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Journal

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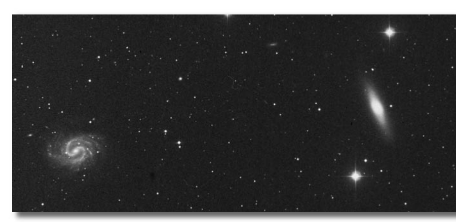

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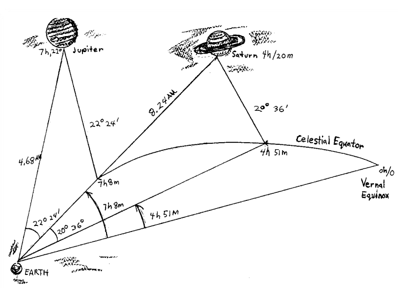

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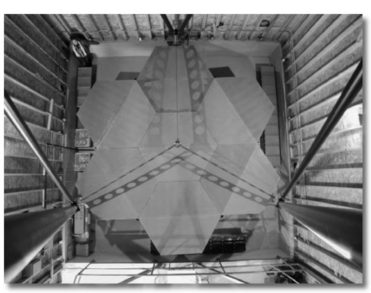

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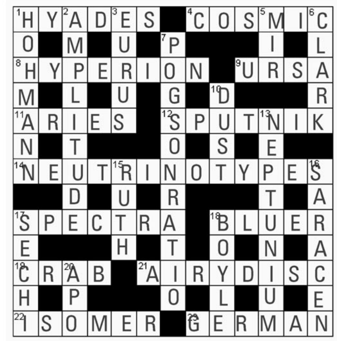

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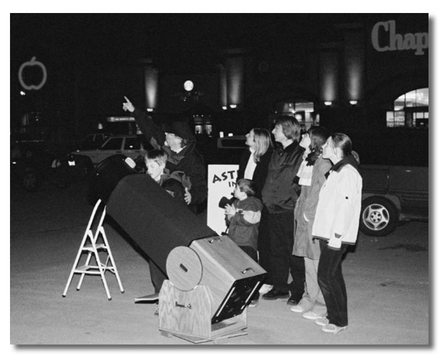

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Guy Mackie points out Jupiter during a Sidewalk Astronomy session in front of the Chapters store in Kelowna (photo by Jim Failes).
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President's Corner

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

Perspective is unique to humans, or at least is developed to a much higher level than in other animals. The ability to put events, actions, reactions, objects, and feelings into perspective has given us an evolutionary advantage over other creatures. Obviously then, perspective is a trait worth pursuing. Perspective is one of the few human attributes that actually can, and usually does, improve with age; nearly everything else seems to deteriorate. Along with experience and wisdom, to which it is closely related, perspective has value to society and should be developed to as high a level as possible in as many people as possible. Astronomy, with all of its extremes in time, distance, temperature, density, *etc.*, is a good vehicle for enhancing perspective in the astronomers themselves, as well as in the public.

Observing alone on a clear, dark, quiet night, when the stars are giving up some of their most precious secrets, is when I have had my best insights and perspectives. As a graduate student at the University of Chicago, I worked as a Research Assistant for W.W. Morgan and for 3 years I observed during half the clear nights with the old forty-inch refractor at Yerkes Observatory. Dr. van Biesbrook used the brights and I used the darks. Unlike most of my peers, I didn't have time to sit at my desk for long hours, head in hands, trying to figure out the next step in a problem set. Instead, I would work on a problem until I got stuck, then take it to the dome with me. More often than not, in the middle of a long exposure, when my mathematical muse was freed by the cosmic perspective, my thoughts would become crystal clear and the solution would be obvious. I would thus be over the hump and next day could continue working on the homework problems.

I was accustomed also to observing alone using the Helen Sawyer Hogg Telescope of the University of Toronto Southern Observatory on a remote mountain in Chile, 180 km from the nearest town and in the southern part of the driest desert in the world. Looking up at the magnificent southern skies, it was easy to put my research work and life in general into perspective. Especially during long exposures, while staring at a star on the slit of the spectrograph, my mind would stop its usual spinning and every part of my life would become crystal clear. Such nights, such thoughts, and such meditative perspectives have had an important influence on my life.

We don't observe that way any more. Now we sit in a brightly-lit warm room, remote from the telescope and the beauty of the night sky, staring at a computer monitor. Though practical and sophisticated, something has been lost: the romance, the peaceful contemplation, the clarity of thought, and the perspective. I'm not suggesting that we turn back. Indeed, the new incarnation of Helen is designed for remote operation. I

Journal

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

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am suggesting that we be aware of what we've given up in the name of efficiency. Perhaps a new perspective will arise.

For me, as for many others, traveling always has been a good source of both experience and perspective. All my problems seem smaller in their proper perspective. When I return, my mind is full of reform and new resolve. Then after a few days, my life reverts to its old ruts until the next travel opportunity arises.

During the past few years, it has been my pleasure, first as RASC Vice-President, then as President, to visit 20 of the 26 Centres. By the time you read this, three or four more will have been added to the visited list. Experiencing the entire RASC in this way has given me a unique perspective on the organization. I can now picture the meeting places, the key people, and the entire organization in context. Ironically now that I have acquired this great perspective, my term as president is ending. *C'est la vie*.

The membership has grown to about 4500, which surprises me because it is the same size as the US-based Astronomical Society of the Pacific. There are a few Centres that need some new members, but most are growing steadily and the RASC in general is in good shape. Public awareness and perspective are being raised and we as a society are doing well at fulfilling our mandate.

Editorial

by James Edgar, JRASC Proofreader (jedgar@sk.sympatico.ca)

Editor-In-Chief Wayne Barkhouse has given me the opportunity to editorialize for this issue of the *Journal*. Wanting to write about Canadian contributions to astronomy and space exploration, I did a "Web surf" on that topic and came up with loads of information.

A large group of luminaries (I'm thinking people, not stars) have contributed to our understanding of the solar system, our galaxy, and the universe. Some familiar names show up, like Newcomb, Chant, Plaskett, Hogg, Beals, Northcott, and Herzberg (the first three have RASC medals or awards named in their honour).

Short descriptions (paraphrased or borrowed from the CASCA Web site `collections.ic.gc.ca/universe/astronomers.html`) follow for the three medal/award honourees named above:

Simon Newcomb was born in Wallace, Nova Scotia in 1835. At the age of sixteen, to escape an apprenticeship to a "quack" doctor, he ran away to Maryland in the United States. Following a degree from Harvard University in 1858, Newcomb worked at the Naval Observatory at Washington, DC. When, in 1877, he was put in charge of the American Nautical Almanac office, he began calculating the motions of the bodies in the solar system. This work was to prove outstandingly precise and was used as a daily reference around the world for over fifty years. Newcomb's greatest contribution was to establish, with Arthur Downing, a universal standard system of astronomical constants. This system, which was mostly Newcomb's, is still in practical use today, as are his tables of data concerning various celestial bodies. Newcomb died in 1909.

Clarence A. Chant (1865–1956) — He is often called the "father of Canadian astronomy" because he trained so many young astronomers while a professor of astrophysics at the University of Toronto and because he made great contributions to the Royal Astronomical Society of Canada. It was through Chant's efforts that the University of Toronto acquired its 74-inch telescope at the David Dunlap Observatory, which is to this day the largest optical telescope in Canada.

John S. Plaskett (1865–1941) — If Dr. Chant was the "father," Plaskett must have been a close relative — maybe "the godfather." It's difficult to put into a few words all the contributions made by this man. He was one of the original staff members at the Dominion Observatory in Ottawa. While there, he designed an exceptionally efficient spectrograph for the 15-inch refractor, measured radial velocities, and found orbits of spectroscopic binary stars. He successfully lobbied for, designed, and supervised construction of the 72-inch reflector built for the new Dominion Astrophysical Observatory in Victoria and was appointed its first director in 1917. The Plaskett Telescope there further honours his memory.

Countless numbers of amateurs and educators disseminate astronomical knowledge to the public and our youth. A fourth RASC award honours amateur Ken E. Chilton, an active member of the Hamilton Centre who died an untimely death in 1976. In his short life (born 1939), he served as Hamilton Centre Treasurer, Editor of the newsletter, *Orbit*, Vice-President, and President, plus National Coordinator of Observations. A prominent honour was his involvement in the International Union of Amateur Astronomers (IUAA); he was the first secretary when it was founded in 1969. Chilton, a teacher, pioneered a cable TV program in 1971 called *The Sky Tonight*, broadcast in the Toronto area. He also organized solar eclipse expeditions. In particular, he coordinated the 1972 All-Can Eclipse, scouting suitable sites in the Maritimes and preparing publicity for the event. Established in 1977 by the RASC National Council, the Chilton Prize is awarded annually to an amateur astronomer resident in Canada in recognition of a significant piece of astronomical work carried out, or published, during the year.

Many active, well-known and not-so-well-known Canadians continue to refine and advance our astronomical knowledge pool; they come from rich and varied backgrounds.

The CASCA Web site gives this description for Hubert Reeves: "Born in Montréal, Dr. Reeves received his B.Sc. at the Université de Montreal, and his M.Sc from McGill University in 1955. After receiving his Ph.D. from Cornell University in 1960, he worked there for a while before teaching for four years at the Université de Montréal. Best known for his exceptionally successful popularization of science. His work has earned him several prestigious honours such as the Order of Merit of the French Government, and several honorary degrees." Reeves, although he lives and works in France, continues to teach cosmology at the Université de Montréal for one month of each year.

Hojatollah Vali is a research associate in the Department of Earth & Planetary Sciences of McGill University. Hailing originally from Tehran, Iran, he emigrated to Germany in 1971, completed his M.Sc. and Ph.D. at the Technical University of Munich in 1983, and then moved to Canada. Because of his "exceptional ability to differentiate between minerals of organic and inorganic origin," Dr. Vali was invited to be part of the NASA research team that examined the Antarctic meteorite ALH84001 in the search for signs of Martian life forms (quoted from the McGill University Web site).

Alan R. Hildebrand — A Fredericton, NB native with a B.Sc. in geology from the University of New Brunswick, he worked for a number of years in mineral exploration before returning to university to complete a Ph.D. in planetary sciences from the University of Arizona. He was a Research Scientist in the Geological Survey of Canada, where most of his work centred on studies of impact craters and meteorite falls. He is best known as the first scientist to identify the Chicxulub crater in Mexico's Yucatan peninsula as the remnant from the impact that destroyed the dinosaurs. Hildebrand now is at the Department of Geology and Geophysics, University of Calgary and heads the Prairie Meteorite Search.

Born and raised in Saskatoon, Saskatchewan, Dave Williams is a NASA Shuttle astronaut with a long list of achievements, including a Ph.D. He is currently Director of the Space and Life Sciences Directorate at NASA's Johnson Space Center in Houston. His team of about 1200 people is devoted to understanding the opportunities and challenges involved in life and work in space. In the efforts to better understand the long-term implications of space life, the Aquarius Undersea Laboratory in Florida was used last October by the project team who lived "underwater using Aquarius as a space analogue for working and training under environmental conditions that are surprisingly similar to many of the challenges faced in outer space" (quoted from the Aquarius Web site).

Over three years ago, to ensure an ongoing Canadian presence in astronomy, a handful of people started the Long Range Plan (LRP) to lobby the federal government for funds to see their vision through to fruition. The future of Canadian astronomy hinges greatly on the impetus of the LRP (go to the following Web site for a summary: `www.astro.yorku.ca/casca/castro-en6.html`).

Through the work carried out in schools and universities, at the world-class telescopes in Hawaii and South America, and from observatories in space, Canadians will undoubtedly continue to make significant contributions to our understanding of life in the universe. Active endorsement for the LRP and its recommendations is important. It's not too late to consider writing a letter to your MP encouraging support for this valuable work.

Correspondence
Correspondance

LATER LIFE LEARNERS

The paper by John Percy and Mirjan Krstovic on "Later Life Learners" (*JRASC*, 95, 205, 2001) inspires me to provide some supportive comments to describe and promote this oftentimes-misunderstood community. I have taught introductory astronomy at a local community college for five years. This ten-week course is for anyone interested in astronomy and does not contain the math and formulas that might otherwise repel prospective lay audiences. In each of my classes there has been a significant number of Later Life Learners, their presence representing approximately 40 percent of the participants. In my overall observation of this group, it has been my experience that they have almost perfect attendance in the course, faithfully attending and actively participating in every class. They genuinely enjoy the material and discussions and (to my humble delight) often express their gratitude following each class. Later Life Learners have a strong desire and commitment to learn. They become enlightened with what you can share with them. They, in turn, share their life-long experiences with you and your participants. (I have been privy to some wonderful testimonies of star-night conventions and eclipse experiences). Most importantly, we should be aware that these "senior students" want to be continuously in touch with science and society and, in taking these courses, they feel much a part of the real world (and the universe) of scientific thought and reasoning. This is particularly important to keep in mind whether you're a teacher, a lecturer, or an amateur astronomer sharing the eyepiece of your instrument or your love of astronomy. My final point regarding the interest and market of this important community of people is that Later Life Learners, more than anyone else, have enthusiastically approached me on the last day of every course to ask me if there is a part two!

Lawrence Cresswell,
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Toronto, ON

Errata:

In the article "Physical Models of Haidinger's Brush" (December 2001, *JRASC*, pp. 248), the last paragraph on page 249 should state "The electric field vector E has radial and tangential components $E \sin \Theta$ and $E \cos \Theta$ respectively.";

The table of contents of the February 2002 issue, page 1, should have indicated that "From the Past" was on page 8.

News Notes
En Manchettes

GETTING THE MOST OUT OF A "ROCKOT"

The countdown to the launch of Canada's MOST satellite has begun. The launch is scheduled for October 2002 and will form part of a multiple payload mission to be carried on aboard a Russian SS-19 "Rockot" launch vehicle.

The microvariability and oscillations of stars (MOST) project will showcase and utilize Canadian technology. Crammed into a mere 60-kg microsatellite, the project will use a 15-cm diameter telescope to study the internal structure of stars by measuring the subtle but telltale light variations that result when internal sound waves make the stars oscillate.

The Canadian Space Agency is providing $8.5 million to fund the development of the satellite and ground-control station, as well as the launch and operations. The Ontario provincial government also provided an additional $1.2 million to support the program.

More details on the MOST project can be found at `www.astro.ubc.ca/MOST/index.html`

2001 YB5 – ANOTHER NEAR SHAVE!

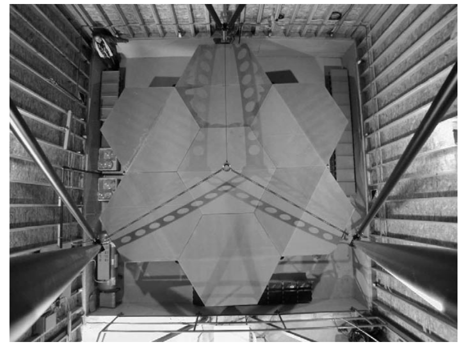
Asteroid 2001 YB5 passed safely by the Earth on January 9, missing us by more than one and a half million times its own diameter, or 65 Earth diameters. It nonetheless caused a distinct stir in the media and reminded us of the certainty that one day the Earth will be struck by a similar body. While the general news media tended to focus on the "what if it had hit" side of the story, the event was truly disturbing in the sense that if the asteroid had actually been on a collision course with the Earth, then we would have had less than a month to prepare for impact.

The Near-Earth Asteroid Tracking Survey Telescope on Mount Palomar in California discovered 2001 YB5 on December 26, 2001. Estimated to be about 400 metres across, the asteroid was designated as "potentially hazardous" by NASA's Near-Earth Object Program Office. This label is given to any object larger than 150 metres across and passing within 7.5 million kilometres of the Earth. More details on the asteroid tracking program can be found at `neat.jpl.nasa.gov/`

While asteroid 2001 YB5 is now one more valuable statistic in the catalogue of near-Earth objects, one less-inspiring statistic that can be reported is the recent closure of Canada's longest-running asteroid-tracking program. The tracking and asteroid detection program operated by David Balam at the University of Victoria was recently closed due to budgetary cutbacks. For a number of years the program had been funded by a US foundation and donated telescope time, but now neither of these resources is available to the program, and no Canadian funds have been found to replace the shortfall. It seems sad and ironic that as the rest of the world has begun to increase its funding towards near-Earth asteroid survey programs, one of the very best tracking programs in the world, operated in Canada, has been closed. For more details, see `astrowww.phys.uvic.ca/~balam/`

ABERRATION IN A SPIN

The simplicity inherent in the design of liquid-mirror telescopes (LMTs) is inspiring. The mechanical problems associated with the simple design, however, are formidable. The art of spinning a mirror of liquid mercury has nonetheless been brought to perfection by Canadian astronomers Ermanno Borra and co-workers at Laval University, and Paul Hickson and co-workers at the University of British Columbia. LMTs work because the natural profile of a spinning liquid is that of a parabola, and since mercury is reflective, the surface can be used to gather and focus light. Because gravity pulls vertically downwards, LMTs have to be zenith-pointing instruments (otherwise the mercury spills out), but for many survey studies this "engineering" feature is not a drawback. One problem of large-diameter LMTs that is a real drawback, however, is the optical aberration (astigmatism and coma) resulting from the Earth's Coriolis effect.



6-metre diameter Large Zenith Telescope project. This view is from the top of the telescope looking down on the seven hexagonal segments that will form the support surface for the liquid primary mirror. Six triangular pieces will be added to complete the circle.

The effect of the Earth's spin on the parabolic profile adopted by the liquid mercury in an LMT can, however, be corrected. One option is to build an optical corrector, but Hickson has recently outlined a cheaper alternative. Writing in the December 2001 issue of *The Publications of the Astronomical Society of the Pacific*, he has shown that very slightly tilting the spin axis of the LMT can counteract the Coriolis aberrations. The tilt angle is latitude-dependent but amounts to about 12 arcseconds for a telescope positioned in the US or Canada.

Hickson further indicates in his paper that by eliminating the aberrations caused by the Coriolis effect, there is now no fundamental reason why large (that is 10-metre sized) LMTs should not perform to their full diffraction-limited potential. More information on LMT technology and LMT projects can be found at `www.astro.ubs.ca/LMT/lm/index.htm`

A BEVY OF CANADIAN ASTEROIDS

Four new asteroids have recently received Canadian-related designations. The Canadian meteor physics community has been favoured this time round with Professor Robert Hawkes of Mount Allison University, Dr. Peter Brown of the University of Western Ontario, and Dr. Martin Beech of Campion College at the University of Regina being elevated to asteroidal status. All of these astronomers have, at one time or another, worked on meteoroid stream formation and meteor light-curve models. Asteroid 1994 SO5 has also been designated as minor planet (12382) Niagara Falls. All of the newly named asteroids were discovered through the Spacewatch program at Kitt Peak. Dr. Jeremy Tatum has in the past maintained a list of asteroids with Canadian connections (his last list being published in *JRASC*, 85, 384, 1991), but he comments that the list is in definite need of revision and further annotation (any takers?). At present some 87 asteroids have Canadian connections either by personal name or by city.

CALL FOR NOTES

If you have any *News Notes* items that you would like to bring to our attention, please forward the information via email to `martin.beech@uregina.ca`

Sidewalk Astronomy

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

The vicarious reward of sharing views of astronomical objects through my telescope has long been one of my favourite aspects of astronomy. Initially my wife and young family were called to "have a look," then came fellow members of the Okanagan Centre, and finally the general public at astronomy day events. All were both coaxed and coached to appreciate the many wonderful sights and concepts of astronomy that can be explored at the eyepiece of an amateur telescope.

Observing reports of sidewalk astronomy sessions by Pierre Martin and Rock Mallin of the Ottawa Valley Astronomy & Observers Group (OAOG) inspired me to approach the Okanagan Centre members to see if there was local interest in putting on such events. In February of 2001, a small group of fellow members (Jim Failes, Jim Fisher, Stewart Hill, Ron Scherer, and Jim Tisdale) discussed the concept and decide to approach the management of the Orchard Park Mall, a large regional shopping center in Kelowna. Once we were armed with a copy of the RASC proof of insurance provided by Bonnie Bird, mall manager Wayne Scherger was quick to give his approval for us to set up our telescopes in its parking lot, with only a few constraints on the locations that we used. We chose as our preferred location a spot north of the high-traffic and late-hours Chapters outlet. The Chapters store events manager Sandra Riddolls was very enthusiastic about our activity and ensured that in-store announcements of our presence were made when we were in the parking lot.

Guy Mackie points out Jupiter during a Sidewalk Astronomy session in front of the Chapters store in Kelowna (photo by Jim Failes).

We usually use only one or two parking spaces to set up our telescopes, four-foot-square "ASTRONOMY IN PROGRESS — Have a Look" sign, table with Moon map, and handout materials. In the summer months when the Sun is our only target, we have a solar evolution and sunspot-detail poster as well. Our sidewalk astronomy sessions are scheduled every month between First Quarter and Full Moon, which guarantees that we will at least have the Moon as a target. From the heavily light-polluted parking lot, just about the only other possible targets are the planets, double stars, passes of satellites such as the International Space Station (ISS), and Iridium flares. An added benefit is that our sessions are never clouded out as many of our targets are visible even under broken cloud or haze, and naturally we only go when conditions provide some expectation of success.

Every sidewalk session that I have attended (now close to twenty) has been memorable, and each one holds something special. Adults eagerly jump from foot to foot in excitement as they await their turn at the eyepiece, then exclaim in joy when they report, "I can see the rings, I can see the rings!" In appreciation some the language barrier. It is sometimes hard to read the emotions of really young children as they quietly peer through the eyepiece, but pre-teens and even some teenagers can get very excited, and the astronomer knows that a link with the cosmos and the imagination has been made.

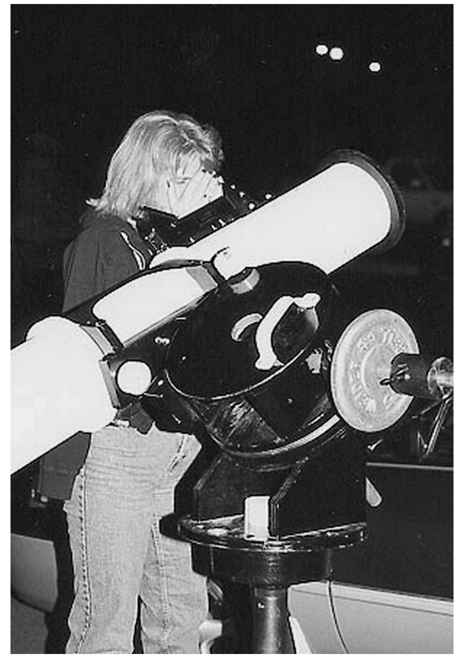
It is important to keep returning to the same location for sidewalk sessions, as this will increase awareness of your activity. Some people will be repeat visitors and will likely give you extra encouragement to keep at it. During a session in November 2001, I was visited by a mother and son who had specifically returned to see Saturn's rings, which during a summer session I had mentioned would be visible in the fall. She must have marked the "Sidewalk Window" on her calendar and then ventured out on a promising night in hopes that we would be set up.

It is natural for the astronomer to be nervous about being presented with questions that we may not be able to answer. If you are asked a question to which you do not know the answer, the best advice is to tell the truth and say you will have the answer the next time you come out. Bring along the *Observer's Handbook* as it is always a great help, and I suggest reading over at least some of the Solar System information before your first session. There is nothing quite like using information and answering questions to develop your own knowledge and confidence, and after one or two sessions you will be more relaxed and can start to really enjoy yourself.

There are a number of Okanagan Centre members (Bryan Kelso, James McRae, Harold Morgan, Ron Seiler, and Wayne Willett) in the Vernon area, 46 km north of Kelowna, who are interested in

Guy Mackie assists Eric Failes use his telescope while Guy's two daughters Jessica and Jolene look on (photo by Jim Failes).

even return bearing hot cocoa and treats from the coffee shop inside Chapters. Family members ask, "How long will you be here?" and a short time later return with a carload of spouses, children, and neighbours. The kids pile out of the SUV in slippers and PJs to get a glimpse of the mountains on the Moon. The appearance of a predicted ISS pass can produce looks of baffled wonder and may even inspire a round of applause from appreciative onlookers. When looking at Saturn, some ask if there is a picture taped inside the scope, thinking there is some kind of trick. I cringe when teenagers skeptically ask, "Do you really think men have been to the Moon?" The conspiracy culture that pervades our society today, fed by the likes of "X-Files," is an equal-opportunity destroyer of fact! However, the sincere gratitude of the majority is ample reward for the frustrations brought on by a few skeptics, and many times our guests will return sheepishly to ask if there is any charge for the celestial tour. It is very gratifying when elderly persons get their first, and maybe last, telescopic views of the Moon and planets. As they reluctantly leave with a sidelong grateful glance, you can't help but feel that you have done a good thing. Kelowna has many Japanese tour groups visiting the area, and one night a group of about fifteen members of such a tour were wandering almost single file through the parking lot. The lead members broke around me like surf on a breakwater, nervously clutching their purses and shopping bags, as they were unable to read my signs and were not aware of what the "big tube" even was. By the time the rear guard passed I had proved my harmlessness, and one member of the group stopped and gave a questioning shrug. Pointing at the Moon and then the eyepiece I persuaded him to have a look. For the next twenty minutes the entire group gathered around, and through body language, hand signals, and wide smiles, we all shared in the joy of astronomical discovery, a pursuit that easily bridges



starting a sidewalk astronomy group in their area as well. They are looking for a suitable location with enough evening pedestrian traffic to provide a large audience. So far, a busy restaurant and a movie theatre parking lot have presented the best possibilities.

Sidewalk astronomy is a very rewarding activity, and even though it is not our primary goal, we have attracted a few new members to our Centre. We have certainly also increased awareness of astronomy and our local Centre, but the most exciting thing is the possible impact we may have had on the children. Who knows where a chance view of Saturn's rings may lead in the future of some impressionable young mind!

Guy Mackie enjoys observing from the dark hillsides near Kelowna, British Columbia. He has completed the Messier and Finest NGC Objects lists and eagerly pushes the limits of his 12.5-inch Dobsonian on the Challenge Objects list and other deep-sky targets.

ASYMMETRIES in the Universe

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

Asymmetries in the universe are the source of some of the deepest problems in physics. Solving them often results in great advances in our understanding, and in leaps in knowledge much bigger than quanta. Our world is inherently symmetric at many scales, from the subatomic to the cosmic. Nevertheless, asymmetries and anisotropies exist, often where they are least expected. In this short article, written expressly for the April issue of *JRASC*, some deeply perturbing asymmetries are shown to exist in the physics underlying the structure of the universe. For an excellent discussion in layman's terms of symmetries and mirror-reversals at all scales, the reader is referred to Martin Gardner's 1990 book *The New Ambidextrous Universe*.

"Our world is inherently symmetric at many scales, from the subatomic to the cosmic. Nevertheless, asymmetries and anisotropies exist, often where they are least expected."

I find it amazing that in astrophysics, and in cosmology in particular, properties of subatomic particles determine the behaviour of the universe as a whole. Indeed, a small change to one of their properties would have a huge influence on the evolution and current state of the universe. Peculiar processes of subatomic particles, postulated to have occurred in the first moments of the universe's existence, have resulted in the properties of matter with which we are familiar today. Anisotropy (unevenness) in the cosmic microwave background radiation, an "echo of the Big Bang," is seen to be at the root of large-scale structure in our universe. The specialized instrument package called the Microwave Anisotropy Probe (MAP) was launched last year specifically to measure these anisotropies, to give theoretical cosmologists some hard data to chew on.

The apparent predominance of matter over antimatter as far as we can see is a conundrum whose solution may also lie in the very young universe. Early attempts by Hannes Alfvén and Oscar Klein to explain this included the idea that there were vast regions of space consisting entirely of one or the other forms of matter, with violent zones of mutual annihilation at their borders. Gardner has listed a half-dozen more recent alternatives, each with its own difficulties. The most appealing involve bizarre concepts such as symmetry breaking in the very early universe, Roger Penrose's twistor space, and time-reversed worlds.

To my knowledge, no one has attempted to explain another asymmetry evident in the universe. This is related to the rotational behaviour of spiral galaxies. Photographic and CCD surveys of nearby and distant galaxies have amassed vast quantities of data, compiled in catalogues and computer databases. Painstaking analysis of this database has revealed (Attas, unpublished) the existence of a small but statistically significant ($p<0.001$) asymmetry in the rotational direction of the galaxies. Preliminary results indicate that $50.022 \pm 0.003\%$ of galaxies in the database rotate clockwise, with the remaining 49.978% rotating counterclockwise. Line-of-sight velocity profiles across the galaxies, as determined by measurements of the Doppler shifts of spectroscopic lines as a function of radius, have confirmed the validity of this result. Explaining it, however, requires original thought and bold speculation.

It turns out that there may be a deep connection between this rotational asymmetry and the matter/antimatter conundrum. If we postulate that galaxies rotating clockwise are composed primarily of matter, and those rotating counter-clockwise are composed primarily of antimatter, then the same phenomenon could eventually explain both asymmetries. Although speculative at this point, this hypothesis could provide a new foundation for cosmological thought and early-universe modeling.

A test of the hypothesis is to be found in the study of spiral galaxies that are interacting gravitationally. Although their interaction is commonly termed a collision, in fact impacts between stellar bodies are relatively rare; rather, gravitational forces profoundly disrupt the spiral patterns of the two galaxies, and dispersed matter comes into contact. The rotations of a pair of interacting galaxies may be in the same sense (*i.e.* both clockwise or both counter-clockwise), or they may be in the opposite sense (*i.e.* one each clockwise and counter-clockwise). If our hypothesis were correct, pairs of galaxies with opposite senses of rotation would be matter-antimatter pairs, so their interaction would result in significant mutual annihilation. The annihilations would release much more energy (in the form of gamma rays) than interactions of galaxy pairs rotating in the same sense. Analysis of the gamma-ray flux from interacting spiral galaxies would thus assist in confirming or disconfirming the hypothesis.

A researcher who has specialized in the study of interacting galaxy pairs is Dr. Elizabeth Barton, until recently at the Herzberg Institute of Astrophysics (National Research Council). A report by her team on some aspects of interacting galaxies has recently appeared in the *Astronomical Journal* (121, 625-648, February 2001). Once her full database is published, we can examine it for evidence to confirm or rule out the link between direction of spin and composition. The examination would need to be tied into the database of gamma-ray flux measurements made by the Compton Gamma Ray Observatory from 1991 to 2000. It would be foolish to try to predict the outcome of this analysis at this point; nevertheless, combining data from several observational bands has a long history of providing new insights into deep scientific problems. Who knows — perhaps it could even contribute to the current heated debate on dark matter, quintessence, and the accelerating expansion of the universe we think we know something about.

"If *JRASC* readers write to their government representatives requesting priority funding, within a few years this burning question could be answered."

What would confirmation of this hypothesis mean? Apart from the satisfaction of adding another piece to the jigsaw puzzle that is the universe, it has practical applications closer to home (cosmically speaking). Determining the rotational sense of our own Milky Way galaxy would become an urgent priority. Perhaps a pair of instrumented probes could be sent in opposite directions on missions outside the galactic plane, to observe and report its rotational behaviour. If *JRASC* readers write to their government representatives requesting priority funding, within a few years this burning question could be answered. (Calculating how many years it will take is left as an exercise to the reader.) The probes might be named Twin Rotational Isotropy Corroboration Kelvinometry Spacecraft (TRICKS).[1]

By day, Michael Attas is an imaging scientist with the National Research Council's Institute for Biodiagnostics in Winnipeg, developing methods of diagnosing disease non-invasively using infrared light. As a sideline, he is an associate editor of the JRASC, *occasionally contributing pensive pieces such as this one. He does his daydreaming at night.*

[1] Disclaimer: The official publication date of this article is April 1, 2002. This should be an indication to the reader that the ideas presented here have little or no scientific merit. Nevertheless, readers are invited to speculate on them, perhaps even to the point of finding a useful nugget or two buried within.

Lamplighter Moment[1]

by Curt Nason, Moncton Centre (nasonc@nbnet.nb.ca)

When I arrived at work on November 26, 2001 at 7:25 a.m., a light rain was just beginning. A bad omen for a Monday morning. Just as my coffee was ready, the phone rang. It was a co-worker asking me if I had seen the rainbow. I said I hadn't, and the reply was, "You're the astronomy guy. Go see it!"

I work at the Point Lepreau Nuclear Generating Station, which is situated on the Bay of Fundy coast in New Brunswick. I looked out of my dungeon window and saw part of the southern arc. As I climbed the east-side stairs toward the second floor, I could see the Sun a few degrees above the water, with a cloud layer just above it. Locally, the light rain was continuing.

Looking out a west-side window, I saw the full rainbow. It wasn't the brightest nor the sharpest I had ever seen, but it was a beautiful sight nonetheless. The secondary arc was visible to the south only. As I studied the colours, trying to distinguish the blue and violet, I noticed the rainbow's position with respect to the surrounding area. This was when I had my Lamplighter Moment.

The two ingredients of a rainbow are water and light. The southern arc fell directly over a demineralized-water tank, and the northern arc terminated on a streetlight. As if this weren't enough, directly under the centre of the arc was our communications/meteorological tower.

Sigh — no camera.

Curt Nason has been interested in astronomy since he was knee high to an elephant. He is employed as a Health Physicist at New Brunswick's largest nuclear power plant.

[1]Dedicated to the memory of Father Lucian Kemble (1922–1999), *a.k.a.* "Lamplighter," who touched the lives of countless members of the RASC through his love for all aspects of observing. A "Lamplighter moment" is simply an occasion where, through careful observation of the mundane, one unexpectedly discovers something profound, something achieved by Lucian Kemble fairly regularly during his lifetime. This section is a regular part of the *Journal* devoted to guest articles by authors describing their Lamplighter moments.

The Astronomical Basis of Our Calendar

Part 1: Days, Months, and Years

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

I have been interested in calendars and their astronomical basis ever since my teenage years, when I read Isaac Asimov's *The Clock We Live On* (Collier, New York, 1963). My library has expanded since then, but I still recommend Asimov's book as an accurate and easy-to-read primer (if you can find it!). In January 2002, I gave a talk to the Halifax Centre entitled "A Date With the Stars: The Astronomical Basis of Our Calendar." The talk was developed from the knowledge and insight I have gleaned over the years from reading and thinking about the topic. Although I have performed no scholarly research in this area myself, many of the points I made seemed to be new to many listeners. From their comments, I was encouraged to write down some of my thoughts, and here is the first installment, in which I will talk about the fundamental cycles that govern our calendar. In subsequent issues I will follow up with a discussion of calendars themselves. I hope you enjoy the story!

This French woodcut from 1504 depicts the annual cycle of the seasons, with appropriate agricultural activities for each month.

Heaven and Earth

My calendar talk began with a quotation from the *Bible*, not because I am a religious man, but because the story of our calendar is entwined with Judeo-Christian beliefs and history. Indeed, Canada is a multicultural society, but there is no denying that the dominant social mores are Christian, and the civil calendar that we share with most "Western" countries has such a bias: Christmas and Easter are major public holidays, while the principal holidays of other religions are respected. Other cultures have different religions, and different calendars to go with them, but they all make the connection between our life on Earth, the motion of the heavenly bodies, and the creation myths that establish the existence of Heaven and Earth. "Our" creation myth is told in the *Book of Genesis*, and the selected quotation was:

> "And God said, let there be lights in the firmament of heaven to divide the day from the night; and let them be for signs, and for seasons, and for days, and years." (*Genesis* 1:4)

Whether or not you believe the biblical creation story (either figuratively or literally), the point of including the quote was to establish that the authors of *Genesis* were fully aware that the calendar by which we map out our social time is directly connected to the Sun and the Moon, whose motions unfold in cosmic time, unrelated to the comings and goings of life on Earth.

The Day

Genesis introduces day and night, marked by the rising and setting of the Sun. Together these form the fundamental cycle governing our lives. Even in these modern times, when so many of us have become disconnected from the pageant that unfolds in the celestial sphere, we have not fully abandoned the metronomic rhythm of the day. A human life span, however, is measured in tens of thousands of days, a very large number. Civilization needs longer units of time, and calendars to organize them. Religion, with its concept of a Creator and a creation event, breaks the cyclical pattern of natural life and injects a creation instant, along with — in most cases — an end to time itself. Religion unrolls the cycles of time into linear time, with a start and an end. Cycles still have meaning, but now we want to measure longer durations and mark our progress: calendars are intertwined with religion.

The Month

The day is one apparent passage of the Sun around the Earth, from noon to noon (on average). The lunar month is one passage of the Moon around the Earth, from a given phase to the next phase of the same type (on average). This is the *synodic* month, or the time between "meetings" of the Moon and the Sun, from the Greek word *sunodos*. The average synodic month is $T_M = 29.530589$ days. At the dawn of civilization, fishermen and nocturnal hunters would have become savvy to the tidal and illumination cycles of the Moon. The passage of 29-30 days is easy to estimate by monitoring the lunar phase; no wonder the earliest calendars were lunar calendars.

Calendars, however, cannot indicate fractional days. How convenient it would be if a month were exactly an integral number of days! One copes with fractional days by letting some months have 29 days and others 30 days, according to a pattern that allows the month to lag or lead the Moon ever so slightly, but never to fall completely out of step. The Muslim calendar is a purely lunar calendar, with the first day of a new month declared through the sighting of a very young crescent Moon by the *mullah*, or priest. The observational basis of the Muslim calendar avoids complicated calculations and tables of data. We will see that the calendar we use today abandoned the Moon in favour of the Sun. Consequently, the month durations became longer than the synodic month, so that twelve months streched out to form one year, and the inception of the month became totally unsynchronized with the true phase of the Moon. Before we explore this, we must discuss seasons and years.

The Week

What about the week? We have skipped over this, for several reasons. Firstly, one could write a whole article on the week and the naming of the days, and such an article has already appeared: "Astronomical Names for the Days of the Week" (*JRASC*, June, 1999), by Michael Falk of the Halifax Centre. There appears to be no natural cycle that compellingly suggests a seven-day week. Primitive societies in different parts of the world naturally invented weekly cycles ranging from 4 to 10 days, based on market days and other social conventions. The seven-day week possibly derives from the mystical properties of the number 7, which happens to be the number of rapidly-moving objects the ancients recognized in the sky: Moon, Mercury, Venus, Sun, Mars, Jupiter, and Saturn. The nearest we get to an astronomical cycle for the week is dividing the synodic month into four equal portions, the time between successive principal phases, which is about 7 $^3/_8$ days. The closest integer is 7, so a seven-day interval is about one phase to the next, a convenient measure of time between one day and one month.

The Seasons

The annual voyage of the Earth around the Sun would have little significance if the Earth's axis of rotation were not inclined obliquely to the orbital plane. The Sun passes through the various zodiacal constellations, but this cannot be observed directly; rather, the stars opposite the Sun change slowly night by night, so the passage of the year can be gauged by the star patterns on the meridian at midnight, or the stars that appear just before dawn in the morning. The 23$^1/_2$-degree axial tilt creates an annual variation of daylit hours and solar altitude that induces an annual cycle of heat delivery at temperate latitudes on the Earth. The resulting weather patterns are much more tangible than star patterns in the sky! At temperate latitudes, we experience the familiar cycle of the seasons: spring, summer, autumn, and winter; at tropical latitudes, typically there are two seasons: rainy and dry. The temperate seasons are each roughly 90–91 days long, about three 30-day months. As human social organization progressed from hunting and gathering nomadic tribes to farming communities, the progress of the seasons became crucially important, as crop-bearing fields need to be planted, nourished, harvested, and cultivated.

The Year

There are several "years", but the relevant year for our calendar is the *tropical* year, the time between equinoxes or solstices of the same type, as this is what drives the all-important seasons. From a vantage point on Earth, the Sun lazily cycles in declination relative to the celestial equator, spending half of the year north of the equator and half of the year south of it. The equator crossings mark the equinoxes, or days of equal daylight and night. The dates of maximum declination mark the solstices, when the Sun's rising (and setting) points stop, and turn back in the opposite direction. The Greek word *tropikos* means "turning", so the *tropical year* marks the time between turnings. The tropical year is $T_Y = 365.242190$ days. The history of our calendar and the creation of the somewhat complicated formula for determining leap years is the story of the strategies that evolved to account for that peculiar fraction of a day: 0. 242190.

Where the human life span is measured in hundreds of months, in years it is only tens, a very manageable number. (Someone — I cannot remember who — speculated that Methuselah's 969 years were actually months, reducing his fabled longevity to an accident of translation.) There is little need for a longer unit of time. With the popularity of the decimal system of reckoning, decades and centuries seem obvious; however, these are simply conveniences for counting, and have no celestial basis.

Conclusion of Part 1

I started by citing a very good but out-of-print book. For those who cannot wait for the next installment and want to read more, there are other books. If I could only recommend one, it would have to be the book I received as a surprise Christmas present from my wife, who observed me labouring over my calendar talk during the winter solstice celebration: *The Calendar: History, Lore, and Legend*, by Jacqueline de Bourgoing (Harry N. Abrams Inc., New York, 2001). This little book is well-written, beautifully printed, and only costs $12.95 Cdn (The ISBN number is 0-8109-2981-3). The author is a French academic who has produced a television series on the calendar for French television. She published the book in 2000, and this is a translated version.

Next time, I will show how these fundamental celestial cycles form the basis of the calendar, and how they interplay and create apparently random dates for some of our principal holidays.

David Chapman is a Life Member of the RASC and a past President of the Halifax Centre. By day, he is Acting Chief Scientist at Defence R&D Canada–Atlantic. Visit his astronomy page at:
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Second Light

Martian Trade Winds

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

A windy spring day often brings a warm breeze to much of Canada, as air heated in the southwestern part of the continent circulates towards the northeast in the prevailing westerlies. Other planets also have winds. Clouds on Jupiter and Saturn are visible as they stream in those planets' winds, but probably few have given thought to what the winds are like on Mars. After all, the Martian air pressure is less than 1 percent of sea-level pressure on Earth. Seasonal variations in the climate, along with long-term climate changes caused by Mars' elliptical and slightly inclined orbit around the Sun, have been thought to average out over sufficiently long times. But Mark Richardson of Caltech and his collaborator John Wilson of the Geophysical Fluid Dynamics Lab show in the 21 March issue of *Nature* that the large difference in mean elevation between the northern and southern hemispheres drives warm air strongly from the southern summer towards the equator, leading to an overall warming of the north.

Mars' polar ice caps are very different from each other. The northern polar cap has a lot of water ice, while the southern polar cap is mostly frozen carbon dioxide ('dry' ice). These polar differences, along with seasonal differences in the Martian climate, have generally been attributed to variations in solar heating having to do with its orbital inclination and eccentricity. In other words, the poles we see now are very different from the poles of 10,000 or so years ago.

We generally are much less aware of Earthly winds these days than two hundred years ago, because world trade and naval power no longer depend on winds. However, winds still are an important factor in determining surface conditions on Earth.

Winds serve the purpose of distributing atmospheric energy and water more evenly around a planet, and so are driven by solar energy, planetary rotation, and other factors (such as clouds and fronts on Earth). On Earth, one general circulation pattern is known as the 'trade winds.' Broadly speaking, in the region from about 5 to 25 degrees north latitude, the winds blow from the northeast, while in the corresponding band south of the equator, the winds blow from the southeast. There are related downwellings of air around the equator and upwellings around 30 degrees north and south latitude; these are responsible for the tropical rain forests and the clear dry air over the subtropical deserts like those in Arizona and Egypt.

Most readers of the *JRASC* will know that the seasons on Earth are not associated with the Earth-Sun distance, but rather with the tilt of the Earth. Summer happens when a hemisphere is tilted towards the Sun, and winter when it is tilted away. At this time in Earth's history, summer in the northern latitudes happens to fall when Earth is farthest away from the Sun, thereby moderating the difference between summer and winter. The situation is reversed in the southern hemisphere, when summer occurs near perihelion — just as on Mars. The Earth's Southern Hemisphere, however, is mostly ocean, and the water tempers the swings in temperature because of its great 'thermal inertia'. It takes the ocean a long time to heat up, but then it retains its heat through much of the colder season. On Mars, of course, there are no oceans to moderate the fluctuations. The southern summer on Mars therefore is shorter and hotter than the northern summer, and the contrast between northern and southern summers is greater than on Earth.

Planetary orbits change over timescales of a few tens of thousands of years because of precession. Imagine a spinning gyroscope that is tilted away from vertical; the direction in which the top of the gyroscope is pointing slowly rotates. On Earth, the precession period is about 26,000 years, during which time we have a succession of different pole stars. This influences the winds and climate too, because 13,000 years from now the northern summer (and southern winter) will occur near perihelion. Mars' precession period is longer — about 100,000 years.

Orbital variations have been thought to play a dominant role in moving air and dust around Mars. This means that over very long periods of time (many precession periods) the general climatic variations — and overall relative appearance of the poles — should tend to average out. Richardson and Wilson show that this is not true. Because the mean elevation of the southern hemisphere is higher than that of the northern hemisphere, there is a fixed asymmetry in the global circulation that does not average out over time. In particular, there will be a steady transport of water from the southern hemisphere to the north, which means that a water-ice cap at the south pole cannot survive except under some extreme orbital conditions. Moreover, there seems to be an abundance of dust in the southern hemisphere during the southern summer that can be transported to the north, producing the 'layered' appearance of the north polar ice cap.

This analysis raises in my mind questions about the interpretation of features on Mars that have been attributed to the presence of recently running water, because these features generally lie in the southern hemisphere. A global asymmetry in circulation that has systematically moved water from the south to the north over a billion or more years could pose significant problems for those who want to believe that waves were lapping at southern shores not so long ago.

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A MULTI-WAVELENGTH STUDY OF THE H II REGION SHARPLESS 217

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ABSTRACT. A multi-wavelength study of the H II region Sharpless 217 (Sh217) has been carried out. This includes 1490-MHz radio-continuum observations, optical narrow-band filter observations of four spectral lines, 21-cm neutral-hydrogen line observations and infrared observations. The four optical filters were centred on lines of O III (λ436.3, λ495.9 and λ500.7), and on the Hα line (λ656.3). The radio-continuum and Hα images show the regions of ionized gas, the other three optical bands show the stars, the 21-cm images show the atomic hydrogen, and the infrared images show the regions of warm dust. Fluxes of the exciting stars for Sh217 were measured. Sh217 is seen to consist of two different structures: a compact and a diffuse H II region. Surrounding the ionized regions of Sh217 is a large shell of atomic gas. The compact H II region and the southwest portion of the shell show significant emission from warm dust. The diffuse H II region is well resolved, and the CLOUDY modeling program is applied to the diffuse region to understand its physical properties.

RÉSUMÉ. Une étude de longueurs d'ondes de la région H II Sharpless 217 (Sh217) a été entreprise. Cette étude comprend des observations du radiocontinuum à 1490 MHz, des observations de quatre lignes spectrales à l'aide de filtres à bande étroite, des observations de la ligne de 21-cm de l'hydrogène neutre et des observations en infra-rouge. Les quatre filtres optiques ont été centrés sur les lignes d'O III (λ436.3, λ495.9 et λ500.7) et sur la ligne Hα (λ656.3). Les images du radiocontinuum et d'Hα présentent les régions de gaz ionisé, les trois autres bandes optiques montrent les étoiles, les images 21-cm montrent l'hydrogène atomique et enfin, les images en infra-rouge montrent les régions de poussière chaude. Le flux des étoiles excitantes de Sh217 a été mesuré. Sh217 est composé de deux structures différentes: une région compacte d'H II, et une diffuse. Une grande enveloppe de gaz atomique encercle les régions ionisées de Sh217. La région compacte d'H II et la partie sud-ouest de l'enveloppe montrent une émission importante provenant de la poussière chaude. La région d'H II est bien séparée, et le modèle CLOUDY a été utilisé pour tâcher de comprendre les propriétés physiques de la région diffuse. SEM

1. INTRODUCTION

The large flux of ultraviolet photons from a hot star will ionize the interstellar medium, which is mainly neutral hydrogen (H I), in its immediate surroundings to produce an H II region. The basic physics of the radiation transfer is summarized, for example, in Shu (1991). The H II region is highly ionized out to a distance, called the Stromgren radius, where a narrow transition zone to the exterior neutral gas occurs. Beyond the ionized region, stellar photons dissociate molecular hydrogen into atomic hydrogen (*e.g.* Roger & Dewdney 1992).

Here radio and optical measurements have been obtained on the spatial distribution of radio flux density and of optical emission line fluxes for the H II region Sh217. Sh217 (l = 159.2°, b = +3.3°) was chosen since it is large enough to be relatively well resolved spatially, and was thought to have a fairly smooth structure. This allows one to test non-spherically symmetric models for H II regions and reliably extract information about the physical conditions in Sh217.

Fich & Blitz (1984) give Sh217 a distance of d = 5.2 ± 0.8 kpc, a height above the galactic plane of z = 297 ± 46 pc, a galactic radius of R = 15.0 ± 0.9 kpc, and a diameter of D = 13.6 ± 2.1 pc. Moffat, Fitzgerald & Jackson (1979) use a Zero-age Main Sequence (ZMS) fit (on 6 stars) to give a distance modulus 13.6 ± 0.3 or distance from the Sun of d = 5.2 kpc. Roger & Leahy (1993) give the 1420-MHz flux as 470 mJy, the peak emission measure as 2250 cm^{-6} pc, and the distance as 4.7 kpc.

In this paper new observations of Sh217 are described. Then, modeling of the H II region is carried out to understand the physical properties.

2. OBSERVATIONS

The radio observations were made with the Very Large Array (VLA) at a frequency of 1489.9 MHz (wavelength of 20 cm). The data were calibrated, and the image made and cleaned with the AIPS software package. The resulting spatial resolution is 13″. Figure 1 shows the 20-cm radio map of Sh217 with an overlay of contours. The contours are at flux density levels of 1, 3, 5, 7, 9 and 11 times 0.833 mJy/beam; the greyscale is from 0 to 15 mJy/beam. The total radio-flux density is 470 mJy in agreement with the value at 1420 MHz from lower resolution data (Roger & Leahy 1993). The 408–1420-MHz and 408–4850-MHz spectral indices from Leahy & Roger (1996) are consistent with optically-thin free-free emission. The 1490-MHz flux was separated into two components: a 17.5-mJy excess (over background emission from the diffuse region) from the compact region in the SW of Sh217 and 453-mJy for the diffuse region (without the excess from the compact source).

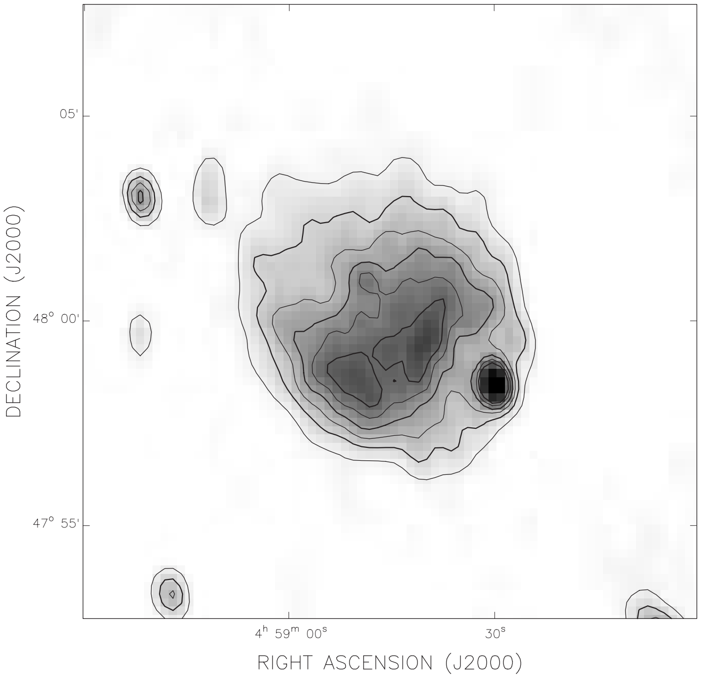

Fig. 1 — Greyscale with contours image of Sh217 at 1490 MHz.

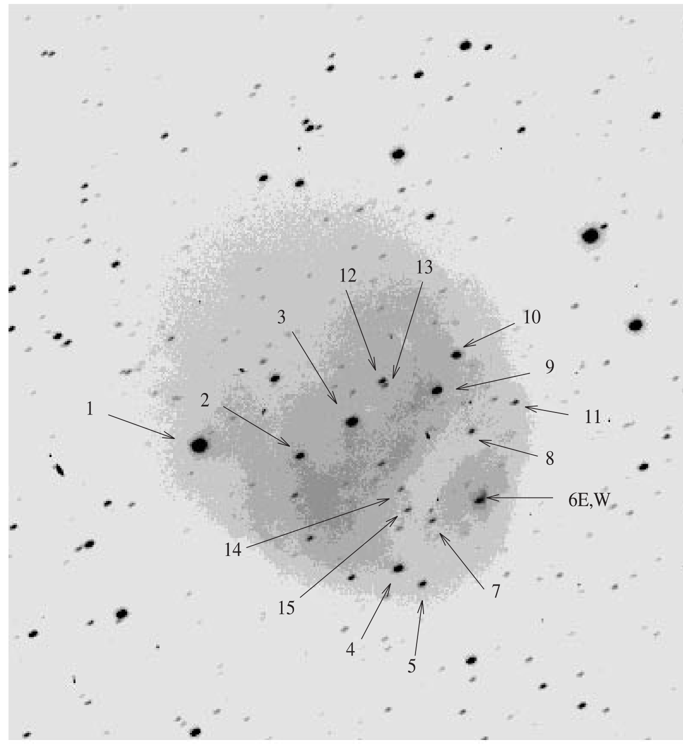

Fig. 2 — Greyscale image in Hα narrow band filter. Diffuse Hα emission from Sh217 is visible as well as stellar continuum emission in the filter bandpass. The stars listed in Table 1 are labeled.

The optical observations were made with the Burrell-Schmidt telescope at Kitt Peak National Observatory in January 1994. Images were taken in four narrow-band filters centred on three O III forbidden lines at λ436.3, λ495.9, and λ500.7, and on Hα (656.3). The spatial resolutions of the images are ~ 1″ × 3″, due to a combination of seeing and tracking error during the exposures. Atmospheric extinction coefficients and conversion to standard star magnitudes were determined from observations of the standard stars Hiltner 600, Fiege 34, and G191 B2B.

Figure 2 shows the Hα image of the Sh217 region (the field is 15 arcminutes square with 2 arcsec pixels, centred on Sh217). The three other optical images (λ436.3, λ495.9, and λ500.7) show no apparent diffuse emission from Sh217. Only stars are detected clearly, via their continuum radiation in the filter bandwidth. The diagram and star labeling scheme of Moffat, Fitzgerald & Jackson (1979) is used here. Star 3 is the bright star near the geometrical centre of Sh217. The pair of stars 6E,W (not resolved in Figure 2 here) is the bright object near the centre of the SW diffuse Hα emission. The 6E,W pair is also coincident with the bright radio source seen in Figure 1 in the SW part of Sh217. The magnitudes determined here for stars 1 through 15 are given in Table 1. Star 1 is a nearby K star unrelated to Sh217. The values are consistent with the broad band *V* magnitudes of Moffat, Fitzgerald & Jackson (1979). This was confirmed by plots of the spectral energy distributions for the stars, including the data here and the archival data. Star 3 is the source of ultraviolet photons that ionize the main diffuse H II region, and the pair of stars 6E,W is the source of ultraviolet photons that ionize the compact SW H II region.

For line emission, the conversions from counts s^{-1} to line fluxes for the four filters were calibrated by using the observations of the standard stars and converting from continuum to line flux using the filter transmission curves. No diffuse emission from Sh217 is detected to the sensitivity limit of the O III images. The 3-sigma upper limits to the line fluxes, integrated over the area of Sh217 (with stars omitted), are 5.0, 9.4, and 3.8 × 10^{-13} erg cm^{-2} for λ436.3, λ495.9, and λ500.7, respectively. The net line flux for the Hα (λ656.3) is 6.54 × 10^{-12} erg cm^{-2}. Corrected for extinction, using E_{B-V} = 0.8 (Moffat, Fitzgerald & Jackson 1979), the intrinsic Hα flux is 4.3 × 10^{-11} erg cm^{-2}.

The 1420-MHz HI line observations were made with the Dominion Radio Astrophysical Observatory's Synthesis Telescope and 26-m Telescope (see Roger & Leahy 1993 for observing details). The spatial resolution is 1.0′ × 1.4′ (EW × NS). Figure 3 shows the H I image integrated over the velocity range −15 to −20 km s^{-1}, which is the range over which detectable H I associated with Sh217 is found. A shell of H I is clearly seen, which is thicker in the S and SW. Figure 8 of Roger & Leahy (1993) shows an overlay of ^{12}CO emission on Sh217. This shows that a molecular cloud starts at approximately the southern

Table I

Narrow Band Photometry of Stars in SH 217

Star	λ436.3	λ495.9	λ500.7	λ656.3
1	9.86	9.96	9.55	9.40
2	13.93	13.39	13.34	12.51
3	11.85	11.52	11.48	10.80
4	13.14	12.64	12.49	11.78
5	14.61	14.10	14.08	13.03
6E,W	14.82	14.27	14.22	12.97
7	15.11	14.52	14.45	14.05
8	14.89	14.47	14.40	13.73
9	12.51	12.06	12.03	11.45
10	13.84	13.29	13.27	12.34
11	15.14	14.65	14.56	13.79
12/13	14.90	14.38	14.25	13.18
14	15.56	15.23	15.02	14.29
15	15.64	15.33	15.17	14.04

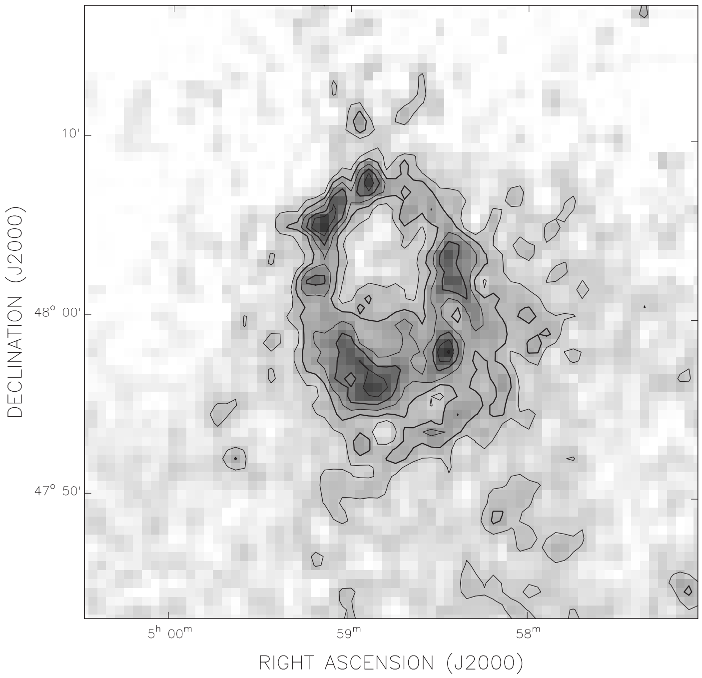

Fig. 3 — Greyscale with contours image of Sh217 in the 21-cm hydrogen line. The contour spacing is 6×10^{19} cm^{-2}.

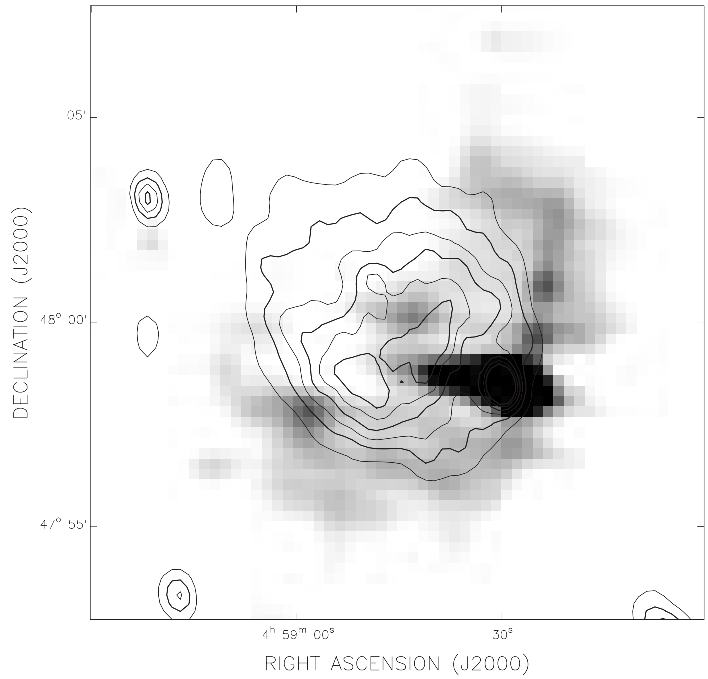

Fig. 5 — Greyscale image of the IRAS HIRES 25-μm data overlaid with 1490-MHz contours.

boundary of the 1.49-GHz radio contours and extends SSE approximately 20 arcminutes. The molecular cloud is the probable source of the higher density and more extensive H I in the southern half of Sh217. The Hα image is overlaid on the 21-cm contours in Figure 4. This shows that the ionized gas of Sh217 is located within the H I ring but offset to the SW.

Infrared images of the region from the InfraRed Astronomical Satellite (IRAS) were obtained from IPAC. HIRES images were made for the four IRAS bands (12, 25, 60, and 100 μm). The images in the three longer wavelength bands are consistent with the 12-μm image, but have lower spatial resolution. The 12-μm image has a spatial resolution of 53″ × 27″ with major axis at position angle 80° east of north. Figure 5 shows the 12-μm image in greyscale with the contours from the 20-cm radio-continuum image overlaid. There is bright infrared emission coincident with the compact H II region associated with stars 6E,W and diffuse infrared emission associated with the outer edge of the diffuse H II region. The IRAS 12-μm image is overlaid on the H I contours in Figure 6. It is seen that the diffuse infrared emission comes mainly from the SW half of the H I ring.

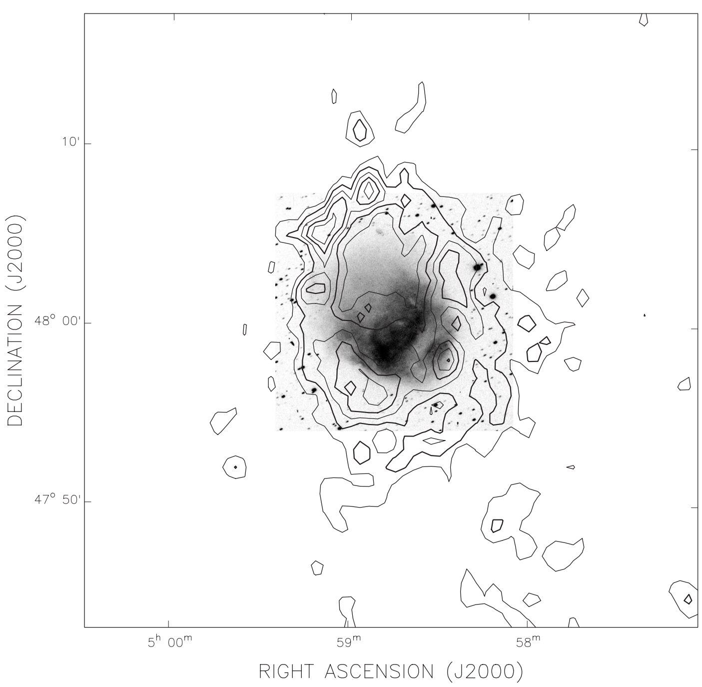

Fig. 4 — Greyscale image of the star-subtracted Hα image of Sh217 overlaid with H I contours.

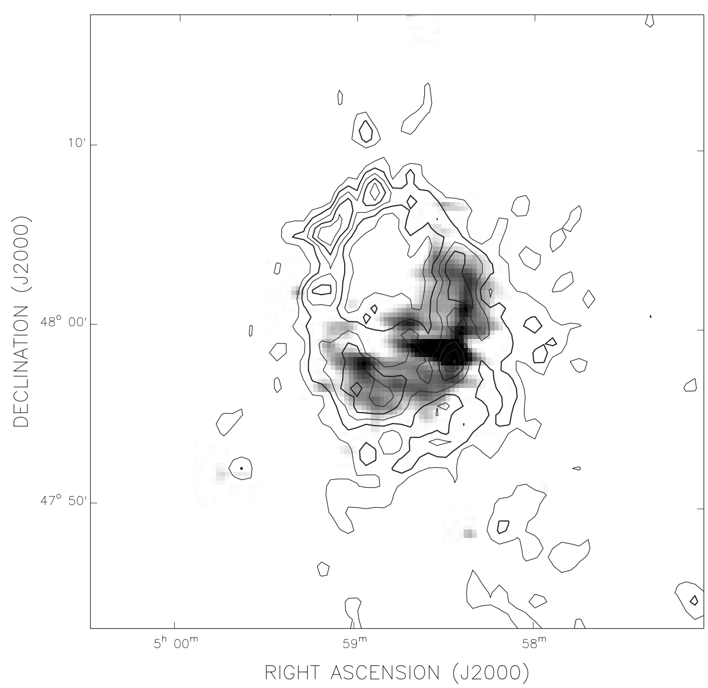

Fig. 6 — Greyscale image of the IRAS HIRES 25-μm data overlaid with 21-cm contours.

The IRAS Low Resolution Spectrum (LRS) was extracted from the IRAS LRS database maintained by the astrophysics group at the University of Calgary. The LRS spectrum of Sh217 (IRAS 04547+4753) is shown in Figure 7. It has the distinctive features characteristic of spectra from H II regions (*e.g.* Kwok, Volk & Bidelman, 1997): a rising continuum towards longer wavelengths, with broad emission features (the UIR bands) near 7 μm and 11–14 μm. The spectrum is dominated by the flux from the compact H II region, so this confirms that the compact region is indeed an H II region.

3. Analysis and Results

The 20-cm radio map of Sh217 here shows that it consists of two components: the main H II region, and a bright compact region in the SW interior. For the modeling below, the data for the diffuse part of Sh217 are utilized. First a uniform temperature and density model for the ionized gas in the diffuse part of Sh217 is applied. The program used was *radphys*, which is part of the DRAO export software package. The inputs were: He abundance 0.14, He 100% singly ionized, frequency = 1.49 GHz, electron temperature T = 7500 K, diameter = 8 arcminutes, d = 4.7 kpc. In order to produce the observed peak emission measure (2250 cm^{-6} pc), the model electron density was adjusted to 14.4 cm^{-3}. The main discrepancy with the observations is that the model flux density is too high. This cannot be fixed by varying the parameters of *radphys*, but requires a more sophisticated modeling program.

The photoionization program CLOUDY (Ferland 1996) is the most suitable program. It models the radiation transfer within a nebula with user-specified parameters. First it is necessary to determine the stellar energy input to the nebula.

Star 3 is at the centre of the main H II region and stars 6E, W are at the centre of SW compact region. The other stars in the cluster are significantly fainter, thus it is clear that star 3 excites the main H II region and stars 6E,W excite the compact SW region. Moffat, Fitzgerald & Jackson (1979) give that the pair of stars 6E,W have combined spectral type B0V; and that star 3 has spectral type B0V. These are consistent with our narrow-band filter photometry. The stars 6E,W and the compact SW region, from inspection of both the 1.49-GHz map (and consistent with the Hα map), do not appear to affect the overall structure of the main body of Sh217. In fact, since the compact SW region is nearly spherical, it appears to be separate from the rest of Sh217. The best explanation why the SW compact region does not distort Sh217 is that it is slightly background or foreground to the main region of Sh217. Thus the main diffuse region of Sh217 is modeled here, not the SW compact region.

The effective temperature and luminosity of star 3 (B0V) were taken as 35,000 K and 55,000 $L_\odot$. These were chosen based on examination of several references (*e.g.* Panagia 1973; de Jager & Nieuwenhuijzen 1987). With the stellar parameters given above, the program CLOUDY was used to calculate the expected radio-continuum flux. Initially, a uniform-density spherical nebula was assumed. A density of 18 cm^{-3}, a filling factor of 0.33, and an outer radius of 5.6 pc give a 1.49-GHz flux density of 420 mJy, in good agreement with the observations. CLOUDY was next used to construct 1.49-GHz images for model H II regions. The three-dimensional structure of the H II region was calculated and then projected onto a 64-by 64-pixel grid to make the map. The parameters in all of the models were adjusted so the model flux fit the 1.49-GHz flux and the model image fit the observed 1.49GHz.

Since Sh217 shows deviation from spherical, an elliptical density distribution was used with x, y, and z semi-axes 7.2, 6.4 and 5 arcminutes. X, y, and z correspond to N, E, and along the line-of-sight prior to rotation. The ellipsoid was rotated 140° clockwise about the line-of-sight, then projected to make the image. This model is referred to as Model 1. The observed 1.49-GHz flux and peak-emission measure are reproduced for an electron density of 17.6 cm^{-3} and electron temperature of 8,000 K. The model 1.49-GHz image resembles the data in that it matches the outer boundary well but the peak brightness is at the centre rather than displaced to the SW as in the data. Figure 8 shows contours from the 20-cm radio continuum overlaid on a greyscale of the model image.

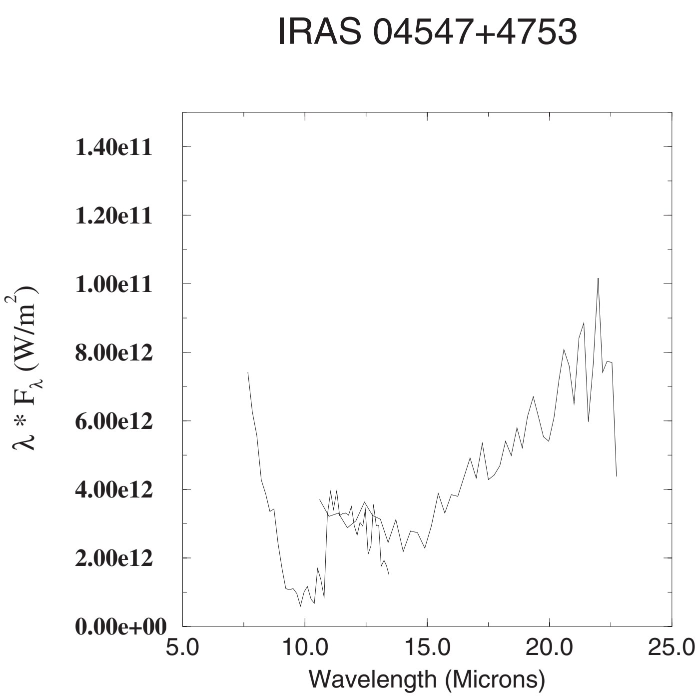

Fig. 7 — IRAS LRS spectrum of Sh217.

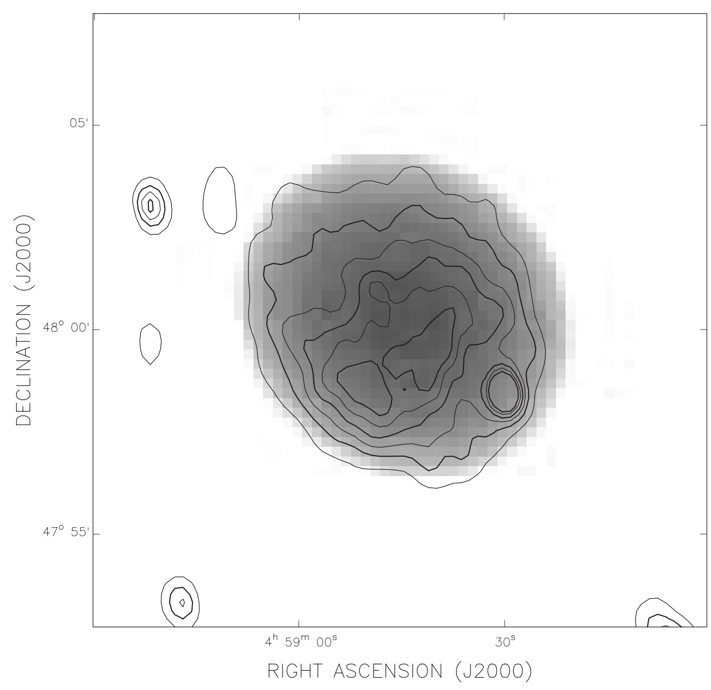

Fig. 8 — Greyscale image of Model 1 (constant density in an ellipsoidal region), overlaid with 1490-MHz contours.

In order to reduce the model central surface brightness, a central cavity was introduced of radius 0.2 of the outer ellipsoidal boundary (other parameters were the same, except electron density slightly increased to produce the observed 1.49-GHz flux). A central cavity is expected due to the influence of the stellar wind from the central star. However the radius of such a cavity is sensitive to the wind parameters (*e.g.* Castor *et al.* 1975; Weaver *et al.* 1977). The resulting model (Model 2) image is more like the observed image in the SW half but is more discrepant in the NE half than Model 1.

For the next model (Model 3), two half spheres with different densities were joined at the equator. Component 1 had density 18.0 cm^{-3} and outer radius 3.35 arcminutes. Component 2 had density 12.2 cm^{-3} and outer radius 3.4 arcminutes. The model was rotated 130 degrees clockwise about the line-of-sight, then 20° toward the observer, before projection. The resulting image is shown in Figure 9. The image reproduces very well the observed NE-SW asymmetry, but is smoother in the NW-SE direction than the observations.

A modification (called Model 4) was made similar to Model 3 but with an interior cavity: component 1 (the higher density region) has a cavity of 10% of its outer radius; component 2 (the lower density region) has a cavity of 30% of its outer radius. The model image was an improvement over Model 3: the cavity improved the fit to the image in the SW-NE direction, but does not yield the NW-SE asymmetry.

The last model (Model 5) has a higher-density region inside a lower-density envelope. The high-density region is taken as a cylinder of density 18.4 cm^{-3}, radius 2.42 arcminutes, and z extent −0.1 to −2.2 arcminutes, which is then rotated by 120° clockwise about the line-of-sight, and tilted 20° toward the observer. The low-density envelope is a spherical region of radius 3.4 arcminutes and electron density 14.0 cm^{-3}. The result is shown in Figure 10. This model fits the NE-SW profile well and the NW-SE profile well, although it is still symmetric in the NW-SE direction.

The set of models above is sufficient to discuss what the intrinsic structure of Sh217 is likely to be. It is likely to be ellipsoidal in shape as in Model 1, but to have a density gradient from SW to NE, approximated by Model 3. It may also have a significant cavity in the interior as in Model 4, which showed improvement over Model 3. Models consisting of two constant-density half-spheres joined together can reproduce the NE-SW brightness profile but cannot reproduce the NW-SE profile. Model 5 was constructed to show that an enhanced-interior density (in this case a cylinder inside a sphere) can explain the steeper NW-SE profile. The conclusion is that the interior-density structure of Sh217 is likely to contain aspects of all of the above models. However, a model containing all of the above is too complicated for the current CLOUDY program to calculate.

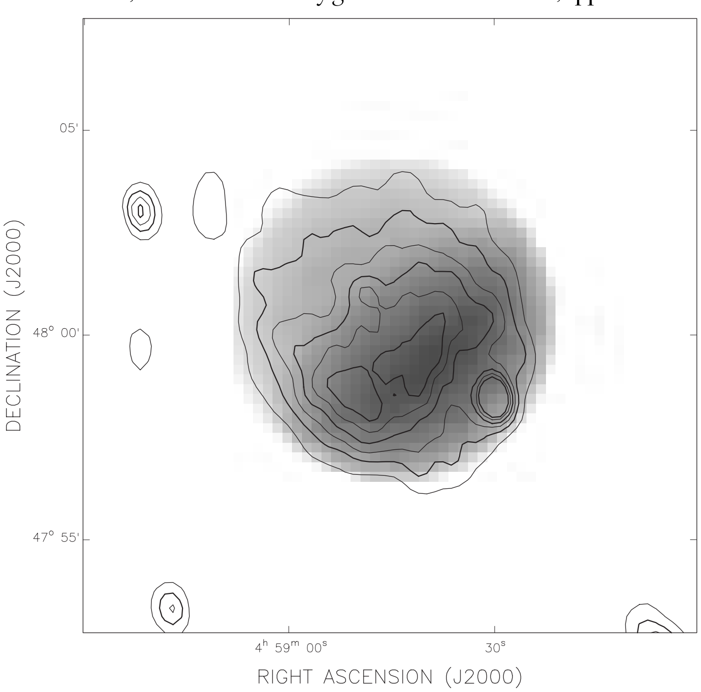

Fig. 9 — Greyscale image of Model 3 (two half-spheres of different density joined together and tilted), overlaid with 1490-MHz contours.

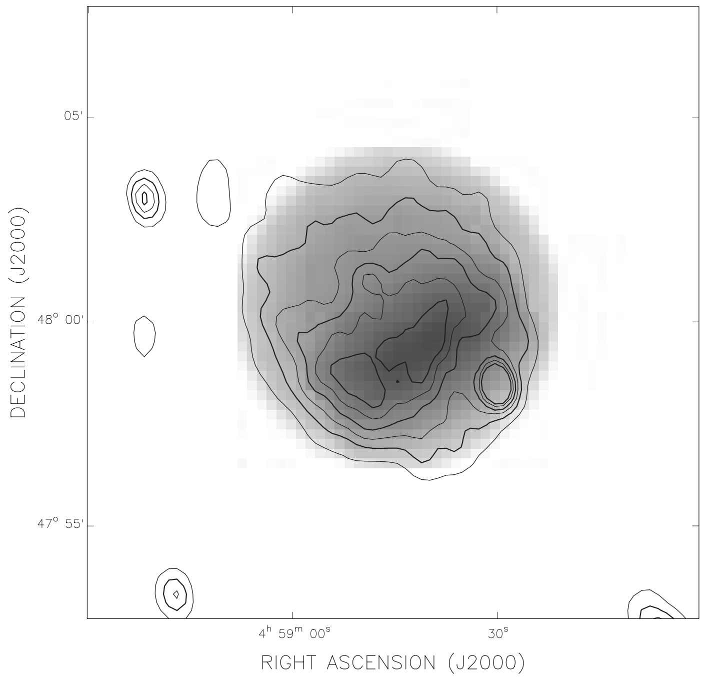

Fig. 10 — Greyscale image of Model 5 (a higher-density cylinder inside a lower-density envelope and tilted) overlaid with 1490-MHz contours.

4. Discussion

A multi-wavelength observational study of Sh217 has been carried out. The overall structure of Sh217 is an H II region imbedded in a cloud of neutral hydrogen. The central part of the cloud is ionized by the stars that excite Sh217. From Figure 4, it is seen that the surrounding cloud and also the H II region both have a density gradient, with higher density toward the southwest. The IRAS infrared emission, from warm dust, has a compact component associated with the compact component of the H II region (see Figure 5) and a diffuse component concentrated along the southwest boundary of the H II region (see Figure 6). The structure of the infrared emission is due to the density distribution of the dust (which affects the diffuse component most strongly) and due to the heating distribution by hot stars (which affects the compact component most strongly).

The new 1.49-GHz radio-continuum and Hα images (Figures 1 and 2) show that Sh217 H II region consists of two components: the main H II region, and a bright compact region in the SW interior. The SW compact region does not distort the diffuse part of Sh217, leading to the conclusion that the compact region is slightly background or foreground to the diffuse region. Star 3 excites the main H II region and stars 6E,W excite the compact SW region.

The main diffuse H II region of Sh217 has an asymmetric but smooth structure in the Hα and 1.49-GHz radio-continuum images. It was thus chosen for 3 dimensional modeling using the CLOUDY program. Several CLOUDY models were constructed to model the flux and the image of the main diffuse H II region of Sh217. The different models were successful in reproducing different aspects of the image. One can deduce that the main diffuse H II region of Sh217 probably contains the following structures: an ellipsoidal shape tilted to the line of sight, a density gradient along the long axis (SW-NE), an interior cavity, and enhanced density near the centre as compared to the edges along the NW-SE axis.

Acknowledgments

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THE NATURE OF THE DOUBLE STAR M40

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Abstract. WNC 4 is listed as a double star in the literature dating back to 1869. Charles Messier catalogued this object as M40 in his famous list. Using new TYCHO-2 and other data, the minimum distance to the pair is found to be 170 ± 70 pc. The new parallax and proper motion data failed to support any assumption that the two stars in the pair are gravitationally connected. The observed position angle changes of the pair can be explained by the TYCHO-2 proper motions of two optically aligned stars instead of real orbital motion. If the components were gravitationally connected, the data suggest a minimum separation of 5,000 AU, and a minimum period of 232,000 years, which is highly improbable for a true binary star system.

Résumé. Depuis 1869, WNC 4 est classée dans la littérature comme étant une étoile double. Charles Messier a nommé cet objet M40 dans sa célèbre liste. A l'aide de nouvelles données parvenant de TYCHO-2 et d'autres sources, la distance minimale de la paire est établie à 170 ± 70 pc. Les nouvelles données au sujet du parallax et du mouvement propre de ces deux objets n'ont pas réussi à appuyer l'hypothèse qu'ils ont un lien gravitationnel commun. Les changements de l'angle de la position observée peuvent s'expliquer par les mouvements propres observés par TYCHO-2 de deux étoiles alignées optiquement, plutôt que de par leur mouvement propre réel. Si ces objets sont bien liés par la gravitation, les données suggèrent une séparation minimale de 5 000 UA, et une période minimale de rotation de 232 000 ans, ce qui est très improbable pour un véritable système d'étoiles binaires.

1. Introduction

WNC 4 (Winnecke 4, WDS 12222 +5805, SAO 28353 and 28355, TYC 3840:1031 and 3840:0564), is a faint double star originally found by Charles Messier in 1764. He catalogued it as M40 in his famous list (RA = $12^h\,22^m\,12^s$, Dec = +58° 4′ 59″, J2000). Since no known nebula exists at this location, historians have suggested that Messier made a mistake in this entry. The galaxy, NGC 4290, m = 12.7 is 9 arcminutes west of M40, but was probably too faint to be seen by Messier in his 90-mm telescope. WNC 4 consists of two stars with visual magnitudes 9.7 and 10.1. Only a few measurements of position angle and separation of the pair appear in the literature and in the NASA Astronomical Data Center database, with the most recent one from the HIPPARCOS/TYCHO astrometry mission. The present investigation combines data from the TYCHO-2 Catalog and other scarce sources to determine if WNC 4 is a real binary system that is gravitationally connected or a chance optical alignment of two stars.

2. Measurements and Reductions

Winnecke (1869) published the position angle and separation of the pair as 88.0° and 49.2″ for the epoch 1863. In 1991, TYCHO positions from the HIPPARCOS/TYCHO astrometry mission showed only a small change in position angle and separation to 77.0° and 52.8″. Only a few other measurements of the pair exist from the archives of the *Washington Double Star Catalog* (Worley & Douglass 1996).

With a scarcity of observations for this slow moving pair, an additional photograph was selected to compute position angle and separation. A photograph taken in 1966 by Kreimer (Mallas & Kreimer 1978) was reduced using the image scanning method described by Nugent (1998). This resulted in a separation of 51.7″ and a position angle of 80.6°. Existing position angle, p and separation, ρ data for WNC 4 are given in Table I.

Table I
Data for WNC 4

Date	Separation ρ(″)	Position Angle p(°)	Source
1863	49.20	88.0	Winnecke 1869
1903	49.60	84.6	WDS[1]
1912	50.40	83.0	WDS
1912	49.50	83.2	WDS
1913	49.72	83.1	WDS
1916	50.34	84.3	WDS
1918	50.14	83.2	WDS
1930	50.43	82.3	WDS
1947	51.10	81.2	WDS
1958	51.27	80.4	WDS
1966	51.70	80.6	Kreimer[2]
1983	52.10	78.3	WDS
1991	52.80	77.0	Derived from TYCHO-2 Catalog

3. Discussion

No trigonometric parallax data were available for the pair prior to the HIPPARCOS/TYCHO astrometry mission. The HIPPARCOS-TYCHO Catalog gives a parallax π = 6.4 ± 17.9 mas for the primary and a negative parallax for the secondary. With this information the distance to the primary (brighter) component is computed as 150 pc, but with the error nearly 300% larger than the parallax, this distance is meaningless. However, this parallax and error give an estimate for the minimum distance to the primary. Based upon the spectral types of the primary and secondary, K0III and G0V from Skiff (2001), the absolute visual magnitudes are M_v = +0.88 and +4.0, and masses are

[1] Washington Double Star Catalog Data
[2] Derived using published photograph from Mallas & Kreimer (1978).

$1.1M_\odot$ and $1.2M_\odot$ respectively (Lang 1992). With the relatively high galactic latitude of the system, $b = +58.6°$, the absorption correction is +0.014 (Schlegal, Finkbeiner & Davis 1998), giving a negligible effect on the absolute magnitudes.

Using the method of spectroscopic parallaxes, distances of 590 ± 230 pc and 170 ± 70 pc are computed for the primary and secondary. The uncertainty in this method is due to observational errors in estimating true $B–V$ magnitudes and the scatter in the H-R diagram magnitudes (±1.0m). If we assume the distance to WNC 4 is at least 100 pc, the observed separation of 50″ yields a physical separation of at least 5,000 AU. Since the 50″ measurement is a projected separation, the 5,000 AU distance represents a minimum distance between the primary and secondary components. There are no known binaries with this large physical separation in the literature. Assuming Keplerian orbits, the period P (in years) is related to the separation of the pair a, (in units of AU) from:

$$P^2 = [4\pi^2 / G\,(M_1 + M_2)]\; a^3$$

Using 5,000 AU for a, $M_1 + M_2 = 4.6 \times 10^{33}$ gm, G the gravitational constant, the period comes to 232,000 years. (At 150 pc distance, a = 7,500 AU, P = 427,000 yrs). This result alone, independent of observed orbital motion, clearly shows the implausibility of the pair being a real binary star system.

Additional evidence to discount the physical association of the pair comes from the change in position angle. The observed change in position angle is only 11° in 128 years. While this position angle change is not uncommon in close (< 2″) binary pairs, it is unheard of with large separations in the 50″ range. If we again assume circular Keplerian orbits, independent of any projection effects, and extrapolate this motion to 360° (a complete orbit) this corresponds to a period of some 4,400 years, a very high value. Even with this period, the physical separation computes to over 355 AU. While this separation is not unrealistic for a binary, the distance to the system with a 50″ observed separation would be 7.1 pc. If the apparent orbit were projected in such a way so that the actual separation was 500 AU, the distance to the system would be 10 pc. Obviously, these distances are gravely inconsistent from the observed TYCHO mission parallaxes.

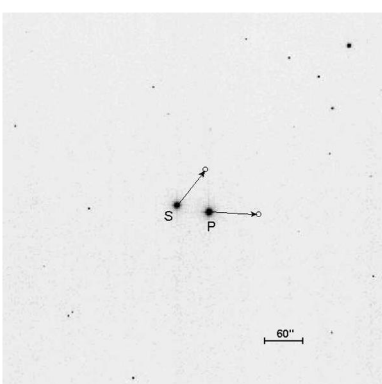

Fig. 1 — TYCHO-2 proper motion components of the primary, P and secondary, S. Proper motion errors are 2 mas, given by error circles by the arrow heads. Field of view: 10′ × 10′. North is at the top, East is to the right. Kitt Peak National Observatory 0.9-metre CCD image of WNC 4 at f/13.5, February 1996, Copyright NOAO/AURA/NSF.

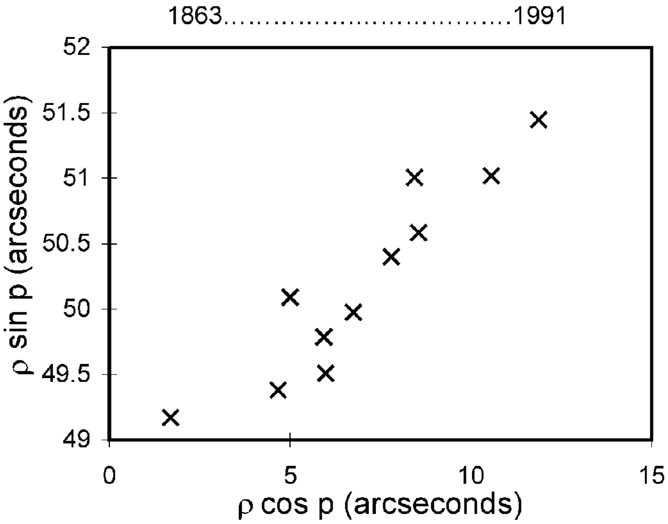

Fig. 2 — p and ρ converted to rectangular coordinates as a function of time from Winnecke's first measurement in 1863 to TYCHO-2 position for 1991. The uncertainties in the plotted data are smaller than the data point characters themselves.

The TYCHO-2 proper motion data are graphically shown as Figure 1. For a true binary system, the motion of the pair's barycenter should remain constant across the sky. The proper motions of WNC 4 show the two stars moving in discordant directions 55° from one another. Earlier proper motion data from the Smithsonian Astrophysical Observatory (SAO) (SAO staff 1966) and the Catalogue of Positions and Proper Motions (PPM) (Roeser & Bastian 1988) catalogs also show different motions for the components of WNC 4. The TYCHO-2 proper motions support these earlier results. Figure 2 illustrates the change in position angle and separation of the pair over time resulting in a linear relationship. This would be expected for two stars that are passing each other in the sky.

4. Conclusion

For a true visual binary star system, parallax, proper motion and observed orbital data should be in agreement within the observational errors. For WNC 4, the new TYCHO and TYCHO-2 data do not add any support for any real physical association of the pair. The highly accurate HIPPARCOS/TYCHO parallaxes have given astronomers some surprises, but such is not the case for WNC 4. The apparent orbital motion of the pair can be explained by the proper motion of two optically aligned stars, indicating no gravitational connection. TYCHO and spectroscopic parallax data verify the distance to the fainter star is at least 150 pc and to the brighter star 570 pc. At 150 pc distance, the calculated physical separation is 7,500 AU which is unrealistic for a binary.

The addition of radial velocity data for the WNC 4 stars will not likely change the case presented here for the non-physical association of the pair. No such radial velocity data exists currently, thus future work in this area can add to our knowledge of WNC 4.

It is concluded that WNC 4, more commonly known as M40, is thus an optically aligned pair of stars, and not gravitationally connected.

Acknowledgements

Brian Mason of the U.S. Naval Observatory kindly provided data for the pair from the *Washington Double Star Catalog* archives not available online. This research has made use of the Astronomical Data Center (ADC) from NASA's Goddard Space Flight Center. Figure 1 image courtesy National Optical Astronomy Observatory (NOAO) operated by the Association of Universities for Research in Astronomy (AURA), Inc. under cooperative agreement with the National Science Foundation.

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Richard Nugent, a full-time real estate investor, is currently the Executive Secretary for IOTA. His main interests are asteroid occultations and using observations of Baily's Beads during solar eclipses as a method to detect possible solar radius changes.

Education Notes
Rubriques pédagogiques

GAS GIANTS IN RECTILINEAR COMPONENTS

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I spent last July at home in Toronto, living through a taste of a Venusian environment following a runaway greenhouse effect. After the weather returned to normal summer warmth, I took a trip to Kingston.

While in Kingston, when resting by the shores of peaceful Lake Ontario or in the tempting restaurants of downtown Princess Street, I developed the first draft of two articles applying simple high school trigonometry to astronomy. Both use the easily available data presented in the *Observer's Handbook*, the 2001 edition that I was travelling with.

The mathematical methods can be found in the Ontario Academic Grade 10 Mathematics program. In this course, students are introduced to trigonometry, including the Cosine and Sine Laws, and make extensive use of the Euclidean distance formula.

To honour my friends in the Kingston Centre, the stellar article dealt with Regulus ("Little King") and other bright stars of the constellation Leo. It has already been published in their newsletter, also called *Regulus*. I've already started work on a second article on this theme, calculating stellar distances by various methods.

For both school years 2000-2001, and 2001-2002, Leo Enright, author of the *Beginner's Observing Guide*, had developed a student's "Observing Guide to the Gas Giants." This article is conceived as a mathematical supplement to Leo's work.

In November 2001, the gas giants Saturn and Jupiter were approaching opposition. Opposition is the position in their orbits that a planet lines up with the Earth and the Sun. It is also the time that the planet and the Earth are closest together.

By converting the Celestial Coordinates (r, α, δ), as listed in the *Observer's Handbook*, to rectilinear coordinates (x, y, z) we can determine a number of interesting results about their position and movements. The transformation equations are

$$x = r \cos \delta \cos \alpha$$

$$y = r \cos \delta \sin \alpha$$

$$z = r \sin \delta$$

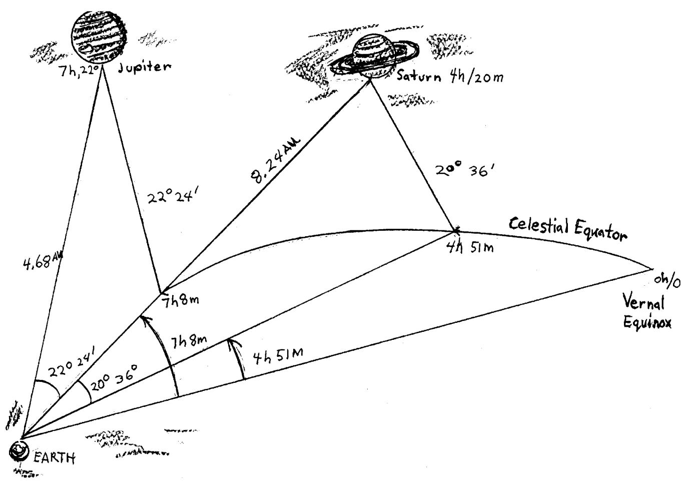
where α is in angular, not time, measurement.

These equations can be found in any standard astrometry book such as Green (1985). For example, on November 1, in a geocentric framework

$$\text{Saturn} = (r_S, \alpha_S, \delta_S) = (8.24\text{ AU}, 4^h\,51^m, +20°\,36')$$

$$\text{Jupiter} = (r_J, \alpha_J, \delta_J) = (4.68\text{ AU}, 7^h\,8^m, +22°\,24')$$

$$\text{Earth} = (r_E, \alpha_E, \delta_E) = (0.00\text{ AU}, 0^h\,0^m, 0°\,0')$$



If your calculator doesn't have a built-in conversion to decimal degrees, here is how you would convert the original data for Saturn to decimal degrees:

$$\alpha_S = 4^h\,51^m = 15°/\text{h} \times (4^h + 51^m / (60\text{ m/h}))$$
$$= 15°/\text{h} \times (4.85^h) = 72.75°$$

$$\delta_S = +20°\,36' = +(20° + 36'/(60'/°))$$
$$= +20.60°$$

Similarly, $\alpha_J = 107.0°$ and $\delta_J = +22.4°$.

Saturn's Rectilinear Coordinates (using one more significant figure than the data)

$$\begin{aligned} x_S &= r_S \cos \delta_S \cos \alpha_S \\ &= 8.24 \text{ AU} \cos (20.6°) \cos (72.75°) \\ &= 8.24 \text{ AU} \times 0.93606 \times 0.29654 \\ &= 2.353 \text{ AU (carrying one extra digit)} \end{aligned}$$

$$\begin{aligned} y_S &= r_S \cos \delta_S \sin \alpha_S \\ &= 8.24 \text{ AU} \cos (20.6°) \sin (72.75°) \\ &= 8.24 \times 0.93606 \times 0.95502 \\ &= 7.366 \text{ AU} \end{aligned}$$

$$\begin{aligned} z_S &= r_S \sin \delta_S \\ &= 8.24 \text{ AU} \sin (20.6°) \\ &= 8.24 \text{ AU} \times 0.35184 \\ &= 2.899 \text{ AU} \end{aligned}$$

To check the conversion use the definition of distance in Euclidean 3-space:

$$r^2 = x^2 + y^2 + z^2$$

or

$$r = (x^2 + y^2 + z^2)^{0.5}$$

For Saturn.

$$\text{LS} = r_S^2 = (8.24 \text{ AU})^2 = 67.8976 \text{ AU}^2$$

$$\begin{aligned} \text{RS} &= x_S^2 + y_S^2 + z_S^2 \\ &= (2.353 \text{ AU})^2 + (7.366 \text{ AU})^2 + (2.899 \text{ AU})^2 \\ &= 68.198766 \text{ AU}^2 \end{aligned}$$

Rounding error explains the discrepancy of 0.22%.

Similarly,

$$x_J = 4.68 \text{ AU} \cos 22.4° \cos 107° \quad = -1.265 \text{ AU}$$

$$y_J = 4.68 \text{ AU} \cos 22.4° \sin 107° \quad = 4.138 \text{ AU}$$

$$z_J = 4.68 \text{ AU} \sin 22.4° \quad = 1.783 \text{ AU}$$

and of course

$$x_E = 0 \text{ AU} \cos 0° \cos 0° \quad = 0 \text{ AU}$$

$$y_E = 0 \text{ AU} \cos 0° \sin 0° \quad = 0 \text{ AU}$$

$$z_E = 0 \text{ AU} \sin 0° \quad = 0 \text{ AU}$$

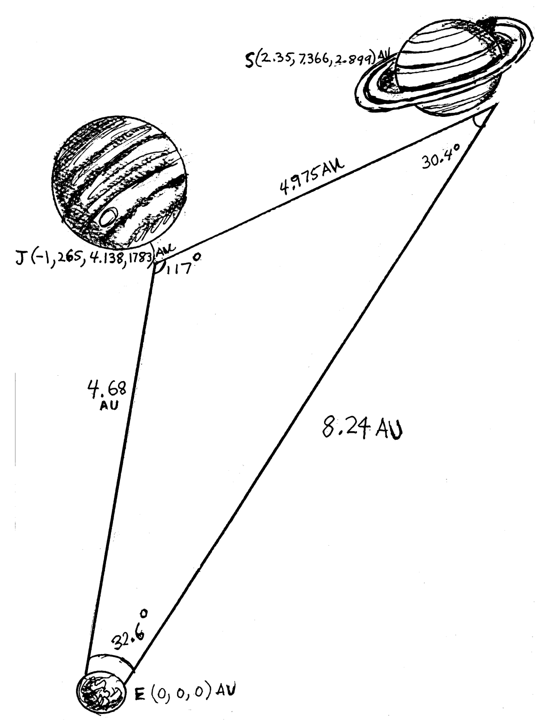
Check:

$$\text{LS} = r_J = 4.68 \text{ AU}$$

$$\begin{aligned} \text{RS} &= (x_J^2 + y_J^2 + z_J^2)^{0.5} \\ &= [(-1.265 \text{ AU})^2 + (4.138 \text{ AU})^2 + (1.783 \text{ AU})^2]^{0.5} \\ &= 4.678 \text{ AU} \end{aligned}$$

That's agreement!

We're given the Earth-Jupiter and Earth-Saturn distances. Now we can easily calculate the Jupiter-Saturn distance by using the Pythagorean distance formula extended to 3-space.



$$\begin{aligned} \text{JS} &= [(x_S - x_J)^2 + (y_S - y_J)^2 + (z_S - z_J)^2]^{0.5} \\ &= [(2.353 - (-1.265))^2 + (7.366 - 4.138)^2 + (2.899 - 1.783)^2]^{0.5} \text{ AU} \\ &= [3.618^2 + 3.228^2 + 1.116^2]^{0.5} \text{ AU} \\ &= [24.755364]^{0.5} \text{ AU} \\ &= 4.975 \text{ AU} \end{aligned}$$

This is best reported as 4.98 AU. We now have a plane triangle in 3-Space. The vertices are the Earth, Jupiter and Saturn on November 1, 2001. We now know the length of all three sides: Earth-Jupiter (EJ = 4.68 AU), Earth-Saturn (ES = 8.24 AU), Jupiter-Saturn (JS = 4.98 AU). This is enough information to find how big the angles are in this triangle by using the Cosine Law.

By letting JS = a, ES = b, and EJ = c, and thus identifying $\angle$A as the angle between Jupiter and Saturn in the sky, the Cosine Law looks like this:

$$a^2 = b^2 + c^2 - 2\,b\,c\,(\cos \angle \text{A})$$

Solving for $\angle$A:

$$\angle A = \arccos\left[\frac{b^2 + c^2 - a^2}{2bc}\right]$$

$$\angle A = \arccos\left[\frac{8.24 AU^2 + 4.68^2 - 4.98^2}{2 \times 8.24 AU \times 4.68 AU}\right]$$

$$\begin{aligned} &= \arccos[64.8976/77.1264] \\ &= \arccos[0.84277] \\ &= 32.567° \end{aligned}$$

Best to give the answer as 32.6°.

It's now easier to use the Sine Law to find ∠B (the angle between Earth and Saturn as seen from Jupiter):

$$\frac{\sin\angle B}{b} = \frac{\sin\angle A}{a}$$

$$\sin\angle B = (b/a)\sin\angle A$$

$$\angle B = \arcsin\left[\left\{\frac{8.24AU}{4.98AU}\right\}\sin 32.6^\circ\right]$$

= arcsin [0.89086]
= 117.0° in this case

Thus,

$$\begin{aligned}\angle C &= 180^\circ - (\angle A + \angle B)\\ &= 180^\circ - (117.0^\circ + 32.6^\circ)\\ &= 180^\circ - 149.6^\circ\\ &= 30.4^\circ\end{aligned}$$

Now we know that we could look out at the November 1 night sky, Jupiter and Saturn would be separated by 32.6°. Looking from Saturn, Jupiter and the Earth would be separated by 30.4°, but since you would be looking in the direction of the Sun, what you would actually see would depend on the Sun's glare. Jupiter, in the middle would see Saturn and the Earth separated by 117.0°.

Further insights come with calculating positions for other dates and other planets and using solar celestial coordinates to rework to a heliocentric system. Similar calculations can be done with stars of a constellation or the members of a galaxy cluster. This will provide yet more data for three-dimensional modeling.

This year I have two Grade 10-mathematics classes that are beginning their study of trigonometry. As we slowly developed trigonometric skills, we applied them to astronomy.

Every student was assigned one planet from one month in "The Sky Month by Month" in the *2002 Observer's Handbook*. On the first day, they converted Right Ascension and Declination into decimal degrees, applying degree/minute/second notation. Subsequently, each trigonometric stage had a parallel astronomic application. Furthermore, we were also reviewing their Grade 9 science astronomy unit.

Once the students had their rectilinear (*x, y, z*) coordinates for their planet on the three days of their month, they could then examine the geocentric motions of their planet. How far did Jupiter travel from February 1 to 11, 2002? How fast was Mercury moving on March 6, 2002? By what angle did Mars move across the sky from January 1 to 31, 2002?

Thus, early in their high school career, these classes were able to use $10 scientific calculators and their fresh trigonometry techniques, for quite a sophisticated scientific analysis.

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David Orenstein teaches mathematics at Danforth CTI and observes from Trinity-Bellwoods Park, both in downtown Toronto. Cloudy evenings are spent enjoying the local cultural riches, weekends and holidays of other Canadian cities. He is a member of the RASC's National Education Committee and the Toronto Centre.

800 Bright Deep Sky Objects

by Paul Markov (pmarkov@ica.net)

In this day and age having the right information is everything, and this rule seems to apply to deep sky observing as well. More specifically, having the correct deep-sky lists and catalogues will open up a window of deep-sky observing possibilities of which you were probably not aware. Did you know that there are almost 800 deep-sky objects brighter than 10th magnitude that may be visible with your telescope from your light-polluted backyard? This is hard to believe, but if you obtain a good deep-sky catalogue, you can prove it to yourself.

I chose the Saguaro Astronomy Club (SAC) deep-sky database (available as a free download at `www.saguaroastro.org`) that contains a total of 10,593 deep-sky objects from a collection of deep-sky catalogues. All the information in this article is derived from version 7.2, the latest SAC database revision.

All of you are familiar with the *Messier* and *New General Catalogues*, and most have also heard of the *Index Catalogue*. However, many observers do not know about the multitude of smaller catalogues like *Trumpler, Collinder, Stock, Harvard, Basel, Berk, Melotte, etc.* These lesser-known catalogues make up about 20% of the entire SAC database and many of these are well within the reach of an average amateur telescope, even from urban skies.

The database includes objects visible from both Northern and Southern Hemispheres. Therefore, before determining the number of objects visible from a given latitude, one must first eliminate objects that are too close to, or never rise above, the horizon. As an example, I chose to determine this for observers in Toronto, where objects with declinations as low as −45° should, theoretically, be visible. Due to atmospheric extinction (see the *2002 Observer's Handbook* pg. 57), however, I chose to include only objects with declination −35° or higher. In doing so the number of available deep-sky objects decreases from 10,593 to 8,728.

Because the purpose of this article is to discuss brighter objects, I chose to eliminate objects fainter than magnitude 10, which further reduces the number of objects to 556. It is very important to note that many deep-sky objects (especially the ones listed in the more obscure catalogues) do not have measured magnitudes and are not included in the 556 noted above. There are 703 of these magnitude-less objects in the SAC database with a declination of −35° or higher. From the 703 objects, I estimated that approximately 237 are magnitude 10 or brighter. Based on my own observations, I find that the majority of deep-sky objects that are stellar in nature, such as open clusters and asterisms, are relatively bright. Thus I estimated that 50% of such objects are brighter than magnitude 10. Galaxies and all types of nebulae were not included at all because these are most certainly fainter than magnitude 10.

The sum of 556 and 237 results in a total of 793 deep-sky objects that are waiting to be observed, even from your urban backyard! The only caveat is that many of these obscure catalogue objects are not terribly impressive visually. The number 793 is only an approximation and may have a large margin of error, but the point of the calculation is to demonstrate that there are lots of relatively bright deep-sky objects that most observers do not even know about.

Let us take a closer look at these 793 brighter deep-sky objects and try to categorize them. Table 1 outlines deep-sky object types of magnitude 10 or brighter, while Table 2 outlines deep-sky objects whose magnitudes are unknown, but are estimated to be magnitude 10 or brighter.

TABLE 1
Magnitude is known to be 10 or brighter

Object Type	Quantity
1 star	8
2 star	1
Asterism	1
Bright Nebula	10
Cluster + Nebula	20
Galaxy	100
Globular Cluster	64
Open Cluster	330
Planetary Nebula	18
Supernova Remnant	4
Total	**556**

TABLE 2
Magnitude is unknown, but estimated to be 10 or brighter

Object Type	Quantity
Asterism	43
Open Cluster	194
Total	**237**

Objects categorized as "1 star" and "2 star" in Table 1 are typically NGC objects that were thought to be actual deep-sky objects but were later found out to be just individual stars. There are hundreds of these objects without a measured magnitude, but I suspect most are quite faint, therefore none were included in Table 2. Certainly these will be the most "boring" deep-sky objects you will ever see, but you can use them to practice your star-hopping skills! Although these are not true deep-sky objects they are still part of the *NGC Catalogue* and can be checked off your list when found. Asterisms are star groupings that, to us amateur astronomers, are just as nice to look at as "real" open clusters, except that, scientifically speaking, asterisms are not considered to be true deep-sky objects because they are just chance alignment of stars. The 44 asterisms listed in Table 1 and Table 2 all carry NGC designations, thus these are also worth observing and checking off your observing list.

The objects listed as "Bright Nebula", "Cluster + Nebula", "Galaxy", "Planetary Nebula", and "Supernova Remnant" in Table 1 may be a little more difficult to see depending on your telescope's size and amount of light pollution, however, with a telescope of about 8-inch aperture and moderate light pollution these non-stellar objects should be visible.

That leaves just the "Open Cluster" objects listed in both Tables 1 and 2 — a total of 524 objects. Coincidentally open clusters are the most abundant given the magnitude 10 limit, and they also happen to be the least affected by light pollution. The sheer number of objects should be enough to keep you busy for years, but do not expect any of these clusters to be very impressive. The majority will be just one or two dozen scattered stars, which can be easily mistaken for background stars, yet a handful of these open clusters are ridiculously bright and many observers do not realize these are actual deep-sky objects that belong to one catalogue or another. Table 3 lists some of these objects to a limiting magnitude of 4 (it does not include obvious objects such as the Pleiades, the Beehive, or Hyades).

Finally, if you intend to track down these hundreds of objects, you will definitely need a good star atlas. *Uranometria 2000* as a minimum. Most are not be plotted in *Sky Atlas 2000* and some are not even plotted in *Uranometria 2000*. You cannot rely on a GOTO telescope to reveal these objects, due to inaccuracies in telescope pointing and because distinguishing the target from background stars may be difficult in many cases. The only way to be absolutely certain you have located an object is to compare what you are seeing against a good star atlas. Another alternative is to get a good star-charting software package, such as *Earth Centered Universe*, which actually uses the SAC database as its primary deep-sky engine and can plot stars to magnitude 15.

Paul Markov has been an avid deep sky observer since 1982. His tips on how to maintain an observing logbook can be found in the 2002 Observer's Handbook. *When not observing or making a living, he operates the Canada-Wide Astronomy Buy and Sell web site (*`www.astrobuysell.com`*).*

Table 3
Short list of bright deep-sky objects

Object	Type	Const.	R.A.	Dec.	Mag.	Comments
Cr 121	OPNCL	CMA	06 54.2	−24 38	2.6	
Cr 132	OPNCL	CMA	07 14.4	−31 10	3.6	
Cr 140	OPNCL	CMA	07 23.9	−32 12	3.5	The Tuft in the tail of the dog
Mel 111	OPNCL	COM	12 25.0	+26 00	1.8	Coma Berenices star cluster (Cr 256)
Steph 1	OPNCL	LYR	18 53.5	+36 55	3.8	Delta Lyrae cluster
NGC 2232	OPNCL	MON	06 28.0	−04 51	3.9	
NGC 2264	CL+NB	MON	06 41.0	+09 54	3.9	20 stars magnitude 6 to 10 with nebulosity
Mel 186	OPNCL	OPH	18 01.0	+03 00	3.0	(Cr 359)
Cr 65	OPNCL	ORI	05 26.0	+16 00	3.0	Very large, just north of Cr 69
Cr 69	OPNCL	ORI	05 35.1	+09 56	2.8	Orion's head stars
Cr 70	OPNCL	ORI	05 36.0	−01 00	0.4	Orion's belt stars
Mel 20	OPNCL	PER	03 22.0	+49 00	1.2	Alpha Persei moving cluster (Magnitude does not include Alpha Persei) (Cr 39)
Cr 302	OPNCL	SCO	16 26.0	−26 00	1.0	Antares moving cluster
Cr285	OPNCL	UMA	12 03.0	+58 00	0.4	Ursa Major moving cluster (stars that make up the Big Dipper!)
Cr 399	OPNCL	VUL	19 25.4	+20 11	3.6	Brocchi's cluster or The Coathanger cluster

(Cr = Collinder, Mel = Melotte, Steph = Stephenson)

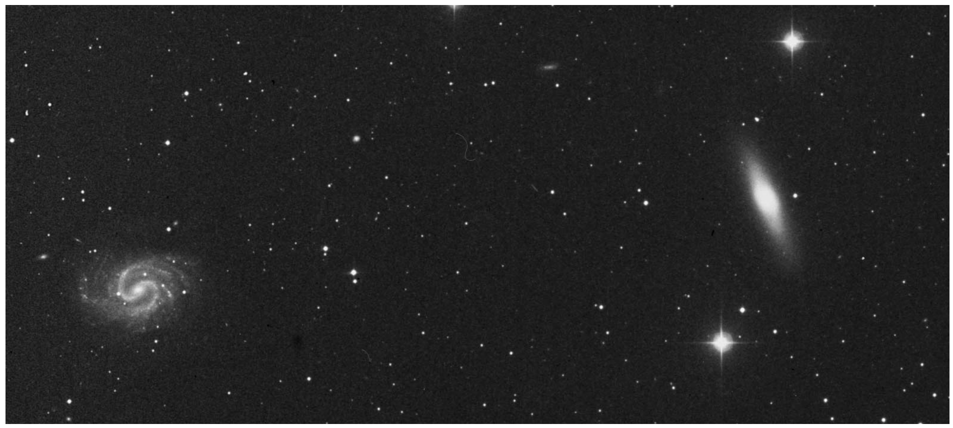
Fear and Loathing in the Virgo Cluster

by Mark Bratton (mbratton@generation.net)

My observing records over the years indicate that I have observed 131 individual galaxies in the constellations Coma Berenices and Virgo. While in some respects this is an impressive total, it nonetheless masks the fact that I, like many amateur astronomers, have an almost irrational fear when it comes to tackling our "local" supercluster, the Virgo Cluster.

Part of the problem is the sheer enormity of the task at hand. Three hundred and eighty-five individual galaxies in the Virgo Cluster region are plotted in *Uranometria*, and, according to Robert Burnham Jr., more than one hundred of these should be in the range of an 8-inch telescope. This is not a project to be completed in one evening or even one observing season! For most amateurs, including myself, the problem is knowing where to begin. Attack from the north? From the west? Start at Markarian's Chain and spiral outwards? And even when a decision is made, only a little progress can be made during the course of an evening. When the next observing session comes, does one pick up where one left off? Or attack from the north? Attack from the west? You get the idea.

For years, I have been "nibbling around the edges" of this exhausting structure. It is one of my last great challenges to observe this cluster methodically, field by field, until I can truly say that I "know" this region as well as the neighbourhood in which I live. In the meantime, here's a small sample of interesting galaxies taken from some of my nibbling sessions!



A digitized sky survey[1] image of NGC 4535 (left) and NGC4526 (right). North is to the left in this 45 × 20 minute field.

Because of the remoteness of this cluster of galaxies (the nearest members are at least 40 million light years distant) not much in the way of structure can be seen in individual members. But much of the interest in the region comes from the fact that often two or more galaxies can be viewed in a given field and then the observing becomes a study in contrasts.

A good place to start is the field of NGC 4216. This galaxy, easily visible in a small telescope, is a superb example of an edge-on spindle with a sharp, brilliant core. There are two companions that can be picked up with larger instruments. NGC 4206 and NGC 4222 are also edge-on galaxies, 4206 being considerably brighter than 4222. Neither galaxy displayed a brighter core in my 15-inch reflector and their slightly different orientations from NGC 4216 make this an attractive field in a medium power eyepiece.

A bright, interesting pair of galaxies lies almost due west from the bright star epsilon Virginis. NGC 4754 and NGC 4762 are both visible in small telescopes and NGC 4762 is quite similar to NGC 4216 above. It is a well-defined galaxy, very much elongated northeast/southwest, with a smooth-textured outer envelope that tapers to sharp points. A round, bright core is a notable feature. NGC 4754 is quite different: round and well condensed with a bright core. The outer envelope is mottled at high power in my 15-inch reflector and a few faint sparkles are

[1] The Digitized Sky Survey was produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166. This image is based on photographic data obtained using the Oschin Schmidt Telescope on Palomar Mountain. The plates were processed into the present compressed digital form with the permission of this institution.

visible at high magnification.

Another pair of galaxies visible in a small telescope but showing greater contrast is the pair NGC 4666 and NGC 4668. I observed this pair back in 1993 from the dark skies east of Ayer's Cliff in the Eastern Townships of Quebec. NGC 4666 is a bright, easily-located galaxy, elongated northeast/southwest with a prominent central bulge. This bulge appears brighter than the extensions but not particularly concentrated. NGC 4668, on the other hand, is a very faint circular glow, detectable with averted vision but tough with direct vision. It just follows a close pair of magnitude +10 stars and is slightly brighter to the middle.

"… I, like many amateur astronomers, have an almost irrational fear when it comes to tackling our "local" supercluster, the Virgo Cluster. Part of the problem is the sheer enormity of the task at hand."

One of the best contrast pairs for small telescopes is the one that illustrates this article. NGC 4535 and NGC 4526 are both visible in a low power field of a small telescope. Of the two, NGC 4526 is much the brighter; a greatly-elongated galaxy with a prominent core, easily located between two bright field stars. A bright supernova occurred in this galaxy in 1994. NGC 4535 is located 30 arcminutes to the north. In a small telescope, this beautiful S-shaped spiral appears as a ghostly patch of light; my 1992 notes describe it as appearing slightly triangular in outline.

In a seminal article that appeared in *Sky & Telescope* in the mid-fifties, Leland S. Copeland nicknamed NGC 4535 the "Lost Galaxy." This is a description that most observers will find apt, especially when the galaxy is compared to its brighter neighbour in the field. Both galaxies are included in the *Observer's Handbook* "Finest NGC Objects" list.

The last entry for this article is a galaxy field that represents a little bit of unfinished business on my part. Two moderately-bright objects dominate this field of 17 galaxies: NGC 4261 and NGC 4281. The galaxies in this one-degree field all display significantly higher red shifts than the Virgo Cluster as a whole and what we may be seeing is part of the far side of the local supercluster. On an April evening in 1994 I set out to observe and identify each galaxy in the field. I managed to view four of the cluster members: NGC 4281, NGC 4270, NGC 4273, and NGC 4268. All were easy to observe and I did a quick sketch and description at the time, as an infamous "Sutton haze" was moving into the region. The haze grew into heavy cloud cover, which put an end to a successful evening of observing.

Eight years have passed since that night and I have never found the time to return. The challenge is out there as are many other challenges in this daunting region of the sky. Success in the Virgo Cluster comes eventually to the patient, methodical observer. It is measured in small victories and quiet satisfaction on warm spring nights; in witnessing feebly glowing patches of light that few people ever get to see. Lucky indeed is the amateur astronomer who returns again and again to this Realm of the Nebulae.

Montreal Centre member 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.

Sirius **Schmirius**

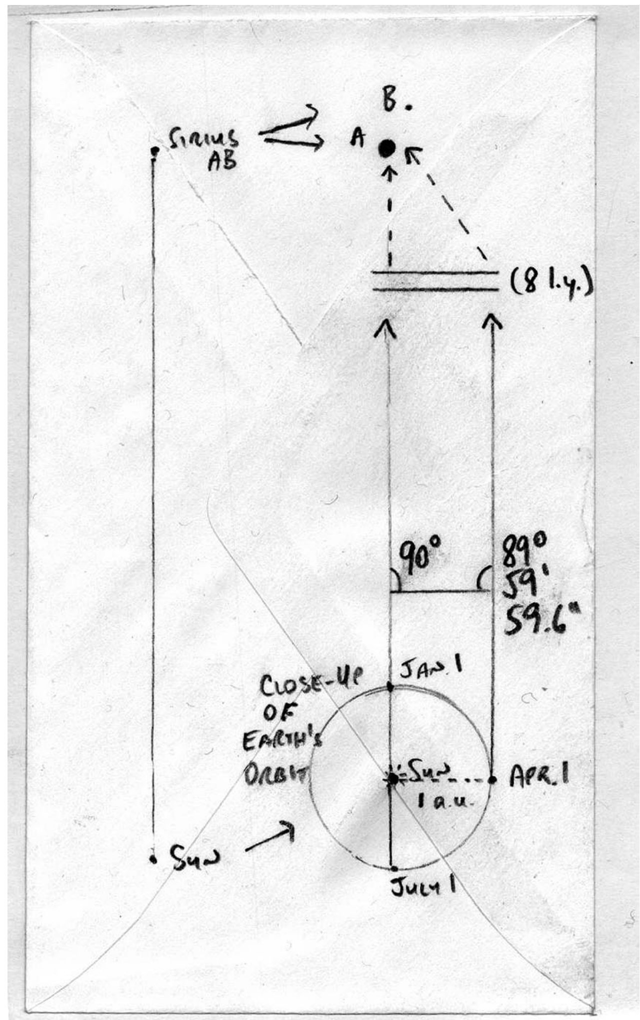
by Bruce McCurdy (bmccurdy@telusplanet.net)

"If logic had anything to do with it, it would be the men who ride side saddle."
— George Steiner

April is traditionally a time for fun and tomfoolery at the Edmonton Centre of the RASC, a thriving group of some 250 members. Our April meeting typically features a few gags, stunts, and a barely comprehensible talk by a weird-looking guy in a white lab coat (as differentiated from the weird-looking guys in T-shirts who usually give our barely-comprehensible talks). *StarBust*, the spoof issue of our newsletter, is, with the possible exception of the *Observer's Handbook*, the most eagerly anticipated publication of the membership year. People with a legitimate message know better than to have it published in April, knowing it's bound to be puzzled over and misinterpreted with the various lumps of star stuff about astroflash-photography, trumped-up observing lists, rants, cheap shots, "schwarzenagler" eyepiece ads, reports from the Provisional Wing of the Light Pollution Committee, and various other manifestations of improbability theory.

The tradition was started by a heavenly April Fool's joke played on a graze expedition of 13 unlucky Edmonton Centre members by an unlikely conspiracy involving the Moon, a star, and a cigar-shaped cloud. A prolonged period of planning, preparation, and practice preceded a platoon of peripatetic prowlers of the planet-peeking persuasion pooling our pupils in pursuit of precise positional particulars. At the very last minute a single, fast-moving, short-lived cloud appeared with exquisite accuracy and timing to foil all but the most imaginative observers. Some time thereafter, a weird-looking guy in a white lab coat — me, actually — gave a barely-comprehensible talk entitled "Amazing Graze," noting that the graze occurred on April 1, 1990 (UT), and proceeding to draw logical conclusions from the badly-garbled data. Because the star disappeared for longer than expected, the Moon was clearly much bigger than previously measured, with vast tracts of *Luna Incognita* inferred; the fact that Larry Wood in the centre of the graze line could briefly see the star while all other observers in both directions could not, made Larry the discoverer of the first and only known hole in the Moon. And so on.

Around that time *StarBust* put in its first annual appearance, and I have since delighted in contributing the occasional dirty snowball to the cause, typically grounded in logic as tenuous as a comet's tail. However, recently I have graduated to writing for the *Journal of the RASC*, the staid, solidified scientific serial of our august society. The fact that it's an August society and not an April one suggests that different



A back-of-the-envelope sketch reveals the madness in the author's method. On the left is a simple diagram showing the Sun-Sirius line. At right are enlargements of the immediate environments of both stars, showing the Pup Star as well as Earth's advantageous orbital position on April 1. Drawing is not to scale.

traditions apply and that I should honour them with due, uh, staidness. Besides, by the time the "April" edition of *JRASC* reaches your hands, it could well be August. The faint fuzzy logic of spring galaxy season might no longer be appropriate. On the other hand, by the time you get far enough into the issue to actually read my stuff, it could well be next April.

So, let's get Sirius.

I have long been fascinated with the Dog Star, the brightest in the nighttime sky. Why it was named after a dog is beyond me; several mutts have enriched my life, but in general I've not experienced them to be all that bright.

Sirius occupies several unique spots on our calendar. It culminates — the stellar analogue to opposition when the star's right ascension is twelve hours removed from the Sun's — on January 1 of all days. This is the one night of the year when I will succumb to another ancient tradition/superstition and wish upon a star. The chosen star is of course Sirius, due south at local midnight, while the wish itself is often in direct opposition with the New Year's "resolution" *du jour*.

Six months later, on Canada Day, Sirius comes into conjunction with the Sun. I have worked many Canada Day afternoon shifts at the Public Observatory of the Odyssium, formerly known as The Edmonton Space & Science Centre, which was in fact first opened to the public on July 1, 1984. I will invariably point a refractor 40° straight down from the Sun and sweep up twinkling Sirius. People are startled to be able to see a star in the broadest of daylights, although Sirius is of course much fainter than at culmination since Earth is on the other side of its orbit and therefore a full 2 astronomical units more distant from it. No stranger to the art of repetition, I take the opportunity to give a quick lesson on relative distances. "The light from the Sun takes eight minutes to reach us," I drone, "whereas the light from Sirius takes about eight years. How many minutes in a year?" Funny, nobody can ever seem to answer this question, or perhaps I don't give them time to get a word in edgeways before answering myself, "About half a million. That's how many times further Sirius is than the Sun." While they're still looking, I'll patter on, "In ancient times they thought that the heat from Sirius combined with that of the Sun to cause the hot Dog Days of summer. What I don't get is whatever happened to the Dog Nights of winter?" (Insert laugh track here.)

So Sirius is aligned with Earth and the Sun on January 1 and July 1. The technical term for such a three-body alignment is *syzygy*, a silly word which I've always wanted to use in this space. It follows that midway between these dates, right around April 1 in fact, Earth is at right angles to the Sun-Sirius line, altering the viewing angle towards Sirius by 1 AU. High-thinking stellar scientists refer to this effect as parallax, but "local yokels," as we small-minded Solar System aficionados are lovingly referred to, would consider Sirius to be at quadrature. This effect has a remarkable impact when viewing the shadows of the Galilean satellites crossing the face of Jupiter. Jupiter is about 5 AU away when at quadrature; Sirius, at 500,000 AU is only five orders of magnitude more distant. I figure any math that can be done on the fingers of one hand doesn't amount to a hill of beans, so it's obvious that the change in viewing angles to Sirius is measurable and significant. (See Figure)

Earth's advantageous position on April 1 surely offers the attentive observer an excellent opportunity to observe the Dog Star's elusive companion. Rather prosaically referred to as the Pup Star by the amateur community, this dim bulb has been whimsically dubbed Sirius B by those imaginative stellar scientists. Although it is the brightest white dwarf star in the sky — let's call it the Sirius of white dwarfs — it is a full 10 magnitudes dimmer than its pesky primary companion. After developing spreadsheets and related graphs, conducting computer simulations, and using all ten of my fingers, I have theorized that the Pup Star is darn tough to see. But I'll attack it afresh on April 1 with the renewed conviction of my latest calculations.

Aware as I am that all avid observers refer regularly to the latest *JRASC* for hot observing tips, I'll try not to disappoint. It's a well-known fact that white companion stars often display the complementary colour of their primary. For example, the white companion of red Antares often suggests a greenish hue. Since Sirius A is a pure white star, its complement is therefore black. Look for a tiny black spot in the area immediately around the brilliant star. Another trick is to take your leviathan light bucket and wait for a particularly obnoxious flash of red, green, or blue light from that most notorious of twinklers. What you might have thought was an afterimage of the complementary colour may in fact be the reflection of that vivid flash off the companion. The idea of a dwarf throwing us such a curve is yet another example of nature's scintillating sense of humour. To Sirius B or not Sirius B?

Finally I would be remiss if I didn't point out that the line of apsides of Earth's orbit is very closely aligned with Sirius. Every year Earth's perihelion occurs within a couple of days of culmination, and aphelion likewise happens very close to the conjunction of Sirius with the Sun. This is clearly a tidal effect. Your dogged correspondent is constantly hounded by such profound insights, which frequently leave him muttering incomprehensibly if not barking up the wrong tree. This latest inference will warrant several minutes of Sirius study by the author, to of course be followed by a dog's breakfast of several thousand words of doggerel in a future column. Maybe next April.

Bruce McCurdy is an amateur astronomer and an amateur writer. He is also an amateur mathematician, an amateur music-lover, an amateur sports fan, an amateur patron of the arts, and a very amateur husband and father. His professional status is uncertain.

The Friendly Stars

by Fae Mooney (faemooney@kermode.net)

"But if by chance we come to know by name one bright star, it immediately separates itself from all the others and becomes an individual."
— Martha Evans Martin

> **" There is no doubt that a starry night is beautiful. We gaze up at the twinkling points of light and enjoy the sight. And perhaps we do not care to know more about them in intimate detail."**

Have you ever felt that way about a star? Is there one particular bright beauty, glittering in the heavens, that you look for eagerly when you step outside on a clear, dark night? I do.

To me, there is something comforting about being able to look up and see a familiar "face" shining in the crowd, right where I expect to find it: "Hello, old friend. It's good to see you again..."

Wait! Don't give up on me just yet — I'm not the only one who has felt this way. There is a fine old book, written almost a hundred years ago, with the affectionate title, *The Friendly Stars*. It was written by Martha Evans Martin, who had a very personal relationship with her stars.

"One knows the more conspicuous stars by name and at a glance," she wrote, "and is able to greet them as pleasant acquaintances when they return year after year in the due seasons, or each evening as they pass over their prescribed paths serene and stately, or dancing and twinkling, according to their several habits." The language seems dated a century later, but the affection expressed is as easy to interpret today as it was to understand way back then.

It is never enough for me simply to glance up at this pleasant acquaintance of mine. I might sigh audibly and declare silently: "How radiant you are tonight, old friend, flashing all the colours of the rainbow." Yes, I know, I am personifying a mere object. I am a hopeless romantic, an unabashed sentimentalist. I admit it.

But I take some comfort in knowing that at least one other person down through the ages has felt as I do: "More than any other natural objects, the stars, as they appear to us in the skies, seem to me to have individuality," Ms Martin confessed.

Over the years, I have come to know this pleasant acquaintance of mine very well, and many others besides. And they never fail to excite me, stir in me an inexplicable yearning, or fire my imagination, whether I am out under that vast black canopy reaching out to grasp infinity, or snug inside in a darkened room gazing through a window.

"One has a fine sense of companionship with the stars when he has secured this kind of acquaintance with them," wrote Ms Martin, "when on looking out of the window at any hour of the night he can see a familiar face twinkling at him as if in friendly recognition of the fact that he must know it is due at that hour and is expecting to see it." The stars — her companions — are the same stars that, on a clear dark night in this 21st century, twinkle and beckon me outside to say hello "in friendly recognition."

Why is this important? "If we enlarge our acquaintance in the skies, the whole aspect of the heavens is changed, and, instead of a brilliant assembly of impersonal points of light, we see a host of individuals," was Ms Martin's response in her book.

"And this satisfaction we may secure without troubling about meridians and ecliptics, or right ascension and declination, or any other of the scientific trappings of the stars... The only thing one needs to do in order to have such an acquaintance with the stars is to look for them." Which means, if we are blessed with a clear, dark sky (and no light pollution), even the poorest among us can be rich in celestial acquaintances.

But if we don't look up, we miss something extraordinary. And we soon forget an important point: "Intimate knowledge of the stars really preceded the science of astronomy," Ms Martin reminded her early 20th century readers. "The stars were better known even to people at large before there was any such science than they are known now." And how much better known are they to us today, one hundred years later? We, inhabitants of the "information age," are surely without excuse. Yet to many of us the stars have become little more than curiosities, if they are considered at all.

Recalling the reproach of 19th-century American essayist Ralph Waldo Emerson, Ms Martin warned (and shames us today, by quoting Mr. Emerson) that even then, in those days "of nautical almanacs, 'the man in the street does not know a star in the sky. The solstice he does not observe, the equinox he knows as little; and the whole bright calendar of the year is without a dial in his mind.'" How sad to ignore and neglect what such a host of friends has to offer.

We need to look up at them, with only the naked eye, and become acquainted with them. It is to our shame if we do not. Ms Martin wrote: "For all the stars that attract special notice and have individual names were noticed and so named long before the invention of the telescope; and the principal constellations were traced and named by simple shepherds who tended their flocks at night in the open fields and had nothing to aid them but their own eyes and [imagination]."

There is no doubt that a starry night is beautiful. We gaze up at the twinkling points of light and enjoy the sight. And perhaps we do not care to know more about them in intimate detail. But — "if by chance we come to know by name one bright star, it immediately separates itself from all the others and becomes"...a friend.

Fae Collins Mooney writes a monthly column for the Prince George Centre's newsletter PeGASus. *This story appeared in the October 2001 issue.*

FROM THE PAST — AU FIL DES ANS

THE AMATEUR ASTRONOMERS

The amateur astronomer does not make any claim to distinction. He knows he is "just ordinary," and the best he ever hopes for is to get his bearings in the universe. The only difference between him and any other citizen is that he is a little more anxious than the average man to explore the unexplorable. He knows that he is crawling around on a spinning ball held in space without any visible means of support, but he tries to get and retain a sense of direction, just as the airman trains himself to preserve his equilibrium, no matter how far above the earth he may fly, or how strong an eddy he encounters. The amateur astronomer, unlike the rest of humanity, is not satisfied to utter the words of the hymn —

Or if on joyful wing
Cleaving the sky,
Sun, moon, and stars forgot,
Upwards I fly —

but rather he is hopeful that when his time comes to cleave the sky, he will at least have some knowledge of his surroundings. He would be unhappy if sun, moon, and stars were forgot, and would want to remember those companions of Earth — the Planets, old Sol, and his intimate friend, the Moon. The first thing he would want to do would be to take a look at that other side of the Moon which has ever been turned away from his earthly eye.

by One of Them,
from *Journal*, Vol. 17, pp. 342, October, 1923.

In Memory of a True Astronomy Enthusiast[1]

by Lee Beck (leebeck@accesscomm.ca)

Good morning. My name is Lee Beck and I am the National Representative for the Royal Astronomical Society of Canada, Regina Centre — the Centre in which John has been a very active member since January 1997. Astronomy was not his hobby but his passion. John's interests were not limited to observing. He had an unquenchable thirst for anything astronomical and a desire to pass this knowledge on to anyone who was interested. He was always the first one out to our observing site waiting for the last of the day to end so his night of wonder could begin. And likely as not, there would be an eager body waiting to be shown the jewels of the night sky by the man who had never ceased to be amazed by night sky beauty himself. He was a fixture at our public events with his trusted 8-inch "go-to" scope eliciting ooohs and ahs from those at the eyepiece. His favourite event was the Saskatchewan Summer Star Party held over a weekend every summer in the Cypress Hills. Well, for most people it was a weekend. I think John and his daughter Theresa managed to stretch that out to about 10 days! There, he could do what he truly did best — share his wealth of knowledge and love of the night sky.

His latest contributions to our Centre were his ceaseless efforts to bring the Saskatchewan Millennium Telescope project from blue prints and financial hurdles to an operational 21st Century observatory, located on the roof of the Saskatchewan Science Centre. From swinging a hammer and operating the power tools to fine tuning our new computerized scope, John was there. In fact, we owe his wife Pat and family our deepest gratitude and thanks for sharing his time with us. We couldn't have accomplished what we have without his tireless dedication.

John was also a great scope collector! Within the space of a few short years, the Mulvenna basement was transformed into "TelescopesR-Us"! It was there that he housed his 8-inch and 10-inch Meade Schmidt-Cassegrains, complete with computerized tracking and each with a database of over 64,000 celestial objects (in case you got bored with looking at the same thing), along with the monster of all scopes, the 16-inch Newtonian! With each telescope addition came his famous saying, "God, Lee, if I come home with one more scope I think Pat will divorce me!" Which, of course, she never did! Then there were all the accessories that accompanied the scopes: off-axis guiders, focal reducers, dew caps, solar filters, lunar filters, nebula filters, and eyepieces that had been added along the way, all of which he shared with whomever wanted a look.

For me, however, John Mulvenna was my friend. It's hard to believe that it was only three years ago that I had the pleasure of meeting John and Theresa. I was attending my first SSSP in the Cypress Hills. I was a little nervous and a little shy but, like them, I am a smoker and naturally smokers tend to flock together and conversation begins. We started talking and I mentioned that I would like to join the Regina Centre. John thought it would be a great idea but it came with a warning. He said the only problem the club had was that there were way too many men! With warning in hand I joined anyway!

That fall John took me under his wing and became my observing partner. He even gave me a nickname so that when he had to introduce me he would say "this is my observing partner and she answers to the name of Eyepiece Hog!" My ultimate John memory was the day he asked me if I would help out at Buffalo Days if he set up his scope for public solar viewing. I said "of course" and off we went. It was probably the hottest day of the year and, of course, if you're going to look at the sun, you have to be in the sun! John did not stop all day. As long as there was someone wanting to look through the scope, he was ready. If children needed lifting to view from the eyepiece, John lifted them. If someone asked a question John had the answer. NO ONE left the eyepiece without a detailed explanation of what it was they were seeing. At the end of that long, hot day, he packed up all his equipment, which was no easy task, met a few of us southwest of the city, set up his scope again, and, as the sun set in the beauty that only happens on the prairie, shared a partial solar eclipse with all of us. But what I most remember about that day, as the eclipsing sun had finally set, was John saying how it was the end of a perfect day. If I could have personified passion, there it was!

I have always thought of the night sky as a gift for humankind and, for those of us who have had the joy of sharing this gift through John's love of the celestial, it has become his legacy and we are all truly richer for the experience.

Lee Beck is the National Representative of the Regina Centre and Chair of the National Public Education Committee. John was her mentor and observing partner for three years.

[1] Eulogy presented at the funeral of John Mulvenna.

Reviews of Publications
Critiques d'ouvrages

Towards Models and Constants for Sub-Microarcsecond Astrometry. Proceedings of IAU Colloquium 180, edited by Kenneth J. Johnston, Dennis D. McCarthy, Brian J. Luzum, and George H. Caplan, pages 427 + xx, 18 cm × 25 cm, Publications of the U. S. Naval Observatory, Washington, D.C., U.S.A., 2000. Price $2.00 US, softcover (ISBN not listed).

Astrometry, the sub-science of precisely and accurately measuring the positions and motions of stars and other celestial bodies, is undergoing a revolution. The *Hipparcos* satellite of the European Space Agency produced in 1998 a catalogue of 120,000 stars with positions and proper motions (angular velocity across the sky) accurate to one milliarcsecond (mas = 10^{-3} arcsecond). That is accurate to 1/1000th of 1/3600th of a degree of arc. That effort for visual sources parallels similar work using the Very Long Baseline Interferometry (VLBI) array of radio telescopes focusing on compact extragalactic radio sources such as quasars and active galactic nuclei (AGN) to establish an International Celestial Reference System and Frame (ICRS and ICRF). Over the next decade missions are to be launched (*Fame, Sim*, and *Gaia*) to achieve a precision as low as 4 microarcseconds (muas = 10^{-6} arcsecond).

In "Towards Models and Constants for Sub-Microarcsecond Astrometry," Kenneth Johnston of the U. S. Naval Observatory (USNO) and his co-editors present the exciting proceedings of the International Astronomy Union's Colloquium No. 180 held at the USNO in 53 short papers with abstracts. Participation was truly international, but unfortunately no one was there from Canada. All participants are listed with electronic addresses.

The papers are grouped into five sections: Celestial Reference System and Frame, Improved Definitions and Models, Relativistic Considerations, Time and Standards, and Observational Projects. Looking at a sample from each section, we see Patrick Charlot (Observatoire de Bordeaux, France) describing how the actual physical structure of quasars and AGNs spans a significant angle at the milliarcsecond scale that must be corrected for.

Alan Fey (USNO) looks at improving the accuracy of Radio Astrometry through observations at higher frequencies, through a better understanding of the structure of extragalactic sources, and by improved modeling of the troposphere (the lower few tens of kilometres of the atmosphere) through which radio waves must pass.

Nicole Capitaine (Observatoire de Paris) recommends definitions for the fundamental anchor points, the Celestial Ephemeris Pole and Origin "to be consistent with the most recent models for nutation (the wobble imposed upon the precession cycle) and polar motion at microarcsecond accuracy." That provides a means of measuring Earth's rotation in a non-rotating geocentric celestial frame — one that has no global rotation and is no longer dependent on the Earth's motion.

According to Sergei M. Kopeikin (University of Missouri-Columbia) and Carl R. Gwinn (University of California at Santa Barbara), the achievement of submicroarcsecond precision (less than 1/1,000,000th of 1/3600th of a degree) will allow for such relativistic tests as: (i) a static gravitational field for alternative theories of gravity, (ii) effects caused by any difference in the speeds of propagation of gravity and electromagnetic waves, (iii) specific pattern of proper motions of quasars over the whole sky caused by gravitational waves, and (iv) precision limitation of fundamental frames arising from flyby of stars in our galaxy or gravitational waves given off by binary stars.

"Coordinated Universal Time (UTC) is related to the unpredictable, variable rotation of the Earth," according to Dennis McCarthy (USNO). "With the increasing importance of a continuous, uniform time scale, that must be addressed by discontinuing leap seconds, redefining the second, or establishing a conventional model for the insertion of leap seconds."

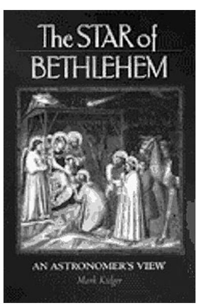
The chief editor, Kenneth Johnston (USNO), reports on "The Future of Space Astrometry" in the light of the forthcoming *Fame, Sim*, and *Gaia* missions. Star Trek fans will be glad to know they are all scheduled for five year missions to start respectively in 2004, 2008, and 2009. *Sim*, for example, with a global accuracy of 4 muas, "will have a narrow capability and astrometric accuracy of 1 mas" to enable "the discovery of near terrestrial size extra-solar planets." NASA's Terrestrial Planet Finder (*TPF*) will be studying in detail the planets discovered by *Sim*. The project websites in the note are up and running. All of them include an educational and outreach aspect.

Naturally, a work like this contains considerable mathematical analyses. Yet the mathematics is accessible to anyone who has completed non-specialist university level courses in calculus and linear algebra. Second order ordinary differential equations, single integration, double summation and 3×3 rotation matrices are as difficult as it gets. Furthermore, many of the texts are discursive with no calculations involved at all.

"Towards Models and Constants for Sub-Microarcsecond Astrometry" is highly recommended to any professional or amateur astronomer who wants to understand the fundamental background of all our measurements. The power of such measurements has grown immensely in recent years with great potential for yet further revolutionary growth in the near future. All this for only two dollars!

David Orenstein

David Orenstein (david.orenstein@utoronto.ca) (Toronto Centre) teaches mathematics at Danforth Collegiate Technical Institute on the east side of downtown Toronto. There, mathematical astronomy, especially astrometry, is on the course of study. Still a binocular observer, David is currently sorting out the varying advice he is getting for his first telescope from across the RASC.



The Star of Bethlehem: An Astronomer's View, by Mark Kidger, pages 306 + xi, 14.5 cm × 22 cm, Princeton University Press, 1999. Price $24.95 US, clothbound (ISBN 0-691-05823-7).

The Star of Bethlehem: An Astronomer's View is the third book on the Star of Bethlehem that I have reviewed for the Journal, the previous two being *The Star That Astonished the World*, by Ernest L. Martin, and *The Star of Bethlehem: The Legacy of the Magi*, by Michael R. Molner. A review for yet a fourth independent volume on the subject is still in preparation.

Of the four books on the Christmas Star that I have read in recent years, Mark Kidger's *The Star of Bethlehem: An Astronomer's View* is the most well grounded in astronomy, perhaps a consequence of the fact that the author is by his own account a practising observational astronomer. Yet that does not mean the text is free of astronomical errors. On page 154, for example, Kidger attributes the stellar magnitude system to Claudius Ptolemy in the second century A.D., whereas the system was developed by Hipparchus in the second century B.C. On page 221 Kidger states that, "When you see an eclipse, for example in Paris on any particular day, you know that another eclipse will often be visible from the same place one complete Saros cycle, or 18 years and 11.3 days, later." In fact, as the author himself notes in a section at the end of the book, the extra one third of a day's rotation of the Earth means that the eclipse will be displaced about 120° westward in longitude from the original site, and so would be visible from the same site some three Saros cycles later, *i.e.* 54 years and 34 days. Otherwise the text is remarkably free of blunders of that type and is generally well written.

The contents of the book are fairly comprehensive for such a short volume, although personally I would have liked to see more elaboration of those areas dealing with background information on the Star and less emphasis on possible explanations for the Star which involve celestial phenomena generally discredited as being relevant to the story outlined in the Book of Matthew. To his credit, Kidger provides rather detailed explanations of every conceivable identification for the Star and delves into enough background material along the way that the text can be read much like an introductory textbook dealing with observations of the night sky.

The book begins with an overview of the Star's description in the Book of Matthew and explores in depth the origins of the four New Testament gospels and of the apocryphal texts that relate to the story of the Star. This section, like most sections of the book, draws upon a wealth of information derived from various unstated sources. Such a relaxed style of writing, without formal attribution of sources, is disconcerting if one is interested in learning the actual foundations for given statements, although it can be noted that most references are identified in the chapter notes as well as in the lengthy bibliographies given at the end of the book. Diligent readers should therefore be able to reconstruct the published evidence on their own if they wish. Despite that criticism, the discussion by Kidger is an excellent introduction to the theological questions concerning the origins of the Star story. In fact, it is one of the best historical introductions to the problems surrounding the source of the Star story that I have seen in books on the subject.

What follows is a detailed reconstruction of where and when the Star was probably seen, given the adoption of the statements in Matthew as literal truth. That is followed by a discussion of the historical details needed to isolate the events associated with the Star into a specific range of potential dates. This section is not as thorough as in other books on the Star, and the author falls into the trap of identifying the lunar eclipse associated with events leading up to the death of Herod the Great with the 35% partial eclipse of the Moon that took place in the morning hours of March 13, 4 B.C. Kidger is clearly not well informed regarding the historical problems associated with such a conclusion, which include the well-formulated criticisms published by Timothy Barnes in the *Journal of Theological Studies* in 1968. Quite simply, if one reads through the sections of Josephus' *Antiquities of the Jews* that relate to the reign and death of Herod the Great, it becomes evident that the lengthy sequence of events following the eclipse that occurred prior to the subsequent Passover (in the spring of 4 B.C.?) are extremely difficult to fit into a one month time interval. An added problem is that the eclipse was recorded from Jericho, the site of Herod's winter palace, following Herod's recent move there from nearby Jerusalem, where he had stayed for a lengthy period of time associated with the trial of his son Antipater. By inference the eclipse must have occurred at a time of year associated with the coming of the cool, wet months in Palestine, which normally begin in the late fall (as argued previously by Barnes). On that basis the only acceptable candidates for the lunar eclipse associated with the death of Herod are those in November of 9 and 8 B.C., September of 5 B.C., and January of 1 B.C., none of which produces truly acceptable agreement with other information about the duration of Herod's reign. Such problems are beyond the scope of Kidger's book.

In subsequent sections Kidger describes at length the numerous possible astronomical objects or events that have at one time or another been raised as possible candidates for the Star. It is at such a point in most books on the subject that authors begin to describe their own favourite candidates for the Star. But Kidger refrains from the direct route in favour of a more pedantic approach and methodically describes each type of astronomical candidate in turn and why it is unlikely to be the Star. This portion of the text is actually very informative and makes great reading for the uninitiated. All sorts of astronomical tidbits are presented for the curious reader, and the pages are a delightful learning experience in places. I was initially puzzled by Kidger's inclusion of shooting stars as possible candidates, immediately following a lengthy section on comets, but then I read his comments about the Cyrilid meteor shower of 1913, marked by a short-lived series of spectacular meteors that crossed the sky on about the same track on the evening of February 9, Saint Cyril's Day. Given our complete lack of knowledge of what exact celestial phenomenon guided the Magi to Judaea, it is probably a good idea to discuss just about any out-of-the-ordinary celestial phenomenon as a candidate for the Star.

The possibility that the event was a supernova or bright nova is entertained next, along with a delightful retelling of Arthur C. Clarke's 1954 fictional short story *The Star*, in which a supernova is positively identified as the Star of Bethlehem on the basis of its age (from its measured rate of expansion) and distance (in light years) from the Sun. There may be a few typos in this section, since two dates are given for the story (1954 and 1956), only one of which (1954) seems to follow from the text. Despite such an entertaining possibility, the evidence presented appears to rule out a supernova as a candidate for the Star. Besides, such an obvious celestial event would have been seen by anyone looking up at the night sky of that era, whereas the description in the Book of Matthew leaves one with the impression that only the Magi were able to witness the event and properly interpret it.

So who were the Magi after all? Kidger goes into the problem at length, offering two primary possibilities, namely that they were Babylonian stargazers or Zoroastrian astrologers from Persia. The latter seems to be less likely according to the author, despite his fondness for the idea, so the former is preferred. In either case, both regions were incorporated into the Hittite Empire of that era, so the Magi would have had to cross an international boundary into a satellite kingdom of the Roman Empire in order to pay homage to the newborn child. For some reason, the historical aspects of the era are sometimes forgotten in descriptions of where the Magi could have originated. Surely international travel was a lot simpler then than now?

Planetary conjunctions are the next topic of discussion in the book, and Kidger discusses every conceivable conjunction of planets that took place in the era in question, from the much-discussed Jupiter-Venus conjunctions in Leo during August 3 B.C. and June 2 B.C., to the various triple conjunctions of Jupiter and Saturn that took place in the millennium prior to the birth of Jesus. The triple conjunction of 7 B.C. is properly noted, as well as the planetary massing that included the planet Mars in the spring of 6 B.C. But the astrological "meaning" of the events is glossed over in Kidger's relation of how the event might have been interpreted as the celestial sign by the Magi. It is noted, for example, that triple conjunctions between Jupiter and Saturn are moderately rare and take place at rather irregular intervals of the standard 20-year cycle for normal Jupiter-Saturn conjunctions. A table in the book indicates that there were seven during the millennium leading up to the birth of Jesus, some of which were more spectacular than others — that of 146-145 B.C. in Cancer being the most spectacular. So why did the Magi not make their trip to Judaea in 145 B.C.? Kidger does note that the constellation of Pisces for the 7 B.C. triple conjunction is of some importance but, like most writers, states simply that it is "the constellation associated with the Jews." But Michael Molnar might take issue with such a claim, and it misses the point entirely that Pisces is also the symbol of the current astrological era in which we exist, an era that began ~2200 years ago when precession of the equinoxes carried the "first point of Aries" from the constellation of Aries the Ram into the adjacent constellation of Pisces. (The triple conjunction of 7 B.C. was also the *first and only* triple conjunction of Jupiter and Saturn to take place in Pisces during the Piscean era, but I have already pointed that out previously.) In the end, Kidger does not find the triple conjunction of Jupiter and Saturn to be a compelling candidate for the Star but does note the possible significance of the similar conjunctions and planetary massings that occurred in the years and centuries prior to 5 B.C.

At this point the author's preferred explanation begins to appear, as he discusses the record of guest stars recorded by the Chinese, along with the less complete records of such objects made by Korean and Arabian stargazers. A tally of recorded guest stars is presented and discussed with reference to the possible associated event: comet, nova, or supernova. Kidger uses the list to present an interesting update of the record of historical supernovae and proceeds to discuss the curious event witnessed in Aquila in March 5 B.C. according to the Chinese records — or in Capricorn in March 4 B.C. according to the Korean records. Were the two events one and the same, with the error arising from an incorrect transcription of previously recorded events? The point is discussed for the reader, and the conclusion is reached that they were indeed the same event, which probably occurred in 5 B.C. Kidger goes one step further and identifies the variable star DO Aquilae as the potential recurrent nova that gave rise to the event in question.

The final conclusion reached by Kidger is that the true "Christmas Star" was a sequence of events that took place between 7 and 5 B.C., namely the triple conjunction of Jupiter and Saturn in Pisces during the summer and fall of 7 B.C., the subsequent planetary massing in Pisces in April 6 B.C., a special pair of conjunctions that occurred in Pisces in February 5 B.C., and finally a bright nova in Aquila in March 5 B.C. Whew! And all of that would have had such special significance to the Magi that it could only have been interpreted as the celestial sign associated with the birth of a Messiah.

I suppose that I am still skeptical, if only because I find the arguments much less convincing than does Kidger. There is more to the research side of the problem than is presented in this book, and the search is undoubtedly far from over. Yet the book makes extremely interesting reading throughout and presents a very thorough discussion of possible celestial candidates for the Star, much more so than other books on the subject. I recommend it highly, if only for the delightful tidbits which are presented throughout. Mark Kidger has done a very creditable job at researching the Christmas Star problem, and his thoughts on the matter are well worth reading. I apologize for giving away the ending, but please do not let that deter you from adding the book to your collection.

DAVID TURNER

David Turner teaches astronomy and physics at Saint Mary's University and is the review editor for the Journal. *In a previous "life" he spent six years as director of the Doran Planetarium at Laurentian University in Sudbury, where, among his other responsibilities, he wrote, produced, and directed several Christmas Star shows.*

Uranometria 2000.0 Deep Sky Atlas, Volume 1: The Northern Hemisphere to –6°, by Wil Tirion, Barry Rappaport, and Will Remaklus, pages 308 + xxvi, 22.5 cm × 30.5 cm, Willmann-Bell, Inc., 2001. Price $49.95 US hard cover. (ISBN 0-943396-71-9)

Uranometria 2000.0 Deep Sky Atlas, Volume 2: The Southern Hemisphere to +6°, by Wil Tirion, Barry Rappaport, and Will Remaklus, pages 306 + xxvi, 22.5 cm × 30.5 cm, Willmann-Bell, Inc., 2001. Price $49.95 US hard cover. (ISBN 0-943396-72-7)

Uranometria 2000.0 Volume 3: Deep Sky Field Guide, by Murray Cragin and Emil Bonanno, pages 538 + iv, 22.5 cm × 30.5 cm, Willmann-Bell, Inc., 2001. Price $59.95 US hard cover. (ISBN 0-943396-73-5)

The history of amateur astronomy in the last century can be told in terms of star atlases available to the amateur. Until 1950 the interest was in stars, and that was primarily what atlases depicted. My old 1954 *Norton's Star Atlas* has a full page of double stars listed for each of eight double-page charts, close to 400 in all, but a grand total of only 76 "nebulae and clusters." Many more deep-sky objects are plotted on the charts, including all of the Messier objects and a large number of Herschel objects, but the latter are designated using Herschel's original eight-fold classification, based on telescopic appearance rather than the object's true nature. NGC numbers appear only in the tables of suggested objects, and all of the deep-sky objects are represented by a single generic symbol: an asterisk-like grouping of seven dots.

In the late '40s, Walter Scott Houston started writing his column "Deep-Sky Wonders" in *Sky & Telescope*, encouraging amateurs to seek out objects beyond our local stellar neighbourhood. About the same time, Antonin Becvar in Czechoslovakia produced a new atlas, named *Skalnate Pleso* after his observatory. The charts were larger, more numerous, and on a larger scale, showed much fainter stars, but, best of all, used different symbols in varying sizes to distinguish between open and globular clusters, planetary, diffuse, and dark nebulae, and galaxies. More deep-sky objects were shown, many now labeled with their NGC and IC numbers, though fainter ones remained annoyingly anonymous. Wil Tirion's popular *Sky Atlas 2000.0*, which first appeared in 1981, is a fine continuation of the tradition.

The arrival of large inexpensive Dobsonian reflectors in the early '80s brought another revolution. Observers were soon penetrating way beyond the "easy" objects in the atlases of the day, and the time was ripe for new atlases that went deeper. The pioneer in 1987 was *Uranometria*, fusing the cartography of Wil Tirion, the computer skills of Barry Rappaport, and the historical perspective of George Lovi. It offered more stars, more deep-sky objects, and much larger scaled charts, and soon became the deep-sky observer's standard reference. Its main defect was a very confusing arrangement of the chart sequence, involving many page turns while star-hopping across the sky.

Uranometria was joined in 1994 by the *Herald-Bobroff Astroatlas*, not as well known as the others because of its Australian origin, which carried the idea of symbols for deep-sky objects to an almost ridiculous extreme and added the useful concept of larger scaled charts for complex areas of the sky. Finally, in 1997 the European Space Agency and Sky Publishing produced the massive *Millennium Atlas*, by far the largest and most expensive to date. *Millennium* improved the accuracy and scale and included a larger number of fainter stars made possible by the *Tycho/Hipparcos* project. All three atlases are distinguished by a move from a relatively small number of very large charts to a large number of charts bound into one or more volumes.

Rather than repeat their 1987 efforts, the editors of the new 2001 edition of *Uranometria* (which I will call "*Uranometria2*") have absorbed the best ideas of their competitors and responded by producing something almost entirely new. Instead of a single set of 473 one-page charts, all of the same scale and arranged counter-intuitively by increasing right ascension, they have gone to a smaller number of 220 two-page charts, arranged by decreasing right ascension so that the sky continues from the right side of one chart onto the left side of the next. They have supplemented the 220 basic charts with a 22-page mini-atlas at the front of each volume, plus 26 larger scale charts for areas where objects are too dense to plot on the scale of the main charts. It is a compromise between the 1548 uniform scale charts of *Millennium* and the six different scales found in *Herald-Bobroff*. Finally, they have beaten every other atlas out in the "faint fuzzy" sweepstakes by including three times as many deep-sky objects as any previous atlas.

Let us look at a typical two-degree square area centred on the Leo Triplet: M65, M66, and NGC 3628. *Norton's* shows just three galaxies in the area. *Skalnate Pleso* shows the same three plus two more, but only labels three of them. Most later atlases, including *Uranometria* and *Millennium,* show six or seven galaxies. *Herald-Bobroff* shows 13, and *Uranometria2* shows 20!

What are the down sides to the new edition? The switch from 473 single-page charts to 220 double-page charts, while it greatly simplifies navigation, makes the new chart numbers completely incompatible with the old, which are widely quoted in many reference books. And it is not just a matter of converting chart numbers; the actual boundaries of the charts in the two editions are quite different. I have become used to the large chart scale of *Millennium; Uranometria2's* smaller scale charts seem cramped. The star dots themselves are smaller than in any of the three earlier atlases, making them harder to see under dim red light. The large number of newly added faint galaxies may be a boon to the owners of gigantic Dobs but really clutter up the charts for more modestly equipped deep-sky explorers.

The newly added objects go far beyond the lists generally available to amateurs. To provide reference material on such faint objects, *Uranometria2* has expanded the *Field Guide*, available as a separate volume from the two volumes of charts. For each of the 220 charts, the *Field Guide* lists *all* of the deep-sky objects plotted within the (non-overlapping) boundaries of that chart, so that each object appears under only one chart heading. For any one chart, there are separate lists for each category of object, providing newly measured co-ordinates, dimensions, classification, and notes. They are all cross-indexed in the back, for a total of 25,895 galaxies, 671 galaxy clusters, 1,617 open clusters, 170 globular clusters, 14 star clouds, 377 bright nebulae, 367 dark nebulae, and 1,144 planetary nebulae: 30,255 objects in all! Having the material in paper form is useful, but I hope that it will be made available digitally as well.

So, is *Uranometria2* now the star atlas of choice? For the very serious and well-equipped deep-sky observer and imager, the answer is definitely yes. It will serve as a prime reference for some time to come. It is outstandingly well done. For the rest of us, I am not so sure. I have been hard pressed to find most of the objects plotted in *Sky Atlas 2000.0* in my Ontario skies. But then, atlases, whether of Earth or sky, have never been tied to day-to-day reality for me… they are the stuff of dreams! Perhaps when I retire to Arizona…

Geoff Gaherty

Geoff Gaherty has been a star atlas junkie since he bought his first Norton's Star Atlas *in 1957. Until now his favourite has been the* Millennium*, with whose help he recently completed his Finest NGC Certificate.*

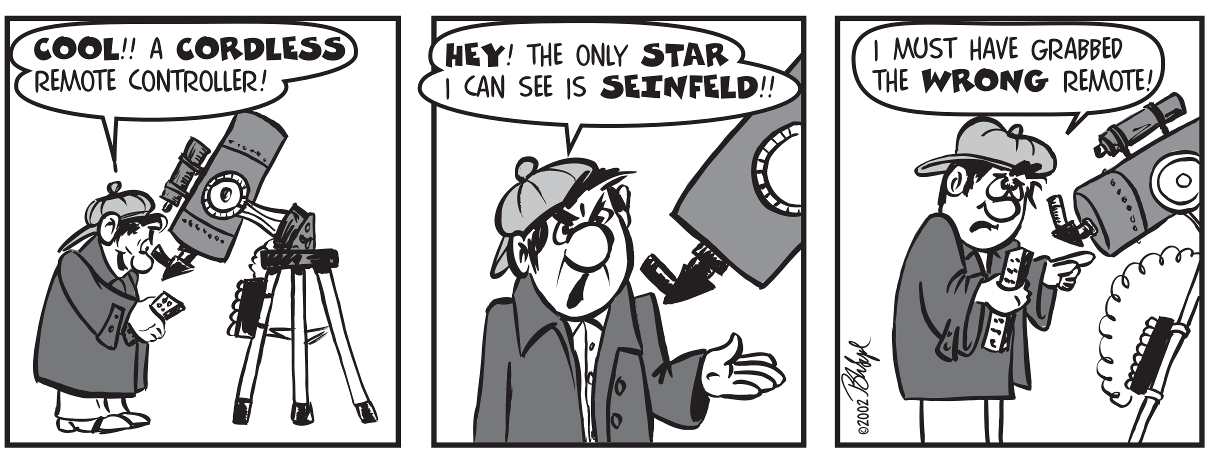
Astrocryptic

by Curt Nason, Moncton Centre

Here are the answers to last issue's puzzle

1 H	Y	2 A	D	3 E	S	■	4 C	O	S	5 M	I	6 C
O	■	M	■	U	■	7 P	■	■	■	I	■	L
8 H	Y	P	E	R	I	O	N	■	9 U	R	S	A
M	■	L	■	U	■	G	■	10 D	■	■	■	R
11 A	R	I	E	S	■	12 S	P	U	T	13 N	I	K
N	■	T	■	■	■	O	■	S	■	E	■	■
14 N	E	U	T	15 R	I	N	O	T	Y	P	E	16 S
■	■	D	■	U	■	R	■	■	■	T	■	A
17 S	P	E	C	T	R	A	■	18 B	L	U	E	R
E	■	■	■	H	■	T	■	O	■	N	■	A
19 C	R	20 A	B	■	21 A	I	R	Y	D	I	S	C
H	■	P	■	■	■	O	■	L	■	U	■	E
22 I	S	O	M	E	R	■	23 G	E	R	M	A	N

ANOTHER SIDE OF RELATIVITY



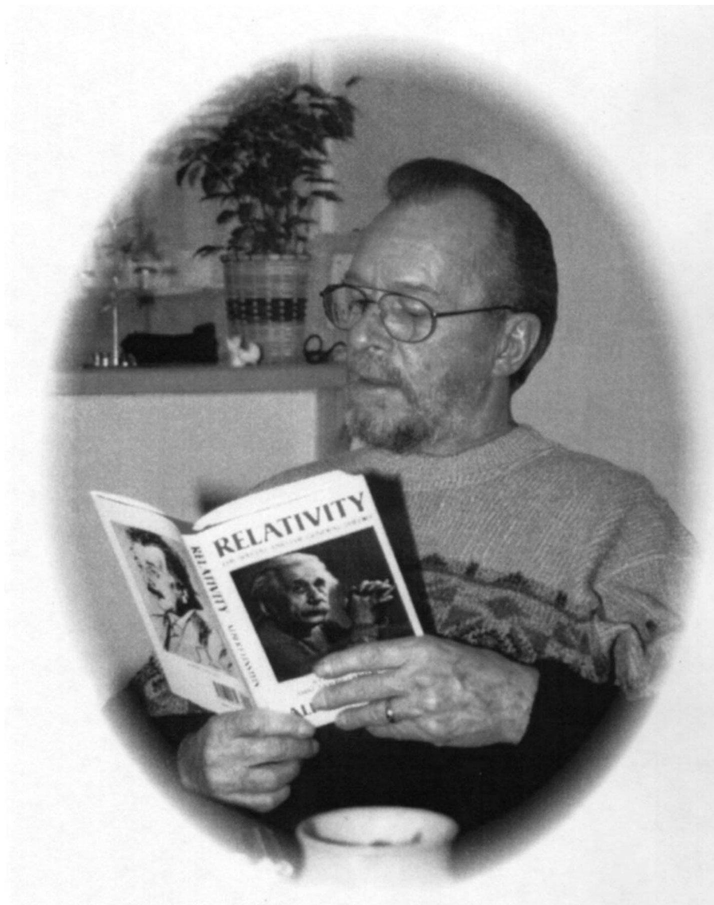
Uncle Ernie grapples with the new technology!

A Tribute to John Mulvenna (1936-2001)

To the avid astronomer, the advent of robotic telescopes meets with mixed reviews. There's nothing more annoying than having a newbie astronomer, with his fancy, new telescope, pushing buttons and whirring to the next object every 30 seconds. After about 10 minutes of this, everyone in a 100-foot radius starts searching for earplugs. In many of the observing nights with John, one thing I began to notice was that John's robotic telescope was often very quiet in the darkness; a sign of a true astronomer. He would patiently view distant nebulas and far away galaxies searching for any hint of detail that he had not glimpsed before and, of course, showing anyone who happened to walk by. It was this thirst for learning that was so prevalent in John. As some people would say it, "John was bit by the astronomy bug!" And as any good father would do, John graciously passed the bug on to his daughters.

A couple of weekends ago, I had the wonderful pleasure of spending time with John at the Kalium Observatory. We were there until 2:00 a.m. testing out the new CCD camera on the telescope. The hours flew by while we watched with anticipation as each new CCD image developed on the laptop screen. So much to see and so little time! We were two people exploring the wonders of the universe through new, digital eyes. It was a wonderful night that will not be forgotten.

I also had the pleasure of spending time with John at our public observing night last week. After my presentation, I wandered outside to where the telescopes were set up. I noticed that all the children were hovering around his telescope in anticipation of what they might see. I stopped to listen. Immediately I was reminded of years gone by when I too was teaching young children the wonders of the night sky. I recognized that spark in his voice. It was the spark of a teacher driven by a caring and sincere willingness to show something wondrous to a new pair of eyes. His enthusiasm for astronomy and his intriguing explanations of the heavens always kept people wanting more. It was easy to see why John always had so many people around his telescope.



John Mulvenna

John was always eager to share his love of astronomy with others and it showed every time he was out observing. When there was a public event scheduled, John was always there showing the children and adults the wonders of the heavens. He used his knowledge of astronomy to open new doors and touch people's lives in a way that was both fascinating and enthusiastic.

And, as sure as the clouds float in the gentle breeze, the living Earth rotates on its axis, the moon waxes and wanes across the sky, the planets revolve endlessly in their orbits, the shining sun travels around the galactic plane, and the Milky Way galaxy traverses the far reaches of intergalactic space, so will John's memory live on in all of us, whose lives he touched through his love of astronomy.

Vance Petriew, President
Regina Centre
(Discoverer of Comet P/2001 Q2 Petriew)

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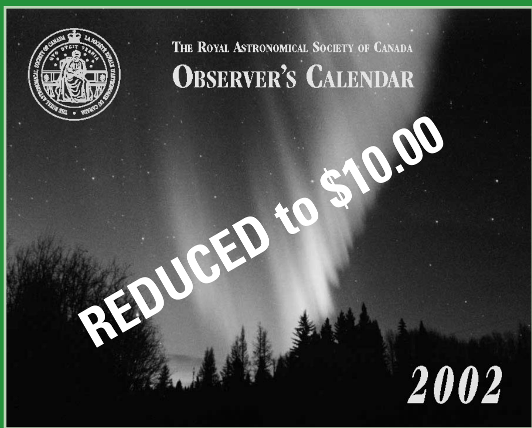
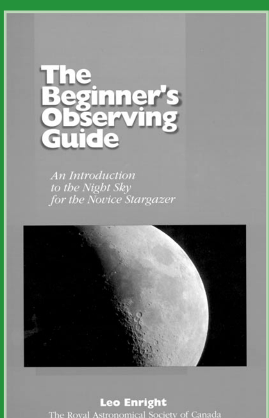


Observer's Calendar — 2002

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

It is designed with the observer in mind and contains comprehensive astronomical data such as daily Moon rise and set times, significant lunar and planetary conjunctions, eclipses, and meteor showers. The 1998, 1999, and 2000 editions each won the Best Calendar Award from the Ontario Printing and Imaging Association (designed and produced by Rajiv Gupta).

Price: $15.95 (members); $17.95 (non-members)
(includes postage and handling; add GST for Canadian orders)



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 that allows the book to lie flat).

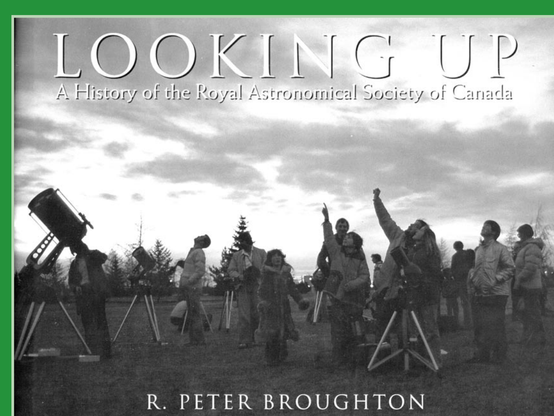
Price: $15 (includes taxes, postage and handling)

Looking Up:

A History of the Royal Astronomical Society of Canada

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

Price: $43 (includes taxes, postage and handling)



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