the east formed the crater. Well 12-19 apparently penetrated the central structural uplift immediately below the Cretaceous cover at a depth of 184 m, establishing a minimum structural uplift of ~1100 m relative to the surrounding basement surface. Pre-burial erosion of up to ~1 km at the crater rim is indicated by the amount of extra stratigraphy preserved in the slumped blocks in well 16-19 and an assumed rim-to-crater-floor depth of 0.5 km.

The Kitchener, Ontario, Meteorite: Fell 08:30 EDT (local time), July 12, 1998, John C. Rucklidge and Graham C. Wilson, University of Toronto, Richard K. Herd, Geological Survey of Canada, and John F. Wacker, Battelle Pacific Northwest Laboratories, Richland, Washington.

The Kitchener meteorite fell on a golf course in the valley of the Grand River. A brief search and local media exposure failed to unearth additional samples. The stone was spheroidal, circa 4.5 centimetres in diameter and weighed 202 grams, with a near-complete black fusion crust. Gamma-ray counting revealed Sc^{46} consistent with the date of fall. The major minerals are olivine, orthopyroxene, feldspar, troilite, kamacite, and taenite. The mode comprises 35 volume percent granular matrix, 35% chondrules, 10% troilite, and 7% metal, 8% coarse olivine, 5% coarse orthopyroxene and feldspar, plus accessory chromite. The well-developed and preserved fusion crust shows a three-layer structure, and averages 0.4 millimetres thick. The chondrite is very weakly shocked, based on the strain state of olivine (S2 shock). Key results of electron microprobe analysis (quoting number of points analyzed, mean value, and two standard deviation uncertainties) are: olivine (10, Fa25.8 ±0.2), orthopyroxene (11, Fs21.4 ±0.4), kamacite (12, 0.95 ±0.04 wt.% Co, 6.30 ±0.76 wt.% Ni) and taenite (10, 0.37 ±0.12 wt.% Co, 29.0 ±4.4 wt.% Ni). The silicates show no trace of zonation within or between grains of different sizes and textural settings. There is minimal apparent variation in kamacite (5.6–6.9% Ni, 0.92–0.99% Co), but within the taenite Co declines from 0.50 to 0.30% as Ni increases from 25.8 to 31.8%. The two metal phases form composite grains in which they are cleanly separated by simple arcuate boundaries, and the result is considered at least an indication of a genuine variation. Kitchener, Ontario is an unbrecciated, troilite-rich, L6 (S2) ordinary chondrite, with a well-developed fusion crust. The petrologic grade is assigned on the basis of indistinct margins on most chondrules, lack of the beautiful chondrules of unequilibrated ordinary chondrites, and the presence of coarse feldspar. The bulk of the fall resides in the National Meteorite Collection of Canada in Ottawa.

ASTRONOMICAL REFRACTION AND THE EQUINOX SUNRISE

by Russell D. Sampson

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Abstract. A ray-tracing model is used to illustrate the influence of astronomical refraction on the azimuthal position of the equinox sunrise. The variation in sunrise azimuth as a function of the range in astronomical refraction and the observer's latitude is also investigated.

Résumé. Un modèle basé sur la technique de lancer de rayons est utilisé pour illustrer l'influence de la réfraction astronomique de la position de l'azimut à la levée du soleil durant l'équinoxe. La variation de l'azimut à la levée du soleil en fonction du champ de la réfraction astronomique et de la latitude de l'observateur est aussi examinée. SEM

1. Introduction

The original motivation for this paper was the *Journal* article by Attas & McMurry (1999) entitled "Nailing the Equinox Sunrise." In the article it is stated that "on the equinox, the Sun should rise due east." Since the Sun crosses the celestial equator at the equinox, and since the celestial equator crosses the horizon at 90° and 180° azimuth (due east and west), that statement appears on the surface to be correct. Once the effects of astronomical refraction are considered, however, the phenomenon becomes a little more complex.

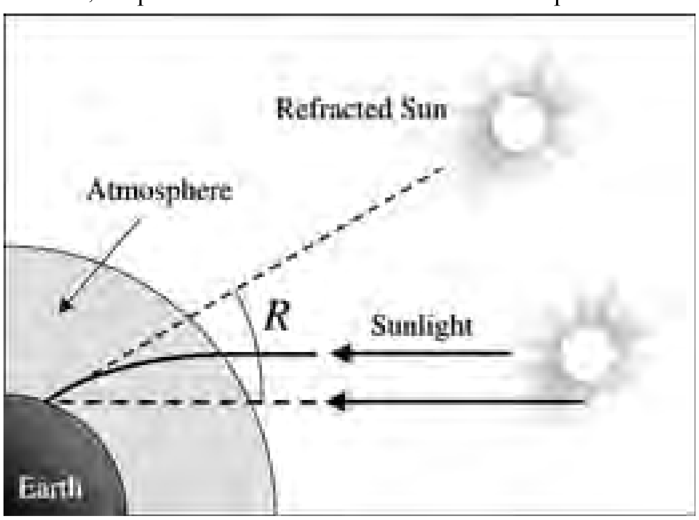

Fig. 1 — A schematic of astronomical refraction. The angle *R* is the amount of refraction.

Before proceeding, a formal definition of sunrise needs to be established. Most sources define the moment of sunrise and sunset as the time when the upper limb of the Sun makes contact with a horizon (Green 1985). In other words, sunrise and sunset occur when the upper limb of the Sun reaches an altitude of 0°.

Astronomical refraction is the bending of light from celestial objects by the Earth's atmosphere. The overall effect is to increase the observed altitude of a celestial object as it gets closer to the horizon (see figure 1). Often empirical formulae or tables are used to estimate the amount of astronomical refraction at a particular altitude above the horizon (*e.g.* Orlov 1956; Green 1985; Seidelmann 1992). Such tables and formulae become highly inaccurate very near the horizon. That is a consequence of the variability of atmospheric properties, which change with geography, season, time of day, and the presence of passing air masses. In Sampson (2000) it is shown that a ray-tracing model employing fine-scale atmospheric sounding profiles appears to be fairly successful at modeling astronomical refraction near the horizon.

According to Snell's Law, the angle of refraction of a light ray of a given wavelength passing between two transparent media is a function of the refractive indices of the two media. In turn, the refractive index is a function of the density of the medium. Since the atmosphere is compressible, it has a continuous density gradient. The density of the atmosphere at any particular location is dependent on its temperature, pressure, and composition. The highest variability in atmospheric composition is attributable to water vapour. Since the temperature, pressure, and water vapour content vary both spatially and temporally, it is not surprising that astronomical refraction can also change with the atmospheric conditions.

In this paper the unrefracted Sun is referred to as the geometric Sun. From the definition of sunrise and sunset, the azimuthal location of the geometric equinox sunrise can be shown to be less than 90° (north of due east in the northern hemisphere). The magnitude of the difference depends on the observer's latitude and the apparent diameter of the Sun (see figure 2). From figure 2 it is apparent that the only location where the equinox sunrise occurs exactly at the east point is on the equator.

2. The Refraction Model

The model presented here is a time-reversed ray-tracing model that uses an incremental search routine. The rays are sent out from the observer instead of from the Sun. The path of such time-reversed light rays is exactly the same as for time-forward rays. A planetary

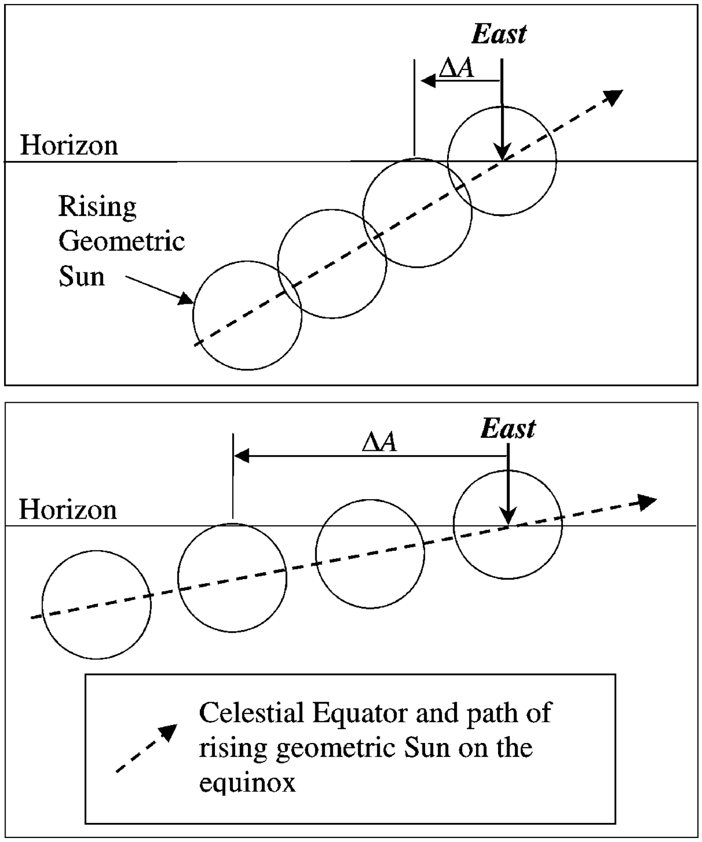

Fig. 2 — The dependence of the geometric sunrise azimuth on the latitude of the observer. The upper schematic is for a lower latitude observer, while the upper diagram is for an observer nearer the pole. The angle ΔA is the difference in azimuth between the sunrise point and due east. On the equinox the centre of the geometric Sun crosses the horizon at an azimuth of 90° (due east), as long as the time of sunrise is the same as the time of the equinox. On the equator the equinox sunrise occurs due east.

orbital model first calculates the celestial co-ordinates of the geometric Sun (Meeus 1988). From a first guess for the amount of astronomical refraction computed from an empirical formula (Seidelmann 1992), the software computes an initial estimate for the ray angle. A ray of particular wavelength is then propagated from the observer towards the Sun. Once the ray exits the atmosphere, its miss-angle is calculated. The initial angle is then adjusted and another ray is propagated until the miss-angle is 6 arcseconds or less. That level of tolerance was chosen to match the accuracy of current experiments into photogrammetric measurements of low altitude solar images.

As a ray propagates through the atmosphere, its trajectory is advanced by increments of 0.36 arcsecond with respect to the centre of the Earth. That translates into a horizontal distance of about 11 metres on the Earth's surface. At the end of each increment the refractive index is computed according to the atmospheric conditions at that location. Snell's Law and a curvature term (Bruton 1996) are then applied to the resulting incident ray. The model assumes a horizontally homogeneous atmosphere, since the vertical density gradient is much larger and, therefore, has far more influence on astronomical refraction.

The vertical profile of the atmosphere is found from weather balloon data. They are obtained from the twice-daily rawindsondes launched from the Stony Plain Environmental Monitoring Station about 25 km west of Edmonton. By convention, all Canadian rawindsondes are launched at 23:15 and 11:15 UTC, fortuitously timed for sunrises and sunsets from Edmonton. The current rawindsonde model is the Vaisala RS 80, which provides temperature, pressure, and humidity every 10 seconds (approximately every 50 metres). The temperature, pressure, and humidity for each ray increment are interpolated from the measurements. The refractive index is then computed using a scheme developed by Ciddor (1996).

3. Simulating the Autumnal Equinox Sunrise

In order to eliminate the effects of solar motion along the ecliptic from the azimuthal location of the autumnal sunrise, the solar declination is set at zero. In 1999 the moment of the autumnal equinox and the sunrise are approximately concurrent at a longitude of 86° W. A latitude of 50° N was chosen for the simulation, since Attas and McMurry were located at that latitude when their photographs were taken. An 11:15 UTC (05:15 MDT) rawindsonde launch from September 22, 1997, was chosen from the library of atmospheric soundings from the Stony Plain Alberta station. A sunrise was observed from Edmonton on that day. Climatic conditions between southern Manitoba and central Alberta are considered to be quite similar. The differences in elevation and meteorological conditions between the two locations, however, make the profile only roughly applicable to the September 23, 1998, situation.

The model was run until a small portion of the yellow light (580.0 nm) image of the Sun appeared above the horizon. The results appear in figure 3. The simulation suggests that autumnal equinox sunrise occurred at an azimuth of 88° 53′ — over a full degree north of due east. It is also apparent from the figure that equinox sunrise is about 50′ further north than the geometric sunrise.

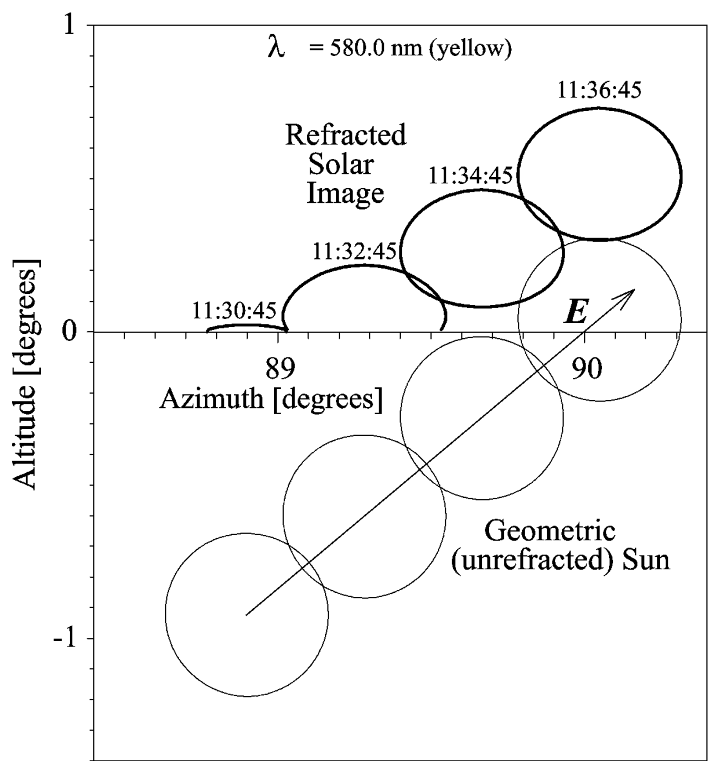

Fig. 3 — Simulated 1999 autumnal equinox sunrise from 89°W longitude and 50°N latitude. The wavelength of light is 580.0 nm (yellow), and times are in UTC.

4. Latitude, Refraction, and the Equinox Sunrise

As illustrated in figure 2, the azimuthal location of sunrise is also dependent on the observer's latitude. The azimuth A of the sunrise or sunset point can be calculated from the cosine law for spherical trigonometry (Green 1985):

$$\cos A = \frac{\sin\delta - \sin\phi \sin a}{\cos\phi \cos a} \qquad (1)$$

where δ is the declination of the Sun, ϕ is the latitude of the observer, and a is the altitude of the centre of the Sun at the moment of sunrise or sunset. The altitude of the centre of the Sun at sunrise or sunset is the sum of the solar semi-diameter and the amount of astronomical refraction. At the time of the 1999 autumnal equinox, the solar semi-diameter was 15′ 56″.4. The amount of refraction at sunrise or sunset is highly variable, and can range from about 30′ under normal conditions to more than 4° when a Novaya Zemlya arctic mirage occurs (Lehn 1974). At the moment of the equinox, the declination of the Sun is equal to zero. A plot of the variation of sunrise azimuth versus latitude can be seen in figures 4 and 5. From the graphs it is apparent that the change in the azimuth of the sunrise is greatest near the pole. It is also obvious that the azimuthal location of sunrise is highly dependent on the amount of astronomical refraction.

Figures 4 and 5 also show that the higher the latitude, the more sensitive the azimuth of the equinox sunrise is to changes in astronomical refraction. Figures 6 and 7 show a plot of latitude versus the difference in equinox sunrise azimuth between 30′ and 1° astronomical refraction.

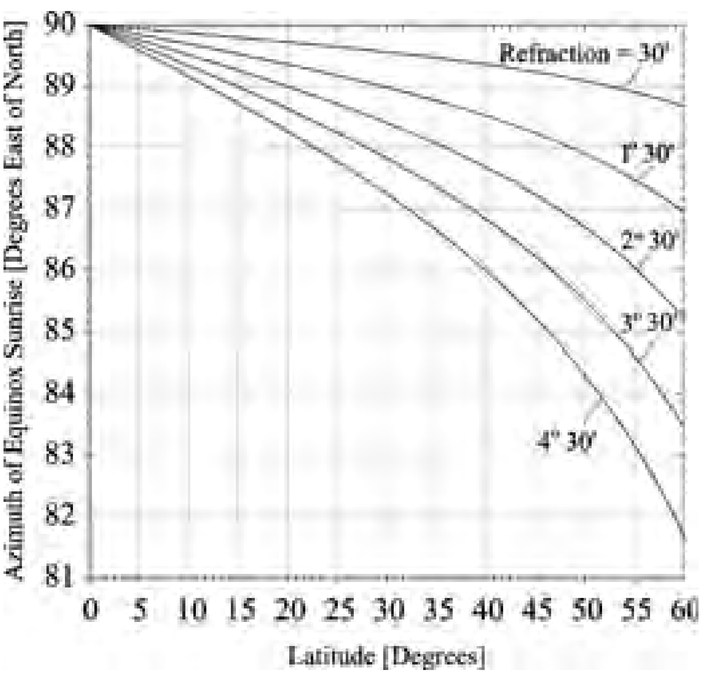

Fig. 4 — The relationship between sunrise azimuth, latitude, and astronomical refraction. Under more normal circumstances the amount of astronomical refraction is between 30′ and 48′ (Sampson 1994). Extreme refraction events appear to be confined to the polar regions (Lehn 1974), although sunrise events with over 1° of refraction have been recorded by the author during summer sunrises from Edmonton (and over 2° for winter sunrises).

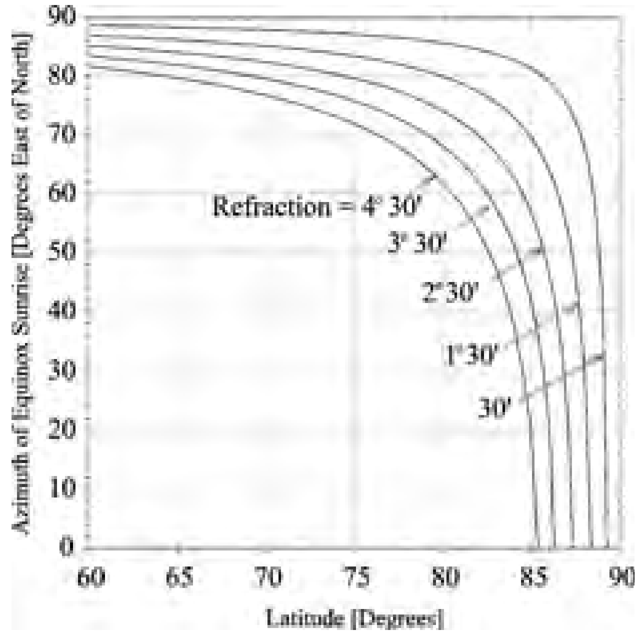

Fig. 5 — See figure 4.

5. Conclusion

On the surface, the exact azimuthal location of the sunrise and sunset point appears to be determined solely by celestial and geographic co-ordinates. As the preceding arguments have demonstrated, however, the azimuthal location of the sunrise point is also a function of astronomical refraction. Since astronomical refraction can vary with the conditions of the atmosphere, the accurate location of the sunrise point is therefore difficult to forecast without a detailed understanding of the atmosphere at the time of the event.

Astronomical refraction decreases the azimuth of the sunrise point. From figures 4, 5, 6, and 7 it is apparent that the azimuthal

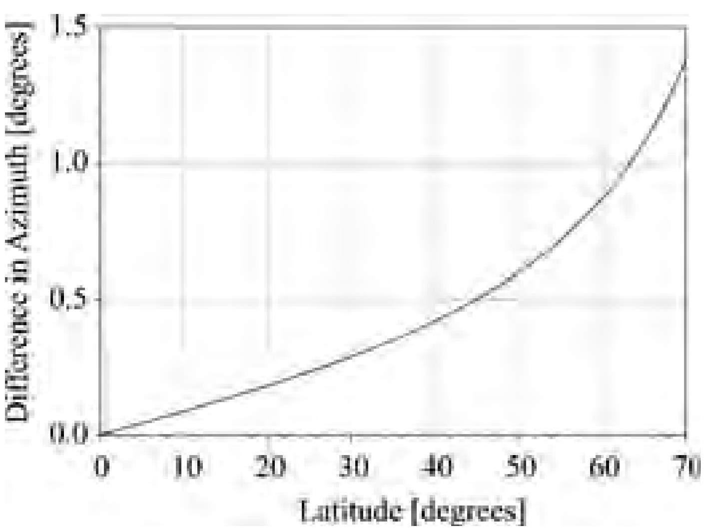

Fig. 6 — The difference between the equinox sunrise azimuth produced by 30′ of astronomical refraction and that produced by 1° of astronomical refraction plotted as a function of latitude. This illustrates the increase in sensitivity of the sunrise azimuth to variations in astronomical refraction as the observer approaches the poles.

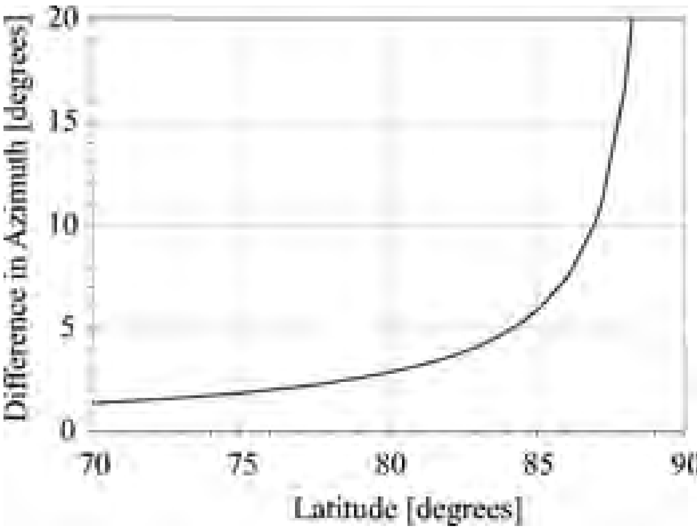

Fig. 7 — See figure 6.

location of the sunrise (or sunset) point becomes more sensitive to changes in astronomical refraction as latitude increases. It also appears that such northerly regions are more likely to experience extreme refraction events (Lehn 1974), which further enhance the variability in sunrise and sunset azimuth.

I am sincerely grateful to Dr. Edward P. Lozowski of the Department of Earth and Atmospheric Sciences, Prof. Arthur E. Peterson of the Department of Civil and Environmental Engineering, and Dr. Douglas P. Hube of the Department of Physics at the University of Alberta for their assistance in this research. This work was also supported by the University of Alberta Dissertation Fellowship, Province of Alberta Graduate Fellowship and NSERC.

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Education Notes
Rubriques pédagogiques

EXPANDING THEIR UNIVERSE: Helping Ontario Teachers with Astronomy

by Laura Gagne

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In 1999 the Kingston Centre took on an enormous project with the hope that it would make a difference in the community. As most of you may know, the new science curriculum for Ontario high schools includes a major astronomy component in grade nine. Many high school teachers have no training in astronomy and were less than enthusiastic to have such a foreign subject introduced into their curriculum without the proper training they needed. We all know that waiting for the government to come to the rescue is a waste of valuable time, so the Kingston Centre decided to tackle the issue themselves.

In the spring of 1999 the new textbooks were offered to the high school science teachers in order for them to make a choice. I managed to secure a copy in order to find out what material was to be covered. Apart from a number of errors in the information presented in the textbooks, I was amazed at how much detail the children were going to be taught. My personal reaction to the curriculum expectations outline was, "You must be kidding…". I thought that it would be wonderful if the students could learn all about the origin of the universe, the lives and deaths of stars, how planets form, Canada's role in space, physical laws, and all the other interesting things I learned while at university… and all in grade nine! Perhaps the expectations were a little high, especially since grade nine science is compulsory and there is no distinction between general and advanced levels. I realized fairly quickly that there was great potential for kids to be turned off from astronomy forever unless someone did something to help the teachers. I decided to write a book.

As the book was being typed, I asked members of the Kingston Centre if they thought they would like to help me to produce a one-day seminar to give the teachers some background information. As is typical of the Kingston Centre, I had plenty of volunteers with a wide variety of specific areas of interest. I invited our President, Doug Angle, to do a workshop about telescopes, since some schools own telescopes but may not know how to use them. I also invited Tom Dean to produce a workshop about how to use *The Starry Night*, the computer software that most schools purchased as recommended by the government. They wrote summaries of their lecture notes that were included in the book. Other contributions to the book came from various experts: Kim Hay wrote about meteor observing, Leo Enright provided information about keeping a log book, David Levy gave us information about comet hunting, Don Mastrianni wrote a brief history of astronauts, and Fred Werthman provided us with beautiful diagrams and illustrations. Kevin Kell put it all together in the form that it now has: a three-ring binder full of reproducible pages of information, games, and activities designed for ease of use by teachers. Copies are available from the Kingston Centre for $15 (foreign orders should contact us for details).

The seminar was held on the afternoon and evening of November 3rd, 1999, in a local high school. We had planned an observing session for which several members turned out with telescopes. Unfortunately it rained and snowed and everything else you can imagine that would prevent us from going outside. There are 21 activities in the book we produced, five of which we performed in the seminar. It was very successful, and the teachers wanted to spend the rest of the day doing more activities. John Hurley made a comet, Peggy Hurley made pinhole cameras, Kim Hay decoded a message from an alien civilization, Hank Bartlett plotted stars from a photograph onto an H-R diagram and speculated about the existence of planets around some of them, and Doug Angle took everyone on a journey through time to explore the changing phases of the Moon. Also helping to answer questions and demonstrate telescopes were Paul Bowman, Susan Gagnon, Don Mastrianni, Fred Werthman, Tim Seitz, and Kevin Kell.

The teachers who came to the seminar were very grateful for our help. Most commented that they felt more comfortable with astronomy than they had previously, and were very appreciative of the materials we provided as well as our offer to help them in the future. We will be providing an "Astronomer in the School" outreach program for those who request it, as well as holding special observing sessions at a local park aimed at the high school students who are studying astronomy. I think our Centre has been able to make a big difference in our own community, and I am sure that any Centre could do the same. As can be seen, not many people on the Kingston Centre's Education Committee were involved with the project, and yet it worked. There are just a few steps to take initially, and the rest falls into place.

First we decided what we would be able to offer. We drafted an initial agenda to let teachers know which topics we could cover for them. We then contacted the head of the science department at the school where I have a friend who works as a teacher. She asked the head of all of the heads of science in Kingston to put us on the agenda of their next meeting. We went to the meeting and made our offer, telling them how much it would cost them per person attending. Doug made the arrangements for the date and the place, while I wrote up the seminar agenda and found speakers. Of course, if your Centre wishes to do the same thing, you can get the books from the Kingston Centre, which are already tailored to suit the new grade 9 Ontario high school curriculum.

Overall it was fun, and it feels good knowing that we, as amateur astronomers, were able to help. It is our mission statement after all. I am glad that I was able to be a part of the project. I am also proud to be associated with such a fine group of people as the Royal Astronomical Society of Canada, and especially the Kingston Centre.

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LAURA GAGNE is the Vice President (1999) of the Kingston Centre and the Chair of its Education Committee. She is the author of "The Student's Guide to Careers in Space" and "Expanding Their Universe — The Ontario Teacher's Companion for Grade 9 Astronomy," both publications of the Kingston Centre.

EuRo **Eclipse** '99

by Ovidiu Vaduvescu, Toronto Centre (ovidiuv@yahoo.com)

August 1–16, 1999, Romania

During EuRo Eclipse/Perseids 99, about 170 visitors to Romania, along with another 80 hosts and citizens from Romania, assembled in seven different groups to be present at the total solar eclipse of August 11, 1999, which was visible from Romania. The 170 international visitors consisted of amateur and professional astronomers (mostly from the United States, Netherlands, Hong Kong, United Kingdom, and Canada), as well as tourists, and included nine members of the Toronto Centre. The eclipse tour was co-organized by the author in conjunction with the Romanian Society for Meteors and Astronomy (SARM) and the local tour operator "Romantic Travel."

Local leaders welcome the foreign participants, including Ralph Chou (Toronto Centre), to EuRo Eclipse '99.

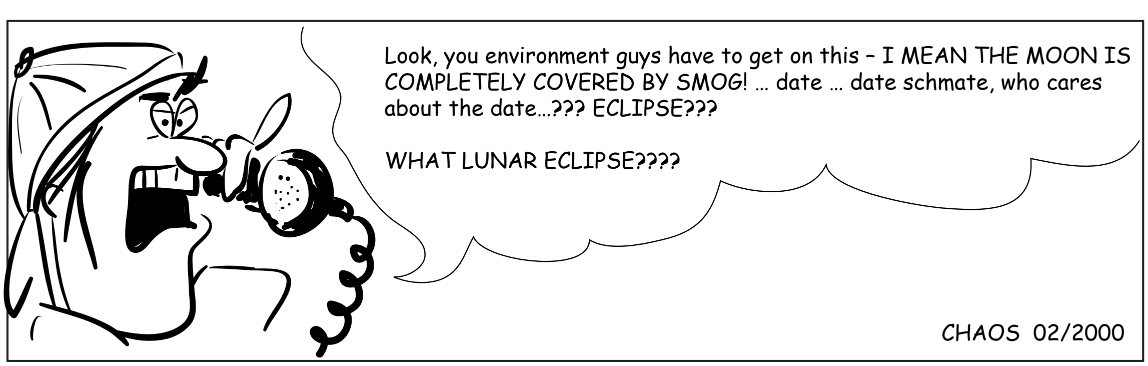
The author and Damien Simon with their modest equipment.

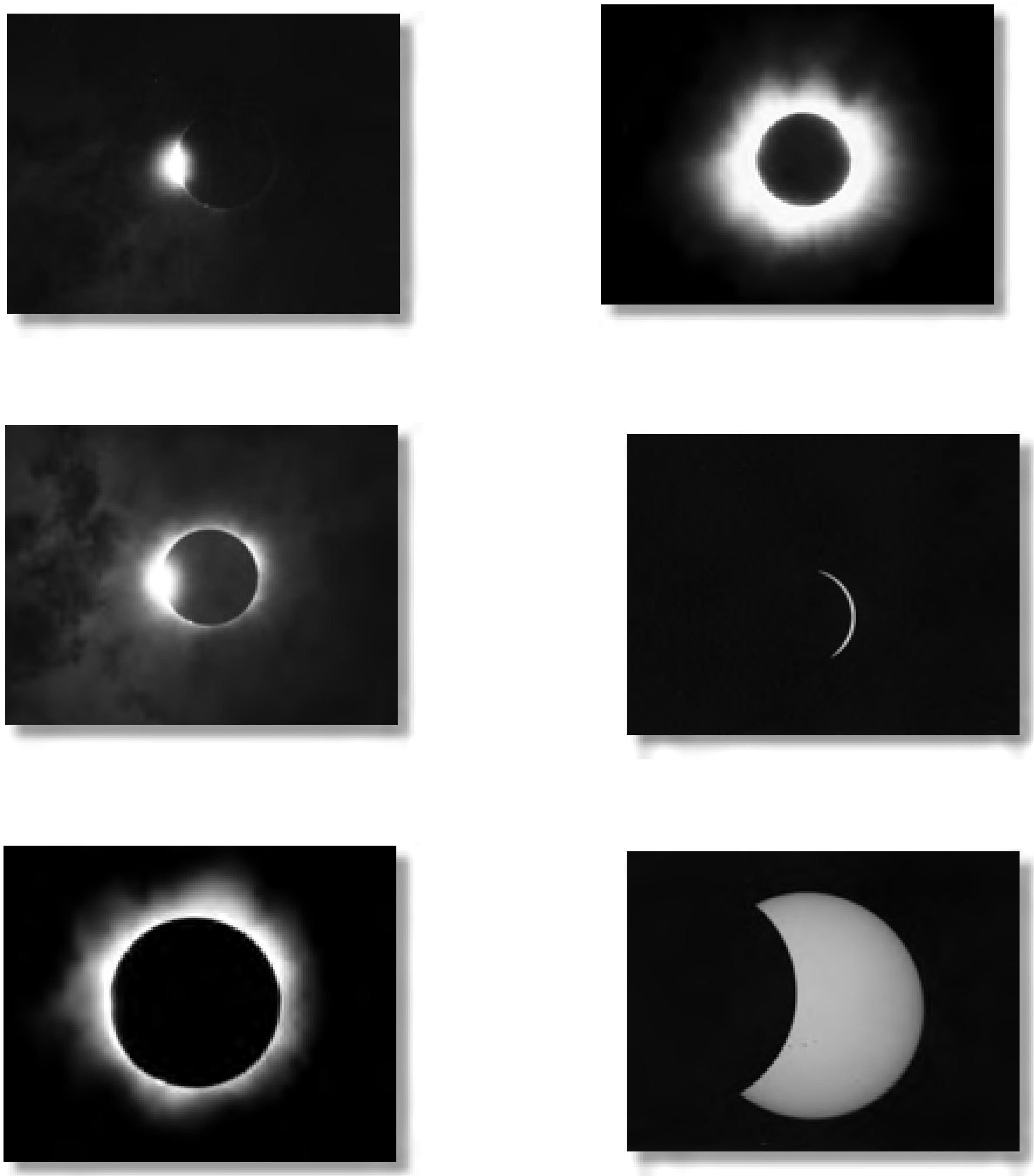
The seven groups attending EuRo Eclipse 99 observed the eclipse from Retezat National Park, Ramnicu Valcea, Targoviste, Pitesti, Bucharest, and Mangalia. Of those locations, only the group at Retezat was clouded out. Among those in attendance who had been to prior eclipses, the following special guests can be noted: Osamu Ohgoe (Japan, 25 eclipses), Wendy Carlos (U.S., 20 eclipses), Roger Tuthill (U.S., 18 eclipses), Ralph Chou (Canada, 15 eclipses), and Robert Slobins (U.S., 11 eclipses). For my colleague Damien Simon and my wife and me, it was our first total solar eclipse, and the experience was unique! It represents a gorgeous gift of Nature, and one that is seen at most once in a lifetime for most people. Because Damien and I were involved in organizing EuRo Eclipse 99, we decided to photograph the event using modest equipment. A selection of our images is displayed here.

Ovidiu Vaduvescu is a computer programmer living in Mississauga, Ontario. His academic degrees include an M.Sc. in Mathematics and Computer Sciences from the University of Craiova (1991) and a Ph.D. in Mathematics and Astronomy from Babes-Bolyai University in Cluj-Napoca (1997), both in Romania. Between 1991 and 1997 he was employed as an astronomical research assistant at the Astronomical Institute of the Romanian Academy in Bucharest. Since coming to Canada in 1997, he has joined the Toronto Centre of the RASC. His main astronomical interests include astronomical software, CCD observations, asteroids, comets, astrometry, and celestial mechanics.

ANOTHER SIDE OF RELATIVITY

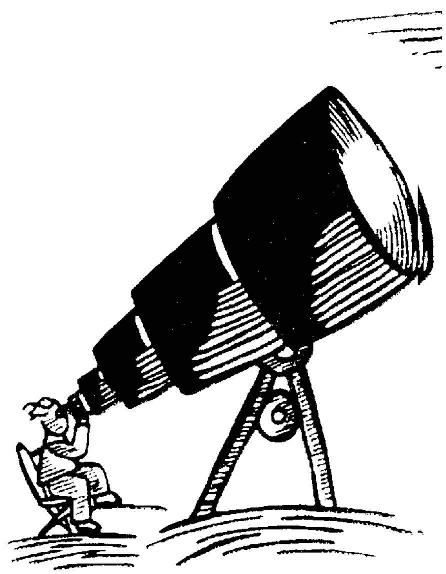
Uncle Ernie completely misinterprets the Lunar Eclipse





Images of the total solar eclipse, August 11, 1999. These images were taken at EuRo Eclipse in Bucharest, Romania, by Damien Simon, and Ovidiu and Simona Vaduvescu. We used a f/500, 80-mm refractor and a Nikon F60 with Fuji Superia 100 film.

Ask Gazer



Dear Gazer,

Okay, I understand that planets move around the Sun on the path of an ellipse with the Sun at one focus. So what the heck is at the other focus, empty space? When I draw an ellipse using the string-and-pins method, I need two pins. So why don't I need two Suns?

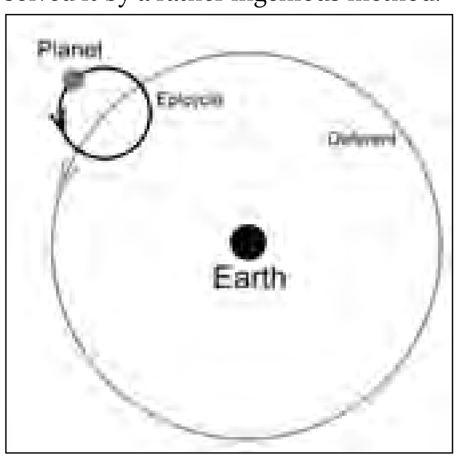
Eccentric Crank

Dear Eccentric:

You are making a mistake that is remarkably common. You are expecting the universe at large to follow what humans like to call "common sense." I believe that it was Mark Twain who once said something to the effect of, "Common sense is not very common." He was referring to it as not being too common among people, but the statement could equally well apply to the universe. Unfortunately (or fortunately, depending on how you want to look at it), the universe does not often work as humans would expect it to. Let's take a little look at where those ellipses come from.

Ancient peoples were able to explain the motions of the Sun and the Moon easily, but not those of the five planets. Mercury and Venus had one thing in common: they were never seen very far from the Sun in the sky, but were repeatedly changed from appearing in the evening sky to the morning sky and back again. The other three planets were a bit more predictable. They gradually moved eastward every night against the background stars (prograde motion), except occasionally they would reverse direction, stop, and then continue their prograde motion. Such odd motion is called a retrograde loop. The planets also appear to be at their brightest during such times.

Some Greek philosophers, such as Aristarchus, thought that the Sun was at the centre of the solar system and all the planets, including Earth orbited about the Sun. Most, however, followed the lead of Plato and Aristotle and placed the Earth at the centre of the universe, a geocentric model. They followed the teachings of Plato and Pythagoras, that the circle was the perfect shape, and tried to explain the motions of the Sun, Moon, and planets by uniform motion on circles. Circles centred on the Earth would easily explain the motions of the Sun and Moon, but the planets were much more difficult to explain that way, especially the retrograde loops of Mars, Jupiter, and Saturn. They solved it by a rather ingenious method.



By adjusting the sizes of the deferents and epicycles, as well as the various speeds, the planets' motions could be predicted accurately enough for the observations. As observation techniques improved, it became increasingly difficult to make the predictions match the observations. The model became increasingly complex, with deferents being placed with their centres offset from the Earth. Epicycles had to be added to epicycles.

Ptolemy's complete version had at least 80 circles! Ptolemy published his collected works (the *Almagest*), and it became the basic text on astronomy, including its geocentric universe, for almost 1600 years.

Fast forward to Tycho Brahe, probably the most skilled observer of his time. His observations of the planets were accurate to one arcminute. He amassed an enormous amount of data on the positions of the planets, but did not have the mathematical skills to analyze them. Shortly before his death, he invited a young mathematician, Johannes Kepler, to work with him.

Kepler tried to use the ideas of Greek geometry to explain the orbits of the planets. He was able to measure the relative sizes of the orbits, but could not explain their motions accurately enough. He tried circles, ellipses (getting the math wrong), and egg shapes, but nothing would give him predictions that matched the observations. He finally retried ellipses and got the math correct. That took him almost 30 years!

He discovered three laws of planetary motion, called Kepler's Laws. Kepler's First Law says that the planets orbit the Sun in an ellipse, with the Sun at one focus. Kepler's Second Law states that a line connecting the Sun and a planet will sweep out equal areas in equal times. Kepler's Third Law is about how a planet's average orbital speed changes with its average distance from the Sun. Kepler's laws were arrived at empirically, that is, entirely from observation, and without any theoretical foundation… "That is just the way it is." An explanation had to wait for Isaac Newton.

Newton was probably one of the greatest intellects of all time. He published his works in a book called *Philosophiae Naturalis Principia Mathematica* (The Mathematical Principles of Natural Philosophy), usually called the *Principia* for short. It contains Newton's laws of motion, the law of universal gravity, and the formulation of calculus.

Newton's First Law states that an

object in motion will continue in a straight line, unless acted upon by an external force. Newton's Second Law says that the acceleration of an object is proportional to an applied force, and inversely proportional to the mass. That is, $a = F/m$, or rewritten in its more famous version, $F = m \times a$. Newton's Third Law says that forces cannot exist in isolation. If one body exerts a force on another, that body exerts a force back, of the same amount but in the opposite direction. This law is common know by the maxim, "For every action, there is an equal and opposite reaction." Lastly we have Newton's theory of universal gravitation, which states that all matter attracts all other matter with a force that acts continuously, the magnitude of the gravitational force depending upon the masses of the objects and their separation.

Now what happens if you take two masses, moving in a vacuum and attracting each other by gravity? Gravity is a force that will cause the masses to change their velocities (acceleration). As their positions change, so does the strength of the gravitational force, which then changes the force acting on them, *etc., etc.* If you now observe the motions of the two bodies, guess what happens? They follow Kepler's Laws! Thus, Newton's Laws result in planets that orbit each other in ellipses with the Sun at one focus… and there is no requirement to have anything at the other focus.

Funny thing about ellipses though. One geometric property that they have is that if you take any point on the ellipse, measure its distance to each focus, and add the two distances together, you always get the same value. As a result, the easiest way to draw one is to put a pin at each focus, then take a string…

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

At the Eyepiece

The All Splendors, No Fuzzies Observing List
(Part 3 of 4)

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

This is the spring section of a new observing list that attempts to include all of the finest splendours in the entire sky. No featureless fuzzies are included. The 158 sights in the complete list are the best that there are. Almost a quarter of the wonders are visible with the unaided eye, and, except for the few close double stars, all objects on the list can be seen under ideal conditions with a 4-inch telescope. The descriptions of the objects, however, reflect the larger apertures widely in use, as well as the advent of nebular filters. Readers knowing the originator of the popular name of any object should please advise me so that proper attribution can be made in the final installment.

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Most deep-sky data are from *NGC 2000.0*. For the few facts not available from *NGC 2000.0*, the following *Observer's Handbook 1999* lists were used in this order of preference: *Galaxies: Brightest and Nearest* by B. Madore (for the dimensions of elongated galaxies and for LMC and SMC data), *The Messier Catalogue* and *The Finest NGC Objects* by A. Dyer, *Nebulae* by W. Herbst, and *Star Clusters* by A. Moffat.

Double star co-ordinates, magnitudes, and separations are from the *Observer's Handbook 1999*, when available. Guide 7.0 software by Project Pluto was used for the remaining doubles, except that the separations for wide pairs are taken from *Burnham's Celestial Handbook.*

Spring Objects

ID	Con.	Type	RA(2000)	Dec(2000)	Mag.	Size	Remarks
2808	Car	GC	9:12.0	−64:52	6.3	14′	Brightest CC I
2903	Leo	G-Sb	9:32.2	21:30	8.9	11′ × 5′	
M81	UMa	G-Sb	9:55.6	69:04	6.9	16′× 10′	6 × 30 finder shows M81, M82
M82	UMa	G-I	9:55.8	69:41	8.4	7′× 2′	13-in: mottled, two diagonal dl
3132	Vel	PN	10:07.0	−40:26	8p	0′.8	Eight-Burst Neb; easy mag 10 cn*
3201	Vel	GC	10:17.6	−46:25	6.8	18′	CC X
Gamma	Leo	Dbl	10:20.0	19:50	2.6,3.8	4″.4	gold, yellow-green
3242	Hya	PN	10:24.8	−18:38	8.6	0′.3	Ghost of Jupiter; pale blue
3372	Car	EN	10:43.8	−59:52	3	120′	NE; Eta Car Neb; chevron dl
IC 2602	Car	OC	10:43.2	−64:24	1.9	50′	NE; Theta Car Cl; 5° S Eta Car
3532	Car	OC	11:06.4	−58:40	3.0	55′	NE; 3° ENE Eta Car; Ri, oblate
M97	UMa	PN	11:14.8	55:01	11.2?	3′.2	Owl Neb [Lord Rosse]; "eyes" with 6-in, [O III]; G-Sc M108 adj
Xi	UMa	Dbl	11:18.2	31:32	4.3,4.8	1″.8	Yellow pair
M66	Leo	G-Sb	11:20.2	12:59	9.0	8′× 3′	Trio with M65, NGC 3628; 16-in, two arms in M66 and 3628's dl
3766	Cen	OC	11:36.1	−61:37	5.3	12′	Five OC within 4°
M106	CVn	G-Sb	12:19.0	47:18	8.3	20′× 6′	
Alpha	Cru	Dbl	12:26.6	−63:06	0.8,1.2	4″.0	Blue-white pair
Coma Ber	Com	OC	12:25.1	26:06	2.9p	300′	NE; very large; 30 st
M86, etc.	Vir	G-E3	12:26.2	12:57	9.2	7′	Heart of Virgo Cl; 10 Gs in 1° field
24 Com	Com	Dbl	12:35.1	18:23	5.0,6.6	20″	Deep yellow, blue-white
4565	Com	G-Sb	12:36.3	25:59	9.6	16′× 3′	Remarkable edge-on; thin dl
Gamma	Vir	Dbl	12:41.7	−01:27	3.4,3.5	1″.5	Both pale yellow; closest in 2007
M104	Vir	G-Sb	12:40.0	−11:37	8.3	7′× 2′	Edge-on Sombrero Galaxy with dl
4631	CVn	G-Sc	12:42.1	32:32	9.3	15′× 3′	Humpback Whale Galaxy [Hewitt-White]; G 4656/7 adj
M94	CVn	G-Sb	12:50.9	41:07	8.2	11′	Defies moonlight (show on Astronomy Day)
Coalsack	Cru	DN	12:51	−63:00	—	360′	NE; OC 4755 (Jewel Box) adj
M64	Com	G-Sb	12:56.7	21:41	8.5	8′× 4′	Black-eye G; dl
M63	CVn	G-Sb	13:15.8	42:02	8.6	8′× 3′	Sunflower G; 7 × 50s reveal it
Zeta	UMa	Dbl	13:23.9	54:58	2.3,3.9	14″	Mizar: bluish-white, greenish-white; Alcor adj
5128	Cen	G-S0	13:25.5	−43:01	7.0	10′× 3′	Cen A; dl from merging spiral
5139	Cen	GC	13:26.8	−47:29	3.7	36′	NE; Omega Cen: best GC; CC VIII
M51	CVn	G-Sc	13:29.9	47:12	8.4	11′	Whirlpool Galaxy [Lord Rosse]; 8-in: spiral arms; 5195 inv
M83	Hya	G-SBc	13:37.0	−29:52	7.6	11′	8-in: bar; 13-in: spiral arms
M3	CVn	GC	13:42.2	28:23	6.4	16′	CC VI
M101	UMa	G-SC	14:03.2	54:21	7.7	27′	Numerous brighter knots
Alpha	Cen	Dbl	14:39.7	−60:49	0.0,1.3	21″	Yellow pair; closest NE star
Epsilon	Boo	Dbl	14:44.9	27:05	2.7,5.1	2″.8	Izar; deep yellow, blue
5907	Dra	G-Sb	15:15.9	56:19	10.4	12′× 2′	Edge-on Splinter Galaxy
M5	Ser	GC	15:18.6	02:05	5.8	17′	CC V
Zeta	CrB	Dbl	15:39.4	36:38	5.1,6.0	6″.3	Blue, greenish

[I have never resolved Alpha Crucis. I have never seen the Carina globular cluster (GC) NGC 2808, the Vela planetary nebula (PN) NGC 3132, or the Vela globular cluster (GC) NGC 3201.]

N.B. All catalogue numbers not preceded by alphabetical letters are NGC numbers

Abbreviations used:

A = component A of a double or multiple star
adj = adjacent
B = component B of a double or multiple star
B = (with number) Barnard's catalogue of dark nebula
C = component C of a multiple star
CC = concentration class for globular clusters, from I to XII
Cl = cluster(s)
cn* = central star of planetary nebula
Dbl = double star
dl = dark lane in galaxy or emission nebula
DN = dark nebula
EN = emission nebula
G = galaxy (with type)
GC = globular cluster
IC = Index catalogue
-in = inch (as in "8-in," meaning a telescope of 8-inch aperture)
inv = involved
LMC = Large Magellanic Cloud
M = Messier catalogue
m, mag = visual magnitude
Mlt = multiple star
[name] = the originator of a descriptive name
NE = visible with the naked eye
Neb = nebula
NGC = New General Catalogue
OC = open cluster
OIII = An Oxygen III nebular filter ([O III]) is recommended
p = photographic magnitude
PN = planetary nebula
Ri = rich in stars
RN = reflection nebula
SMC = Small Magellanic Cloud
SNR = Supernova remnant
st = star(s)
UHC = A filter passing both [O III] and Hydrogen Beta is recommended
Var = Variable Star
? = the author questions the *NGC 2000.0* visual magnitude

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

The History of Astronomy

Unsung Heroes

by Barbara Silverman, Montreal Centre

In the shadows of the past lurk many unsung heroes. No longer physically with us, they exist only as a paragraph or two in a dusty encyclopaedia, or as a passing reference in the biography of one more famous. Their contributions may have been small or indirect, but they have contributed to the growth of astronomy and deserve to have the dust blown from their stories so that their achievements can be more widely known.

The name of Charles Messier is well known to most amateur astronomers. His dedication and perseverance resulted in his famous list of celestial splendours. Messier had one other very important quality: he unhesitatingly gave credit to his colleagues, in particular Bouchart de Saron and Pierre François André Méchain.

Saron was born on January 16th, 1730. He studied at the Collège de Louis-le-Grand, becoming a lawyer and natural scientist. In 1748 he became legal counselor to the Parliament of Paris, and from there his political career advanced quickly. He became Master of Requests in 1750, Advocate General in 1753, and Judicial President in 1755. He was an accomplished mathematician, and computed cometary orbits for his friend Messier, who tabulated his sightings then turned his data over to Saron to do the orbital calculations. Saron also computed the orbit of the planet Uranus, thus becoming one of the first to realize that Uranus was a planet.

As a patron of the sciences, Saron amassed one of the world's best collections of reflecting telescopes and other astronomical instruments. His collection was known for both its quality and quantity. In 1779 the Academy of Sciences admitted Saron as an honorary member. During 1784 he financially aided the publication of the Marquis de Laplace's *Theory of the Movement and Elliptic Figure of the Planets*.

A few months prior to the French Revolution in 1789, Saron became the President of the Parliament of Paris. After the revolution, when that body was dissolved, his vehement protests led to his eventual demise. In September 1793, Saron received data from Messier on a new comet, for what would be the last time. He completed the orbit calculations in prison, only days before the Reign of Terror claimed his life on the guillotine.

Pierre Méchain was more fortunate. Born on August 16th, 1744, in Laon, France, he was the son of a master ceiling plasterer. Forced by family difficulties to terminate his architectural studies, he was re-evaluating his future when he came to the attention of Lalande, the noted French

“Messier had one other very important quality: he unhesitatingly gave credit to his colleagues, in particular Bouchart de Saron and Pierre François André Méchain.”

astronomer. Lalande was impressed with the young Méchain's potential, especially his mathematical abilities. In 1772 Lalande obtained for Méchain the position of astronomer-hydrographer at the Dépôt de la Marine in Versailles. Unfortunately, political instability had an adverse effect on the situation, and Méchain had to leave. When the Dépôt was reorganized eighteen months later, Méchain returned. Shortly thereafter, the Dépôt was moved to Paris, bringing Méchain and Messier together.

In 1791 the French National Assembly decided to introduce a uniform system of measurement, known today as the metric system. In 1792, from prison, King Louis XVI instructed Méchain and engineer Jean Delambre to complete the calculations required to establish the length of the metre. It had already been decided that a metre would be one ten-millionth of the distance between the North Pole and the Equator measured along the meridian passing through Paris. Méchain and Delambe's assignment was to measure the meridian from Barcelona to Dunkirk. The work took many years to complete, but happily for Méchain it took him away from the strife and worst excesses of the French Revolution. Upon completion of the survey, the standard metre was established. The metric system became fact in June 1799.

Pierre Méchain's work received notable recognition from the French Academy of Sciences. He was awarded a prize in 1782 for his essay on the comets of 1552 and 1661. Previously both comets were believed to be the same, but Méchain proved them to be two separate entities. Méchain's lifetime comet count is ten, and he calculated the orbits of all comets he discovered, as well as those of others.

Méchain's telescope was used to find more than just comets. Much of the Messier list is based on the observations of Méchain himself, who is credited with the discovery of at least 32 fixed nebulae. He worked closely with Messier, who verified Méchain's sightings and included the information in his famous catalogue. In the original listing, Méchain's name appears beside M71, M72, M74–M82, M85, and M94–M96.

There were six objects sighted by Méchain that Messier did not have time to verify. Although the discoveries were not published by Messier, they are included in his private notebooks with the notation that they had been discovered by Méchain. Méchain was also the first person to discover the abundant nebulae in the Coma-Virgo region. After he turned the information over to Messier on March 18th, 1781, Messier had one of his best observing nights, discovering nine nebulae.

“Méchain's telescope was used to find more than just comets. Much of the Messier list is based on the observations of Méchain himself, who is credited with the discovery of at least 32 fixed nebulae.”

It was Méchain who discovered that M101 and M102 are actually the same object. His letter announcing the correction was published several times between 1786 and 1917, but always in publications that did not have a wide circulation. It was not until 1947, when Helen Sawyer Hogg published his letter in the *Journal*, that the error was brought to the attention of modern-day astronomers.

After the Revolution, Méchain's fortunes improved. A few years before his death he became director of the Paris Observatory, and joined Messier as a member of the New Academy of Sciences and Bureau of Longitudes. He died September 20, 1805, in Castellon de la Plana, Spain, but not before leaving his mark on the world of astronomy.

Next we come to Dollond and the controversy over the achromat lens. John Dollond, the son of Huguenot refugees, was born June 10th, 1706, in London, England. Originally he joined the family trade of silk weaving, but Dollond's proficiency in optics and astronomy led him to become a maker of optical and astronomical instruments. In 1752 he joined his son Peter in the optical business, and in 1754 introduced the heliometer, a telescope designed to measure the Sun's diameter as well as the angles between celestial objects.

In 1747 Newton had stated that chromatic aberration in lenses was not correctable. Between 1754 and 1758, Dollond devised an achromatic lens consisting of flint and crown glasses, thus disproving Newton's statement and at the same time earning the Copley Medal of the Royal Society for 1758. At that point the Royal Society learned about Chester M. Hall. Back in 1720 that gentleman had experimented and designed achromatic lenses. For reasons known only to himself, Hall did not publicize his invention. The Royal Society, after careful investigation, reversed their decision on the Copley Medal, and recognized Hall as the true inventor of the achromatic lens. Dollond died November 30th, 1761 in London. Though not credited with the original invention of the achromat, he certainly made a lasting contribution by reinventing it and bringing the lens design to the attention of astronomers.

John Dollond's eldest son, Peter, also joined his father in making contributions in the area of achromatic lenses. In 1765, without the necessary theoretical background, Peter Dollond invented the triple achromatic lens. Consisting of two convex lenses of crown glass and one concave lens of flint glass, it was a substantial improvement to both refracting telescopes and the navigational instruments of the time.

Last but not least we have Chester Moor Hall. Why priority claims were unimportant to Hall is a matter of conjecture, but the fact remains that he did invent the achromatic lens. Born on December 9th, 1703 in Leigh, Essex, England, he was a jurist and mathematician. Through studying the human eye, Hall realized that achromatic lenses were possible. After experimenting with many types of glass, in 1729 he devised a lens consisting of crown and flint glass. Not only did he build the first refracting telescope free of chromatic aberration, Hall also constructed several such instruments with apertures of 2.5 inches (65 mm) and focal lengths of 20 inches (500 mm). Why he waited until 1758 to reveal their existence will forever remain a mystery. Hall died March 17th, 1771 at Sutton, Surrey, England. The controversy that erupted two hundred years ago is best forgotten. What does matter is the improvement made by these men to the telescope, the essential tool of astronomers.

Here are the stories of five men whose footprints on the pages of history helped our journey through the uncharted skies. Without their contributions, where would we be?

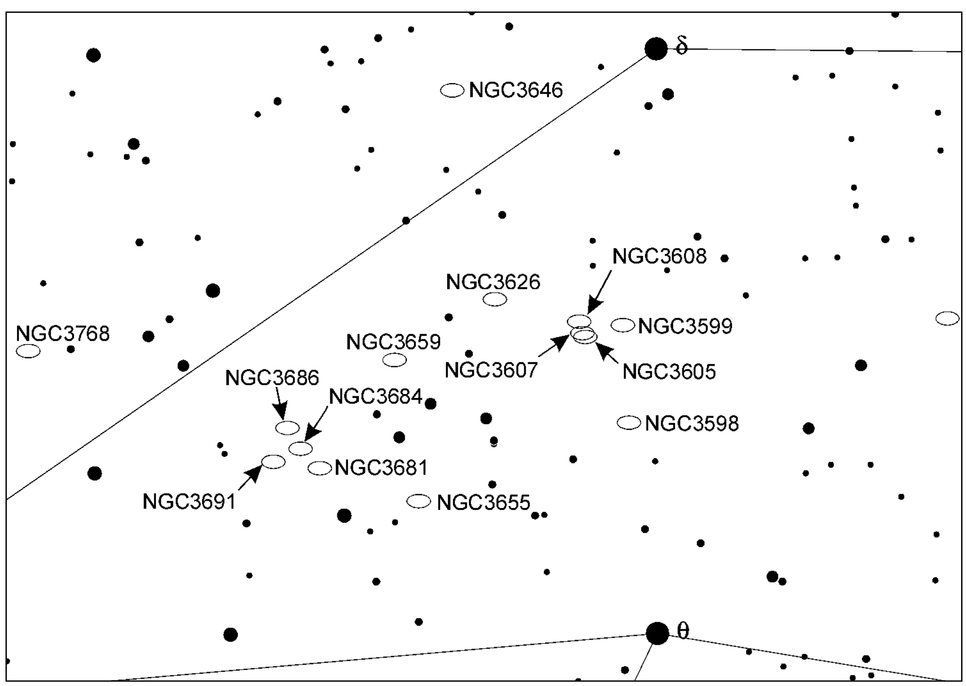
Barbara Silverman recently retired from a career as a junior accountant. She has had a life-long fascination with astronomy, but is relatively new to the RASC. Having joined the Montreal Centre only a few years ago, she is already a member of the Centre's Board of Directors. Her main interest in astronomy is its history, including archeoastronomy. Her other main hobby is science fiction, and she is currently working on a novel in that genre.

Scenic Vistas: Galaxy Groups in Leo

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

Small, bright galaxy groups abound in the constellation of Leo. Many observers are familiar with the famous triplet involving Messier 65, Messier 66, and NGC 3628, a superb field offering three bright spirals tilted at different angles to our line of sight. There is also the fainter group in the belly of the lion — Messier 105, NGC 3384, and NGC 3389 — a group easily within range of a 15-cm telescope under pristine spring skies. There are a number of others, though, not so well known, but still rewarding. Some of them will test the mettle of an observer using a small telescope, but it is always interesting to push your observing skills to the limit. This month we discuss three examples.

The NGC 3190 Group is a tough, though not impossible, challenge even in a 20-cm telescope. NGC 3190 is a very bright, much elongated spiral that features



A 5.8° high finder chart in eastern Leo of the latter two galaxy groups described in this article. Stars to about magnitude nine are shown (ECU Chart prepared by Dave Lane).

a prominent dust lane and disturbed spiral structure when photographed. Visually it appears as a well-defined streak of light with a fairly even surface brightness. NGC 3193, immediately north-northwest, is a round elliptical galaxy with a bright core. Observers should not have difficulty with these two. A little fainter is NGC 3185, located due south of NGC 3190. This spiral galaxy appears as a large circular spot very gradually brightening towards the middle. The toughest challenge is NGC 3187, a small, thin elongated streak west-northwest of NGC 3190.

A much easier group involves the three galaxies designated NGC 3605, NGC 3607, and NGC 3608, located 2˚.5 south-southeast of Delta Leonis. It is an extremely attractive, bright group of galaxies. Each galaxy has a very bright core. NGC 3605 is the smallest and faintest of the three. The group is dominated by NGC 3607, which appears large and round with a very mottled outer envelope. NGC 3608 is slightly smaller, although its core is as bright as that of the preceding galaxy. Its outer envelope is slightly fainter.

A further 2˚.5 southeast is a group of four galaxies that can be observed in a low power field. NGC 3686 dominates the group. It is a large spiral galaxy, slightly elongated north-south, with a smooth envelope and slightly brighter core. NGC 3684 is located further south, a roundish glow, gradually brighter towards the middle. NGC 3681 is smaller, but features a very bright core and a fainter, circular outer envelope. The fourth galaxy of the group is NGC 3691, which is slightly isolated from the other three and, I thought, the toughest of the four to observe. The galaxy appeared oval and was elongated roughly north-south. It appeared pretty much smooth textured, without a brighter core.

All three groups noted above are plotted on *Sky Atlas 2000.0*, and make an interesting observing project on a clear March or April evening.

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.

Astrocryptic

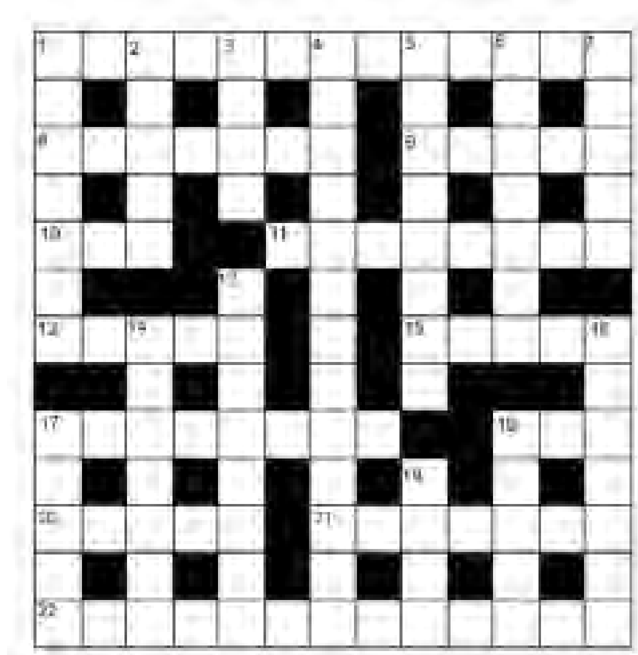
by Curt Nason, Halifax Centre

ACROSS

1. See mentor help out with the cloud thickness instruments (13)
8. Heavy particles you mostly find in barns (7)
9. Russian dog star (5)
10. The amount of light measured from part of Pollux (3)
11. Sound earnings made by early astrologers (7)
13. It was used to map Venus from either direction (5)
15. Computer chip in Cassegrain telescope drives (5)
17. Zero spin around hot particles thought to be missing mass (8)
18. A little time to travel half a parsec (3)
20. Caesar's beyond help in an awful trajectory (5)
21. Cut side off a type of comet tail (3-4)
22. I hear Shakespeare curves down to the galactic types (6,7)

DOWN

1. Cloudlike could be lunar in a certain way (7)
2. Rhenium is added to the holy vessel to make mirror glass (5)
3. The asteroid rose about midnight (4)
4. Robert saves Io around Lick and Kitt Peak (13)
5. Poorly elicit periodic correction from the Sun's path (8)
6. It's obvious, I'd go in the event horizon (7)
7. Headlines and highlights (5)
12. Regular luminosity on the H-R diagram (8)
14. Initial time period around which refractive power is measured (7)
16. Lunar crater disguises its clue (7)
17. The lead line is right (5)
18. With copper in antimony, a diver's need is forged (5)
19. Sagan's program is back around extraterrestrial detection (4)



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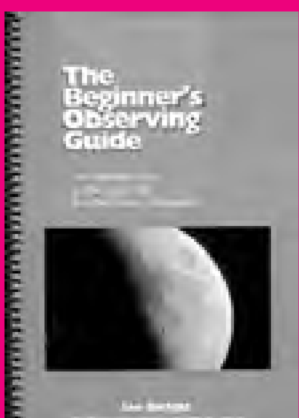
This calendar was created by members of the RASC. All photographs were taken by amateur astronomers using ordinary camera lenses and small telescopes and represent a wide spectrum of objects. An informative caption accompanies every photograph. This year all of the photos are in full colour.

It is designed with the observer in mind and contains comprehensive astronomical data such as daily Moon rise and set times, significant lunar and planetary conjunctions, eclipses, and meteor showers. The 1999 edition received two awards from the Ontario Printing and Imaging Association, Best Calendar and the Award of Excellence. (designed and produced by Rajiv Gupta).

Price: $13.95 (members); $15.95 (non-members)
(includes taxes, postage and handling)



The Beginner's Observing Guide

This guide is for anyone with little or no experience in observing the night sky. Large, easy to read star maps are provided to acquaint the reader with the constellations and bright stars. Basic information on observing the moon, planets and eclipses through the year 2005 is provided. There is also a special section to help Scouts, Cubs, Guides and Brownies achieve their respective astronomy badges.

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

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

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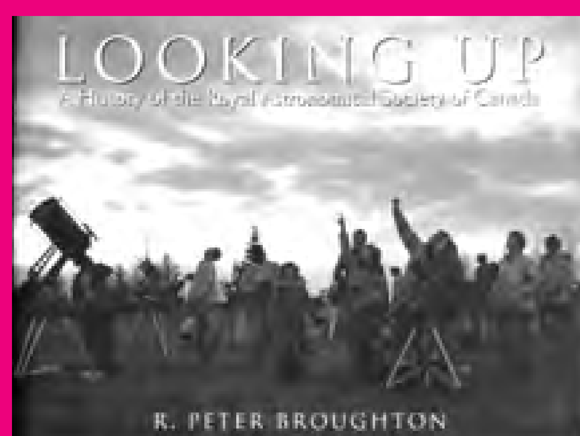

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