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# Journal

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Journal

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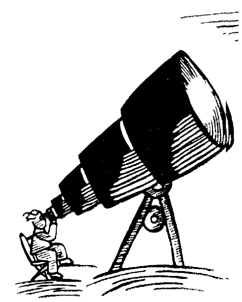

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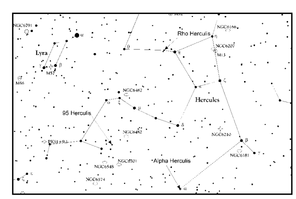

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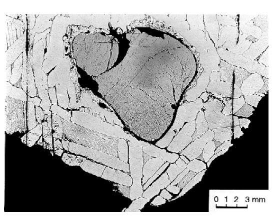

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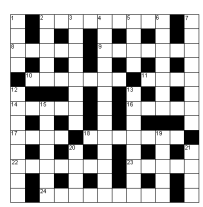

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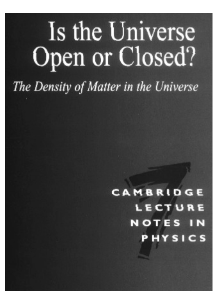




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## DU NOUVEAU DANS LES CENTRES



*Cover Photo:*

A reproduction of Newton's telescope (photo by Réal Manseau)

See page 113

# From the Editor

*by David Turner*

The present year is numbered 1999 in the western calendar, the number designating a year count of 1,999 in the Common Era (CE), according to the language of historians. It is also year 5759 of the Hebrew calendar (the "Double Heinz Year" having occurred two years previous), year 1420 of the Islamic calendar, Ethiopian year 1992, Chinese year Ki-mau and cycle 16, Japanese year Tsutsno-to-ov 2659, Coptic year 1716, Fasli year 1400, and the 694$^{th}$ Olympiad. I could go on, but the point should be evident. The only thing that is special about the number "1999" is that it represents a year count in our particular historical-cultural tradition. Incidentally, it is also the second-last year of the present millennium, but don't get me started on that issue.

It is of interest to note that, despite differences in year count from one culture to another, nearly everyone agrees upon what day of the week it is — provided one takes into account changes occurring when crossing the International Date Line. (The short-lived modifications occurring during the French Revolution and the Russian Revolution represent only a minor glitch.) There may be historical and cultural differences that account for how we count our years, but, as noted by Michael Falk in this issue, there is almost universal agreement on how we keep track of the days of the week — language issues aside.

Also in this issue is another *Focal Plane* article by Joe O'Neil, who seems to be becoming a regular contributor to the *Journal*. His current bone of contention centres on the general lack of telescopic observations being made at high magnification, or "high power observing" as some would call it. The *Focal Plane* item is a forum for opinions on any area of astronomy, and we welcome contributions.


# Journal

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



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# Correspondence
# Correspondance

## NAMING OF VARIABLE STARS

Dear Sir,

In his "Reflections" article on F. W. A. Argelander (JRASC, 93, 17, 1999), David Chapman is not quite correct in saying that Argelander chose to start his lettering of variable stars at "R" because it stood for "rot," the German for "red." In fact, Argelander started with "R" because Johannes Bayer, in his famous *Uranometria* of 1603, and more particularly in the accompanying lists of stars, not only introduced the use of lower case Greek letters, but also (in order) both lower case and upper case Roman letters. In no constellation did he go beyond the letter "Q."

In northern constellations, most of the stars with Roman letter designations are known more frequently nowadays by their Flamsteed numbers, although one or two persist, such as P Cygni. In the south, both lower case and upper case Roman letters are encountered far more frequently, a Car and Q Car being just two examples.

Argelander (1855) gave his reasons for the choice of names as follows (my translation):

> "However, to avoid confusion with the Bayer letters wherever possible, I have chosen the last [letters] of the alphabet, and taken them from the capital letters."

Argelander later explicitly stated that he thought that the nine letters from "R" to "Z" would be more than sufficient to identify all the variables that might be found in any one constellation. He may have been wrong in that, but with his work, and especially his "Appeal to Amateur Astronomers" (Argelander 1844) in which he suggested that amateurs should monitor variables, he was certainly the founder of modern day variable star astronomy.

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### References

Argelander, F. W. A. 1844, "Aufforderung an Freunde der Astronomie," in Jahrbuch für 1844, ed. H. C. Schumacher (Verlag der Cotta'schen Buchhandlung: Stuttgart), pp. 122–254

Argelander, F. W. A. 1855, "Über die Periode von R Virginis," Astronomische Nachrichten, 40, No.959, Columns 361–368

*Chapman Replies:* I thank Storm Dunlop for pointing out the correction to my article. The "R = rot" story is found in Isaac Asimov's *Biographical Encyclopaedia of Science & Technology*, 2nd Revised Edition, by Doubleday, under "Argelander," but is clearly in error.

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*Dartmouth, Nova Scotia*

## AMATEUR ASTRONOMY AND SCIENCE FICTION

Dear Sir,

I am writing in response to your comment in the February 1999 issue of the *Journal* stating that last year only one person responded to your query about amateur astronomers who are also interested in science fiction (SF). I have been into science fiction ever since seeing my first episode of *Star Trek*, as a (very) young child. My tastes have matured considerably since then, although I do still watch *Star Trek* quite often.

I am a voracious reader, reading two to five books a week on average. I am primarily interested in "hard science" writers (who use their knowledge of astronomy, physics, or whatnot to give their story lines a little more credibility and veracity), *e.g.* Larry Niven, Arthur C. Clarke, Isaac Asimov and Jerry Pournelle. Larry Niven wrote the famous and acclaimed novel *Ringworld* (and two sequels), a story based on his ingenious adaptation of the Dyson Sphere, a theory advanced by physicist and futurist Dr. Freeman Dyson. Simply put, a Dyson Sphere is a structure that a technologically advanced species could construct around a star, like a shell, thereby enabling them to harness virtually unlimited sources of energy from the star by using solar collectors, employing (presumably) more advanced technology to do so. I also enjoy the writing of Poul Anderson, Ursula K. LeGuin, Harlan Ellison, and Harry Harrison.

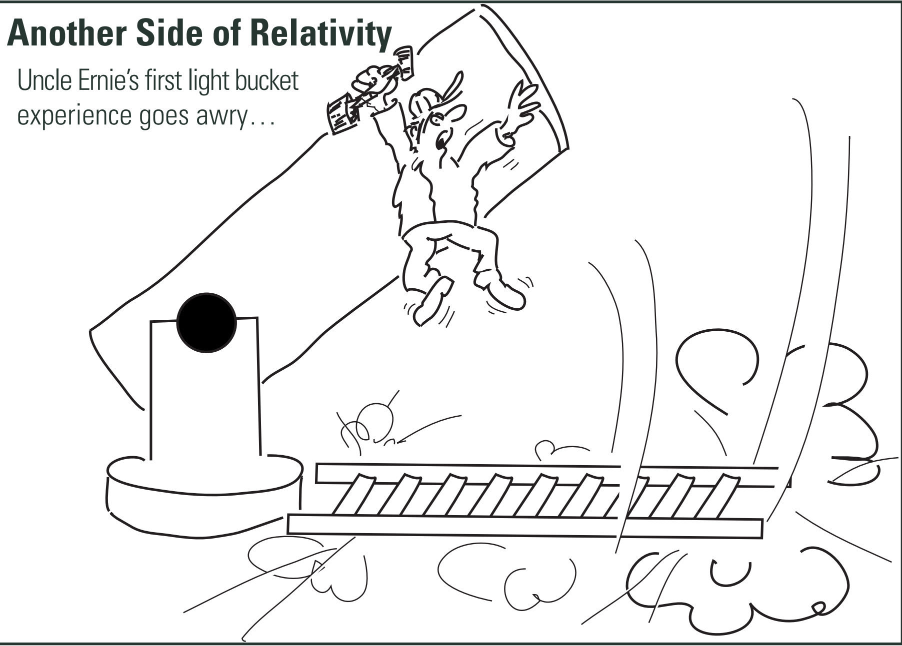
There was also an interesting show I used to watch, now in syndication. It was called "Prisoners of Gravity," and was hosted by Rick Green (currently starring as "Bill" on *The New Red Green Show*). The show was a series of SF book reviews and interviews with science fiction authors, and, as I have said, can still be seen, I believe, on the Space channel.

I would say that my favourite SF writer would have to be Joe Haldeman. Best known for his novel *The Forever War*, which won both the Hugo and Nebula Awards, Mr. Haldeman has been writing for a long time, having written his first poem at the age of nine. I was first turned on to his work by an old friend of mine, who loaned me *The Forever War* when I was in the hospital, aged fifteen, recovering from knee surgery. From the first page onward, I was hooked. What a wonderful antidote for boredom! Haldeman studied astronomy, physics, and computer science at the University of Maryland, currently teaches (part time) a science fiction writing course at MIT, and is a Vietnam veteran. Mr. Haldeman writes with a wonderful grasp of both scientific principle and human nature, and with what can only be described as a wicked sense of humour. You might read his collection of short stories and poems, *None So Blind.* It includes a short story called *None So Blind* (which lent its name to the collection), which contains an apt and hilarious description of how a computer's memory functions. Also check out his trilogy of *Worlds* novels and his book *Dealing in Futures*. He has also written some wonderful and memorable poetry (one of particular interest to astronomers being *The Space Junkie*), and is an accomplished clarinettist and songwriter, as well.

*Robert A. Sears, robertsears99@hotmail.com*
*Hamilton Centre*

**Another Side of Relativity**

Uncle Ernie's first light bucket experience goes awry…



# News Notes
## En Manchettes

### DOES THE RADIUS OF THE SUN VARY DURING THE SOLAR CYCLE?

Does the Sun change its size with the solar cycle? The Sun varies its output in step with the solar cycle, so it seems reasonable that the size of the Sun should also change. Yet a connection between the solar cycle and any changes in the Sun's radius has, so far, been elusive. Over the centuries many methods have been used to measure the size of the Sun, from simple projected transit timings or micrometer measurements to sophisticated solar astrolabes. From such measurements it has been found that the Sun appears to change its radius only slightly and in the past, difficulties in observational techniques have limited the accuracy of measurement. Recent observations have suggested a maximum variation of only about 1 arcsecond (0.1%) from a mean radius of 960.0 arcseconds as seen from a standard distance of 1.0 Astronomical Units.

Dipak Basu, a visiting scientist in the Department of Physics at Carleton University, has examined over three hundred years of solar observations, and has concluded that the Sun appears to grow and shrink in phase with the sunspot cycle (December 1998 issue of *Solar Physics*). According to Basu's findings, the more sunspots there are on the Sun, the larger it appears.

Basu's analysis was made possible by a recent re-examination of historical measurements of the solar radius. Michel Toulmonde at the Observatoire de Paris corrected the original data for such effects as atmospheric refraction, seeing conditions, the observers' reactions, and the diffraction caused by the small aperture telescopes used in the 17$^{th}$ and 18$^{th}$ centuries (September 1997 issue of *Astronomy and Astrophysics*). Missing from Toulmonde's analysis were corrections for instrument error in the micrometer measurements made prior to 1750. According to Randall Brooks of the National Museum of Science and Technology, astronomers in the 17$^{th}$ and early 18$^{th}$ century had a poor understanding of the systematic errors introduced by the filar micrometer. Brooks goes on to suggest that those inaccurate measurements should be given far less weight than the more modern data. Basu also builds upon the results of Fernando Noël of the Universidad de Chile, who is currently producing sub-arcsecond solar measurements from a Danjon astrolabe in Santiago, Chile (September 1997 issue of *Astronomy and Astrophysics*).

More sophisticated long-term observations are required to confirm the claims, since the detected variations are near the limit of, or may even exceed, the apparent accuracy of the pre-1850 data. With the improved accuracy of the modern solar astrolabes, an answer may soon be at hand.

### COSMIC COLLISIONS AND GAMMA RAY BURSTS

A current problem in astrophysics is the source of gamma-ray bursts. Over the past two years, data obtained from a flotilla of orbiting observatories have shown that what are suspected to be titanic events on the energy scale are probably cosmic, rather than local, in origin. Some are observed to be directly superimposed on distant galaxies, and are believed to originate from objects belonging to the galaxies, but at such distances, the observed energy outbursts would make them among the most powerful cosmic events since the Big Bang. Ever since the accidental discovery of gamma-ray bursters in the early 1970s, the astronomical community has been puzzled about their possible origin. Most competing models agree that the observed energy and time scales likely involve the birth or death of a black hole or neutron star.

Recent work by a Canadian team of researchers has put a new spin on such models. Brad Hansen and Chigurupati Murali of the Canadian Institute for Theoretical Astrophysics (CITA) in Toronto have suggested that gamma-ray bursts are the result of the collapse of a neutron star into a black hole, triggered by an impact with a more normal star (September 20, 1998 issue of the *Astrophysical Journal Letters*). Collisions between stars are extremely rare, but Hansen and Murali argue that stellar encounters may be frequent enough inside the dense stellar neighbourhood of a globular cluster to account for the observed number of gamma-ray bursts. According to the CITA team, the sparse nature of the interstellar medium in a globular cluster is also an ideal environment for the gamma ray event. The observed gamma ray fireball and afterglow would be difficult to produce in the denser interstellar gas usually found inside the disk of a galaxy.

Hansen and Murali have also provided a possible test for their model. Most other models require the gamma-ray burst to occur in a galaxy that is undergoing a great deal of star formation. Such starburst galaxies appear very distinct. The Hansen and Murali scenario, on the other hand, uses the older population of stars in globular clusters as the precursors, and globular clusters are found in almost every type of galaxy. If gamma ray bursts are not found to be specific to a particular type of parent galaxy, then the CITA team may be on the right track.

## AMATEUR TECHNIQUES AND MODERN DISCOVERIES

A major step toward the resolution of one of the biggest mysteries of modern astronomy was made recently with the detection of the optical flash from a gamma-ray burster (see *Second Light: A Gamma-ray Burst Caught in the Act* by Leslie Sage in this issue, and also *Sky & Telescope* for May 1999). Amateur astronomers will be interested to learn that the equipment used in the detection of the optical counterpart to the burster is comparable to that used by advanced observers who have moved into the world of CCD imaging. Telephoto lenses, CCDs with computer support and computer-driven mounts are all familiar to amateurs, if not yet in every enthusiast's backyard. The constantly decreasing costs for such high-tech equipment suggest that it will soon be within the grasp of most interested observers. Although many will continue to thrill at photons from a favourite Messier galaxy streaming directly onto their retinas, others may wish to participate in the systematic study of the cosmos and to spend at least some of their observing time in front of a computer monitor.

The discovery of the gamma-ray burst counterpart is only one area where high-tech equipment can play a role. Although large professional telescopes will continue to dominate where very faint objects, especially those of small angular size, are to be studied, the high demands for time on oversubscribed telescopes preclude lengthy studies of all but the most scientifically "productive" objects. Searches for light-varying or moving objects are often difficult to schedule on larger telescopes. In such areas, amateurs, particularly with the apparatus now available, can make a valuable contribution. Many types of variable stars could benefit from systematic study, from very short-period stars of the SX Phoenicis class to long-period variables. According to Brian Martin of King's University College in Edmonton, the short period variable DY Pegasi, as an example, is easily studied with small CCD-equipped telescopes. With its average magnitude of 10.6, amplitude of variation of $0^{m}.7$, and a period of only 105 minutes, DY Peg undergoes a complete cycle in one evening. Explosive drama, albeit on a smaller energy scale than that of gamma ray bursters, is provided by the cataclysmic variables or "dwarf novae." Not only are the outbursts of such objects unpredictable and in need of monitoring, but there are also more subtle variations resulting from movement of gas in an accretion disk around a white dwarf star.

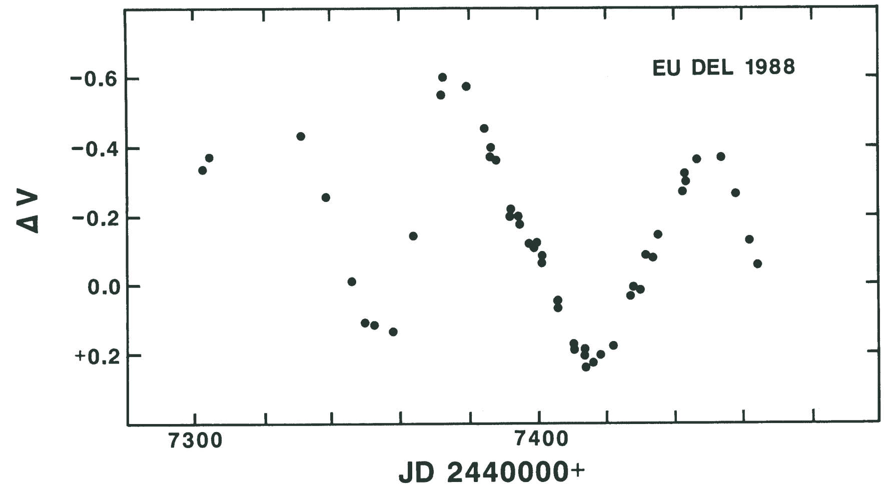
In keeping with the need for continuous monitoring, the Center for Backyard Astrophysics (`http://cba.phys.columbia.edu/`) attempts to co-ordinate observations of cataclysmic variable stars by instruments worldwide on advanced-amateur/small professional-class telescopes. Amateurs have long dominated the search for comets and asteroids. That they have been surpassed in recent years by large automated projects such as *Skywatch* and *LINEAR*, may be a situation that can be countered as more amateurs use equipment similar to that employed for the important discovery of the gamma-ray burster counterpart. Who knows what limits there are for those with a great love for the skies and a budget to support their infatuation?

## STELLAR OSCILLATIONS

Activity continues at the University of British Columbia on the MOST satellite project described in the *Journal* for December 1998. Those wishing to follow the progress of Canada's first scientific satellite in over two decades are welcome to visit the MOST web site at `http://www.astro.ubc.ca/MOST/`. The name of the satellite (an acronym for Micro Oscillations of STars) is well-chosen, but web browsers tend not to like it since the MOST link is difficult to find by web searching!

In eastern Canada, stellar oscillations are already being used to study the mysteries of the end phases of stellar evolution. Gilles Fontaine, Pierre Bergeron, François Wesemael and Pierre Brassard of the Université de Montréal, in collaboration with French researcher G. Vauclair, use variations in the luminosities of white dwarf stars (of spectral type DA) to study the properties of the thin layers of hydrogen that lie at the surface of these stellar remnants. White dwarfs are mainly composed of the nuclear ashes that remain from the conversion of hydrogen to heavier elements during nuclear processing in the interiors of stars. The tiny amount of remaining hydrogen that they contain is forced to float to the surface through the action of their intense gravitational fields.

"Temperature waves" travel through the outer layers of such stars and produce variations in their total light output. The variations, in turn, can be used to deduce the properties of the layers, once analyzed with the aid of sophisticated computer algorithms. The observations are challenging since white dwarfs, largely because of their small size, are faint, typically about fifteenth magnitude. Even by allowing all of a star's light to fall on the 3.6-m diameter mirror of the Canada-France-Hawaii Telescope (no filters are used) and sampling for 10 seconds at a time, the team requires several hours to obtain the precision of a few thousandths of a magnitude that is required for the analyses of the light curves. Several hours corresponds to many periods of variation, which are typically from about one to twenty minutes in white dwarfs of the ZZ Ceti type — the designation for the class of objects that exhibit this type of light variability. In practice, many periods are present simultaneously in a single star, which complicates the analysis but allows much to be learned about the structure of the stars. The collaborators in the project have now patiently acquired a high-quality data set that permits reliable comparisons to be made with white dwarf models.




Differential photoelectric photometry of the bright semi-regular pulsating red giant EU Delphini — mostly by amateur astronomers Howard Landis and Russ Milton of the AAVSO. Their observations, over many years, have demonstrated that EU Del and other stars like it are periodic variables (graph from John Percy).

## LONG PERIOD VARIABLES

Variable stars of long period have been the subject of study by amateur astronomers since the discovery of the prototype *o* Ceti (Mira) by David Fabricius in 1595. In several recent papers, John Percy of the University of Toronto, in conjunction with a number of students (some from high school), has studied the properties of long-period variable stars using visual and photoelectric data assembled by the American Association of Variable Star Observers (AAVSO), as well as other sources including data from the *Hipparcos* satellite. Percy has examined the statistical properties and light curves of red giant and supergiant stars, such as EU Del shown above, and finds that a large part of the variability in the light curves of long period variables seems to be random in nature, and is unrelated to the evolution of the stars. Understanding what types of change are random, and which are caused by the effects of stellar evolution (including shell flashes attributed to ignition of helium burning), is important for obtaining a more detailed picture of the late stages in the life of a star. Ultimately, such stars lose mass and make the transition from red giant to white dwarf. Pulsations undoubtedly play a role in that process, although one that is understood incompletely. Percy's results are illustrative of the type of work that can arise through amateur/professional partnerships in research in astronomy. He is convenor of a session on the topic at the upcoming RASC General Assembly, which is part of a joint meeting with the AAVSO and the Astronomical Society of the Pacific (`http://www.aspsky.org/u99/pa.html`).

## SLOW BOAT TO MARS

The *Canadian Thermal Plasma Analyse*r, which is the first Canadian scientific instrument launched toward Mars, left Earth in July 1998 as planned. As reported in the August 1998 edition of the *Journal*, sounding rocket tests of a twin instrument in Earth's ionosphere were very successful, and the instrument being carried toward Mars rides aboard a Japanese spacecraft initially called *Planet-B*. After a successful launch, the designation was changed to *Nozomi*, which in Japanese means "hope." While there is still every hope that the instrument will get to Mars and function as expected, a misfire during a midcourse correction has delayed the expected arrival to late 2003, rather than later this year as initially planned. A new trajectory has been established that includes two flybys of Earth. The gravitational boost technique, which has now been used with many interplanetary spacecraft, will allow the mission to continue with the fuel remaining, but at a slower pace than foreseen.

# Pushing the Envelope

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

When the opportunity permits, I love observing at high power. Sadly, the profusion of cheaply made department store telescopes with outrageous claims of "675 power" has given the whole concept a bit of a black eye. There exist other obstacles as well, but perhaps the point is best made in this fashion: not taking advantage of high power observing, if and when the opportunity presents itself, is a terrible waste.

> **"Not taking advantage of high power observing, if and when the opportunity presents itself, is a terrible waste."**

I find that most people observe visually at magnifications of about 150×. Seldom does one hear reports of observations being made at over 250×. Why are there so few reports of observations being made at four or five hundred power? My answer is: Objects, Opportunity, and Optics.

With regard to objects, if you could, would you observe M31 or M42 at 500×? Both objects are rather large, and gain little from high magnification. With notable exceptions, observations at high magnifications are best suited to planetary, lunar, and double star programs, which is where the first problem arises. Many amateur astronomers are obsessed with deep sky observing, otherwise why else would one see 90-mm telescopes with computerized 12,000-object data bases built into the mounts? I recently reported on the Internet that I had chanced upon a lunar occultation of a 4.4 magnitude star in Taurus, and asked if anyone else had witnessed the event. The silence was deafening.

Perhaps very few people read the message, but I am amazed at how many people think to themselves, "The Moon is up, I might as well forget about observing." Why? If you wish to learn the skies, you should be out there every clear night, even if it is only for five minutes with a pair of binoculars from the middle of a light polluted city. Put another way, consider your favourite sport or musical instrument and imagine two people who, over the period of one year, practice the art or sport. The first person practices for ten minutes a day every day, while the second person does it once a week for two hours. Who do you think will have mastered the art in question more at the end of the year? It is the same with observing. Every time you observe any object in the heavens, you are training your eyes, body, and mind to become a better observer. Do not neglect any opportunity available.

Another obstacle to observing arises from the feeling of obligation. "It is clear, therefore I must observe." It is best to alter one's frame of mind about such matters. I like to brew a cup of tea before I go outside, or indulge in a fine malt liquor during warmer nights, and just sit there, vegetating under the stars. Yes, alcohol can interfere with one's skill at the eyepiece, but high blood pressure and stress are even more of a detriment. Observing should be a relaxing influence on one's life, a chance to escape the noise and madness of modern living, if even for a brief period.

Next is the question of opportunity, which is a true quagmire. As a nation, we sometimes define our identity as a land of lousy weather. The great thing about Canada, no matter where you live, from Alert to Point Pelee or from St. John's to Victoria, if you complain about the weather, instantly you speak perfect Canadianese.

Given the variety of weather we experience in our fair land, observers should be aware that the combination of transparent skies and steady seeing may only present itself a few nights each year. Since some of those nights will occur during the full phase of the Moon, vigilance is essential.

Another hindrance to Canadian astronomers is our northern latitude. While winter nights are long (and hard), the dark hours in the warmest periods of summer seem only like fleeting memories, especially as the latitude grows higher. For most observers, the few hours of night that do occur are often "ruined" by displays of the northern lights. (You can always distinguish Canadian astronomers from those of any other nationality by the way they criticize things in which others delight.)

With regard to telescope optics, there are two remarks I wish to make. First, who among us has not heard the term "refractor snob"? It might help to understand that many high-end instruments are actually designed primarily for photographic or CCD work, where tolerances are fairly strict relative to those for visual observing. That is not to imply that such instruments fail at visual work. Quite the contrary, they do work, but permit me to make a bit of an apples-versus-oranges comparison, for argument's sake.

An 8-inch Schmidt-Cassegrain telescope, complete with mount, tripod, drive motors, eyepieces, diagonal and finder, can easily cost $2,000. By way of comparison, a professional photographer, who depends upon optical equipment to make a living, can spend $2,000 to $4,000 on a single camera lens. That is for a *single* lens. Camera body, light meter, tripods, film, *etc.* are all extra. I am referring to professional quality equipment, not the average chain store camera lens. The point is that the optical equipment available in amateur astronomy is relatively inexpensive.

A second point is the myth that telescope making costs the same as buying an instrument. That is not true if you compare optics of equivalent quality. Many people do not realize that even a first time amateur telescope maker can turn out a beautiful mirror if the person is willing to take the time. People often complain that they have neither the time nor the inclination to grind a mirror. While that is a valid point, among hobbies and professions that make use of optical equipment, only in astronomy do there exist traditions and infrastructure that support the construction of one's own instrument. In the worlds of birding and photography, the traditions and infrastructure do not exist. If you want good optical equipment, you have to pay for it.

It is essential to have high quality optical equipment to obtain high powers, whether the equipment is acquired through sweat or cash. A simple Dobsonian telescope with a plywood mount and cardboard tube can be an excellent telescope for observing at high magnification if the optics are good, unlike the demands of imaging where everything from mount to tube assembly has to be just right.

Even when one has good optical equipment, the battle does not stop there.

**"It is essential to have high quality optical equipment to obtain high powers, whether the equipment is acquired through sweat or cash."**

All telescope optics, even refractor optics, need time to cool to ambient temperature to perform at 100%. That poses a chronic problem for large telescopes. Consider the situation of an observer in Edmonton who, during a warm June night, is waiting for the mirror of his 16-inch Dobsonian to cool to ambient temperature. Even with the aid of a small fan, by the time the mirror has acclimatized, sunrise might be taking place.

I should mention that a large telescope with good optics can be one of the best instruments one ever uses for planetary observing, even though large Dobsonians are typecast as deep sky instruments. Most observations of planets and lunar events at high power seem to be made with smaller, high quality refractors. It is almost impossible to find reflectors smaller than eight inches in aperture with superior optics, unless they are homemade. While good optics are certainly capable of surpassing the "50× per inch" rule, one of the best observations I ever had of Jupiter was through a 16-inch Dobsonian that possessed exquisite optics.

The next question is when is the best time to observe? If one simply waits for objects to climb out of the murk near the horizon to a point near the zenith, more problems are encountered. The combination of climate and latitude for observers in Canada can result in a variety of frustrations: too cold in winter, too many bloodthirsty insects in summer, observing sites in winter blocked by snow drifts, summer rains turning fields into mud, and more. One peculiar problem I experience is from trains. Among the busiest rail lines in all of North America is the Quebec City–Windsor/Detroit–Chicago corridor, which passes a mere 300 metres from my observing site. Each and every time a train rolls by, be it passenger or freight train, my telescope shakes and I experience an instant earthquake inside the eyepiece. Changing mounts makes no difference, for the tremours can be felt in the ground itself. Even if all conditions of object, opportunity, and optics combine favourably on one of those rare occasions that occur three or four times a year, I still take a rest every time a train passes.

One often hears the expressions "pushing the envelope" and "expanding one's personal limits," usually in conjunction with physical activity. I think astronomy is an area where, in simple ways, we can do the same with body and mind, as long as it remains enjoyable — a personal goal to achieve instead of a yardstick to be measured by. Opportunity is fleeting, so grab it when you can. In the process of doing so, you can teach yourself more than you ever imagined possible.

*A member of the London Centre of the RASC, Joe O'Neil has been interested in astronomy since grade school. In his spare time he enjoys planetary and lunar observing from the light polluted skies of London, and black and white astrophotography from the family farm near Granton, Ontario, about five kilometres due north of Western's Elginfield Observatory.*

# Seeing Double

Seeing Double

*by Doug Middleton, Montreal Centre, reprinted from* Skyward

Sooner or later, for those of us who have done a bit of observing, the question arises: is there life after Messier? Having worked our way from M1 to M110, where do we go from there? For some, the next step is the list of the finest NGC objects as given in the *Observer's Handbook*. For others it is the Herschel 400 catalogue of deep-sky objects. For those blessed with an abundance of aperture, the sky is literally the limit. Recalling the fun (?) I had with my trusty six-inch Dobsonian identifying the faint fuzzies in Virgo and Coma Berenices, I decided that none of the above appealed to me very much. Of course, stars can also be faint, but rarely fuzzy. What about double stars? It is generally reckoned that more than half of the stars in our Galaxy are double or multiple, so that should keep me occupied for a little while!

There was not a great deal of double star observing during the first century of the telescopic era, although in 1650 the Italian astronomer Giovanni Riccioli determined that Zeta Ursae Majoris (Mizar) was a double with a companion fourteen arcseconds distant. In 1656 Christian Huygens found that Theta Orionis was a triple; a fourth component was found in 1684. The first serious observer was William Herschel, who started to observe doubles in 1779. His observations of Alpha Geminorum (Castor) and five other doubles led him to the conclusion that in those cases the non-linear motion of one star with respect to the other was a result of orbital movement. That conclusion, published in 1803, supported the view that the theory of Newtonian gravity applied beyond the solar system and was therefore a universal law.

Another pioneer in double star observing was F. G. Wilhelm Struve. In 1837, using a 24-cm refractor, he examined no fewer than 120,000 stars. It is noteworthy that the sons of both pioneers carried on the work of their fathers. Otto Struve issued the Pulkovo supplement to his father's Dorpat catalogue, and John Herschel extended his father's observations by spending four years at the Cape of Good Hope surveying the southern hemisphere. Later, Robert Grant Aitken examined all the stars in the Bonner Durchmusterung down to magnitude 9.0, and in 1932 issued his New General Catalogue of double stars (Aitken's Double Star Catalogue) containing 17,180 pairs. It is the basis for ADS numbers, which are still in use today. Currently over 60,000 double stars are catalogued, but most are out of the reach of amateur telescopes.

At first sight there appears to be some confusion regarding the nomenclature for double stars, which are variously described in the literature as naked eye, optical, binocular, visual, telescopic, *etc*. That is more a description of how the star system is observed than of the system itself. We also have the case where two stars appear to be very close together in the sky because they happen to lie almost in the same direction, but are actually a considerable distance apart. Such systems are usually known as *optical doubles*. The Alcor/Mizar pair in Ursa Major is often cited as an example of an optical double system, but actually both lie at similar distances from Earth at the core of the Ursa Major moving cluster, and are the brightest members of their own multiple star systems. There are, in fact, comparatively few examples of optical doubles. Most stars that appear double are indeed *binaries, i.e.* gravitationally connected. In general the two stars in a binary system revolve about a common centre of gravity, with orbital periods ranging typically from less than two years to many centuries. The apparent orbit of one star about the other is an ellipse, with the primary star (the brighter of the two) lying at one focus. Unless the observer's line of sight happens to be perpendicular to the plane of the ellipse, the observed ellipse will be a projection of the true ellipse on the plane of the sky, and the primary star may *not* lie at one of the two foci. It is possible to determine the size and shape of the true ellipse through analysis of the apparent ellipse, but that requires a large body of observations for the system. Fewer than a thousand binaries have calculated orbits.

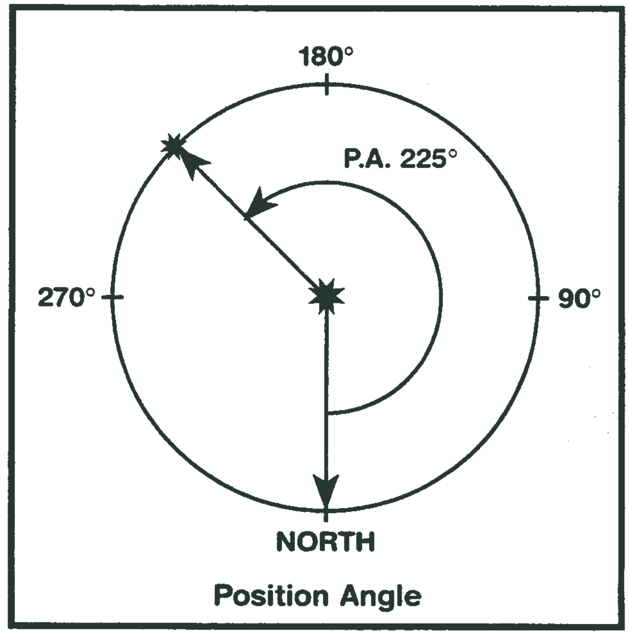
A *visual binary* is one that can be detected by direct observation or by photographic means, and its detection is limited by the resolving power of the instrument being used. Binary systems that cannot be detected visually can be discovered by other methods. If the orbital plane is edge-on or at a very small angle to the line of sight, one star may occult or transit the other, resulting in periodic variations in the apparent brightness of the system. A plot of the brightness over a period of time is called a *light curve*, which can be analyzed to determine the orbital elements. Such a system is referred to as an *eclipsing* or *photometric binary.*

Some stars may appear as single in the telescope, but the periodic doubling or periodic velocity shifts in their spectral lines will indicate the orbital motion of a two-star system. The motion in such a case is detected by means of the Doppler shift — the spectral lines shift to the red when a star is receding and to the blue when approaching. A system detected in this fashion is termed a *spectroscopic binary*. It has been estimated that one star in four is a spectroscopic binary. Normally only close binaries can be detected by this method. Wider binaries have larger orbits in which the two stars orbit one another with much slower orbital motions and radial velocity variations. Spectroscopic observations of radial velocity variations produced by orbital motion are also the means used in recent years for the detection of companions orbiting 51 Pegasi and other stars, although in such cases the Doppler shifts are extremely small and so require special techniques for detection.

Observations of a star's proper motion over a period of time can show cyclical variations that arise from motion of the star about the barycentre of a binary system. The secondary in the system may either lie too close to the primary to be visually separated, or be so faint that it cannot be detected. Such periodic wobbling with respect to background stars is the characteristic of an *astrometric binary*. A classic example is Sirius, which has a white dwarf companion. Prior to the visual detection of the companion by F. W. Bessel in 1844, Sirius was a recognized *astrometric binary* system in which the secondary was too faint to be seen telescopically.

*Multiple systems* of three or more stars also exist. The stars in such systems are sufficiently close together that their mutual gravitational attraction dominates all other gravitational forces. Although multiple systems of six or more components have been detected, the most common are hierarchical systems consisting of a close pair with a distant third companion, or two well-separated close systems orbiting a barycentre between them.

The brightest stars can often be seen to have different colours, indicative of the different temperatures in the atmospheres of the stars. Typical colours range from the steely blue-white of an O-type star (*e.g.* Zeta Orionis), through the yellow of a G-type star (*e.g.* our Sun), to the deep red of an M-type star (*e.g.* Betelgeuse). One of the most attractive features of visual binaries is the colour contrast between two components of very different temperature. Unfortunately, the human eye is not well-suited to determine star colours. Rods in the retina are adaptable to low light conditions, but see only in black and white. Cones, which perceive colour, are designed for normal daylight use, but are relatively ineffective at low light levels. Observations by the Webb Society have shown that there is a high probability that the components of a visual binary will have the same or very similar colours. Binaries of high colour contrast, such as Beta Cygni (Albireo), are the exception rather than the rule. In general, the smaller the separation, the greater the probability that the colours will be the same. Again, there are notable exceptions, such as Gamma Andromedae with its blue and orange-yellow components separated by only ten arcseconds.



This illustration shows how to determine position angle in an astronomical (inverting) telescope.

How would my six-inch Dobsonian fare in the observation of doubles? To find out, I had to delve lightly into its optical performance. As a result of the diffraction of starlight by the aperture of a telescope, in extremely good seeing the light of a star is seen as a small disk surrounded by a series of concentric rings. That is the *Airy disk* named after Sir George Airy who, in 1834, determined that the angular radius (in dimensionless angle units of radians) of the first dark ring is given by $1.22 \times \lambda \div D$, where $\lambda$ is the wavelength of the light and $D$ is the diameter of the telescope (both dimensions being expressed in the same units). It was further stated by Lord Rayleigh that, for a double to be just resolved, the angular separation of the stars should match the radius of the first dark ring. The *Rayleigh limit* for visual observations corresponds in arcseconds to $14 \div D$, where $D$ is the diameter of the telescopes in centimetres. You will note that the resolution limit depends upon the aperture, and is not affected by the brightness of the star. The theoretical Rayleigh limit is somewhat larger than in practice.

An empirical formula given by the Rev. W. R. Dawes specifies a minimum separation in arcseconds of $11.6 \div D$ for a pair of sixth magnitude stars in a small telescope. For brighter and fainter systems, and especially for pairs of unequal brightness, the results may be very different — up to $91 \div D$ for very unequal pairs. That is to be expected, since it is very difficult to detect a faint companion close to a bright primary.

Such theoretical considerations are all very interesting, but are secondary to atmospheric conditions. My 6-inch telescope has a resolution limit of 0.76 arcseconds according to the Dawes formula, but the best I have been able to achieve is 1.5 arcseconds, and that was under very good seeing — a rare occurrence! On the plus side, telescopes up to six inches are less affected by bad seeing, and the larger diffraction disk makes it easier to distinguish colour hues. Sky darkness is also a factor, since lack of contrast makes the resolving of faint doubles more difficult. As most of us know, practice and perseverance pay dividends. That is particularly true in observing doubles. On occasion I have found myself staring unsuccessfully at an elongated fuzzy blob, when suddenly, for an instant, the seeing steadied and a gap appeared between the stars that one could drive a truck through!

A binary system is defined by the magnitudes of its components, the *position angle* and the *angular separation*. The brighter star is considered to be the primary. The fainter star is the *secondary*, and the position angle of the secondary is measured in degrees, counterclockwise from north as shown in the diagram. The separation is usually given in arcseconds, although for wide pairs it may be given in arcminutes. The system was first introduced by John Herschel, and has been used ever since.

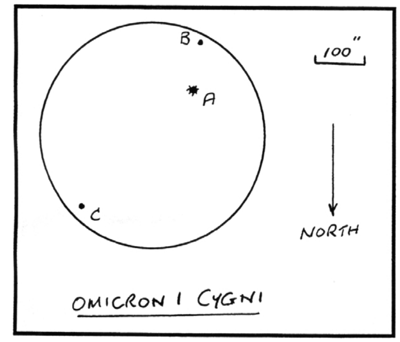
Such details seem all very straightforward, until you are at the eyepiece and you have to figure out where north is located! A suggestion in some articles that I have read is to nudge the telescope in the direction of Polaris, in which case new stars will enter the field from the north. Having spent some time star hopping in the celestial boondocks to find a faint double, the last thing I want to do is nudge my scope anywhere! Fortunately, there is a very simple solution. Centre the double in the eyepiece and let it drift to the edge of the field — that is to the west, corresponding to a position angle of 270°. For those with a clock drive, just switch it off. In the beginning I thought such a practice was too easy, but it works!

Now we have the problem of being able to estimate the separation of the stars in arcseconds. To do that, it is necessary to calibrate the various eyepieces being used. For example, if the eyepiece being used has an apparent field of view of 50° and gives a magnification of 50×, dividing the apparent field of view by the magnification gives a true field of view of one degree or 3,600 arcseconds. It is fairly easy to check that by measurement. Select a bright star on or near the celestial equator and time its drift from one side of the field to the other in seconds. Dividing by four gives the true field of view in minutes of arc.

I have found it useful (and timesaving) to prepare a list of objects to be observed beforehand. For double stars, I thoroughly recommend Volume 2 of *Sky Catalogue 2000.0*, which contains 8,315 separate double or multiple systems. The list includes objects well beyond my telescope's capabilities. Since I use Wil Tirion's *Sky Atlas 2000.0*, which plots stars to eighth magnitude, I decided to select doubles where the primary star is no fainter than seventh magnitude. I also tried to avoid large magnitude differences by restricting the companion stars to at most tenth magnitude. I soon discovered that there was no point in listing a double where the primary was fourth magnitude, the secondary was eighth magnitude, and the separation was a mere three arcseconds. Even with such restrictions, I was able to come up with a total of nearly 400 candidates. That should keep me out of mischief for a little while! A selection of some of the doubles and multiple systems I have observed is given below. They are not in any particular order nor are they all spectacular, but they have impressed me, as noted in my observing log. You may like to try some of them!

Some years before I had built my telescope and done any serious observing, I attended an open night at the observatory on the University of British Columbia campus. It had a 24-inch telescope, a computer-driven SCT, and towards the end of the presentation the technician asked if there was anything we would like to see. A small voice was heard to say "Can we see Albireo please?" We did. It is still one of my favourite objects.

**Beta Cygni — Albireo:** On everybody's list and no wonder — it has everything going for it. It is readily located, lying in the head of an easily recognizable constellation, Cygnus the Swan. The primary is a magnitude 3.1 K3 star, and the secondary is a magnitude 5.1 B8 star — the pair is separated by a generous 34″. The colours are blue and gold. It is visible in binoculars and a glorious sight at low power in a scope. Being an optical double does not detract from its beauty.




**Omicron 1 Cygni:** A wide triple with magnitudes of 3.8, 6.7 and 4.8, and with separations of 107″ and 336″. The colours are yellow, blue, and blue. In binoculars the brighter pair are likened to a wider version of Albireo.

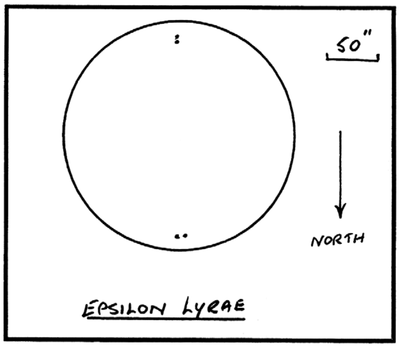
**61 Cygni:** This is Struve 2758. It is a pair of sixth magnitude red dwarfs, both of type K5. Separated by 29″, they are easily resolved at 100×. Both stars are deep yellow — like cat's-eyes in the dark! The pair is only ten light-years distant.

**Alpha Canum Venaticorum — Cor Caroli:** A nice bright pair. Magnitudes are 2.9 and 5.5 at 19″ separation. Both stars are listed as blue-white, but I see a touch of yellow in the primary, which is of type F0.

**Delta Lyrae:** A very wide optical double, but it is included for its nice colour contrast. The primary is a magnitude 5.6 star of type B4, with the secondary being a type M4 red giant at magnitude 4.3. The binocular view is of a blue and orange pair.

**Zeta Lyrae:** Another colourful pair. At magnitudes 4.3 and 5.9, and with a separation of 44″, the system is easily resolved at low power. The colours are blue and yellow.

**Epsilon Lyrae:** This is the well-known Double-Double, easily separated by binoculars into two stars of magnitudes 4.7 and 5.1. Each "star" is a close double separated by about 2.5 arcseconds and oriented almost at right angles to each other — a unique sight. I see all of the




components as white. I have resolved this quadruple system from light-polluted skies, but have failed to do so at a dark site. — dark skies do not always mean good seeing!

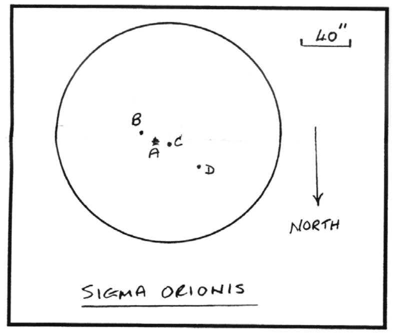
**Delta Corvi:** Here we have a large difference in magnitude, the primary being 3.0 and the secondary 9.2. The separation of 24″ is enough to resolve it at 100×, but the faint secondary, which is type K, has only a tinge of red.

**Nu Draconis:** No colour contrast here, but for a change, a very bright pair! Both stars are of spectral type A and have a magnitude of 4.9. They are separated by 62″ and easily split at low power, making their duplicity visible in binoculars.

**Eta Persei:** A nice colour contrast. The primary is a type M giant, of magnitude 3.8, with a type A companion of magnitude 8.5. At 28″ separation, they are easily resolved at 100×. Colours are yellow and blue. There is a tenth-magnitude third component that I was not able to detect.

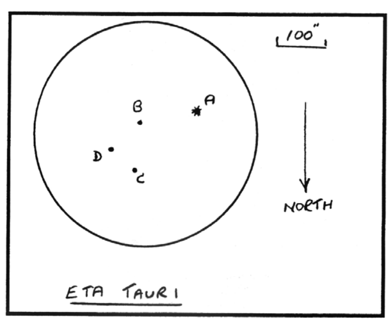
**Gamma Andromedae:** A bright colourful pair. Magnitudes are 2.2 and 5.1. Separated by 10″, they are easily resolved at 100× revealing nice yellow and blue hues.

**Sigma Orionis:** My first quadruple! Readily located — it is the bright, magnitude 3.7 star just below the left-hand star of Orion's belt. For multiple systems I have found it easier to identify the components alphabetically in order of increasing separation from the primary. In some listings, they are given in decreasing order of brightness, which I find confusing.




For Sigma Orionis, the magnitudes are: A (3.8), B (10.3), C (7.5) and D (6.5). Separations from the primary (A) are 11", 13″ and 43″ arcseconds, respectively. They are all blue-white in colour, and roughly in a straight line with C and D on one side of the primary and B on the other. Components C and D are easily resolved at 100×, but D, at magnitude 10.3, is just resolved at 160×. The primary star is actually a very close binary (0.2″), making Sigma a quintuple system!

**Omicron Draconis:** With magnitude 4.8 and 7.8 stars separated by 34″, the system is easily resolved at 50×. The primary is deep blue with a blue-white companion, making a nice contrast. There is some doubt as to whether the system is actually a true binary instead of an optical double.




**Eta Tauri:** This is Alcyone in the Pleiades, a quadruple system with a magnitude 2.9 primary and three eighth magnitude companions. All of the stars are well-separated and easily resolved at 50×. It is an unusual grouping, with the three companions forming a triangle on one side of the primary. Like most of the stars in the Pleiades, they are blue-white.

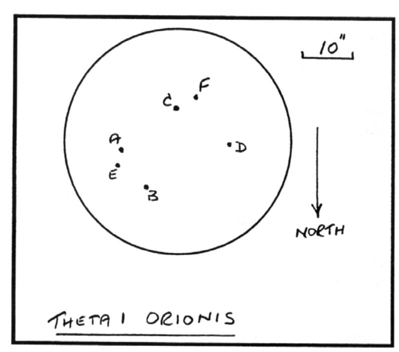
**Alpha Herculis:** The primary is a red supergiant (type M5) of magnitude 3.2 (variable). The secondary is magnitude 5.5 and separated by 5″. It is resolved at 100×, and although they are fairly close, the brightness of the components helps. The colours are orange and blue — a nice pair.

**Alpha Geminorum — Castor:** At first glance it looks like a triple system. The component magnitudes are A (1.9), B (2.9) and C (8.8), separated by 3.8″ and 73″. Stars A and B are blue-white A0 stars. C is a red dwarf, but faint, so only a tinge of red is seen. It resolved at 100×. Stars A and B are spectroscopic binaries, and C is an eclipsing binary making the system, in fact, a sextuple!

**Beta Orionis — Rigel:** This double has magnitudes 0.1 and 6.8 separated by 10″. It is just resolved at 100×, but it is a very difficult pair because of the glare from the primary, which is a blue-white supergiant.

**Zeta Coronae Borealis:** A brilliant blue-white pair of sixth magnitude type B stars separated by 6″. This system is no problem at 100×, and the equal magnitudes seem to enhance the colours of the stars.

**Xi Boötis:** This double comprises a magnitude 4.6 type G8 star with a magnitude 7.4 type K4 companion separated by 7″. It is resolved at 100×, but with some difficulty. It is frequently listed as a showpiece double for small telescopes, but I found the yellow and orange colours very pale. The conditions must have been below par that night.



**Theta l Orionis — The Trapezium:** In the heart of the Orion Nebula and one of my favourites! The four main stars have magnitudes of A (6.7), B (7.9), C (5.1) and D (6.7), separated from A by 9″, 13″ and 22″ respectively. There are also two eleventh magnitude components, E at 4″ from A, and F at 4″ from C. To resolve all six components requires very good seeing and a bit of patience. I find that it is very useful to plot some multiple systems to scale, on the basis that it is easier to find faint stars if you know where to look! I have observed the Trapezium many times, but the faint components are sometimes conspicuous by their absence!

*Doug Middleton joined the Montreal Centre in 1990, and found that it has a very active observing group. With their advice and encouragement, and using his homemade 6-inch Dobsonian, he successfully completed the Messier List. Later, he decided to concentrate his observing on multiple star systems. He is currently in his fifth year as the Centre's treasurer, and to the surprise of all, the Centre still remains solvent.*

# Histoire et construction du premier télescope Newton

*par Réal Manseau, membre non-associé de la SRAC et membre du club d'Astronomie de Drummondville (reprinted from* Le Québec Astronomique*)*

*Pour un grand nombre d'amateurs, l'astronomie est un loisir agréable que l'on partage à l'occasion avec ces amis. Pour d'autres, ce sont les possibilités de participer aux programmes de recherche qui complémentent ceux des astronomes professionnels, qui les attirent. Toutefois, pour un très petit nombre, l'astronomie se marie à d'autres passions, telles que la peinture, la programmation d'ordinateurs, etc.*

*L'auteur de la présentation qui suit, Réal Manseau, a su joindre ces talents de fabricant artisanal avec un intérêt recherché dans les télescopes historiques, tels que ceux de Newton, pour pouvoir en créer des répliques. Les photos et le texte ci-bas illustrent bien son expertise en présentant quelques-unes de ces répliques. Il faut noter que la qualité de leur fabrication et leur fidélité aux caractéristiques des originaux lui ont permis, en autre, de vendre une de ces répliques au Centre Muséographique de l'université Laval à Québec. De plus, comme l'atteste son ami, Guy Roy, il sait fabriquer des télescopes modernes qui font preuve de la même qualité de construction et de caractéristiques optiques supérieures.*

*— Suzanne Moreau*

## Introduction

Un pas des plus importants de la philosophie naturelle des sciences fut mis à jour sur la fin de l'année 1671. C'est décembre 1671 qu'un jeune homme de 29 ans, inconnu des scientifiques de Cambridge et London, présenta à la *Royal Society*, la version du premier instrument grossissant en se servant de miroirs. Isaac Newton l'appela le télescope catadioptrique. Ce petit instrument ne mesurait pas beaucoup plus de deux pouces de diamètre et avait une focale de six pouces. A cette époque, la lunette fut popularisée par Galilée. A partir de 1609, lorsque Galilée observa les satellites de Jupiter, les phases de Vénus, et les cratères lunaires, ce fut l'émerveillement dans le monde des savants.

L'objectif était un verre convexe et l'oculaire une lentille concave, ce qui donnait un champ très étroit et des images très floues. Quelques années plus tard, Kepler suggéra que le champ visuel pouvait être plus large en se servant d'un oculaire convexe. Aucune mention de la construction d'un instrument semblable nous est parvenu.

Dans les annees 1660, Newton fit ses expériences sur la lumière, les lentilles, l'observation chromatique, et l'étalement du spectre au passage de la lumière à travers un prisme. Malgré toutes ces recherches, Newton n'arrive pas à conclure comment corriger l'aberration chromatique des lentilles. Cette découverte fut faite par Chester Hall et John Dollond soixante-dix ans plus tard.

## Le Télescope de Newton

Voici, selon diverses sources et documents (Letters on Natural Philosophy, 1672, by Isaac Newton), des croquis et dimensions probablement du premier modèle présenté à la Royal Society. Le miroir (spéculum) primaire de deux pouces de diamètre et de 6 $^1/_3$ pouces de focale. Un oculaire de $^1/_6$ pouce de focale correspondait à un grossissement de 38 fois. Ces notes de manuscrit correspondent bien au modèle de Cambridge.

Isaac Newton fut le premier à présenter un télescope réflecteur en 1671. Cependant, Newton n'était pas le seul à expliquer correctement les raisons des défauts de couleurs produits par un réfracteur. James Gregory, astronome écossais et mathématicien, publia, à 24 ans, ses propres dessins maintenant connus comme le réflecteur Grégorien. Ses dessins sont présentés dans son livre *Optica Promota* (1663). Robert Hooke fut le premier à construire un Grégorien et le présenta à la Royal Society en 1674.

D'autres dessins de N. Cassegrain, professeur de physique au Collège de Chartres, furent publiés. La présentation de Cassegrain est semblable au télescope Grégorien, à l'exception que le miroir secondaire est convexe et placé à l'intérieur du premier foyer du miroir primaire.

Newton dessina de plus grands modèles de télescopes, mais n'en fabriqua jamais d'autres. Durant les trois siècles qui suivirent, les télescopes deviendront de plus en plus grands. Nous pouvons suivre l'évolution avec les travaux d'Herschel et Lord Ross, etc.

Suite à mes recherches sur l'origine de la vraie description du "Premier telescope de Newton," j'en viens à la conclusion suivante. Newton fabrique un premier télescope: tube de tôle de plomb, spéculum de 2" diamètre avec une diagonale et une oculaire. Ce modèle, présenté par le jeune Newton, a été refusé par la Royal Astronomical Society de Londres; on considéra le télescope comme un jouet et mal présenté par Newton.

## Description du telescope de Newton

Publié dans *Philosophical Transactions* du 25 mars 1672, par Isaac Newton:

- Le miroir de 2 $^3/_8$ pouces de diamètre est appelé spéculum ou miroir de métal. L'alliage du spéculum fut fait par Newton et se compose de six onces de cuivre, deux onces d'étain, et une once d'arsenic. Ce mélange était employé pour éliminer les bulles d'air qui se formaient dans le métal.
- Le polissage fut fabriqué à la main par Newton. A cette époque, l'appareil de Foucault n'était pas encore inventé; c'est pour cette raison que le spéculum fut poli, essayé et repoli à plusieurs reprises pour arriver à une courbe sphérique.
- Le tube de papier carton mesure approximativement neuf pouces de long, deux pouces de diamètre, et $^1/_8$ pouce d'épaisseur.
- Le spéculum et la diagonale sont en laiton. La diagonale est fixée à un support et placé à 45°. Ces deux miroirs sont retenus dans le tube par des anneaux extensibles détendus à l'intérieur du tube.
- Les tubes sont fixés à un support en acier forgé pour permettre la mise au foyer, en glissant les deux tubes l'un dans l'autre. Ce support est fixé à une boule de bois sphérique, freiné par des pinces en acier à ressort, forgé.
- Sur la base de bois circulaire, mesurant six pouces de diamètre, une plaque de laiton y est fixée où nous pouvons y lire: "The First Reflecting Telescope, Invented by Sir Isaac Newton and made with his own hands in the year 1671. Royal Society, 28."

Nous pouvons y apprendre d'autres vérités sur le premier télescope de Newton, suite à la lecture d'un article "Newton's Telescope Revealed" par Roy L. Bishop, RASC.

La plupart des professionnels et des amateurs admettent que le premier télescope réflecteur fut fabriqué par Newton et il fut le premier à présenter un secondaire incliné à 45°. Son premier télescope fut fabriqué en 1668, et son second en 1671.

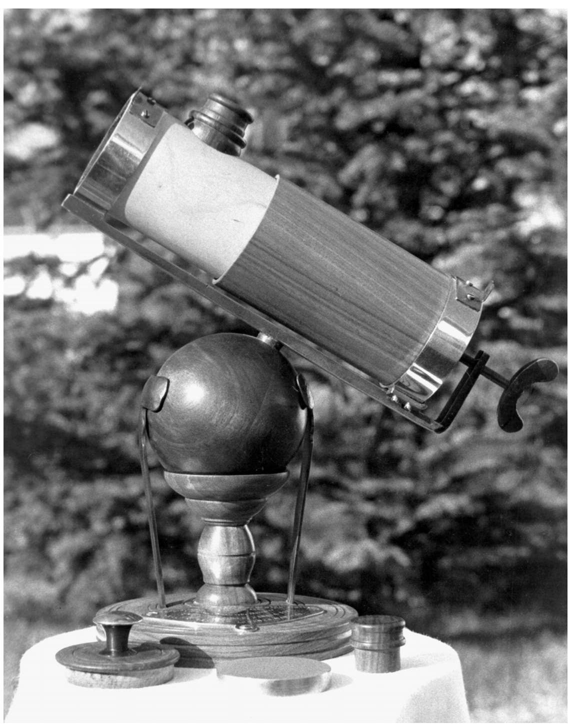
Les notes qui suivent proviennent d'une lettre de A. H. Mills et P. J. Turney, publié dans Records of the Royal Society, 33, 133, 1979:

- Le télescope maintenant conservé par la Royal Society fut donné en 1766 par Hearth and Wings, une compagnie fabriquante d'instruments à Londres.
- La longueur focale du spéculum (8.2 pouces) à l'intérieur du télescope ne correspond pas aux notes de Newton (6.3 pouces), pour le second télescope.
- Aussi, le spéculum ne contient aucune trace de l'argent que Newton dit y avoir ajouté au métal du miroir, avant de le présenter à Londres.
- Le spéculum qui accompagne le télescope sur la plupart des photos est trop large en diamètre pour le tube.
- La focale est inappropriée pour la

longueur du tube et la composition des alliages est plus récente que l'époque de Newton.

- La très pauvre qualité de la diagonale est si irrégulière qu'il ne semble pas provenir des mains de l'habile artisan Newton.
- Ce télescope est assemblé avec des lentilles retenues par des filets et il semble que, du temps de Newton, les lentilles étaient retenues à pression dans un tube.
- La cellule du spéculum et du porte oculaire sont faits de bois dur importé et ne semblent pas avoir été employés par Newton.
- En plus, les filets de précision qu'on peut voir sur le télescope semblent d'une qualité qu'on a acquise qu'un siècle plus tard.
- Le second télescope de Newton, conservé à la Royal Society, semble avoir disparu autour de 1700. Il semble que le premier télescope de Newton était en possession de Thomas Hearth.
- Le fabricant d'instruments de Londres, Mills and Turvey, suggère que le spéculum qui se trouve à l'intérieur du télescope conservé à Londres soit celui du premier télescope. Ce qui explique le mot "First" inscrit sur la base.
- Aussi, il se peut que les parties en acier forgé, c'est-à-dire les pièces à ressort qui retiennent la boule et le support du tube, soient des pièces du second télescope.

Il semble bien que l'assurance de l'authenticité des pièces du télescope de Newton ne soit pas certaine, car dans son livre *Optics*, Newton mentionne que les miroirs des deux télescopes qu'il a construit était de deux pouces de diamètre et $1/3$ de pouce d'épaisseur et ayant une focale approximative de 6 $1/4$ pouces. Donc, pas plus la focale et l'épaisseur coordonnent avec le spéculum extérieur.



Le deuxième modèle, mieux présenté par Newton: tube de carton, spéculum 2 ⅜" diamètre, ouverture du tube de 2" diamètre, focale 6 ¼" et un grossissement de 38×, monté sur une base en forme de rotule et attaché au socle par deux pinces en acier ressort. Ce second modèle est consideré, par la majorité des historiens, comme étant le "Premier Télescope de Newton." On y fait référence dans la plupart des articles.

## Conclusion

Suite à ces lectures et à l'examen de plusieurs photos de ce fameux télescope, j'ai constaté beaucoup d'erreurs de présentation. D'abord, certaines représentations sont annotées comme authentiques et, en réalité, sont des répliques plus ou moins fidèles. Sur certaines répliques, nous pouvons voir des moulures manquantes. Sur d'autres, les viseurs fixés aux extrémités des tubes sont souvent complètement désalignés.

## Références

"The First Newtonian," R. A. Wells, *Sky & Telescope*, December, 1971, p. 342.

"Newton's Telescope Revealed," Roy L. Bishop, *Sky & Telescope*, March, 1980, p. 207.

"Newton's Principia: A Retrospective," *Sky & Telescope*, July, 1987, p. 18.

## ANNEXE 1

### La construction d'une réplique du telescope de Newton

Suite à la lecture de l'article "The First Newtonian" publié dans *Sky & Telescope* de décembre 1971, j'ai proposé à mon oncle Lorenzo Manseau, artisan et sculpteur, de nous construire deux répliques du télescope de Newton. Après mûres réflexions sur les dimensions et les matériaux nécessaires à ce projet, j'ai consacré un dizaine d'heures aux plans et à la conception de ce petit instrument.

L'entente sur notre projet fut négociée comme suit. Pour ma part, j'ai fourni les plans, les conseils techniques vis-à-vis l'optique et la mécanique du télescope, et fabriqué les portes diagonales, les portes cellules en laiton, les cercles de garniture au bout des tubes, et les viseurs. J'ai fourni les oculaires et il ne me reste qu'à polir les deux spéculum, qui devront mesurer 2 $3/8$ pouces de diamètre et seront polis avec une surface sphérique de F4,5 de focale.

Notre projet avançait bien, mon oncle, retraité depuis quelques années, avait comme travail la fabrication de tubes en bois laminé en trois épaisseurs. Il a eu le plaisir de tourner les boules sphériques, les colonnes, et les socles en noyer noir americain. La forge d'artisan lui a servi à former les ressorts qui retiennent la boule sphérique, et le support forgé qui permet de faire glisser les deux tubes l'un dans l'autre. En tournant la poignée forgée fixée au bout du tube, nous pouvons faire la mise au point selon les oculaires employés ou l'acuité visuelle des observateurs.

Les oculaires et le porte-oculaire sont en bois de Gayac africain. Ce bois sans finition garde toujours un fini brillant, huileux, spécifique à sa propriété. Les pieces de bois sont finies avec un vernis d'artisan poli au chiffon.

Le dernier travail de la fabrication fut les plaques d'identification fixées à la base. Sur ces plaques est gravée l'inscription suivante: "Quelques soirées et samedis nous ont été nécessaires pour assembler toutes les pièces." Pour ma part, j'ai investi 64 heures et mon oncle 70 heures de travail. Il me reste à polir les deux spéculum et diagonales, un travail de quelques dizaines d'heures.

Ce petit bibelot, emblème de Newton, m'a servi à commémorer le 300e anniversaire de la publication du livre *Philosophiae Naturalis Principia Mathematica*. J'ai reçu beaucoup de commentaires élogieux lors des différentes expositions auxquelles j'ai participé en 1987:

- Astronomy Day, Musée National des Sciences et de la Technologie, Ottawa.
- Expo-Science Internationale, Québec.
- Congrès annuel de la Société Royale d'astronomie du Canada, Premier Prix, Instrumentation, Toronto.
- Concours des fabriquants de télescopes Stellafane, U.S.A., Premier Prix, Special Exhibit.
- Congrès de l'A.G.A.A. à Drummondville.
- Concours des fabriquants de télescopes, CAFTA, à Lanoraie, Québec.

## ANNEXE 2

### Les télescopes de bois réalisés par Réal Manseau avec un collègue– François St-Martin

- 1ère réplique. Vendue au Cosmodôme de Laval, Québec.
- 2ème réplique. Vendue à Jean-Marc Carpentier, consultant scientifique et technique, Montréal, Québec.
- 3ème réplique. Appartient à François St-Martin, Roxton Falls, Québec.
- 4ème réplique. Vendue à Alain Vaillancourt, Dr. chiropraticien, astronome amateur, Drummondville, Québec.
- 5ème réplique. Vendue au Centre Muséographique de l'Université de Laval de Québec, Québec.

*Réal Manseau a été un membre non-associé de la Société Royale d'Astronomie du Canada pour plus de vingt ans. Il est aussi membre du club d'astronomie de Drummondville.*

## LES QUALITÉS ET LES OBSERVATIONS AVEC MON TÉLESCOPE ARTISANAL

Je suis astronome amateur de la région de Drummondville au Québec depuis une dizaine d'années, et je possède un télescope artisanal de type Newton sur monture Dobson qui fut fabriqué de toutes pièces par mon ami Réal Manseau. Seul l'optique du télescope fut acheté à un endroit spécialisé, mais tout le reste a été fait à la main avec des materiaux standards tels que: tube de carton, feuilles de contreplaqué, poignées métalliques, et boulons divers.

Mais, je peux vous dire que ce télescope est une merveille de solidité et est très facilement transportable. Les caractéristiques principales du télescope sont les suivantes:

- Newton 5" f/7.8
- monture Dobson (très stable)
- viseur (guide) muni d'un "LED" rouge
- support à oculaires intégré à la monture
- porte-oculaire 1 1/4"
- oculaires 25-mm Erfle et 12.5-mm Plössl
- base d'élévation de la monture

Les qualités de mon télescope sont nombreuses mais par-dessus tout, à part sa grande qualité optique, il est d'abord et avant tout très solide, très stable, et facilement transportable avec ses poignées de transport intégrées au tube de télescope, à la monture Dobson et à la base d'élévation.

Ce télescope s'est promené un peu partout: sur nos sites d'observation dans notre région, ainsi qu'au Mont Mégantic et même jusqu'aux États-Unis lors de l'eclipse annulaire du Soleil du 10 mai 1994. Pour ce qui est de l'observation, ce télescope s'est retrouvé dans des conditions de toutes sortes. Que ce soit en hiver à –25°C, ou pour des nuits complètes d'observation au printemps et en été, il a vu beaucoup de lumière. Voici d'ailleurs tout ce que ce télescope a pu me permettre de contempler: tous les 110 objets Messier plus au-delà d'une centaine d'objets "NGC," une douzaine de comètes, une éclipse solaire, deux ou trois éclipses lunaires, sans parler des innombrables taches solaires grâce à un filtre adéquat, et finalement, la Lune et ses cratères ainsi que les magnifiques planètes: de Mercure à Saturne en passant par les petites taches noires nous indiquant les impacts de la comète Shoemaker-Levy 9 sur Jupiter.

Comme vous pouvez le constater, ce télescope a fait passablement de chemin, et ce, grâce à sa solide construction et à sa grande portabilité. Il peut voir jusqu'à des magnitudes s'approchant de 12,5 par nuit impeccable et sans Lune. Il m'a permis de contempler parmi les plus beaux joyaux cosmiques à regarder, et j'en suis... astronomiquement heureux!

Guy Roy, astronome amateur
Drummondville, Québec

# Bessel, The Man and the Functions

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

Once in a while I come across a topic or an individual that spans several of my interests. For the purpose of this article, those interests include astronomy, acoustics and music; the individual is Friedrich Wilhelm Bessel, a German scientist whose 215th birthday takes place this summer.

Bessel made lasting contributions to the fields of mathematics, physics and astronomy (see "Friedrich Wilhelm Bessel — A Bicentenary," by Allen Batten, JRASC, 78, 133, 1984). He was born on July 22, 1784, in Minden, Brandenburg (now Germany). When just 14 years old, Bessel began a career as an accounting clerk in an import-export business. In his spare time he taught himself mathematics, astronomy, geography and navigation. In 1804 he wrote a paper on Halley's comet, calculating the orbit from observational data collected in 1607. He sent the paper to Heinrich Olbers, who deemed it to be a doctoral-level dissertation and recommended its publication. Olbers encouraged Bessel to turn professional by urging his acceptance of the post of assistant at the Lilienthal Observatory. After some thought, Bessel left the affluence of his commercial job for the poverty of the Observatory post. (No, it is not what we call a "Bessel transform"!)

His career as a professional astronomer was a success, and he turned down several better job offers before he reached the age of 26, when Frederick William III of Prussia appointed him Director of a new observatory at Königsberg. Bessel's lack of a formal education nearly scuttled his promotion to university professor, as he had never received a doctoral degree. On the recommendation of Carl Gauss, the University of Göttingen solved the problem by granting Bessel a doctorate based on his impressive record of astronomical observations. He remained at the observatory in Königsberg (now Kaliningrad, Russia) for the rest of his life, which ended on March 17, 1846.

Friedrich Wilhelm Bessel (1784–1846).

Bessel pioneered the precise measurement of the positions of stars in the sky. With the new, powerful telescopes available at the time, astronomers were discovering that some stars creep slowly across the sky in relation to other stars beyond them. In 1838 Bessel chose to observe a star named 61 Cygni, which takes 350 years to move one Moon diameter across the sky. On top of its steady motion, Bessel noticed a yearly wobble in the star's apparent position caused by the Earth's annual motion around the Sun. With the aid of those observations, in 1838 Bessel became the first person to calculate the distance to a star. His distance for 61 Cygni turned out to be within 10% of the currently accepted value of 11.4 light years.

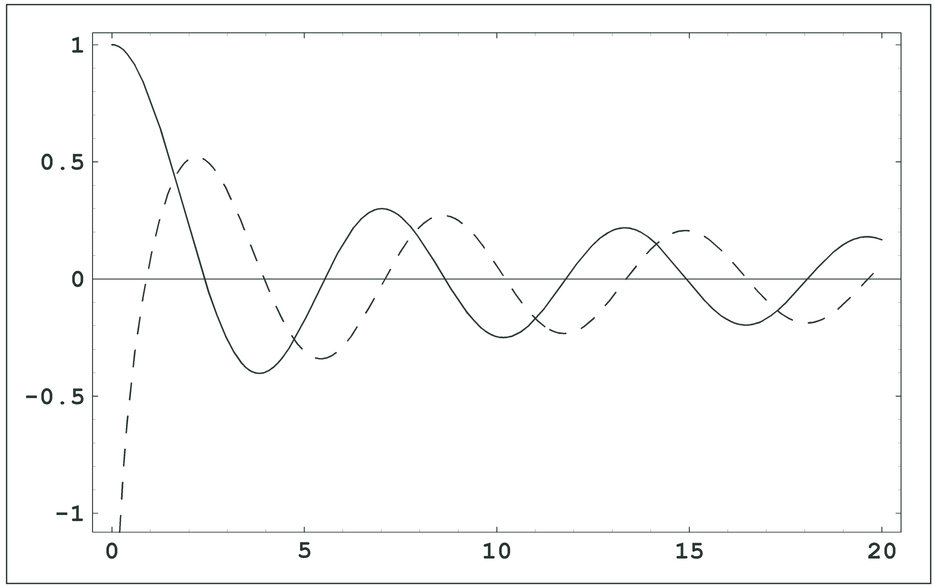
During his career Bessel accurately measured the positions of 50,000 stars. His work was continued by his student Friedrich Argelander, the subject of February's column. In one series of observations, Bessel noted a peculiar wobble in the position of Sirius, the brightest star in the sky. He correctly deduced that the wobble was caused by the gravitational pull of an unseen companion star revolving around Sirius, but he did not live to see his prediction confirmed. In 1862 the American telescope maker Alvan Graham Clark focused one of his new instruments on Sirius to test the telescope's lens. Clark observed a small speck of light almost lost in the glare of Sirius, and at first he assumed it was a defect in the telescope. Other bright stars did not show the suspected defect, however, and Clark realised that he had actually discovered a small companion to Sirius. That companion star, now called Sirius B, is the star whose existence was predicted by Bessel.

The story of Sirius B does not end with Alvan Clark. Later, in 1915, analyses of the light emitted by Sirius B showed that it is hotter than our own Sun, yet in diameter it is about the size of Earth. Sirius B turned out to be the first of an entirely new class of small, hot stars called white dwarfs.

As one of his many achievements, Bessel worked out a method of mathematical analysis involving what we now call Bessel functions. He introduced them in 1817 as part of his study of Kepler's problem, namely determining the motion of three bodies moving under their mutual gravitation. In 1824 he further developed Bessel functions in a study of planetary perturbations.

That brings us to the connection with acoustics and music. My first introduction to Bessel came in my third year of undergraduate physics at the University of Ottawa. Many physical relationships can be described mathematically through differential equations (yuk... calculus!), and that year we were progressing through the litany of differential equations that arise in several classic physics problems. The solutions to the more frequently occurring equations have been given the generic title "special functions," and each has its own name and symbol.

Bessel functions are just one family of such special functions. You may have come across them from time to time: the symbols $J_0(x)$ and $Y_0(x)$ are typical examples. In my underwater acoustics career, I first encountered them in modelling the propagation of acoustic waves in the ocean. The modes of vibrations of the circular membrane of a drumhead are also described by Bessel functions. The functions look a bit like "damped" sine and cosine functions, and are the natural solutions when the medium has cylindrical symmetry.




The solid line is $J_0(x)$, the Bessel function of the first kind of order zero. The dashed line is $Y_0(x)$, the Bessel function of the second kind order zero. Note the resemblance to "damped" sine and cosine functions

It may seem like we have strayed a bit too far from the astronomical theme of this journal, but we are closer than you may think. The 1997 June issue of *Sky & Telescope* contains an article entitled "Seeing Under the Sun's Skin," which discusses the work of the Global Oscillation Network Group (GONG), a collaboration of researchers who are engaged in the study of helioseismology. The Sun undergoes internal acoustical oscillations with periods on the order five minutes. Of course, we can only observe the surface expression of these pulsation modes. The geometry of the surface of the ball-like Sun is quite different from that of a drumhead, however, and consequently the vibrational modes of the Sun are described not by Bessel functions but a different family of special functions called Associated Laguerre polynomials. (Thanks to David Guenther of Saint Mary's University's Department of Astronomy and Physics for this tip.)

This column has been quite a ride — from comet orbits, stellar parallax, underwater sound and drum beats, to the GONG show. It attests to the breadth of Bessel's interests and his rich legacy to the field of science.

*David Chapman is a Life Member of the RASC and a past President of the Halifax Centre. Speaking of banging drums, he invites web surfers to visit Dave Chapman's Astronomy Page, whose URL is* `www3.ns.sympatico.ca/dave.chapman/astronomy_page.html`, *to view some of his astronomical writings.*

# A Gamma-Ray Burst Caught in the Act

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

Two years ago in this column, I wrote about the first detection of an optical counterpart to a gamma-ray burster (JRASC, 91, 110, 1997). The fading afterglow of the explosion that caused the burst was seen about 19 hours after the burst. Since that time, a number of afterglows have been observed. One can picture the burst in terms of a nuclear explosion, with the explosion corresponding to the prompt emission of gamma rays, and the mushroom cloud to the fading afterglow. Under the impetus of actual observational data on gamma-ray bursts, our theoretical understanding of them has sharpened considerably over the past two years. Until two months ago, however, no one had yet seen optical emission at the time of the burst. The main problem has been lack of knowledge of where to look in the sky, because the positions available while the bursts are still underway are too crude — accurate only to about 5 degrees — to allow a telescope to be pointed in the precise direction. Bursts typically last less than 100 seconds.

Carl Akerlof of the University of Michigan, and his collaborators at the Los Alamos National Laboratory in New Mexico (and elsewhere), built an instrument designed to find transient optical signals in a large area of the sky. On January 23, 1999, they found a bright new source just 22 seconds after the burst started (see the 1 April issue of *Nature*). In the 25 seconds between the first observation and the second, the source increased in brightness by a factor of 16, to a peak magnitude of about 9. Fortuitously, the first optical observation took place at the peak of the gamma-ray burst, allowing astronomers their first look at the actual flash of the explosion, rather than the fading fireball that is left afterwards.

The *Robot Optical Transient Experiment* (ROTSE) that detected the burst is a clever design that incorporates four standard telephoto lenses (for a Canon 35 mm camera) in a 2×2 array, directing the light onto a large-format CCD chip. The total field of view is 16 degrees × 16 degrees, so a positional uncertainty of 5 degrees would leave the source visible somewhere in the field. The cameras are mounted together on a platform that can slew across the sky in less than 3 seconds, in response to signals received through the internet from the *Burst and Transient Experiment* (BATSE) on the *Compton Gamma-ray Observatory*. When not responding to bursts, which happen on average about once a day, the camera follows a pre-set program of photographing the entire sky, so that for each detection there will be a recent reference photograph. Since ROTSE became operational about a year ago, it has responded to 53 burst triggers — about half of which were from actual gamma-ray bursts. The event of January 23 was the first time it caught a GRB in the act.

One of the leading contenders as a source of the bursts is the merger of two neutron stars. The initial burst is thought to occur when a shock wave from the central explosion encounters a small amount of gas surrounding the original source. As the surrounding gas is accelerated very quickly to highly relativistic speeds (99.9% of the speed of light), it gives off a burst of gamma rays. Part of the energy of the explosion is reflected off the surrounding gas back towards the source in a "reverse shock," and it is the reverse shock that is thought to produce the prompt optical emission. The fading afterglow results from the expanding and cooling gas, which is composed of both ejecta from the explosion as well as the surrounding gas that was heated as the shock wave passed through it. Another possibility that is gaining popularity is the "hypernova" model, in which the bare core of a massive star undergoes the same catastrophic collapse that makes a supernova (of type II), but without the overlying layers of the stellar envelope. In general, supernovae do not give rise to gamma-ray bursts because the shock wave has to accelerate too much material — the stellar envelope — and therefore the material does not reach the highly-relativistic speeds needed to produce the gamma rays.

As a result of the detection of optical emission from the burst itself, as well as from a comparison of the relative fluxes at different wavelengths, theorists will be able to constrain what is actually happening. Perhaps, after we have collected observations of enough events, we will even be able to determine the underlying nature of the burst.

GRB990123 (the number indicating the year, month, and day of the burst) had the distinction of being one of the "brightest" events ever detected in terms of gamma rays. The redshift of the galaxy associated with the burst is $z = 1.6$ (Kulkarni *et al.*, 1 April issue of *Nature* and Anderson *et al.*, 26 March issue of *Science*), which implies a burst energy equivalent to the total conversion of about two solar masses of material into energy, if the energy was emitted equally in all directions. That amount of energy is so large that Shri Kulkarni regards the result as strong evidence that the gamma rays are beamed toward us — that is, we are looking down a narrow cone of emission rather than seeing photons from an expanding sphere. Such a model has been proposed in the past to get around problems associated with the burst energy. It allows us to continue thinking in terms of merging neutron stars from the point of view of the energy, but may introduce problems with regard to the frequency of such events. The estimated number of merging neutron stars anywhere in the universe over its entire history should be on the order of about one gamma-ray burst per day, as is observed. If the emission is beamed, however, then we will see only a fraction of the total number of events. The narrower the cone of the beam, the more events there have to be in order for us to see one per day, though the uncertainties in the merger rate and the "opening angle" of the cone of the burst are both large.

What can we expect to learn about gamma-ray bursts in the near future? If the optical emission scales with the gamma-ray emission (and that is very controversial), then ROTSE should detect about 12 optical bursts per year. At that rate it will take considerable time to build up enough detections to provide meaningful statistics. ROTSE is in the process of being upgraded, however, and that will make it much more sensitive — by about a factor of 40. It will also be interesting if, during its normal patrol of the skies each night, ROTSE can detect optical transients that are not associated with gamma-ray bursts. Such detections may indicate that the optical emission is much less strongly beamed than the gamma rays, which would tell us more about the nature of the explosion.

The *Robot Optical Transient Experiment* (ROTSE) on the roof of a modified military communications enclosure at Los Alamos National Laboratory in New Mexico. The enclosure was previously used in the Gulf War, and obtained by the researchers from a scrap-metal dealer for $250. The entire enclosure, which houses the computer that drives ROTSE, can be picked up with a forklift truck and moved to any location accessible by road.

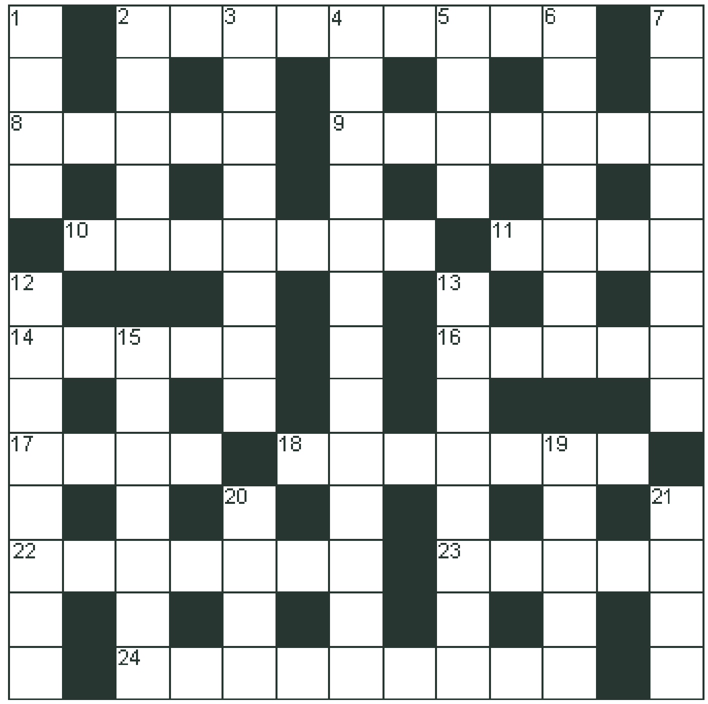
*Dr. Leslie J. Sage is Senior Editor, Physical Sciences, for* Nature *Magazine and a Research Associate in the Astronomy Department at the University of Maryland. He grew up in Burlington, Ontario, where even the bright lights of Toronto did not dim his enthusiasm for astronomy. Currently he studies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

# Astrocryptic

*by Curt Nason, Halifax Centre*

## ACROSS

2. Tycho at first feels mad about his old star charts (9)
8. Cassiopeia had an interesting rocker, initially (5)
9. He was detected by a Norman (7)
10. The zodiac temple ended badly at right ascension (7)
11. Remove the postscript from optics for hearing (4)
14. He was perhaps depressed by the adage, but collected maps (5)
16. The end of the universe described in poetry (5)
17. Tuning back to ε Pegasi (4)
18. Mad gene syndrome evident near end of chess match (3,4)
22. Big Momma singer in one famous division (7)
23. Oddly, he didn't duck the issue of extraterrestrial intelligence (5)
24. Was Pete close to realigning his Newtonian? (9)




## DOWN

1. Mechanically raise one Newton (4)
2. Feynman's head is real bad after solar discharge (5)
3. Out of focus circle around 102 yards (4,4)
4. Lion's double star perturbed mercurial phenomena (5,8)
5. Use acid in sketches of Mars (4)
6. Sol turns astray after dusk begins (3,4)
7. He turned cheers into hearty laughter first after finding a planet (8)
12. Convenient ocular sets conceived of carpal consideration (8)
13. He had a number of atoms, constantly (8)
15. It could picture Earth from within Sol and Saturn's orbit (7)
19. Scope makers have it made around the capital of England (5)
20. Generally, the target of Mont Mégantic astronomers (4)
21. The French poles can bend light (4)

### STAR QUOTES

"The scientific theory I like best is that the rings of Saturn are composed entirely of lost airline luggage."

Mark Russell

# ASTRONOMICAL NAMES FOR THE DAYS OF THE WEEK

by Michael Falk
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*(Received December 14, 1998; revised March 19, 1999)*

**Abstract.** Day names generally follow one of two conventions: *the numerical convention*, in which the days are numbered from one to seven (as in Portuguese, Mandarin, or Swahili), and *the astronomical convention*, in which the days are named after the Sun, the Moon, and the planets (as in English, Hindi, or Quechua). The two naming conventions originated about 2600 years ago and together account for most of the day names in the majority of the world's languages. Day names of specifically religious origin are more recent, and are usually limited to days of religious significance, mainly Friday, Saturday, or Sunday. The survival of the astronomical day names in many of today's languages is remarkable, in view of the passage of time and the many past efforts to eradicate such relics of our ancient past.

**Résumé.** Le nom des jours de la semaine se conforme généralement à l'un de deux usages: soit l'usage numérique selon lequel les jours sont numérotés de un à sept (comme, par exemple, en portuguais, en mandarin, ou en swahili), ou soit l'usage astronomique selon lequel les noms du Soleil, de la Lune, et des planètes servent à nommer les jours (comme, par exemple, en anglais, en hindi, ou en quéchua). L'origine de ces deux usages remonte à environ 2 600 années et ensemble expliquent la grande part des noms des jours dans la majorité des langues à travers le monde. Les noms des jours avec des liens religieux spécifiques sont apparus plus récemment, et ils sont généralement limités aux jours qui ont une portée religieuse particulière, surtout le vendredi, le samedi, et le dimanche. La survie des noms d'origine astronomique dans de nombreuses langues même aujourd'hui est remarquable étant donné le passage du temps et les maintes efforts par le passé de supprimer ces vestiges des anciens temps. SEM

## 1. The Origin of the Modern Seven-Day Week

The lunar month, based on the Moon's cycle of phases and containing on the average 29.53 days, was at one time universal in all cultures. Shorter groupings of days also came widely into existence in early agricultural societies in connection with the need to maintain cycles of market days and other recurring socio-economic and religious activities. Market cycles consisted of different numbers of days in different cultures. An eight-day cycle (nundinae), for example, was commonly used in ancient Rome and a ten-day cycle (decades) in ancient Greece. Some eight-day cycles are still in use today in sub-Saharan Africa and probably elsewhere. Most of the earlier non-seven-day cycles were forgotten, however, along with the names of their days, once the present seven-day week had been adopted.

The modern seven-day week, now very nearly universal, appears to have originated in Babylonia some time between the eighth and sixth century BCE (Duncan 1998; O'Neill 1978). The ninth century BCE Babylonian calendar was based on the lunar month, and is known to have had recurring "bad luck" days, which included the 7th, 14th, 21st, and 28th day of each month (Table I). On those days travel was not undertaken, and certain priestly functions, such as divination and healing, were not performed. The Babylonian month being lunar, the four special days corresponded closely (though not exactly) to First Quarter, Full Moon, Last Quarter, and the disappearance of the Moon (New Moon). The Babylonian month therefore contained four seven-day periods, each ending on one of the special days, followed by one or two extra days. It was only a small step to leave out the extra days, making the seven-day cycle continuous and divorced from the lunar cycle.

Table I
Babylonian Lunar Month

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | **7** | ◐ | First Quarter |
| 8 | 9 | 10 | 11 | 12 | 13 | **14** | ○ | Full Moon |
| 15 | 16 | 17 | 18 | 19 | 20 | **21** | ◑ | Last Quarter |
| 22 | 23 | 24 | 25 | 26 | 27 | **28** | ● | New Moon |
| 29 | (30) | | | | | | | |

## 2. Numerical Day Names and the Sabbath

We have no record of when and how the seven-day cycles became continuous. An important contributing event may have been the arrival in Babylon during the reign of Nebuchadnezzar (604–561 BCE) of exiled Judeans, who founded a thriving Jewish community in exile, which lasted many centuries. The Jews made the seven-day week a central feature of their theology. The first chapter of the first book of the Hebrew Bible (Genesis 1) gives an account of the creation of the world in six days, followed by the seventh day on which the Creator rested. In this account the seven days of creation are named numerically, as in Table II. Further along, in Exodus 20, the Bible proclaims the seventh day of the week to be a day of rest for mankind, under the name *Shabbat* in Hebrew, *Shabta* in the closely related Aramaic. The name, known in English as "Sabbath," was most likely derived from *shabattu* or *shapattu*, a Babylonian word for the feast of the Full Moon (O'Neill 1978). The numerical naming convention, based on the Hebrew Bible, is to number the first six days of the week and to give a special name to the seventh.

It has often been suggested that the word *Shabbat* is of numerical origin, being derived from the Hebrew *sheva* "seven," but the differences in the Hebrew spelling of the two words show that the two roots are distinct. It has also been suggested that *Shabbat* is derived from the Hebrew verb meaning "cease, desist, rest" (*shabbat* in the past tense), but it seems more likely that it is the verb that is derived from the noun signifying the day of rest. In all probability, the word *Shabbat* is related to the Babylonian *shabattu* and was originally connected with the Full Moon. Later, the meaning could have been extended to all four lunar phases. We should therefore consider "Sabbath" as an astronomical rather than a numerical name.

The name "Sabbath" was borrowed repeatedly from one language to another until today it occurs, in various modified forms, in very many languages. Most commonly it designates Saturday, but sometimes Sunday, and in some languages it also means "week" (Table III).

Table II
The Day Names in Genesis 1

| Hebrew Bible | Meaning | Aramaic Bible |
|---|---|---|
| Yom Ekhad | "day one" | Yoma Khad |
| Yom Sheini | "day two" | Yom Tinyan |
| Yom Shlishi | "day three" | Yom Tlitai |
| Yom Revii | "day four" | Yom Reviayi |
| Yom Khamishi | "day five" | Yom Khamishayi |
| Yom Hashishi | "day six" | Yom Shetitayi |
| Yom Hasheviyi | "day seven" | Yoma Sheviyaah |

Table III
Some of the Names for Saturday Derived from Babylonian *shabattu*

**ANCIENT LANGUAGES:**

| | | | | | | |
|---|---|---|---|---|---|---|
| About 1000 BCE: | **Babylonian:** | shabattu ("Full Moon") | | | | |
| About 500 BCE: | **Hebrew:** | Shabbat | **Aramaic:** | Shabta | | |
| Middle Ages: | **Latin:** | Sabbatum<br>Sabbati Dies<br>(Sambati Dies) | **Greek**: | Sabbaton<br>(Sambaton) | **Arabic:** | AsSabt |

**MODERN LANGUAGES**:

| | | | | | |
|---|---|---|---|---|---|
| **Spanish:** | Sabado | **French:** | Samedi | **Georgian:** | Shabati[3] |
| **Italian:** | Sabato | **Romanian:** | Sîmbata | **Chechen:** | Shot |
| **Sardo:** | Sappadu | **German:** | Samstag | **Ingush:** | Shoatta |
| **Russian:** | Subbota | **Swabian:** | Samschdich | **Maltese:** | Is Sibt |
| **Ukrainian:** | Subota | **Greek:** | Savvaton | **Hausa:** | Subdu |
| **Czech:** | Sobota | **Hungarian:** | Szombat | **Fula:** | Aset |
| **Polish:** | Sobota | **Farsi:** | Shambeh[3] | **Tuareg:** | Essebtin |
| **Slovene:** | Sobota | **Kyrghiz:** | Ishembi[3] | **Kabyle:** | Sebt |
| **Bizkaian:** | Zapatu | **Azeri:** | Senbe[3] | **Malagasy:** | Asabotsy |
| **Armenian:** | Shapat | **Uzbek:** | Shanba[3] | **Malay:** | Sabtu |
| **Tagalog:** | Sabado | **Tatar:** | Shimba[3] | **Fulfulde:** | Assebdu |
| **Bobangi:** | Sabala | **Pashto:** | Shanba[3] | **Teda:** | Essebdu |
| **Papua:** | Sabat[2] | **Baluchi:** | Shembe[3] | **Harari:** | Sabti |
| **Majel:** | Jabot[2] | **Turkmen:** | Shenbe[3] | **Mandinka:** | Sibitoo |
| **Hebrew:** | Shabbat[3] | **Kazakh:** | Sembi[3] | **Egyptian:** | Essabt |
| **English:** | Sabbath[2] | **Amharic:** | Senbet[1] | **Syrian:** | Issabt |

Notes: [1] Denotes both Saturday and Sunday
[2] Denotes Sunday
[3] Also means "week"

### 3. Astronomical Day Names

The astronomical day-naming convention, in which the seven days are named after the Sun, the Moon, and the five planets known in antiquity, also arose in Babylonia, though it was totally ignored by the Jews. The Babylonians associated the planets with seven of their important deities. The connection between gods and planets was shared by many early cultures. Partly through independent myth-creating processes and partly by borrowing, the names given to the planets in the Greek, Roman, and Hindu civilizations were those of deities roughly analogous to those of the Babylonian gods (Table IV).

The order of the Sun, the Moon, and the planets in the naming of week days may at first seem strange. An explanation has been provided by Dio Cassius, a Christian historian of the third century (O'Neill 1978). According to Cassius, astrologers assigned the 24 hours of every day of the week to the seven moving celestial objects in the specific cyclic sequence Saturn–Jupiter–Mars–Sun–Venus–Mercury–Moon, which is simply in decreasing order of their sidereal periods. In such fashion, Saturn was assigned the 1st, 8th, 15th, and 22nd hours of the first day, and the first hour of the second day fell to the Sun. Each day of the week was then named in honour of the planet to which its *first hour* was assigned, yielding the current sequence Saturn–Sun–Moon–Mars–Mercury–Jupiter–Venus, as summarized in Table V. Roman calendars have been preserved that show the assignment of the twelve hours of each day and night to the seven planets as described by Cassius (Salzman 1990). The hours assigned to the different planets were understood to be good (*bona*), bad (*noxia*), or indifferent (*communis*). The astrological concept of "lucky" and "unlucky" hours has been strongly ingrained in Western culture, going back to antiquity.

While the seven-day week with astronomical day names appears to have been already in use in Babylonia in the reign of Nebuchadnezzar, no direct evidence exists. The early use of the astronomical day names by the Babylonians may be inferred, however, from the fact that the Hebrew name for the planet Saturn, used for example in the Babylonian Talmud, is *Shabbetai*. The name, meaning "related to Sabbath" or "the Sabbath planet," implies that at the time it was coined by the Jews, presumably in the early stages of the Jewish exile in Babylon, the day celebrated as the Jewish Sabbath was dedicated by the Babylonians to Saturn (Babylonian Ninurta).

Table IV
Names of the Divinities given in Antiquity to the Sun, Moon, and Planets

| | Babylonian[1] | Latin | Greek | Sanskrit | Germanic |
|---|---|---|---|---|---|
| Sun | Shamash | Sol | Helios | Surya, Aditya, Ravi | Sun |
| Moon | Sin | Luna | Selene | Chandra, Soma | Moon |
| Mars | Nergal | Mars | Ares | Angaraka, Mangala | Tiw |
| Mercury | Nabu | Mercurius | Hermes | Budh | Wotan |
| Jupiter | Marduk | Iupiter | Zeus | Brihaspati, Cura | Thor |
| Venus | Ishtar | Venus | Aphrodite | Shukra | Freia |
| Saturn | Ninurta | Saturnus | Kronos | Shani | ...[2] |

Notes: [1] Duncan (1998)
[2] Not known

**Table V**
Astronomical Names for the Hours and the Days

| Hour | Day | | | | | | |
|---|---|---|---|---|---|---|---|
| I | Sat | Sol | Luna | Mars | Merc | Jup | Venus |
| II | Jup | Venus | Sat | Sol | Luna | Mars | Merc |
| III | Mars | Merc | Jup | Venus | Sat | Sol | Luna |
| IV | Sol | Luna | Mars | Merc | Jup | Venus | Sat |
| V | Venus | Sat | Sol | Luna | Mars | Merc | Jup |
| VI | Merc | Jup | Venus | Sat | Sol | Luna | Mars |
| VII | Luna | Mars | Merc | Jup | Venus | Sat | Sol |
| VIII | Sat | Sol | Luna | Mars | Merc | Jup | Venus |
| IX | Jup | Venus | Sat | Sol | Luna | Mars | Merc |
| X | Mars | Merc | Jup | Venus | Sat | Sol | Luna |
| XI | Sol | Luna | Mars | Merc | Jup | Venus | Sat |
| XII | Venus | Sat | Sol | Luna | Mars | Merc | Jup |
| XIII | Merc | Jup | Venus | Sat | Sol | Luna | Mars |
| XIV | Luna | Mars | Merc | Jup | Venus | Sat | Sol |
| XV | Sat | Sol | Luna | Mars | Merc | Jup | Venus |
| XVI | Jup | Venus | Sat | Sol | Luna | Mars | Merc |
| XVII | Mars | Merc | Jup | Venus | Sat | Sol | Luna |
| XVIII | Sol | Luna | Mars | Merc | Jup | Venus | Sat |
| XIX | Venus | Sat | Sol | Luna | Mars | Merc | Jup |
| XX | Merc | Jup | Venus | Sat | Sol | Luna | Mars |
| XXI | Luna | Mars | Merc | Jup | Venus | Sat | Sol |
| XXII | Sat | Sol | Luna | Mars | Merc | Jup | Venus |
| XXIII | Jup | Venus | Sat | Sol | Luna | Mars | Merc |
| XXIV | Mars | Merc | Jup | Venus | Sat | Sol | Luna |

### 4. The Spread of the Astronomical Day Names

The spread of the seven-day week over the entire Mediterranean region took place about six centuries later, at the beginning of the Christian Era. One of the factors that may have helped the spread was the dispersal of Jews over the whole Roman Empire, especially after the destruction of the Second Temple in 70 CE. Another factor may have been a rising popular interest in astrology. The common use of the seven-day week with the astronomical day names in the first century CE was clearly shown by the discovery in the excavations in Pompeii of bilingual graffiti containing the Greek and Latin day names given in Table VI (O'Neill 1978). The graffiti must have been scrawled during or before the year 79 CE, when Pompeii was buried under a thick layer of volcanic ash in the eruption of Vesuvius. It is also recorded that the Jews, who first appeared in Rome during the first century BCE, were thought to be worshippers of Saturn (O'Neill 1978). That confirms the fact that the Jewish Sabbath coincided with the Roman *Dies Saturnis*. As Christianity spread across the Roman Empire over the following two centuries, the astronomical day names were apparently already well entrenched. Emperor Constantine legally incorporated the seven-day week into the Roman calendar in the year 321 CE, declaring *Dies Solis* an official day of rest and worship.

### Table VI
Early Astronomical Day Names

| | Latin (79 CE) | Greek (79 CE) | Sanskrit |
|---|---|---|---|
| Sun | Dies Solis | Heliu Hemera | Adityavaara or Ravivaara |
| Moon | Dies Lunae | Selenes Hemera | Somavaara |
| Mars | Dies Martis | Areos Hemera | Angarakavaara or Mangalavaara |
| Mercury | Dies Mercurii | Hermu Hemera | Budhavaara |
| Jupiter | Dies Iovis | Dios Hemera | Brihaspativaara or Curuvaara |
| Venus | Dies Veneris | Aphrodites Hemera | Shukravaara |
| Saturn | Dies Saturnis | Khronu Hemera | Shanivaara |

## 5. The Impact of Christianity

The early Church recognized the pagan origin of the astronomical day names and tried very hard to replace them by a numerical system based on the Bible. The attitude of the Church is shown by the following two passages.

1. Ascribed to Pope Sylvester, 314-335 CE (O'Croinin 1981): "The Blessed Pope thus instructed Christians… that they should not name the seven days of the week according to the pagan custom, but name them instead *Prima Feria i.e. Dominicus, Secunda Feria, Tertia Feria … .*"

2. Ascribed to Caesarius, Bishop of Arles, Fifth Century CE (Holman 1994): "Truly, brothers, we must scorn and reject those filthy names (*ipsa sordissima nomina dedignemur*)… and never say *Dies Martis, Dies Mercurii, Dies Iovis,* … but name the days *Prima Feria, Secunda Feria, Tertia Feria,* … according to what is written in the Bible."

The Church-sponsored terminology generally prevailed in Eastern Europe. The original set of seven astronomical day names in Greek, for example, was replaced by four numerical names for Monday through Thursday, and three religion-related names for Friday, Saturday, and Sunday (Table VII). In contrast, the impact of Christianity on the languages of Western Europe was relatively minor (Table VIII). Five of the seven astronomical day names in Latin were retained through the middle ages, religion-related names being adopted only for Saturday and Sunday. One exception in Western Europe was the adoption of numerical names in Portuguese, which replaced astronomical names altogether. It is not clear why the Church was so uniquely successful in Portugal.

Day names did not undergo any changes in the Romance languages since the early medieval period. The majority still reveal their astronomical origin (Table IX). The word *Dies* ("day"), which was optionally added to Latin day names (*Dies Martis* or *Martis Dies*, or *Martis)*, became incorporated at the beginning of the day names in Catalan (*Dimarts)* and Provençal *(Dimars)*, at the end of the day names in French (*Mardi*) and Italian (*Martedi*), but does not appear at all in Spanish *(Martes),* Romanian *(Marti), or* Sardinian *(Martis).* The history underlying the associated geographic distribution has been much discussed (Holman 1994; Dardel 1996).

### Table VII
Impact of Christianity on Greek Day Names

| Pre-Christian Greek | | Modern Greek | |
|---|---|---|---|
| Sunday | Heliu[1] | Kyriake | ("Lord's day") |
| Monday | Selenes[1] | Deftera | (2) |
| Tuesday | Areos[1] | Triti | (3) |
| Wednesday | Hermu[1] | Tetarti | (4) |
| Thursday | Dios[1] | Pempti | (5) |
| Friday | Aphrodites[1] | Paraskevi | ("preparation") |
| Saturday | Khronu[1] | Savvaton[1] | (from *Sabbaton*) |

Notes: [1] Name of astronomical origin

### Table VIII
Impact of Christianity on Latin Day Names

| Pre-Christian Latin | Church Usage | Medieval Latin | Modern Spanish | Modern Portuguese |
|---|---|---|---|---|
| Dies Solis[1] | Dominica | Dominica | Domingo | Domingo |
| Dies Lunae[1] | Secunda Feria | Lunis[1] | Lunes[1] | Segunda-feira |
| Dies Martis[1] | Tertia Feria | Martis[1] | Martes[1] | Têrça-feira |
| Dies Mercurii[1] | Quarta Feria | Mercuris[1] | Miércoles[1] | Quarta-feira |
| Dies Iovis[1] | Quinta Feria | Iovis[1] | Jueves[1] | Quinta-feira |
| Dies Veneris[1] | Sexta Feria | Veneris[1] | Viernes[1] | Sexta-feira |
| Dies Saturnis[1] | Sabbatum[1] | Sabbata[1] | Sábado[1] | Sábado[1] |

Notes: [1] Name of astronomical origin

### Table IX
Day Names in Some Romance Languages

| | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|---|
| Late Latin | Dominica | Lunis[1] | Martis[1] | Mercuris[1] | Jovis[1] | Veneris[1] | Sabatu[1] |
| French | Dimanche | Lundi[1] | Mardi[1] | Mercredi[1] | Jeudi[1] | Vendredi[1] | Samedi[1] |
| Italian | Domenica | Lunedi[1] | Martedi[1] | Mercoledi[1] | Giovedi[1] | Venerdi[1] | Sabato[1] |
| Spanish | Domingo | Lunes[1] | Martes[1] | Miércoles[1] | Jueves[1] | Viernes[1] | Sábado[1] |
| Romanian | Duminică | Luni[1] | Marti[1] | Miercuri[1] | Joi[1] | Vineri[1] | Simbătă[1] |
| Sardinian | Duminica | Lunis[1] | Martis[1] | Merculis[1] | Zobia[1] | Chenapura | Sappadu[1] |
| Catalan | Diumenge | Diluns[1] | Dimarts[1] | Dimecres[1] | Dijous[1] | Divendres[1] | Dissabte[1] |
| Provençal | Dimenge | Diluns[1] | Dimars[1] | Dimercres[1] | Dijous[1] | Divenres[1] | Disapte[1] |

Notes: [1] Name of astronomical origin

## 6. Day Names in German, Celtic, and Balto-Slavic Languages

Germanic languages adopted the astronomical day names in pre-Christian or early Christian times. *Dies Solis* and *Dies Lunae* were simply translated as "Sun-day" and "Moon-day," while the names of the five planets were given the names of Germanic deities, substituted for those of the Roman gods (Table X). In Old English all seven days bore astronomical names, while in Old High German and Old Norse only six days did, the exception being Saturday, which was replaced at an early date by *Sambaztag* (from Greek *Sambaton* and ultimately from Babylonian *shabattu*) and *Laugardagr* (meaning "bath-day") respectively. Later, under Church influence, German *Wodenstag* was replaced by *Mittawecha "mid-week,"* which later became *Mittwoch*, but the other astronomical day names remained. Only in Icelandic did a more substantial replacement of astronomical names occur. Sunday and Monday were retained, but the names of the other days were replaced by numbers (Tuesday and Thursday) or by other church-approved terms (Table XI). The renaming of Wednesday as the "mid-week day" (German *Mittwoch* and Icelandic *Miðvikudagur*) follows the popular late Latin *Media Hebdoma*, still found regionally as Tuscan *Mezzedima*, Dolomite *Mesaledema*, and Dalmatian *Misedma* (Holman 1994). Names for Wednesday signifying "mid-week day" were also coined in all Slavic languages, as well as in Finnish and Estonian.

Celtic languages fall into two distinct groups (Table XII). Breton and Welsh were subjected to early Romanization, and borrowed all seven astronomical day names from pre-Christian Latin. Several centuries later, the Scots and Irish acquired only three of the original seven Roman astronomical names (Monday, Tuesday, and Saturday), adopting religion-related names for the other four days.

The Slavs were gradually converted to Christianity during the years 863 to 988, and adopted a single set of day names now used over a very wide area. The uniformity of Slav day names (Table XIII) is remarkable, in view of the fact that the Slavs spoke more than a dozen mutually unintelligible dialects and came under the influence of either the Western Church or the Eastern Church. The names used in Ukrainian, Belarus, Slovak, Sorbian, Serbo-Croat, and Slovene are very similar to the ones listed in Table XIII. The set of names, clearly coined under a strong Church influence, contains special names for Saturday and Sunday, the remaining days being numbered. The name for Sunday, *Niedziela* in Polish, means "no work" or "no activity." Analogous names have been coined in Manx (*Yn Doonaght*) and in some Amerindian languages. The name for Wednesday, Środa ("middle"), follows *Mittwoch*, *Miðvikudagur* and *Media-Hebdoma*. The persistence of the same set of names in so many languages for over 1000 years is remarkable. The only innovation during that period has been the replacement of the early Russian word for Sunday, *Nyedyelya* ("no-work"), by the current *Voskresyenye* ("resurrection"). (*Nyedyelya* is still used in Russian to mean "week," however.) The replacement of *Nyedyelya* by *Voskresyenye* represents a substitution of one religion-related name by another. There are no astronomical names in Slavic languages, except for *Sobota* (Saturday).

The Balts were Christianized later than the Slavs (1259–1385). The Lithuanian and Latvian day names (not shown) are entirely numerical, except for Sunday, called "holy day." The Balts have no equivalent for *Środa* or *Niedziela* and, unlike the Slavs, simply number Saturday as the sixth day, their numbering starting with Monday.

### Table X
Early Germanic Day Names

| Pre-Christian Latin | Old High German | Old English | Old Norse |
|---|---|---|---|
| Dies Solis[1] | Sunnuntag[1] | Sunnandaeg[1] | Sunnundagr[1] |
| Dies Lunae[1] | Mānetag[1] | Mónandaeg[1] | Mánadagr[1] |
| Dies Martis[1] | Ziestag[1] | Tiwesdaeg[1] | Tysdagr[1] |
| Dies Mercurii[1] | Wodenstag[1] | Wódnesdaeg[1] | Óðensdagr[1] |
| Dies Iovis[1] | Donerestag[1] | Thunresdaeg[1] | Thorsdagr[1] |
| Dies Veneris[1] | Friatag[1] | Frigedaeg[1] | Friádagr[1] |
| Dies Saturnis[1] | Sambaztag[1] | Saternesdaeg[1] | Laugardagr |

Notes: [1]Name of astronomical origin

### Table XI
Later Developments in Germanic Day Names

| Dutch | German | Swedish | Icelandic |
|---|---|---|---|
| Zontag[1] | Sonntag[1] | Söndag[1] | Sunnudagur[1] |
| Maandag[1] | Montag[1] | Måndag[1] | Mánudagur[1] |
| Dinsdag[1] | Dienstag[1] | Tisdag[1] | þriðjudagur ("third-day") |
| Woendag[1] | Mittwoch ("mid-week") | Onsdag[1] | Miðvikudagur ("mid-week-day") |
| Donderdag[1] | Donnerstag[1] | Torsdag[1] | Fimmtudagur ("fifth-day") |
| Vrijdag[1] | Freitag[1] | Fredag[1] | Föstudagur("fast-day") |
| Zaterdag[1] | Sonnabend[1] | Lördag | Laugardagur ("bath-day") |

Notes: [1] Name of astronomical origin

### Table XII
Day Names in Some Celtic Languages

| Latin | Breton | Welsh | Irish Gaelic | Scots Gaelic |
|---|---|---|---|---|
| Dies Solis[1] | Sul[1] | DyddSul[1] | AnDomhnach | Di-Domnaich (*Dominica*) |
| Dies Lunae[1] | Lun[1] | DyddLlun[1] | AnLuan[1] | Di-Luain[1] |
| Dies Martis[1] | Meurz[1] | DyddMawrth[1] | AnMháirt[1] | Di-Màirt[1] |
| Dies Mercurii[1] | Marker[1] | DyddMercher[1] | AnChéadaoin | Di-Ciadaoin ("first-fast") |
| Dies Iovis[1] | Diryaou[1] | DyddIau[1] | AnDéardaoin | Di-Ardaoin (?) |
| Dies Veneris[1] | Gwener[1] | DyddGwener[1] | AnAoine | Di-Haoine ("fast") |
| Dies Saturnis[1] | Sadorn[1] | DyddSadwrn[1] | AnSatharn[1] | Di-Sathurn[1] |

Notes: [1] Name of astronomical origin

Table XIII
Day Names in Some Slavonic Languages

| Polish | Czech | Bulgarian | Macedonian | Russian |
|---|---|---|---|---|
| Niedziela[1] | Neděle[1] | Nedelja[1] | Nedela[1] | Voskresyenye[2] |
| Poniedziałek | Pondělí | Ponedelnik | Ponedelnik | Ponyedyelnik ("after-niedziela") |
| Wtorek | Úterý | Vtornik | Vtornik | Vtornik ("second") |
| Środa | Středa | Sryada | Sreda | Sreda ("middle") |
| Czwartek | Čtvrtek | Chetvyrtyk | Chetvrtok | Chetverg ("fourth") |
| Piątek | Pátek | Petyak | Petok | Pyatnitsa ("fifth") |
| Sobota[3] | Sobota[3] | Sobota[3] | Sobota[3] | Subbota[1](from Latin Sabbata) |

Notes: [1]"no-work"
[2]"Resurrection"
[3]Name of astronomical origin

### 7. Day Names in Other European Languages

Estonians and Finns live in close proximity, and the two languages are closely related but use very different day names. Finnish has simply borrowed the Scandinavian set of astronomical names, while Estonian has borrowed only the names of Friday and Saturday, the other days being named according to a numerical system that recalls the Slavic model (Table XIV).

Hungarian day names (Table XV) include only one of clearly astronomical origin, *Szombat* (Saturday), borrowed from Greek *Sambaton*.

Basque day names (Table XV) are interesting in that they contain a possible trace of an ancient three-day week. Such a short week is implied by the names for Monday, Tuesday, and Wednesday (*Astelehen, Astearte, Asteazken*). The etymology of several other Basque names is uncertain and they could be of astronomical origin. *Ortzegun* (Thursday), for example, could have meant either "sky-day" or "thunder-day," so it may have been named after Jupiter (Trask 1998).

Albanian day names (Table XV) are largely astronomical. The names for Tuesday, Wednesday, and Saturday are derived from Mars, Mercury, and Saturn, while the names for Sunday and Monday carry the Albanian words for "Sun" and "Moon." The names of Thursday and Friday, *Enjte* and *Prémte*, are of uncertain etymology and may also be astronomical.

The languages of the Caucasus region belong to several unrelated language families, but they have all borrowed the Hebrew *Shabbat* or Aramaic *Shabta* for Saturday (Table XVI). Armenian and Georgian also use *shapti* or *shabati* as a counter (meaning "week") to form the names of Monday through Thursday. Most of the day names in the two languages therefore contain the root *shabbat* of astronomical origin. The names for Monday through Thursday are numerical, and those for Friday and Sunday are religion-related, borrowed from medieval Greek. For Monday, Chechen and Ingush have apparently borrowed the Georgian *Orshabati*, or "day two," but they call Tuesday *Shinara*, which also means "two" in their own language. There are many examples of this type of confusion involving separate day-counting systems.

Table XIV
Day Names in Estonian and Finnish

| Old Norse | Finnish | Estonian |
|---|---|---|
| Sunnundagr[1] | Sunnuntai[1] | Pühapäev (*püha* = holy, *päev* = day) |
| Mánadagr[1] | Maanantai[1] | Esmaspäev ("first-day") |
| Tysdagr[1] | Tiistai[1] | Teisipäev ("second-day") |
| Óoendagr[1] | Keskiviikko | Kesknädal ("mid-week") |
| Thorsdagr[1] | Torstai[1] | Neljapäev ("fourth-day") |
| Friadagr[1] | Perjântai[1] | Reěde[1] (from Friadagr) |
| Laugardagr | Lauantai | Laupäev ("bath-day") |

Notes: [1]Name of astronomical origin

### 8. Islamic Day Names

Under Islam, Friday became the all-important day of the week and has been named *Juma'a*, "assembly" in Arabic. Islam has also borrowed the name of Sabbath from Hebrew or Aramaic for the seventh day of the week, *As Sabt* in Arabic ("*As*" is the Arabic article "*al*," with "*l*" assimilated to "*s*"). That is the only day name of astronomical origin. For the other days, Arabic adopted the numerical system of day naming, closely following the Hebrew Bible (Table XVII).

In many languages in the Islamic world, the day names were borrowed from Arabic. The word *yaum* (day) was usually omitted, but the Arabic article "*Al*" was often retained (Table XVIII).

Not all Islamic day names are borrowed from Arabic. In modern Persian (Farsi) only one day name is borrowed from Arabic, *Juma'a* (Friday). The other days are numbered in a system analogous to that in Armenian and Georgian (Table XVI) that uses a numeral plus *shambeh*, a counter meaning "week," borrowed from Greek *Sambaton*, ultimately from Babylonian *shabattu*. Table XIX indicates some of the Persian day names adopted by Indo-European languages closely related to Persian, like Kurdish, Baluchi, and Tajik, or by entirely unrelated Turkic languages like Uzbek, Kyrghyz, Uighur, Kazakh, Turkmen, Bashkir, Tatar or Turkish.

**Table XV**
Day Names in Hungarian, Basque and Albanian

| Hungarian | Basque | Albanian |
|---|---|---|
| Vasárnap ("market-day") | Igande ("resurrection"?) | Diel[1] ("Sun") |
| Hétfö ("week-head") | Astelehen ("week-first") | Hënë[1] ("Moon") |
| Kedd (?) | Astearte ("week-middle") | Martë[1] ("Mars") |
| Szerda ("middle" Slavic) | Asteazken ("week-last") | Mërkurë[1] ("Mercury") |
| Csütörtök (4, Slavic) | Ortzegun[2] ("sky-day") | Enjte[2] (?) |
| Péntek (5, Slavic) | Ortzirale[2] ("sky"-?) | Prémte[2] (?) |
| Szombat[1] ("Sambaton") | Larunbat[2] (?) | Shtunë[2] ("Saturn"?) |

Notes: [1] Name of astronomical origin
[2] Name possibly of astronomical origin

**Table XVI**
Day Names in Four Languages of the Caucasus

| Armenian | Georgian | Chechen | Ingush |
|---|---|---|---|
| Giragi | K'wira | K'irande | K'irandi (Greek *Kyriake)* |
| Yergushapti (2) | Orshabati (2) | Orshot (2) | Oarshuot (2) |
| Yerekshapti (3) | Samshabati (3) | Shinara (2) | Shinara (2) |
| Chorekshapti (4) | Otkhshabati (4) | Qaara (3) | Qeara (3) |
| Hinkshapti (5) | Khutshabati (5) | Eara (4) | Jiera (4) |
| Urpat | P'arask'evi | P'eraska | Ruzba (Greek *Paraskevi*) |
| Shapat | Shabati | Shot | Shoatta ("Sabbath") |

**Table XVII**
Day Names in Modern Arabic

| Day | Name | Meaning |
|---|---|---|
| Sunday | Yaum Al-Ahad | "day one" |
| Monday | Yaum Al-Itsnain | "day two" |
| Tuesday | Yaum At-Tsoulatsa | "day three" |
| Wednesday | Yaum Al-Arbaa | "day four" |
| Thursday | Yaum Al-Khamiis | "day five" |
| Friday | Yaum Al-Joumaa | "day of assembly" |
| Saturday | Yaum As-Sabt | "day of Sabbath" |

**Table XVIII**
Some Numerical Day Names Borrowed from Arabic

| Language | Sunday | Monday | Tuesday | Wednesday | Thursday |
|---|---|---|---|---|---|
| **Arabic** | Al-Ahad | Al-Itsnain | Al-Tsoulatsa | Al-Arbaa | Al-Khamiis |
| **Maltese** | Il-Hadd | It-Tnejn | It-Tlieta | L-Erbgħa | Il-Ħamis |
| **Harari** (Ethiopia) | Alkhad | Isniin | Säläsa | Arba'a | Khamiish |
| **Somali** | Akhad | Isniin | Talaado | Arbaco | Khamiis |
| **Tuareg** (Sahara) | Elkhedden | Lîtniten | Ettenâtetîn | Inardâten | Elremîsen |
| **Kabyle** (Algeria) | Elkhad | Tnain | Tlata | Elarbâa | Khmis |
| **Amharic** (Ethiopia) | Ikhud | Senio | Makseniu | Rebuu | Khamus |
| **Hausa** (Nigeria) | Lahadi | LÌtÌnī n | Tàlata | Laraba | Alhamis |
| **Bahasa Malasia** | Ahad | Isnin | Selasa | Rabu | Kamis |
| **Maranao** (Phil.) | Akad | Isnin | Salasa | Arbaqa | Hamis |
| **Indonesian** | Ahad | Senin | Selasa | Rabu | Kamis |
| **Javanese** (Indon.) | Ngahad | Senèn | Selôsô | Rebo | Kemés |
| **Malagasy** (Madag.) | Alahady | Alatsinainy | Atalata | Alarobia | Alakamisy |
| **Mandinka** (Gambia) | Alahadoo | Tenan | Talatoo | Araboo | Araamisoo |

Table XIX
Some Day Names Borrowed from Persian

| Language | Sunday | Monday | Tuesday | Wednesday | Thursday | Saturday |
|---|---|---|---|---|---|---|
| Farsi | Yekshambeh | Doshambeh | Seshambeh | Chaharshambeh | Panjshambeh | Shambeh |
| Kurdish | Yekshemmé | Dushemmé | Seshemmé | Chwarshemmé | Penjshemmé | Shemme |
| Baluchi | Yekshembe | Dwshembe | Seyshembe | Charshembe | Penchshembe | Shembe |
| Tajik | Yakshanbe | Dushanbe | Seshanbe | Chorshanbe | Panjshanbe | Shanbe |
| Uzbek | Yakshanba | Dushanba | Seshanba | Chorshanba | Panjshanba | Shanba |
| Kyrghiz | Jekshembi | Düyshümbü | Sheyshembi | Charshembi | Beyshembi | Ishembi |
| Uighur | Yäkshänbä | Düshänbä | Sayshänbä | Charshänbä | Päyshänbä | Shänbä |
| Kazakh | Jekshembi | Düysembi | Seysembi | Särsembi | Beysembi | Sembi |
| Turkmen | Ekshenbe | Düshenbe | Siishenbe | Charshenbe | Penshenbe | Shenbe |
| Bashkir | Yäkshämbe | Düshämbe | Shishämbe | Shärshambe | Kesadna[1] | Shämbe |
| Tatar | Yäkshämbe | Dushämbe | Sishämbe | Chärshämbe | Pänjshämbe | Shimbä |
| Turkish | Pazar[1] | Pazartesi[1] | Sali | Çarşamba | Perşembe | Cumartesi[1] |

Notes: [1] Non-Persian name

## 9. Day Names in Other Non-European Languages

The astronomical day names spread to India in pre-Christian times. Variants of Sanskrit day names (*Adityavaara*, *Somavaara*, ...) are used today in all the Indo-European languages of India, in many of the unrelated Dravidian languages like Telugu and Tamil, and also in the Mon-Khmer languages of Indochina, including Cambodian, Lao, and Thai (Table XX), as well as in the Batak dialects of Sumatra.

Many of the Bantu languages of southern Africa borrowed the name of Sunday from English, and it is their only day name of astronomical origin. For the other days they developed a numerical system, starting the day count with Monday (Table XXI). Swahili is exceptional. Under the Islamic influence, it named Friday *Ijumaa* and numbered the other days of the week, starting the count with Saturday so that its numbering is at odds with that of the other Bantu languages. Wednesday in Swahili is *Jumatano*, which contains the numeral *tano* (five). For Thursday, Swahili borrowed the Arabic name *Alhamisi*, so that it has two consecutive days named "the fifth day," another confusion of separate day-counting systems.

Modern Chinese uses a numerical system of day naming for Monday through Saturday, but Sunday is given an astronomical name, containing "Sun" in Cantonese and "sky" in Mandarin (Table XXII).

Japanese and Quechua are two unrelated languages, half a world apart. They have both independently adopted day names following the astronomical convention (Table XXIII), however. The first two days follow the convention explicitly, "Sun-day" and "Moon-day" in both languages. In Quechua, the language of the Inca empire still spoken in Peru and Bolivia, the series continues with other sky-related names, where "wizard" could probably be translated "astronomer." In Japanese, the series continues with the five elements that were believed to make up the physical world.

In many languages around the world, the seven-day week was adopted and the seven day-names borrowed from the language of cultural colonizers. The languages that have frequently served as a source of such borrowings are Arabic, Russian, Persian, English (Table XXIV), Spanish (Table XXV), and French (Table XXVI). In some languages all seven day names have been borrowed, as in Majel (Table XXIV), Tzotzil (Table XXV), or Michif (Table XXVI). In other languages only some of the names have been borrowed, native names having been developed for the remaining days, as in Tongan and Maori (Table XXIV) or in Carrier (Table XXVI). The names borrowed from Russian and Arabic are largely numerical, but those borrowed from English, Spanish, and French are mostly astronomical.

## Table XX
Astronomical Day Names Borrowed from Sanskrit

| | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|---|
| **Sanskrit** | Aditya or Ravi ("Sun") | Soma ("Moon") | Mangala or Angaraka ("Mars") | Budha ("Mercury") | Brihaspati or Curu ("Jupiter") | Shukra ("Venus") | Shani ("Saturn") |
| **Hindi** | Ravivaar | Somvaar | Mangalvaar | Budhvaar | Brihaspativaar | Shukravaar | Shanivaar |
| **Marathi** | Rawiwar | Somwar | Mangalwar | Budhwar | Gurwar | Shukrawar | Shaniwar |
| **Bengali** | Robibar | Shombar | Mongalbar | Budhbar | Brihaspatibar | Shukrabar | Shonibar |
| **Assamese** | Rabibar | Hombar | Mangalbar | Budhbar | Brihaspatibar | Hukurbar | Hanibar |
| **Panjabi** | Aitwaar | Somwaar | Mangalwaar | Budhwaar | Wiirwaar | Shukkarwaar | Haftaa[1] |
| **Urdu** | Itwaar | Piir[1] | Mangal | Budh | Jumaraat[1] | Juma[1] | Sanichar |
| **Telugu** | Aadivaaram | Somavaaram | Mangalvaaram | Budhavaaram | Guruvaaram | Shukruvaaram | Sanivaaram |
| **Cambodian** | Tngay-Qaattit | Tngay-Chun | Tngay-Ong'kea | Tngay-Puut | Tngay-Prohoa | Tngay-Sok | Tngay-Saw |
| **Lao** | Wan-Aathit | Wan-Jan | Wan-Angkhan | Wan-Phut | Wan-Phahat | Wan-Suk | Wan-Sao |
| **Thai** | Wun-Ahtit | Wun-Jun | Wun-Umgkahn | Wun-Poot | Wun-Pareuhut | Wun-Sook | Wun-Sao |

Notes: [1] Non-Sanskrit name

## Table XXI
Day Names in Some Bantu Languages

| Shona (Zimbabwe) | Zulu (Southern Africa) | Bemba (Zambia) | Tonga (N. Zimbabwe) | Swahili (Eastern Africa) |
|---|---|---|---|---|
| Svondo[1] | iSonto[1] | Mulungu | Nsondo[1] | Jumapili (2) |
| Muvhuro | uMsombuluko | Cimo (1) | Musumbuluko | Jumatatu (3) |
| Chipiri (2) | oLwesibili (2) | Cibili (2) | Bwabili (2) | Jumanne (4) |
| Chitatu (3) | oLwesithatu (3) | Citatu (3) | Bwatatu (3) | Jumatano (5) |
| China (4) | oLwesine (4) | Cine (4) | Bwane (4) | Alhamisi (Arabic, 5) |
| Chisanu (5) | oLwesihlanu (5) | Cisano (5) | Bwasanu (5) | Ijumaa (Islamic) |
| Mugovera | iMigqibelo | Cibelushi (6?) | Mujibelo | Jumamosi (1) |

Notes: [1] Name of astronomical origin

## Table XXII
Day Names in Mandarin

| Day | Name | Meaning |
|---|---|---|
| Sunday | Xing"qi"tian | "week-sky" |
| Monday | Xing"qi"yi" | "week-1" |
| Tuesday | Xing"qi"er` | "week-2" |
| Wednesday | Xing"qi"san" | "week-3" |
| Thursday | Xing"qi"si` | "week-4" |
| Friday | Xing"qi"wu$^{v}$ | "week-5" |
| Saturday | Xing"qi"liu` | "week-6" |

### Table XXIII
Day Names in Japanese and Quechua

| Day | Japanese | Quechua |
|---|---|---|
| Sunday | Nichiyoobi ("Sun-day") | Intichay ("Sun-day") |
| Monday | Getsuyoobi ("Moon-day") | Killachay ("Moon-day") |
| Tuesday | Kayoobi ("fire-day") | Atipachay ("wizard-day") |
| Wednesday | Suiyoobi ("water-day") | Qoyllurchay ("star-day") |
| Thursday | Mokuyoobi ("wood-day") | Ch'askachay ("Venus-day") |
| Friday | Kinyoobi ("gold-day")[1] | Illapachay ("lightning-day") |
| Saturday | Doyoobi ("earth-day") | K'uyichichay ("rainbow-day") |

Notes: [1] Or "metal-day"

### Table XXIV
Some Day Names Borrowed from English

| Papua-Pidgin (Torres-Strait) | Papua-Pidgin (Port-Moresby) | Tongan | Majel (Marshall Islands) | Maori (New Zealand) |
|---|---|---|---|---|
| Sande | Sande | Sapate | Jabot | Ratapu[1] ("holy-day") |
| Mande | Mande | Monite | Manre | Mane |
| Tyuzde | Tunde | Tusite | Juje | Turei |
| Wenezde | Trinde | Pulelulu[1] | Wonje | Wenerei |
| Tazde | Fonde | Tuapulelulu[1] | Taije | Taite |
| Praide | Fraide | Falaite | Balaire | Paraire |
| Satade | Sarere | Tokonaki[1] | Jarere | Rahoroi[1] ("clean-day") |

Notes: [1] Name not borrowed from English

### Table XXV
Some Day Names Borrowed from Spanish

| Tzotzil (Mexico) | Papago-Pima (Arizona) | Papiamentu (Curaçao) | Chamorro (Marianas) | Tagalog (Philippines) |
|---|---|---|---|---|
| Rominko | Domig | Djadumingu | Damenggo | Linggo |
| Lunes | Luhnas | Djaluna | Lunes | Lunes |
| Martes | Mahltis | Djamars | Mattes | Martes |
| Melkukes | Mialklos | Djarason[1] | Metkoles | Miyerkules |
| Hweves | Huiwis | Djaweps | Huebes | Huwebes |
| Byernes | Wialos | Djabierne | Betnes | Biyernes |
| Savaro | Shawai | Djasabra | Sabalu | Sabado |

Notes: [1] Origin uncertain

### Table XXVI
Some Day Names Borrowed from French

| Haiti Creole | Michif (N.Dakota) | Carrier (Central BC) | Esperanto (Invented 1887) |
|---|---|---|---|
| Dimanche | Jimawnsh | Dimosdzin (*dzin* = "day") | Dimanĉo |
| Lindi | Laenjee | Landi | Lundo |
| Madi | Marjee | Whulhnatdzin[1] (*nat* = 2) | Mardo |
| Mecredi | Mikarjee | Whulhtatdzin[1] (*tat* = 3) | Mercredo |
| Jodi | Zhweejee | Whulditdzin[1] (*dit* = 4) | Jaudo |
| Venneredi | Vawndarjee | ...[2] | Vendredo |
| Sâmedi | Samjee | Sumdi | Sabato[1] |

Notes: [1] Name not borrowed from French
[2] Name not in dictionary

## 10. Conclusions

The ancient planetary names of the days of the week still survive in many of the world's languages. The survival is remarkable, in view of the many past efforts to eradicate such relics of our ancient past. The form of the names has undergone such changes with the passage of time, however, that today's speakers are usually unaware of their astronomical origin.

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## TIME IN BIBLE TIMES

You move into a different time-world from ours when you open your Bible. You find yourself in a much more leisurely atmosphere, where exact time measurements are unknown and the calendar a very casual affair. A modern city-dweller, living in this mechanized age when minutes are important and when speed contests and radio have accustomed us to split-second timing, is surprised to learn that the words “minute” and “second” are not found anywhere in the Bible. The patriarchs of the Old Testament and even the disciples of Jesus were time-wealthy and had no use for such small change. When hours, days, weeks, months, and years are mentioned in the Scriptures, they seldom correspond exactly to our divisions of time with the same names.

Neither the word “calendar” nor the word “clock” is used in the Bible. Only one sundial is mentioned, and that belonged to a king. It was on this dial of King Ahaz that the prophet Isaiah is said to have caused the shadow to move backward 10 degrees as a sign to King Hezekiah. The story itself bears eloquent testimony to the naive ideas about time that then prevailed. Nobody in Isaiah’s day realized that the Earth would have to reverse its motion if the shadow on the dial were to move backward. No one even dreamed that the result of such a reversal, had it really occurred, would have been a tidal wave that would have wiped Isaiah, King Hezekiah, the sundial, and all the inhabitants of Palestine out of existence!

Today “time marches on” inevitably by regular measured steps, but in Bible days, for all that even the wisest men knew, time might loiter, stop altogether, or even go backward. There was nothing incongruous to them in the thought of Joshua commanding the Sun to stand still until Israel was avenged of her enemies. They were blissfully unaware of the catastrophe to the whole solar system that would have ensued.

* * * * *

The week is not very important in the Bible. It is mentioned only 26 times, while the month is referred to 250 times, the year 884 times, and the day 2,852 times. You would think that the week would be important, because it was popularly supposed that the seven-day week was ordained by Jehovah himself when he created the world in six days and rested on the seventh, thus establishing the Sabbath. But it is extremely probable that the Jews adopted the seven-day week, including the Sabbath, from the Babylonians, who probably got it from the four phases of the Moon. Scholars are inclined to think that the Hebrew week was not derived from the Creation narrative, but vice versa.

In the Old Testament, the word for week is “shabua,” from “sheba,” the Hebrew word for seven. In the New Testament, it is “sabbaton” or “sabbata,” meaning “from Sabbath to Sabbath.” The days of the week were not named like our Sunday, Monday, etc., but were numbered, save the seventh, the Sabbath. Since the week was also named the sabbath, there is some confusion in certain passages. The afternoon of the sixth day (our Friday afternoon) had a name of its own, “the preparation,” since at that time the Jews were preparing for the Sabbath. Our Sunday was known as “the morrow after the Sabbath” or as “the first day of the week” until the very end of the Bible, where we find the first use of a new name for it which later became very popular in the apostolic Christian Church. In Revelation 1:10 the author says, “I was in the Spirit on the Lord’s day.” Even today many Christians prefer that name to Sunday, which they consider an unwarranted concession to heathen sun worship. It was on “the first day of the week” that the Bible says that Jesus rose from the dead, so that day was chosen as particularly His.

* * * * *

by Charles Francis Potter,
from *Journal*, Vol. 35, pp. 163–168, April, 1941.

# THE LEEDS, QUEBEC METEORITE: ITS STRANGE HISTORY AND A RE-EVALUATION OF ITS IDENTITY[1]

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**Abstract.** The Leeds iron meteorite, recognized in 1931 by H. H. Nininger in the Université Laval mineralogical collections as a mislabeled magnetite specimen, has been noted for its similarity to Toluca. Analyses for 13 diagnostic trace and minor elements are available for 21 Toluca samples and 2 Leeds samples. The two data sets were subjected to statistical analysis in order to test the hypothesis that Toluca and Leeds are indistinguishable. The results reveal that Toluca and Leeds are statistically indistinguishable with respect to all 13 elements, and it is concluded that Leeds is a Toluca fragment. Historical research does not reveal where the original Leeds specimen was found or how it was initially acquired, but it was likely acquired from abundantly available Toluca material.

**Résumé.** La météorite ferreuse de Leeds des collections minéralogiques de l'université Laval, reconnue par H. H. Nininger en 1931 comme étant un spécimen magnétite mal étiqueté, présente des ressemblances à la météorite Toluca. Des analyses de 13 éléments mineurs et traces diagnostiques sont disponibles pour 21 échantillons de la météorite Toluca et pour celle de Leeds. Les deux séries d'échantillons ont été assujetties à des analyses statistiques afin d'évaluer l'hypothèse que les deux météorites sont indiscernables l'une de l'autre. Les résultats indiquent que les météorites de Toluca et de Leeds sont du point de vue statistique indifférenciables sur la base de tous les 13 éléments, et donc il faut conclure que la météorite de Leeds est bien un fragment de celle de Toluca. Les recherches historiques ne révèlent ni où le spécimen Leeds a été trouvé, ni comment il a été acquis, mais il provient tout probablement du matériel abondant toujours disponible de la météorite de Toluca.
SEM

## 1. Introduction

Although no new meteorites from Quebec had been recovered since prior to the Second World War, the last decade of the Twentieth Century has been extraordinarily fruitful owing to the St-Robert (H5) fall of 14 June 1994 (Hildebrand *et al.* 1997) and the identification of the Lac Dodon and Penouille irons in 1995 (Kissin *et al.* 1997). These three additions to Quebec's meteorite count, along with the Chambord and Leeds irons, bring the total to five, however, the total is offset by the loss of one, the Leeds (group IAB) iron, which we demonstrate here to be a Toluca specimen.

Suspicions about Leeds arose during examination of trace and minor data from group IAB iron meteorites presented by Choi *et al.* (1995). Tabulations in order of nickel, gallium and iridium content reveal that the elements are nearly identical in Toluca and Leeds, and a comparison of tabulated data for 12 elements reveals that the mean abundances for Leeds ($n = 2$) and Toluca ($n = 7$) are very similar in all cases. As discussed below, the structural and petrographic characteristics of Leeds and Toluca are also very similar.

Such compositional and petrographic similarities in themselves might still leave open the possibility that Leeds is distinct from Toluca if the circumstances of its recovery were well established. Leeds has a strange history, however, which leaves its origins unresolved.

## 2. Historical Background

The Leeds iron was first recognized as a meteorite in 1931 by Harvey Nininger, the world's first full-time, self-employed meteoriticist and co-founder (along with Frederick Leonard) of the Society for Research on Meteorites, the precursor of the Meteoritical Society. At the time of its recognition, Nininger had just given up his position as Professor of Biology at McPherson College in Kansas, was struggling to make a living from his new career, and found it necessary to travel far and wide in search of meteorites for sale or trade. As he did so, he frequently visited geological museums along the way to view their mineralogical collections. On such a trip to Canada, he stopped at the Mineralogical Museum at the Université Laval, reputed to be one of the finest in North America. Laval had been founded in 1852, and benefited from various gifts from the Séminaire de Québec. Among them were scientific instruments, a library, and several museums. As early as 1858 there were close to 4,000 specimens in the Mineralogical Museum,

[1] An earlier draft of this paper was presented at the Research Session of the 1997 meeting of the Meteorites and Impacts Advisory Committee to the Canadian Space Agency, held in October, 1997, in St-Hubert, Quebec.

half of which had been donated by the Geological Survey of Canada. Numerous individuals and institutions donated specimens in subsequent years, making the Laval collection a very strong one. As Nininger (Nininger & Nininger 1950, p. 112; Nininger 1972, p. 111) relates in the story of his 1931 visit, he wandered up an aisle looking over the mineral cases, and happened to notice in the display of heavier iron minerals a 1445g mass which bore a label reading "magnetite from Leeds, Québec." Although Leeds (now St-Jacques-de-Leeds, Comté Mégantic) is known to be a source of magnetite, which occurs in the Appalachian fold belt (R. K. Herd, private communication), Nininger thought that this particular specimen looked like a weathered nickel-iron meteorite.

When he asked permission to examine the specimen, the custodian testily informed him that "there could be no error in the labeling since the curator was one of the top mineralogists of North America." The curator in question was l'abbé Alexandre Vachon, who served in that role from 1917 to 1936. Although he taught mineralogy and geology courses at Laval from as early as 1914, he was primarily a chemist; he was the author of a standard textbook in the field, and the chemistry building on the Laval campus is named after him. Although it is more than likely that he was a very erudite professor, the custodian's characterization of him as "one of the top mineralogists of North America" is no doubt highly exaggerated. Undaunted by the rebuff, however, Nininger sought out the curator in his office, but found only an assistant there. When permission was sought from him, he claimed to be "insulted on behalf of the absent curator." Nevertheless, he reluctantly agreed to open the case and allow Nininger to remove the specimen and examine it. When a small corner of the specimen was ground with an emery wheel in the museum shop, it promptly revealed bright metal instead of black magnetite. Subsequent polishing and etching brought out a beautiful Widmanstätten figure, providing indisputable proof of its meteoritic nature.

Nininger's published writings do not add any further details to the story, however, and thus many questions concerning the origin and history of the meteorite have remained unanswered. For example, when and how did the Université Laval acquire the specimen? How did it come to end up in Nininger's personal collection (to be subsequently divided and distributed to at least nine collections — Center for Meteorite Studies, Tempe; Natural History Museum, London; Field Museum of Natural History, Chicago; Harvard University, Cambridge; Max-Planck-Institut für Kernphysik, Heidelberg; Geological Survey of Canada, Ottawa; University of California, Los Angeles; U. S. National Museum, Washington, D.C.; and the University of Michigan, Ann Arbor)? And if not magnetite from Quebec but a meteorite, where was it really from? Did it represent a new find, or could it be paired with another meteorite? In short, what was its true identity?

Our research now allows us to answer all but the first of these questions. The answer to the question of how the specimen ended up in Nininger's personal collection can best be gleaned from a careful reading of some of Nininger's unpublished writings — particularly his correspondence (much of which is housed at the Center for Meteorite Studies at Arizona State University), and the long (~1500 pages) manuscript draft version of his autobiography (also at the Center for Meteorite Studies). In a letter to Stuart H. Perry, a Michigan newspaper publisher and Vice President of the Associated Press who had become one of North America's leading private meteorite collectors of his day, Nininger (1941) wrote that, when he persuaded the custodian to remove the Leeds specimen from its case, it was "with the understanding that if I were correct he would give me half of the specimen." Although such an "understanding" might sound somewhat brazen at first blush, it is actually not that surprising. As Nininger explains in the draft version of his autobiography, geological museum directors at the time typically had little knowledge of meteorites and, as a result, often mislabeled specimens. He frequently offered to correct their labels and help put their collections in order. In return, he was usually given a small piece of the meteorite in question. "In nearly all such instances the one in charge of the exhibit insisted upon dividing the specimen with me" (Nininger MS, p. 865). Such practice made good sense, since both parties benefited from it. But how did Nininger end up with the entire specimen, not just half? The explanation he gives in the manuscript is that "out of generosity or a desire to avoid making a correction that might leave someone red-faced, the museum finally turned the Leeds meteorite over to me on its own suggestion" (Nininger MS, p. 865). That is surprising, however. Why would the Université Laval Mineralogical Museum want — let alone be willing — to part with an entire (and rare) specimen simply because someone had pointed out to them that it had been mislabeled?

The answer to the question involving the true identity of the Leeds meteorite can now also be made. As is demonstrated below, we argue that Leeds is a specimen from the Toluca meteorite. It is not surprising that an early retrieved specimen of Toluca could have become mislabeled in a museum's mineral collection. What is surprising, however, is that Nininger failed to recognize its proper identity. In the fall of 1929, only two years before his visit to Laval, he had traveled to Mexico to collect meteorites. In the little village of Xiquipilco he collected some 700 pounds of Toluca specimens. In Mexico City he visited the National Museum to view its meteorite collection. He immediately saw that some specimens were mislabeled, and offered to correct the errors and help put the collection in order. Nininger prided himself upon his ability to identify meteorites correctly. "Here was a use for the skill in which I had been training myself, the ability to identify the correct origin and classification of nearly any meteorite specimen by surface features and by the etched Widmanstätten pattern..." (Nininger 1972, p. 26). In light of his skill and his close familiarity with Toluca, how is it possible that he failed to recognize the Leeds meteorite as a Toluca specimen? There is simply not enough information available in the historical record to answer satisfactorily all of the interesting questions about the Leeds meteorite, but the question of its true identity can be answered. Despite its mysterious origins and strange history, the chemical, structural, and petrographic data for the meteorite all leave little doubt that Leeds is a hitherto unrecognized specimen of the Toluca meteorite.

## 3. Analysis of Compositional Data

The data for the element compositions of the Leeds and Toluca meteorites as presented in Choi *et al.* (1995) represent only a portion of the data available for Toluca. Wasson's laboratory has obtained a total of 21 analyses of Toluca, as well as two for Leeds, and the data have all been published previously in various articles. The existence of the two data sets provides an opportunity to apply statistical analyses to test the hypothesis that Leeds and Toluca are identical. Such statistical calculations were carried out by the Lakehead University Statistical Laboratory, L. K. Roy, Director. A 95% confidence level was adopted in the statistical tests.

Table I lists the means, standard deviations, and sample sizes for determinations of the element compositions for the elements arsenic (As), gold (Au), cobalt (Co), chromium (Cr), copper (Cu), gallium (Ga), germanium (Ge), iridium (Ir), nickel (Ni), platinum (Pt), rhenium (Re), antimony (Sb), and tungsten (W). All data from the two samples were subjected to a Kolmogorov-Smirnov test for normality. All data were found to follow a normal distribution, except for gold in Toluca, although the test is trivial in the case of Leeds. Gold therefore required special treatment, since normality is required for the *t* tests cited below.

Table I
A Comparison of Element Concentrations for the Leeds and Toluca Meteorites

| Element | Leeds Meteorite Mean ±s.d. | Samples | Toluca Meteorite Mean ±s.d. | Samples |
|---|---|---|---|---|
| As | 15.7 ±1.3 μg/g | 2 | 16.5 ±1.1 μg/g | 21 |
| Au | 1.69 ±0.01 μg/g | 2 | 1.73 ±0.22 μg/g | 21 |
| Co | 4.82 ±0.01 mg/g | 2 | 4.88 ±0.13 mg/g | 21 |
| Cr | 20.50 ±0.71 μg/g | 2 | 19.85 ±6.60 μg/g | 20 |
| Cu | 175.5 ±0.7 μg/g | 2 | 170.5 ±12.7 μg/g | 21 |
| Ga | 69.2 ±1.8 μg/g | 2 | 67.2 ±3.9 μg/g | 21 |
| Ge | 265.5 ±6.4 μg/g | 2 | 259.1 ±31.4 μg/g | 11 |
| Ir | 2.45 ±0.03 μg/g | 2 | 2.43 ±0.18 μg/g | 21 |
| Ni | 83.0 ±1.8 mg/g | 2 | 80.3 ±2.8 mg/g | 21 |
| Pt | 5.7 ±0.4 μg/g | 2 | 5.7 ±0.8 μg/g | 20 |
| Re | 0.215 ±0.064 μg/g | 2 | 0.271 ±0.045 μg/g | 21 |
| Sb | 406 ±44 ng/g | 2 | 395 ±51 ng/g | 17 |
| W | 0.82 ±0.01 ng/g | 2 | 0.84 ±0.23 ng/g | 21 |

An additional requirement for the *t* test is that the variances be homogeneous, something that can be examined by the Levene test. Such a test revealed that the variances of the remaining 12 elements are homogeneous, and an application of the t test to the sample means indicated that they are indistinguishable.

In the case of gold, the Mann-Whitney test is applicable for two-way comparison when the sample size for one specimen is greater than 20. The results of the test indicate that there is no significant difference in the Au contents of Leeds and Toluca. Leeds and Toluca are therefore indistinguishable with respect to 13 of 13 elements, and on the basis of composition it is highly likely that they are from the same meteorite.

## 4. Mineralogy and Textural Features

Buchwald (1975) has prepared very detailed descriptions of Toluca and Leeds, and his descriptions are the principal source of the material below. Both are coarse octahedrites with kamacite bandwidths of 1.30 ±0.15 mm (Leeds) and 1.40 ±0.20 mm (Toluca) — clearly identical from a statistical standpoint — with identical length/width ratios of ~15. The Vickers Hardness Numbers for kamacite from the interiors of the two specimens are 210 ±15 in the case of Leeds and 235 ±15 in the case of Toluca, both values being identical within two standard deviations. Both specimens also contain troilite-graphite nodules associated with silicate inclusions. Many other petrographic features are common to both, such as abundant rhabdites, pearlitic plessite, schreibersite precipitates along grain boundaries and as spheroidal inclusions within plessite, and sheaf-like graphite crystals in polycrystalline masses containing occasional cliftonite crystals (a cubic form of graphite). Buchwald (1975) remarked in his caption to his Fig. 1048 (showing a section of Leeds), "Structurally, it [Leeds] closely resembles Toluca." He noted in his concluding statement, "Leeds is a typical, inclusion-rich octahedrite, closely related to, *e.g.*, Bischtübe, Deport, Toluca, and Balfour Downs." Polished and etched sections of Leeds (figure 1) and Toluca (figure 2) illustrate the similarity of the specimens.

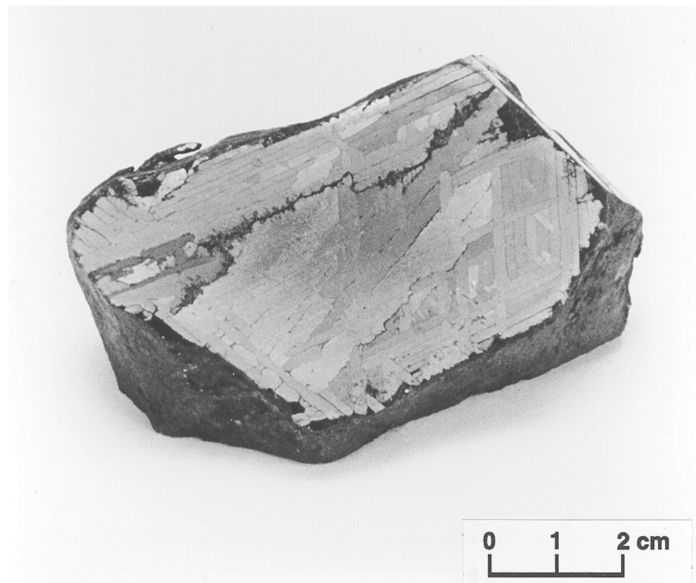


**Fig. 1** — Polished and etched surface of the Leeds 59-g mass (National Meteorite Collection, Ottawa).

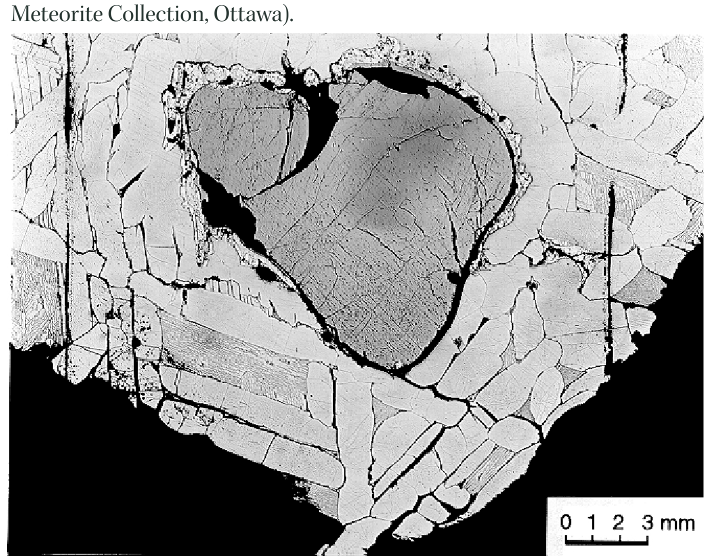


**Fig. 2** — Polished and etched surface of a typical Toluca specimen (Royal Ontario Museum #3378), illustrating a large troilite nodule rimmed by cohenite. Note the similarity of the length/width aspect of the kamacite lamellae to that of Leeds, as well as the regions of net plessite.

## 5. Conclusions

Chemically, analyses for 13 minor and trace elements reveal that Leeds is indistinguishable from Toluca from a statistical standpoint. Their petrographic similarity is strong, as was noted previously by

Buchwald (1975). The historical circumstances surrounding the discovery of Leeds are clearly vague enough that it is entirely possible that Leeds is an unlabeled specimen of Toluca, purchased and misplaced at some earlier time. We therefore propose that Leeds be considered a Toluca specimen with a similar history to that of Michigan Iron, also an instance of a mislabeled Toluca specimen in a university collection (Buchwald 1975). The Canadian and Quebec meteorite totals then decline by one in each case. In light of these findings and recent finds and falls across Canada, the current national meteorite total can be estimated at 52 (a net increase of six in the past 20 years), four of which are in Quebec (see Appendix I).

This study could not have been undertaken without the assistance of J. T. Wasson of the University of California-Los Angeles, who made his complete analytical data available to us. R. S. Clarke, Jr. of the Smithsonian Institution provided valuable assistance by granting access to his collection of files copied from the Nininger Papers at the Center for Meteorite Studies, Arizona State University. The manuscript preparation was carried out by W. K. Bourke, J. M. Huggins, and E. McDonald of Lakehead University.

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*HOWARD PLOTKIN teaches the history of science in the Department of Philosophy at the University of Western Ontario in London, Ontario. He received his Ph.D. in the history of science from Johns Hopkins University in Baltimore, Maryland and specializes in the history of astronomy. He is a member of several learned societies, including the History of Science Society, the Meteoritical Society and the Meteorites and Impacts Advisory Committee to the Canadian Space Agency. He is currently writing a series of articles on the development of meteoritics at the Smithsonian Institution in collaboration with Roy S. Clarke, Jr., who is its Curator Emeritus of Meteorites.*

*ANDRÉ BORDELEAU is a Lecturer at the Planétarium de Montréal, where he has worked since 1994. He has been an amateur astronomer since 1982 and has been involved with the elimination of light pollution since 1987. Academically, he earned both a B.A. and M.A. in political science from the University of Guelph. He is a prominent athlete, serving on the National Rifle Team from 1978 to 1990. He has been Canadian Champion twice, and Ontario Champion once.*

# Appendix I

Chronological Listing of Canadian Meteorites
(Data from Traill 1980, White 1984, and unpublished MIAC materials)

| | Meteorite | Location | Type | Classification[1] | Date of Find/Fall[2] |
|---|---|---|---|---|---|
| 1. | Madoc | Ontario | Iron | IIIA | 1854 |
| 2. | Iron Creek | Alberta | Iron | IIIA | 1869 |
| 3. | DeCewsville | Ontario | Chondrite | H6 | Jan. 21, 1887 |
| 4. | Thurlow | Ontario | Iron | IIIB | 1888 |
| 5. | Welland | Ontario | Iron | IIIA | 1888 |
| 6. | Beaver Creek | British Columbia | Chondrite | H4 | May 26, 1893 |
| 7. | Gay Gulch | Yukon | Iron | IRANOM | 1901 |
| 8. | Chambord | Quebec | Iron | IIIA | 1904 |
| 9. | Shelburne | Ontario | Chondrite | L5 | Aug. 13, 1904 |
| 10. | Skookum | Yukon | Iron | IVB | 1905 |
| 11. | Blithfield | Ontario | Chondrite | EL6 | 1910 |
| 12. | Fillmore | Saskatchewan | Iron | IA | 1916 |
| 13. | Annaheim | Saskatchewan | Iron | IA-ANOM | 1916 |
| 14. | Bruno | Saskatchewan | Chondrite | L6 | 1931 |
| 15. | Osseo | Ontario | Iron | IA | 1931 |
| 16. | Springwater | Saskatchewan | Stony Iron | Pallasite | 1931 |
| 17. | Great Bear Lake | NWT | Chondrite | H6 | 1936 |
| 18. | Edmonton | Alberta | Iron | IIA | 1939 |
| 19. | Dresden | Ontario | Chondrite | H6 | July 11, 1939 |
| 20. | Belly River | Alberta | Chondrite | H6 | 1943 |
| 21. | Garden Head | Saskatchewan | Iron | IRANOM | 1944 |
| 22. | Kinsella | Alberta | Iron | IA | 1946 |
| 23. | Benton | New Brunswick | Chondrite | LL6 | Jan. 16, 1949 |
| 24. | Holman Island | NWT | Chondrite | LL(?) | 1951 |
| 25. | Abee | Alberta | Chondrite | EH4 | June 10, 1952 |
| 26. | Giroux | Manitoba | Stony Iron | Pallasite | 1954 |
| 27. | Bruderheim | Alberta | Chondrite | L6 | Mar. 4, 1960 |
| 28. | Midland | Ontario | Iron | IA | 1960 |
| 29. | Riverton | Manitoba | Chondrite | H5 | 1960 |
| 30. | Vulcan | Alberta | Chondrite | H6 | 1962 |
| 31. | Manitouwabing | Ontario | Iron | IIIA | 1962 |
| 32. | Peace River | Alberta | Chondrite | L6 | Mar. 31, 1963 |
| 33. | Mayerthorpe | Alberta | Iron | IA | 1964 |
| 34. | Catherwood | Saskatchewan | Chondrite | L6 | 1965 |
| 35. | Revelstoke | British Columbia | Chondrite | C | Mar. 31, 1965 |
| 36. | Ferintosh | Alberta | Chondrite | L6 | 1965 |
| 37. | Kinley | Saskatchewan | Chondrite | L6 | 1965 |
| 38. | Skiff | Alberta | Chondrite | H4 | 1966 |
| 39. | Vilna | Alberta | Chondrite | L5 | Feb. 5, 1967 |
| 40. | Wynyard | Saskatchewan | Chondrite | H5 | 1968 |
| 41. | Homewood | Manitoba | Chondrite | H5 | 1970 |
| 42. | Blaine Lake | Saskatchewan | Chondrite | L6 | 1974 |
| 43. | Red Deer Hill | Saskatchewan | Chondrite | L6 | 1975 |
| 44. | Innisfree | Alberta | Chondrite | LL5 | Feb. 7, 1977 |
| 45. | Millarville | Alberta | Iron | IVA-ANOM | 1977 |
| 46. | Penouille | Quebec | Iron | IB | 1984 |
| 47. | Burstall | Saskatchewan | Iron | ? | 1992 |
| 48. | Lac Dodon | Quebec | Iron | IA | 1993 |
| 49. | St.-Robert | Quebec | Chondrite | H5 | June 14, 1994 |
| 50. | Hodgeville | Saskatchewan | Chondrite | H3-4(?) | 1996[3] |
| 51. | Toronto | Ontario | Iron | IA | 1997[4] |
| 52. | Kitchener | Ontario | Chondrite | ? | July 12, 1998 |

Notes: [1] Iron meteorites classified in chemical groups are indicated by a Roman numeral and letter(s). The suffix "ANOM" indicates an anomalous member of a group, and "IRANOM" is an ungrouped anomalous iron. Chondrites are classified by composition indicated by a letter or letters and a number indicating metamorphic grade, where C = carbonaceous chondrite, H= olivine-bronzite chondrite, L = olivine-hypersthene chondrite, and LL = amphoterite.

[2] Year only indicates a find. Full date indicates a fall (date according to local time).

[3] Found at some time in 1970–1976.

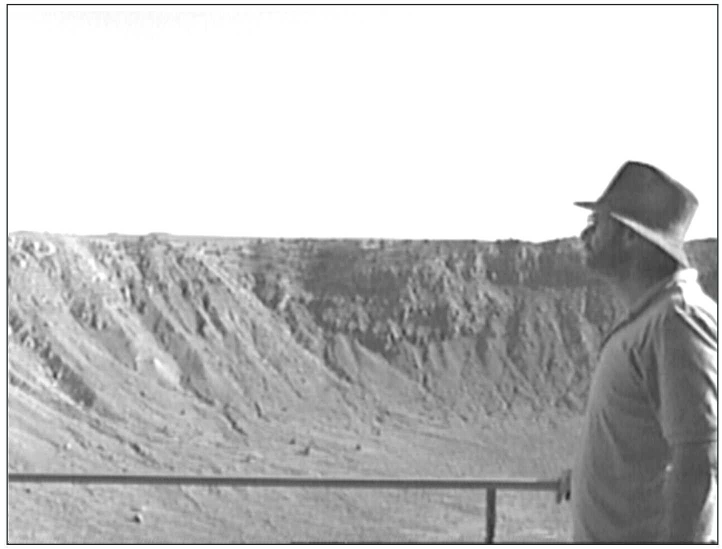
[4] Found during 1960s at unknown location in Québec; named for University of Toronto, where first identified.

# A Pilgrimage to Arizona

*by Roger Hill, Hamilton Centre*

As a child growing up in Liverpool, I was interested in the American and Russian space programs. It was interesting to witness space probes crashing into the lunar surface, sending back pictures just before they were smashed to smithereens. I had a mild interest in astronomy at the time, as many kids did. Then I was influenced by the teacher of a lifetime. Although I was not a particularly good student, Mrs. Cooper, who was near retirement age, noticed my interest in astronomy. She had a set of books at the back of the classroom, and let me read them if I finished my work. The collection contained a book on the Chapman expedition to the Gobi Desert during which dinosaur eggs were discovered, but it was a book on Mars that captivated my interest. The author of the book was Percival Lowell.

I fell in love with the images of Mars that Lowell provided: an old and majestic civilization, hoarding its resources of water, and Martians digging huge canals to spread the liquid life-giving fluid from the poles to the rest of the planet. What a story! He also supported his descriptions with visual observations of the planet made with his magnificent telescope. When *Mariner 4* encountered Mars and sent back to the Earth pictures of the Martian surface, it completely altered our view of the planet and its climate. Unlike Lowell's vision of Mars, the planet proved to be a very arid place, with only a very thin atmosphere composed mainly of carbon dioxide. Craters seemed to be everywhere and there was no trace of the fabulous canals — thus, no evidence of a great and noble Martian civilization having fought a valiant but losing battle against a worsening climate. Strange as it may seem, that "catastrophe" turned my passing interest into a lifelong love of astronomy.



In recent years I have had occasion to travel on business. On two trips to Chicago I hoped to visit the Chicago Field Museum, which I thought had funded the Chapman expedition noted above. On both occasions the Museum was closed for renovations. As a result of that experience, on a subsequent trip to New York I chose to visit the Empire State Building rather than attempting to visit the Museum of Natural History. Later I was disappointed to learn that it was actually the New York Museum, not the Chicago Field Museum, which had funded the Chapman expedition.

In March 1999 I made a trip to Phoenix, Arizona and found time to visit Barringer Meteor Crater and Flagstaff, home of the Lowell Observatory. While watching the *Apollo* Moon landings as a youngster, I recall many images of Gene Shoemaker exploring an impact crater on Earth. It was not some minor ring-shaped mound or a circular lake, but an honest-to-goodness lunar-like crater. Flagstaff is a two-hour drive from Phoenix and Meteor Crater is about an hour from Flagstaff, so it is possible to visit both in one day. If you take the Sedona exit, you pass through some spectacular country on the way. The drive from Sedona to Flagstaff along the back roads is breathtaking.

I reached Flagstaff and followed the directions to the Lowell Observatory, pulling into the parking lot on Mars Hill at 11:20 a.m. The observatory opens to the public at noon, so I had a few minutes to spare. The Lowell Observatory is the site of the 24-inch Clark telescope, where Clyde Tombaugh photographed Pluto for the first time and where Slipher made his observations. Although the domes are not open for general visiting, you can take a guided tour. Public observing on the Clark telescope takes place only on Saturday nights in the winter, so there was no opportunity for me to look through the telescope during my short stay. On wandering through the grounds while waiting for the tour to start, I was surprised to come across a small building with a dome that appeared to be made of black glass bricks. It is Lowell's mausoleum, located in the shadow of the dome containing the Clark telescope.

I was able to begin the guided tour, but had to leave partway through it in order to reach Meteor Crater that same day. I was able to see the large Clark telescope and a few other telescopes, but left before the tour reached Tombaugh's telescope. I took one wrong turn on the way to Meteor Crater, and did not reach the right highway until after 3:00 p.m. By then I was on the high plains and could see for quite a long distance. After about 40 minutes on the highway I noticed an oddly-shaped hill off in the distance. It was a low, flat-topped rise. By 4:00 p.m. I had reached the rise, marking the rim of the Barringer Crater, and was able to visit the site — after purchasing a ticket for $8 U.S.

The crater rim stands about 30 metres above the surrounding countryside and a magnificent sight greets you once you get past it. As is true for many different events and places, you must experience Barringer Meteor Crater first-hand to truly appreciate it. I had seen many pictures of the site as well as TV documentaries on it, but nothing prepared me for the reality. I overheard a couple of people grumbling to each other that it was a lot of money to pay just to look at a hole in the ground, yet the scene is a familiar one on other planets and satellites. The view is similar to what one would see on the Moon, Mars, Venus and many other objects. It is what a lot of the real estate in the universe might look like.

The journey back to Phoenix takes just over three hours via the Interstate highways all the way and I was back just as the Sun set. If I ever get to Arizona again, I hope to visit Kitt Peak. I suspect that the drive will be just as spectacular and that the vistas will be just as awe-inspiring, but it will not be a pilgrimage.

*Roger Hill is a recent recipient of the Society's Service Award. He has been using telescopes since 1965, and has been a member of the Hamilton Centre since 1970. A self-professed computer geek, he is employed by a software development company in Milton, where he lives in a house that contains its own computer network — one that will also include the new observatory he is building in his backyard. Roger has been on three solar eclipse expeditions since 1972.*

# **Society News/**Nouvelles de la société

## RASC CERTIFICATES AWARDED AT THE NOVEMBER AND MARCH MEETINGS OF NATIONAL COUNCIL

**Messier Certificate:**

David H. Prud'homme, Edmonton Centre
Ken Kingdon, Kingston Centre
Peter Manson, Ottawa Centre
Richard Taylor, Ottawa Centre
Alan Sherlock, Winnipeg Centre
John Smith, Winnipeg Centre
Richard Turenne, Winnipeg Centre
Timothy George Zacharias, Winnipeg Centre

**NGC Certificate:**

Mary Lou Whitehorne, Halifax Centre
Leo Enright, Kingston Centre
Christopher Fleming, London Centre
Joe Gurney, London Centre
David J. Nopper, London Centre
Rick Wagner, Ottawa Centre
Richard Huziak, Saskatoon Centre
Daniel Taylor, Windsor Centre

**Membership Certificates:**
**Calgary Centre:**

Alan Clark (27 years)
Steven Morris (30 years)
Thomas Swaddle (33 years)
James Fish (10 years)
Gary Florence (22 years)
Mel Head (11 years)
Walter Lindenbach (24 years)
Leonard Kampel (6 years)
Robert Morgan (6 years)
Patricia Morgan (6 years)
Susan Yeo (6 years)

**Kingston Centre:**

Wayne Morrison (26 years)
Deiter Brueckner (10 years)
Susan Gagnon (6 years)
Kim Hay (10 years)
Ruth Hicks (12 years)
Peggy Hurley (10 years)
Kevin Kell (9 years)
Peter Kirk (5 years)
Sue Knight-Sorensen (16 years)
Walter MacDonald (11 years)

**London Centre:**

Ron Sawyer (28 years)
Grant Carscallen (20 years)
Joe O'Neil (13 years)
John Rousom (10 years)

**Saskatoon Centre:**

Hugh Hunter (27 years)
Ed Kennedy (45 years)
Merlyn Melby (27 years)
Jim Patterson (29 years)
Richard Huziak (22 years)
Bill Hydomako (13 years)
Halyna Turley (15 years)
Mike Williams (20 years)
Jim Young (21 years)

**Toronto Centre:**

Donald R. Austin (51 years)
Michael F. Barrett (27 years)
D. H. Bell (27 years)
M. J. Bronson (26 years)
H. R. Burke (27 years)
Jeffery C. Clayton (31 years)
Michael De Robertis (29 years)
John M. Fincham (29 years)
Richard A. Jarrell (30 years)
Richard Kelsch (27 years)
Lloyd C. Kremer (29 years)
Olga Kuderewko (28 years)
Robert McColl (30 years)
Henry Nothof (26 years)
Klaus Plauschinn (27 years)
Dan Shire (26 years)
Glenn Slover (29 years)
Anthony Sosnkowski (30 years)
John L. Stewart (27 years)
Jacques P. Vallee (29 years)

## NATIONAL SERVICE AWARDS ANNOUNCED

During the past year, the National Council of the Royal Astronomical Society of Canada approved recommendations from the Awards Committee regarding the presentation of Service Awards to the following individuals, the citations for whom are presented here:

**Ralph Chou**
Nominated for the Service Award
by the Toronto Centre

Dr. B. Ralph Chou has played a major role in the activities of the Toronto Centre over the past 25 years. Ralph joined the Toronto Centre in 1971, and has been a member of the Toronto Centre Council since 1973. During that period he has assumed the following Centre positions: Councillor 1971–1973 and 1979, Chair for Public Education 1971–1978, Recorder 1973–1976, Secretary 1976–1979, 1980–1984 and 1990–1992, First Vice President 1984–1986, President 1986–1990 and Treasurer 1992–1998. In addition, Ralph has contributed his time and expertise to the National Society. He has served as: Toronto Centre delegate to National Council 1975–1979, 1981–1985 and 1989–1990, Assistant Editor of the National Newsletter 1977–1980, Editor of the National Newsletter 1980–1985 and National Treasurer 1985–1989.

He has lent his knowledge of solar eclipses to many as an organizer of several Centre eclipse expeditions. During the fall of 1997 he was instrumental in the Centre's acquisition of the new CARR Observatory near Collingwood, Ontario. Ralph Chou has made invaluable contributions to both the Toronto Centre and National Society over the past 25 years and more, and is very deserving of the Society's Service Award.

**John Mirtle**
Nominated for the Service Award
by the Calgary Centre

John Mirtle has been a member in good standing since he joined the RASC in 1986. John helped develop the Calgary Centre's popular Observer's Group Meetings that are held once a month, and has been a major contributor to the meetings for ten years. Each month he creates a list of objects for people to observe and takes astrophotos of the objects on the list so that people can see what they look like. He then shows how to find the objects on a chart. Whenever a guest speaker is needed, John will always sort through his collection of astrophotos to give a presentation, even on short notice. Several of his photos are given away at such meetings.

John is an excellent astrophotographer and was a major contributor to the development of an astrophotography workshop for the Centre. The workshop has been very successful, with eight people participating and seven people continuing to take astrophotos. At star parties, such as the Mt. Kobau Star Party, John has served as a judge for the Astrophotography Awards for the past seven years. At the Alberta Star Party he provides a variety of his astrophotos as door prizes.

For the last four years, John has provided the music for our Annual Banquet, selecting music to go along with the presentations to different individuals. He brings in all of his equipment to provide music for such events and also provides his astrophotos as door prizes. John's musical talents are also evident in the slide show for the Centre's Wilson Coulee Observatory, which attracts various interested groups such as the Girl Guides, Boy Scouts, school groups and others. One of our members wrote the narration for the tours, which was narrated by another member. Some of the music for the show was composed by John Mirtle, and he provided the rest himself. He also provided the astrophotos that are included in the show.

John is active in Public Education events such as Astronomy Day, Saturn Night, Zoonival and many of the other events that occur over the year. He can be counted upon to bring along one of his numerous telescopes to show objects to the general public and he also provides his astrophotos for the bulletin boards that are erected at such public events. They are also displayed at events such as the Home Show.

John is also there when maintenance is needed at the Wilson Coulee Observatory, as well as at the Eccles Ranch Observatory in Caroline. His efforts include erecting buildings as well as maintaining the site. John is also responsible for the maintenance of the computer used to produce our newsletter *Starseeker*, including upgrades and software installations when necessary.

John has been in charge of calendars for ten years. He orders calendars and brings them to all of the meetings for sale to members. He attends every meeting into the new year once calendars appear, so that no one misses an opportunity to have one.

In light of his long service, the Calgary Centre nominates John Mirtle for the Service Award.

## CONGRATULATIONS TO…

…Stéphane Charpinet, who has been awarded the J. S. Plaskett Medal, sponsored jointly by the Royal Astronomical Society of Canada and the Canadian Astronomical Society. The award, consisting of a gold medal, is made annually to the graduate of a Canadian university who is judged to have submitted the most outstanding doctoral thesis in astronomy or astrophysics in the preceding two calendar years. Stéphane completed his doctorate in 1998 at l'Université de Montréal under the supervision of Gilles Fontaine. His thesis is entitled "Le potentiel de l'astéroséismologie pour les sous-naines de type B." A citizen of France, he is presently employed by the Canada-France-Hawaii Telescope Corporation.

…Rajiv Gupta, RASC Observers' Calendar Editor. Under his editorship the 1999 edition recently won two prizes from *The Ontario Printing and Imaging Association*: "Best Calendar" category and "Award of Excellence".

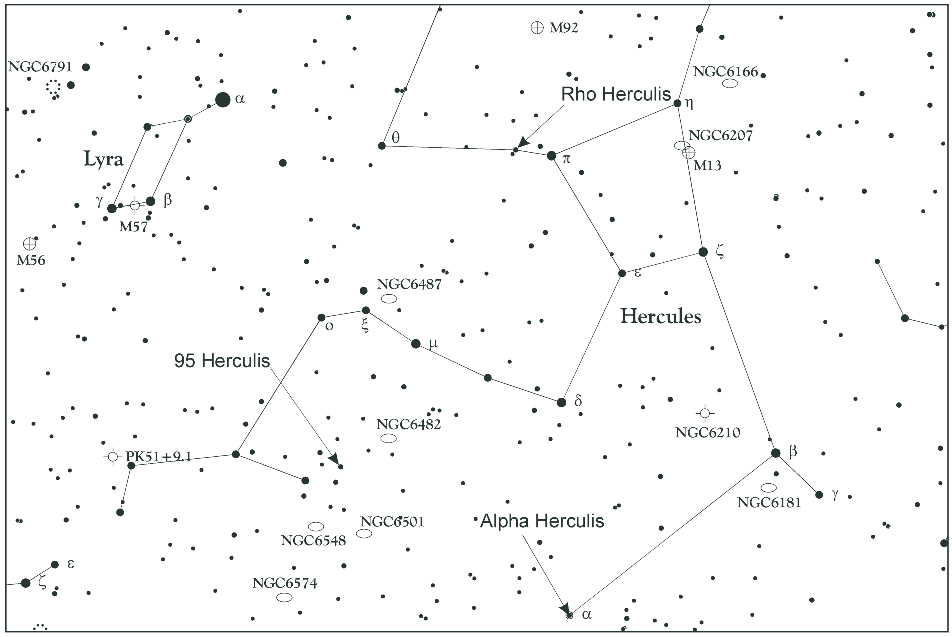
# The Best of **Hercules**

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

Hercules is best known for its two bright globular clusters, M13 and M92, but it also holds a third globular, a bright planetary nebula, a thin scattering of galaxies and some of summer's finest double stars. Try observing a few coloured doubles while your eyes adapt to the dark. None of the following binaries are difficult in a 60-mm refractor on a night of good seeing.

One of my favourites is Alpha Herculis, because of the contrasting colours between the orange giant primary and its green companion. The orange giant actually varies in light between magnitudes 3.0 and 4.0. The magnitude 5.4 secondary star lies 4″.7 to the east. Lately it has become fashionable to state that the green perceived in stars such as the companion to Alpha Herculis is not real, but is instead a perception created by the contrast between the two stars. That is balderdash! The colour is as real as the pastel green seen deep in a glacial crevasse. Most of us observe doubles for aesthetic reasons and the most beautiful doubles are those with contrasting colours. The colours of the stars of Alpha Herculis are perceived as orange and green not only by my eyes, but also by the eyes of every human observer that I know. What a machine may record or what a moth that perceives ultraviolet radiation might see, is irrelevant to any discussion of the appearance of a double star to human eyes. So enjoy the orange and pastel green colours of Alpha Herculis revealed to your eyes.

Authors of the last century had no qualms about describing vivid star colours. If the chromatic aberration of a doublet refractor added to the show, so much the better! Have you ever observed the fine double 95 Herculis? My old 1962-era 60-mm Tasco refractor was known to direct a few rays of colour astray from time to time and my first observation of 95 Her in September 1962 faithfully recorded the double's colours as "the apple-green and red tints…" described in Serviss's turn-of-the-century observing guide. Red, eh? I now realize why I liked double stars so much more when I had that telescope! Now I mainly use a 20-cm Newtonian for doubles and it gives truer colour. This past January I recorded the colours of 95 Her as "gold and silver," as given by Ian Ridpath in the fine little pocket atlas *Night Sky*, on which he collaborated with celestial cartographer Wil Tirion. I suppose that silver and apple-green are not that far apart. What do you see — surely not just white and white? The matched pair of magnitude 4.9 stars are 6″.2 apart.




A finder chart showing the location of many of the objects mentioned in this column (ECU chart by Dave Lane).

White and white works as well. Take a look at Rho Herculis, with its stars of magnitudes 4.0 and 5.1 separated by 3″.8. I see both as white, but Ridpath calls them blue-white.

Other than in binary stars, colour is fairly rare at the eyepiece in deep-sky objects. Most are just too faint to register visually as anything other than shades of gray. The main exceptions are the high-surface brightness planetary nebulae. Most of them are small, such as NGC 6210, a tiny blue disk only 14″ in diameter. Many writers have referred to the colour of that planetary nebula as "robin's-egg blue." While it may sound excessively poetic, it is what my eye sees with moderate apertures. The ninth magnitude nebula is not difficult with almost any telescope — it was the only NGC planetary that I logged with my old 60-mm refractor, but my logbook does not indicate that any colour was discernible with the little refractor.

Without a doubt, Hercules is mainly known as the constellation that harbours the finest globular cluster in the sky's northern hemisphere, M13. Bright enough to be seen with the unaided eye from merely decent sites, the globular is a delight with any aperture. My 10-cm Astroscan resolves the edges at 64×. My 20-cm Newtonian shows masses of stars right across the cluster, with long star-chains around the margins. At moderate power the southeastern part of the central core has three darker lanes, contrast features arranged like a propeller. Using the 0.6-metre at Goldendale Observatory in Washington State in 1981, I wrote: "Bright stars on fainter stars on fainter stars on a mottled background." On a rare night that permited the use of such high magnification, I observed M13 at 424× with another 0.6-metre, the Prince George club's Cassegrain. The globular's central core almost filled the field and the Y-shaped dark lanes were as prominent as I have ever seen them, a view that reminded me of a turn-of-the-century description that I once read somewhere of a view of a great globular through the Yerkes 1-metre refractor. While Omega Centauri, lord of the Southern Hemisphere, is far brighter than M13, it does not have as interesting or distinctive an appearance, in my opinion.

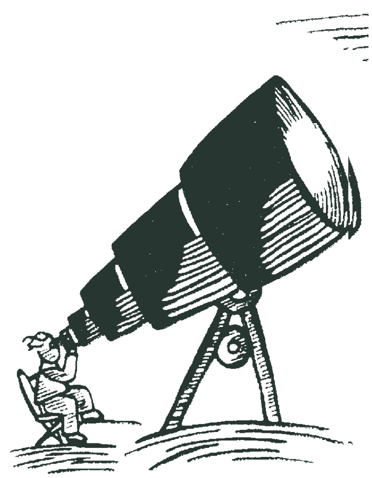
M13 has it all, even a $12^{th}$ magnitude galaxy in its field — you will find elongated NGC 6207 only 0°.5 to the northeast in a 20-cm scope. John Casino's 0.9-metre Dobsonian revealed a bright nucleus in this distant Sc galaxy. For a true challenge, try the magnitude 15.5 galaxy IC 4617, which lies midway between the globular and NGC 6207. My Meade 41-cm Newtonian can just barely concentrate enough photons to make IC 4617 visible at 261× and 348× under the best conditions. Virginian Kent Blackwell has also seen the spiral galaxy in a 41-cm telescope.

After swinging by Hercules' second-ranked globular cluster, NGC 6341, continue on north to NGC 6229. If M92 suffers from being overshadowed by M13, then Hercules' third globular, NGC 6229, suffers from being overshadowed by both. At our First Light Party for my Whirlpool Observatory last September, Ron Scherer made the NGC 6229 star ball one of the first targets for my 41-cm equatorial (a Newtonian which had begun life as a star-hopping Dobsonian). At 140× NGC 6229 was well-resolved even to my champagne-inhibited eyes. One guest wanted to break the champagne bottle over my telescope to launch it on its celestial journey, but thirstier observers prevailed.

There is no pleasure quite like summer observing. Enjoy!

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

# Ask Gazer



*Dear Gazer:*

*I am fearful for the future of amateur astronomy. I was listening to the radio the other day and they were talking about hobbies and future trends expected as a result of the coming retirement of the "baby boomers." Part of the feature dealt with hobbies that are currently growing the fastest and are expected to keep growing. With all of the interest in space and science fiction, I would have thought that amateur astronomy would be fairly high in the list, but it was nowhere near the top. In fact, it wasn't even mentioned. Can you believe that the fastest growing hobby, by far, is bird watching? What gives here?*

*Mixed Up in Moose Jaw*

Dear Mixed Up:

You have raised an interesting issue. In a way, amateur astronomy and bird watching have a lot in common. Disciples of both hobbies come in"observing," "armchair,"and "hybrid"persuasions. I suspect that any difference between the two hobbies lies mainly on the observational side, as reading books is reading books, regardless of whether the pretty pictures are of an astronomical or avian nature. Let us see how they compare on the observational side.

After some consideration, I realized that they are more alike than I had originally thought. Both use optical observing equipment, and you are limited only by your budget (and how much stuff you are willing to carry around with you). In each case, there are some objects that you can see easily from your house (*e.g.* Venus and starlings). Others, for most people, require travelling to a more "pristine"location (*e.g.* the Veil Nebula and bobolinks). And there are some items that simply cannot be seen without travelling great distances (*e.g.* the Large Magellanic Thingy and the Lesser Gold-breasted Ditflicker).

Of course, there are some advantages to bird watching over astronomy. Weather is one. For starters, you can do it during "normal" hours, unless you are into owls. It can be clear and sunny, overcast with drizzle, or cloudy with snow flurries, and you can still look for birds. Another big advantage of bird watching is that birds in the field look like the pictures in the books. Three bird watchers looking at a blue jay will all see a blue jay and recognize it as a blue jay, even if one is using their eyes, one using binoculars, and one using a small telescope. In the same vein, while you can spend a lot of money on binoculars, you do not need a lot of the accessories that you need for astronomy. Bird watchers do not normally need Telrads to help them locate their quarry. I suspect that bird watchers do not say: "I think it's a male cardinal. Pass me my red finch filter. Using that and averted vision, I might be able to confirm it."

Not only do bird watchers have it over astronomers in terms of equipment, they also have a big drawing card in what they look at compared to what astronomers look at. Let's face it, most astronomical objects do not change a lot over time. When was the last time that you saw M51 do anything different? Has it ever moved to a new constellation? Built a home? Eaten? Taken a bath? Propagated with another galaxy? …hmmm maybe I should have picked a different Messier object. You can see my point – while celestial objects do change, birds do too, but on time scales much more amenable to people.

There is also the cuteness factor, which cannot be ignored. While many astronomical objects such as Saturn, the Andromeda Galaxy or a bright comet can inspire awe, there is no way that they can compete for cuteness with a chickadee eating a sunflower seed, a male pheasant trying to impress a female or an adult robin stuffing worms into a "baby"that is almost as big as it is.

Bird watching also has a much greater "lottery"capability. While amateur astronomers can discover new comets and have them named after them or find the odd nova, that usually requires some effort. There is little chance that someone in Halifax is going to casually look out his window some night and spot a new globular cluster. Compare that to bird watching where one never knows for sure what they are going to see when they look out the window. An indigo bunting or a…hey is that a bald eagle circling up there? Where are those binoculars?

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

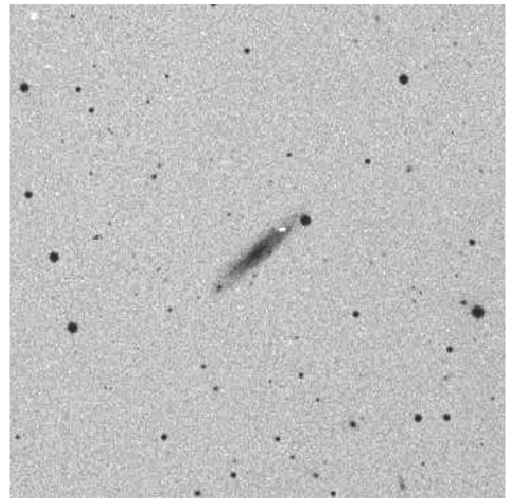
# Scenic Vistas: A Mysterious Galaxy Quartet in Boötes

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

The single biggest challenge for observers of the "deeper sky" is the ability of the observer to correctly identify the object visible in his or her telescope. Most amateur astronomers are limited by the accuracy of the sources readily available to them, whether they be catalogues, star atlases, or, in the 1990s, computer programs. Not surprisingly, the fainter the target is, the more likely there is to be a problem with identification. Bright objects, of course, have been observed countless times by both amateur and professional astronomers, and their identities are well established. Yet a surprisingly large number of objects listed in the *New General Catalogue* and its supplements, the *Index Catalogues*, are poorly observed by professionals as well as amateurs, and their identities and backgrounds are not at all certain. The unsuspecting amateur who trusts the sources at hand can easily be led astray. Sometimes a little detective work is necessary to clear up identification problems.

A problem of this nature began for me four years ago during the course of my project to systematically observe the entire Herschel catalogue. On a warm June evening in 1995, my principal targets for the night were three moderately bright Herschel objects, plotted together on Chart 77 of *Uranometria 2000.0.* NGC 5660, NGC 5673 and NGC 5676 were objects that should have been well within the range of my 15-inch reflector, and indeed NGC 5660 and NGC 5676 certainly were; both were quite bright and stood out well at a magnification of 146×. When it came time to observe NGC 5673, the third galaxy plotted on the chart, I did not have much of a problem either. The galaxy was smaller and fainter than the first two, but not exactly a challenge. I made sketches of all three galaxies and descriptive notes for each, and moved on to other targets for the night.

Doubts about my observations on that night began a couple of months later on an evening when I was casually looking through John Vickers' *Deep Space CCD Atlas: North*. I came upon an image of NGC 5673, and was surprised to note that there was another galaxy in the field. My surprise heightened when I read the caption. One of the galaxies, the brighter one, was identified as IC 1029. The implication was that Sir William Herschel had discovered the fainter galaxy but missed the brighter one, that despite the fact that they should have both been visible in the field of his telescope.



A image of NGC 5673 from the Digitized Palomar Observatory Sky Survey[1].

The first thing I did was to check my own observations. Sure enough, a comparison of my drawing with the CCD image revealed that I had observed the object identified by Vickers as IC 1029. I had made the sketch at 272× and the field of view was not large enough to include the actual object designated NGC 5673. My first reaction was that Vickers had probably made a mistake in identifying the galaxies in his image. I resolved to check our Centre's copy of the *New General Catalogue* at the earliest opportunity. When I did so, I realized that Vickers had gotten it right. The listing for NGC 5673, with discovery credited to William Herschel, was the following: F, S, cE, * 15 np. For those unfamiliar with NGC shorthand, that translates to: "Faint, Small, considerably Extended, a star 15$^{th}$ magnitude north preceding." As can be seen from the accompanying image, it is a fairly accurate description.

Next I checked the listing for IC 1029. Here I found that the discovery of the object was credited to Guillaume Bigourdan, an accomplished observer at the Paris Observatory about a hundred years ago. The description: vF, S, lE, mbM (very Faint, Small, little Extended, much brighter Middle) was also accurate, since he used a smaller telescope than Herschel's, a 12-inch refractor. It was obvious that I had made an error in identification, though an understandable one. *Uranometria 2000.0* only plotted three galaxies in the field when there were actually four. As a general rule the atlas plots NGC clusters, galaxies, and nebulae, and only the occasional IC object. Generally speaking, IC objects, which were all catalogued between 1888 and 1909, are fainter, often discovered by photographic means. In the present instance, though, there was a problem. An obviously brighter object was not plotted, though a fainter one was. I resolved at that point to re-observe the field to see if the true NGC 5673 was visible, and also to try to figure out how Herschel could have missed the brighter galaxy.

An opportunity did not present itself until two years later, in June 1997. On an evening when observing conditions were

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

similar to those of two years before, I again acquired the field and re-examined the three brightest galaxies before trying to find the fourth. After a few moments I found it. In my notes I wrote: "A very faint galaxy, appearing a little brighter at 146× than at 272×. Elongated NW/SE, the envelope is rather diffuse and poorly defined. A little brighter along the major axis, though no brighter core is visible. A magnitude 13 star is visible off its NW tip."

I have long admired Sir William Herschel's observing abilities, and have often been astounded at the faintness of the objects found in his sweeps. His principal instrument, an 18.7-inch Herschelian reflector, was probably similar in efficiency to the 15-inch reflector that I use, but I could not understand how he could have missed IC 1029 yet pick up the other three galaxies in the region. More alarming was the fact that at least a hundred years had gone by between the time of Herschel's observation and the observation of Guillaume Bigourdan. Had no one observed that part of the sky for an entire century?

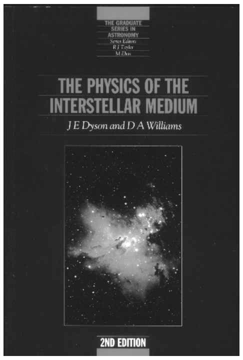
Only recently has the mystery been resolved, and we have that incredible 1990s resource, the Internet, to thank. One of my favourite web sites is *The NGC/IC Project*, which is a project involving professional and advanced amateur astronomers whose stated goal is to resolve and correct all errors in the *New General Catalogue*. While accessing the site, I came upon the work of Dr. Harold Corwin, who has dedicated himself to clearing up as many identification errors as possible. His entry for NGC 5673 provides much information that helps clear up some of the mystery surrounding the two galaxies.

Evidently the identification problem can be traced to a misinterpretation of the data by J. L. E. Dreyer, the person in charge of compiling the *New General Catalogue*. It seems clear that Sir William Herschel discovered the galaxy, later designated IC 1029, during his initial sweep of the region, as his description matches that of the brighter galaxy. He never observed the fainter galaxy. Many years later, when John Herschel retraced his father's sweeps of the sky, he came upon the fainter galaxy, later identified as NGC 5673. Strangely, both Dreyer and John Herschel assumed there was only one galaxy in the field. Dreyer thought that Sir William Herschel had made an error in assigning his position to the galaxy, and since he apparently had never observed the region himself, assumed John Herschel's description and position were correct and so included it in the catalogue. When Bigourdan came along, he observed two galaxies in the field, and since the position and description for NGC 5673 were correct, identified IC 1029 as a new object. He apparently observed that object first, assumed that it was NGC 5673, and stated that the star mentioned in the description for the fainter galaxy was not visible.

Dr. Corwin's conclusion is that the identities of the objects should remain as they are, to avoid confusion. Yet it would seem to me that, in a revised NGC (should one ever be published), the discoverer of NGC 5673 should be listed as John Herschel and not William Herschel. William Herschel should also get credit for discovering IC 1029, with Bigourdan listed as a co-discoverer, albeit a century later. If you are interested in learning about some of the other identification problems in the *New General Catalogue*, you can access the NGC/IC Project at `www.ngcic.com`.

*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, *which is scheduled to be published in the U.S. by Discovery Books in the summer of 1999.*

# Reviews of Publications
## Critiques d'ouvrages




**The Physics of the Interstellar Medium,** 2$^{nd}$ Edition, by J. E. Dyson and D. A. Williams, pages xiv + 165, 15.5 cm × 23 cm, Institute of Physics Publishing, 1997. Price US$38.00 soft cover. (ISBN 0-7503-0306-0 hard cover, 0-7503-0460-X soft cover)

As a one course exposure, or a career-long seduction, the study of the interstellar medium (ISM) offers many rewards. Fascinating astrophysical processes can be found at all scales, from the formation of individual molecules to the vast superbubbles carved out by clusters of hot stars. Environments range from dense regions of star formation to the most tenuous pockets of the Galaxy.

While this book does not purport to be a comprehensive study of the ISM, it does attempt to show how familiar physics can be used to understand, at least in principle, the many wonders found in such an unfamiliar setting. Here the reader will find a wide range of physics at play. For example, atomic physics is required to illustrate how heating and cooling occurs, and gas dynamics to understand interstellar shocks as well as many of the radiation processes by which we learn about the ISM.

The book is identified as part of a series for graduates, but it seems to me to be aimed more towards senior undergraduates in the physical sciences (a view supported by the authors' comments in the preface). In fact, the presentation is very readable and could be enjoyed by even more junior students or others not frightened of a few equations. In a graduate text I would like to have seen more technical information and derivations, and fewer qualitative discussions and statements of results. On the other hand, for its size, this slim volume accomplishes a great deal. I would be happy if all graduate students could acquire, retain and explain the material as well as is done here.

The book begins with an overview of how we observe astrophysical phenomena, touching on various radiation processes and the interaction of electromagnetic radiation with matter. Given its scope, however, the material is not presented with much depth or development, particularly in areas such as atomic spectroscopy or electromagnetic theory. Likewise, observational techniques are not a major focus of the book, and the reader will have to turn to more specialized texts to go beyond what is presented here on molecular physics and on the chemistry and physics of interstellar grains.

The second half of the book gives a coherent view of varied energetic interactions of stars with the ISM, including the evolution of ionized regions, stellar wind- and supernova-driven shocks and bipolar outflows from young stellar objects. There is very little attempt to integrate any astronomy into this section — for example, by presenting real objects that embody the physics being described. To some, that would add to the allure of a course based on this book.

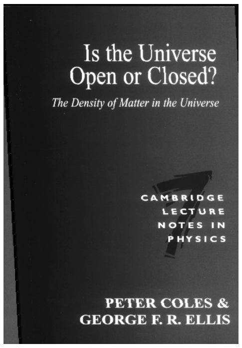
While the book is a second edition, the only major update I could discern was in the final chapter on star formation. Something more might have been added about the importance of magnetic fields, and also a few pages on the cooling of shocked gas. Care has been taken in the rearrangement and presentation of material and in the refinement of a few numbers. There are also some aesthetic improvements, like crisper typesetting and new figures (the colour plates seem unnecessary), as well as a few more instructive problems that have been added to various chapters. A step backwards is the elimination of all references to the extensive literature for those who might like to explore the subject more deeply or broadly, or to trace the historical development of the ideas presented.

To summarize, this book is acceptable for an undergraduate overview, but falls short at the graduate level. My bottom line, though, is that the application of basic physics in an unfamiliar and often extreme environment like the ISM inevitably stretches the imagination, making a book like this a good read. Readers will surely learn a lot about processes that shape the ISM and that influence galactic evolution. Enjoy it.

Peter G. Martin

*Peter Martin is a Professor of theoretical astrophysics at the Canadian Institute for Theoretical Astrophysics at the University of Toronto. His research concerns the evolution of the galactic interstellar medium, as revealed by the multi-wavelength Canadian Galactic Plane Survey and major facilities like the Hubble Space Telescope, with a focus on interstellar dust, molecular hydrogen and galactic nebulae.*

**Is the Universe Open or Closed? The Density of Matter in the Universe,** Peter Coles and George Ellis, pages xv + 236, 15 cm × 22.5 cm, Cambridge University Press. 1997. Price US$32.95 soft cover. (ISBN 0-521-56689-4)




Determining the density parameter of the universe has remained perhaps the central question in cosmology since the discovery of the universe's expansion in the 1930s. General relativity relates the average local density of matter to the change in the rate of expansion. The density parameter is a combination of the matter density and the expansion rate that allows us to describe with a single number the evolution of the universe, its age, fate and overall geometry: open or closed.

This book concentrates on various efforts to measure the density parameter. What is striking is that the result touches on virtually every area of cosmology (indeed the table of contents looks very much like that of many general cosmology texts). It is a clear indication of the central importance of the density parameter to cosmology. The author attempts to draw from each area those aspects which touch on the question of the density parameter, but in a book of some 200 pages it is difficult to cover any one topic in depth. The result is a whirlwind tour through contemporary cosmology at a level and pace that will appeal to some but may be frustrating to others.

To a new student in cosmology, the book provides a quick overview of the subject, but lacks the detail to serve as a central source. New ideas are introduced rapidly and the authors fearlessly dip into mathematical details as they wish. The book includes an excellent bibliography, and is up-to-date in the material it covers.

To someone working in the field, there is relatively little that is new here; the primary attraction of the book is that it serves as a concise primer in each of the selected topics. The topics include: the age of the universe (which must be larger than the ages of its constituents), classical cosmology (angular diameter distances and more recent measures such as gravitational lensing), nucleosynthesis (how the abundances of the light elements depends on the baryon density and expansion rate at early times), constraints from large-scale structure (the growth of fluctuations, gravitationally-driven peculiar velocities, and observations of the inter-galactic medium) and constraints from observations of the cosmic microwave background radiation.

Two of the most interesting chapters in the book address issues that most working cosmologists generally regard as having little practical importance. The first discusses the so-called "fine-tuning" arguments that are invoked to counter the suggestion that we live in a universe with 20 percent of the critical density. (The critical density divides universes that will expand forever from ones that will eventually recollapse.) The problem is that if we run the universe back in time to some very early epoch — perhaps the Planck time, when quantum effects begin to impinge on relativity — the density parameter at that epoch becomes extremely close to the critical value. Indeed, to have a density parameter that is a factor of five below the critical value today implies that it must have differed from the critical density by only 1 part in $10^{60}$ at the Planck time! The fact that we live in a universe that still appears to be "near" the critical value suggests to many cosmologists that it has *precisely* the critical density, an idea that is reinforced by inflationary theory. The authors embark on an interesting discussion of how we measure the concept of "nearness" in such a context, and provide arguments that suggest that we must treat fine-tuning arguments with caution.

In a related discussion, the authors critique the current fashion for a non-zero cosmological constant. This constant contributes an effective energy density to the universe. By choosing an appropriate value we may retain, in a low-density universe, the flat spatial sections that are a chief attraction of the critical density models. Unfortunately, the very recent idea of "quintessence" — that the cosmological constant may be both space- and time-varying — seems to have missed the publisher's deadline. Some mention is made in passing of the anthropic principle — that intelligent life can only form in universes with a restricted range of density parameters — and although interest in such ideas is growing, it is probably not appropriate to seek an extended discussion here.

The cover advertises the book as controversial, but if the controversy refers to the fact that the density parameter may be less than critical, then I think the field has matured three to five years beyond such a debate. Most cosmologists, particularly when discussing post-recombination cosmology, have already accepted it as a true practical possibility. We do still wonder in our naive way about the meaning of fine-tuning arguments and the work hinted at in that section of the book is a fascinating glimpse into the questions that must be answered if the density parameter turns out to be different than critical.

The second topic that is not usually covered in cosmology texts is the question of "smoothing" or averaging in the universe. It is generally assumed that the universe is homogeneous, or smooth, on large scales. Standard practice for a post-recombination cosmologist is to assume that one can simply blur out all of the small-scale irregularities in the universe, such as galaxies and clusters, and the resulting uniform matter distribution will obey the relativistic field equations for a truly homogeneous universe. The metric describing all of the observed irregularities is, of course, extremely complicated, but it is assumed that if one applies the naive classical smoothing, one will arrive at the metric appropriate for a homogeneous universe. That has not been shown in relativity, and there are suggestions that small-scale shear, for example, can contribute a net energy density and, hence, affect the global properties of the universe. Most of us feel sure, however, that it is of little practical consequence.

Finally, this book is a good read. As noted above it covers a lot of ground and proceeds at a good pace. In their preface the authors note that the book originated as a review article in the journal *Nature*. In a few places it is apparent that the sheer scope of the material wanted to expand beyond the confines of the 200 pages, and perhaps some harsh editing has resulted in a few terms like the "Planck" time and the parameters "$\gamma$" describing the equation of state and "$\eta$" describing the baryon density appearing out of nowhere. The "EGS" (Ehlers-Geren-Sachs) analysis, which appeared in a footnote, required a quick trip to the index. A table comparing the success of various cosmological tests in satisfying the standard criteria of a successful theory suffers from inadequate headings and could have been much more powerful. These are small criticisms, however. The book is well presented and builds a cogent argument with effective writing.

A book very similar to this one could have been written in any of the past three decades, albeit with different foci and strengths. Interestingly, the constraints on the density parameter and many of the arguments about it have not changed over that period. This is all set to change if the promise of the measurement of anisotropies in the cosmic background radiation is fulfilled. We stand a good chance within the next decade, or perhaps significantly earlier, of determining the basic cosmological parameters of our universe — including Hubble's constant and the density parameter — to within an accuracy of a few percent. This book serves as a reminder that an epoch of uncertainty may soon be drawing to a close.

Hugh Couchman

*Hugh Couchman is a professor in the Department of Physics and Astronomy at the University of Western Ontario. His research investigates the formation of cosmic structure, ranging from galaxies to large-scale structure, using numerical simulation.*

# LUCIAN KEMBLE

Lucian Kemble and his "Cascade"

Father **Lucian Kemble** (1922–1999), a great friend to amateur astronomers throughout North America and around the world, passed away in Regina, Saskatchewan on February 21, 1999, after a massive heart attack.

Given the name Joseph Bertille Kemble, he was born on November 5, 1922, on a farm near Pincher Creek, Alberta, where he developed a love of nature and an appreciation of the prairie night sky with the encouragement of loving parents. During the Second World War, he served in the Canadian Air Force as a radio operator. The time he spent at an observation post in the Queen Charlotte Islands on the West Coast left a lasting impression on him, and he often talked of his experiences there. Following the war, he entered the Franciscan Novitiate, whereupon he took the name of Lucian. After studying philosophy and theology in Quebec, he was ordained as a priest in 1953.

In the years following his ordination, Luc taught at the seminary in Regina and at colleges in Maine and Saskatchewan. Apart from four years in the late '70s, which he spent in parish work at Port Alberni, B.C., the rest of his vocation was spent in preaching and counseling during retreats at Mount St. Francis, Cochrane, Alberta, and at St. Michael's, Lumsden, Saskatchewan, where he was living at the time of his death. Lamplighter Luc was the sobriquet he adopted to reflect his life-long quest for knowledge and an understanding of our place in the cosmos.

Luc's passion for astronomy was the catalyst in many of the friendships he forged over the years. I first met Luc in the fall of 1974 at Lumsden, shortly after I took a position in the Physics Department at the University of Regina. By then, Luc was already an avid astronomer. He had done his basic training with binoculars and from a delightful book called *The Stars*, by H. A. Rey of Curious George fame, from which he learned new ways to see the constellations and gained a clear understanding of the celestial clockwork. Although there was a 28-year difference in age between us, we very quickly became good friends. He had a Celestron-5 that he would set up in the Retreat House parking lot, and I would bring along another one from the university. We shared many long hours under the dark skies of Lumsden, enjoying views of the planets, double stars, star clusters, nebulae, and galaxies while refining our observing techniques and skills.

Jean, my wife-to-be, joined us in the spring of 1975, and we continued as a threesome of observers. Our notoriety was established late in the summer of that year with the appearance of Nova Cygni, which we noticed within 20 hours of its discovery by observers in Japan. We had been studying objects down in Aquarius, but decided to switch our attention to the Milky Way in the region of Cygnus. When we looked there, the sky was unrecognizable because of one bright "new" star. After consulting Luc's charts, we sent a brave message off to the Central Bureau for Astronomical Telegrams at the Smithsonian Astrophysical Observatory suggesting a possible nova.

Luc developed into an accomplished and dedicated visual observer as evidenced by the certificates and awards he received (RASC Messier certificate in 1980, Astronomical League of America Herschel 400 certificate in 1981, RASC amateur of the year in 1989, Webb Society award of excellence 1997) and by the observations and photos that were published in *Sky & Telescope* and in *Astronomy* magazines.

In 1980, *Sky and Telescope* published an innocent drawing of an observation made from Luc's observatory in Cochrane, Alberta. In the Deep-Sky Wonders column written by Walter Scott Houston, Luc described what he saw as "...a beautiful cascade of faint stars tumbling from the northeast down to the open cluster NGC 1502." Such delicate star patterns, with subtle differences in brightness and colour among the stars, were a source of constant pleasure to Luc, and he delighted in showing them to anyone who was interested. The one he described in *Sky & Telescope* is now generally known as Kemble's Cascade. *The Millenium Star Atlas* in which the Cascade is labeled, presented to him in August, 1998, at the Southern Saskatchewan Star Party, was the award that gave him the most pleasure.

Over the years, we shared many intense astronomical experiences with Luc, including Comet West in 1976, the total solar eclipse of 1979, which we observed from Estevan, and more recently, comets Hyakutake in 1996 and Hale-Bopp in 1997. When the skies were not filled with such exotic objects, we enjoyed watching meteor showers, spectacular auroral displays, and lunar eclipses. We delighted in the knife-edged cutoff of the light from a star as it was occulted by the Moon or by an intervening asteroid, while we listened to the beat from our favourite radio station — the time signal from WWV. Luc even derived excitement from the predicted appearance of satellites as they emerged from the Earth's shadow into sunlight high above us. And when there was no "special event" to observe, we shared the sky to the accompaniment of Bach and Vivaldi, coyotes and owls, or the drumming of male sage grouse.

Luc pushed his observing skills to the limit. Whether it was double stars or planets in the daytime sky or unreasonably faint galaxies in the darkest night skies, he found ways to see them. His enthusiasm was infectious; many nights when Jean and I had to leave early — around midnight — the graveyard shift of young initiates would show up, and they would continue to observe into the wee hours of the morning. At age 76, he wondered why he felt tired at 8:00 a.m. the next morning!

Luc was still looking ahead when I talked to him over the phone on the Friday morning before his death. He was planning to shoot the latest Jupiter-Venus conjunction using the same recipe he had followed for a similar conjunction back in February 1975 — the same two planets in the same constellation, Pisces. He loved to see the completion of cycles in the sky — part of the great cosmic clockwork.

For those who would like to know more about him, there is a web page dedicated to Luc at `http://www.jps.net/davestea/lucian/lucianhome.htm`.

Peter A. Bergbusch

## WILHELMINA IWANOWSKA

**Poland re Professor Wilhelmina Iwanowska** (1906–1999), of Poland, who was an honourary member of the Royal Astronomical Society of Canada, passed away on May 16, 1999, at age 93. She was an Honourary Citizen of Torun, Poland, and of Winnipeg, Manitoba, and a close friend of Helen Hogg.

Professor Iwanowska started her carrier at the University of Stefan Batory in Wilno (Vilnius), and then contributed to the development of astronomy in Torun. She was co-organizer of the Observatory in Piwnice, and the first Director of the Institute of Astronomy of the Copernicus University in Torun.

Professor Iwanowska was known as a great scientist of worldwide reputation, as well as a friend of the Univeristy employees and students. She had many awards and honourary degrees, including honourary doctorates from Torun, Leicester (United Kingdom), and Winnipeg (Canada); she was the Vice-President of International Astronomical Union and an honourary member of the Royal Astronomical Society and the Royal Astronomical Society of Belgium, as well as the RASC.

The funeral took place on May 21, 1999.

The President and Senate of the
Nicolas Copernicus University,
Torun, Poland

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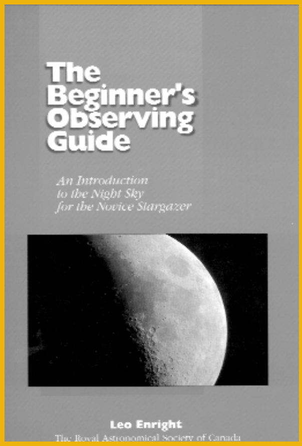


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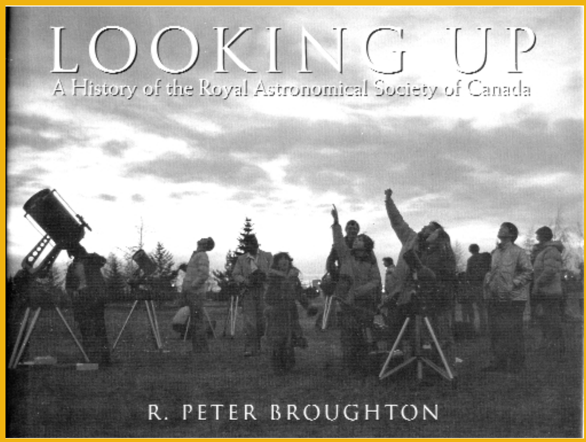


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