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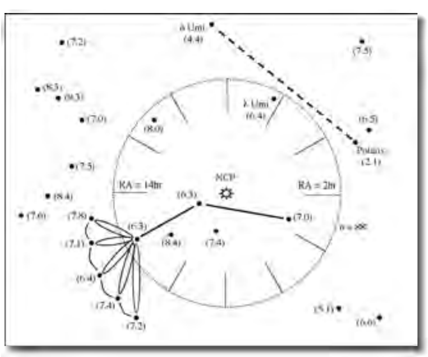

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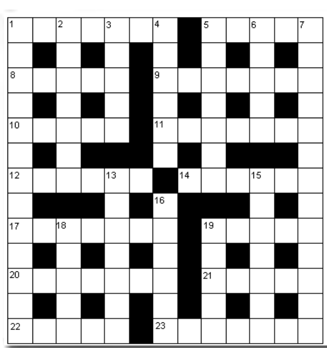

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Editorial

by Peter Jedicke (Pjedicke@fanshawec.ca), RASC President

One sentiment often expressed by members of our Society is appreciation for our profound sense of tradition. Since our origins go back to 1903 (when we received Royal Charter) or 1890 (when our scope became Canada-wide) or 1868 (in Toronto), it's no surprise that we've developed some very strong traditions.

What is "tradition," after all? First, it means continuity. Publications, library holdings, records of meetings — even correspondence and memorabilia! — trace an unbroken path through the decades of our success such as very few organizations can claim. Tradition also means commitment. The Society is devoted to promoting astronomy in any way, forever. It's as simple as that. We are certainly not some fly-by-night club that might leave no forwarding address! And tradition includes respect. We think of the talents and devotion of the men and women who worked so hard for the aims of the Society, and we think of the fellowship that so many members have shared at so many meetings in so many places. As members, we all share these traditions.

Not long after I joined the Society in 1974, I realized that I wanted to be part of all this. Being national President has been my ambition ever since, and I have taken a long look at the tradition of leadership in the Society. Thanks to Peter Broughton's book, *Looking Up*, we have a ready reference for our history. The list of all the officers the Society ever had reveals that I am now the 57th President. Since the term of office is two years, and the list of Presidents began 114 years ago, this tells us that we've had a very consistent flow of leadership, on average. In fact, the only significant deviations from the average were the very first President, Charles Carpmael, and the 7th, Clarence Augustus Chant, who each served four years. This consistency also applies to the other Executive officers: there have been 23 Treasurers and 19 Secretaries since the founding of the national Society in 1890.

But there's more that shows how deep the traditions run. Of the 57 Presidents, 34 of them followed the traditional steps from Second Vice-President through First Vice-President before becoming President. Although not required by our By-law, this progression ensures that the executive leaders have a good understanding of what is going on in the Society. It means that the "entry level" position for the Society's leadership is the Second Vice-President. Even the exceptions are instructive: the two occasions since 1980 when a Second Vice-President didn't continue were connected to the "revitalization" initiatives of 1994, which are widely acknowledged to have fueled our success in the last 10 years. And both of those individuals

Journal

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(Michael Watson and Peter Ceravolo) nevertheless contributed to the revitalization in a positive and meaningful way.

The First Vice-President has risen to the Presidency on every transition since 1947. Only eight times before that did the First Vice-President not make the step to President — and in five of those cases, it was the Second Vice-President who became President. That's an astonishing record of continuity.

As a member (and a Past President) of the London Centre, I note that even in the Centres, the sense of tradition in leadership is strong. The London Centre's first President, Harold Reynolds Kingston, remained in that office from the founding of the Centre in 1922 until 1931 — when he became the 19th national President. I am now only the second London Centre member to be national President. Kingston also served as the London Centre's Honorary President from 1931 until he passed away in 1963.

Tradition is truly inspiring, and I will do my best to honour our Society's traditions. But in the wondrous yin-yang of life, even great traditions need a fresh breeze now and then. What balances tradition? I call it "zaniness." While it's easy to identify a tradition once it's well established, it's much more difficult to pick out the little crazy things that make belonging to the Society so much fun. You can count on me to do my part on that, too.

News Notes
En Manchettes

SALVE SOLA VENERIS PROGENIES

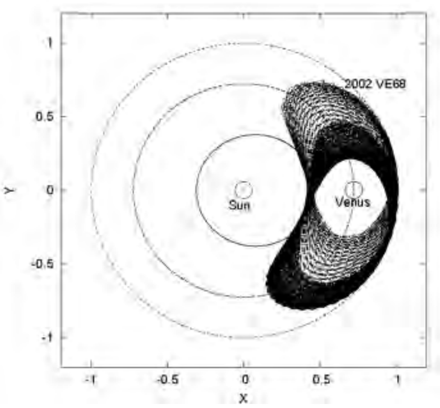

Figure 1. — The motion of 2002 VE68 during the next 150 years. The Sun is at centre in the diagram and the coordinate system rotates with Venus. The (X, Y) coordinate scale is in astronomical units. Image courtesy of Dr. S. Mikkola.

Venus is often called Earth's twin, the two planets being comparable in size and mass. Now the similarity can be extended to their both having a moon. That is to say that a quasi-satellite (QS) of Venus has recently been discovered in the form of asteroid 2002 VE68. The asteroid was first identified in November 2002 through the Lowell Near-Earth Object Search (LONEOS) program but its status as a quasi-satellite to Venus has only recently been determined. The newly revealed status of 2002 VE68 was announced by S. Mikkola (University of Turku, Finland), R. Brasser (York University), P. Wiegert (University of Western Ontario), and K. Innanen (also of York University) in the *Monthly Notices of the Royal Astronomical Society* this past July. Specifically the researchers argue that the asteroid was captured into a QS orbit with Venus some 7000 years ago and will probably retain its QS status for another 500 years.

Although called a QS of Venus, 2002 VE68 is actually in orbit about the Sun. The key point about the asteroid is that it follows an approximately elliptical orbit about the Sun with the same mean period as Venus. In a reference frame that rotates with Venus, 2002 VE68 actually traces out a complex, elongated, retrograde trajectory about the planet (see Figure 1).

MOST SHAKES UP THE STELLAR WORLD

The first results from *MOST* (Microvariability and Oscillations of STars) are in — and they are making waves. Indeed, astronomers working on the Canadian Space Agency sponsored mission have recently reported on the detection of a strong "pulse" in a young adult star called eta Boötis, and a bad case of stellar acne and hyperactivity in a "pre-teen" version of the Sun, kappa 1 Ceti. These new data offer a unique perspective on what our own Sun may have been like in its youth.

"All this talk of stellar pulses and hyperactivity must sound like ER Meets Star Trek," admitted *MOST* Mission Scientist Dr. Jaymie Matthews (University of British Columbia), who presented the findings in a keynote address to the annual meeting of the Canadian Astronomical Society (CASCA) in Winnipeg this past June. "But we really are doing diagnostic check-ups of stars at different points in their lives, by placing them under intensive observation for weeks at a time."

MOST monitored eta Boötis, a slightly more massive and younger version of the Sun, for 28 days without interruption, placing the star under a 24-hour scientific "stake-out" that revealed behaviour that was hidden from the limited view possible for Earth-bound telescopes. Accumulating almost a quarter of a million individual measurements of this star, *MOST* reached a level of light-measuring precision at least 10 times better than the best ever achieved before from Earth or space.

The data reveal the star is vibrating, but at a pitch well below the range of human hearing. The stellar melody should allow the *MOST* team of scientists, including Dr. David Guenther of the Canadian Institute for Computational Astrophysics at Saint Mary's University, Halifax, to determine the age and structure of eta Boötis. "We're now in a position to explore new physics in stars, with observations like these," said Dr. Guenther.

Before observing eta Boötis, and while still in the shakedown phase of its mission, *MOST* was aimed for testing purposes at the star called kappa 1 Ceti. Astronomers already suspected this was a younger version of our Sun, with an age of about 750 million years. The Sun's age is about 4.5 billion years, and it is just entering middle age. In terms of a human life the Sun would be about 45 years old while kappa 1 Ceti would be eight years old — barely a pre-teen. Kappa 1 Ceti is certainly hyperactive, flaring up from time to time, and spinning with much more kinetic energy than sedate older stars like the Sun. It also has a severe case of acne — dark spots on its face that are much larger than those visible on the Sun's surface. The *MOST* data, following kappa 1 Ceti for 29 days, show in exquisite detail how the spots move across the visible side of the star as it spins once every 9 days or so. And because a star is not solid different parts of its gaseous surface spin at different rates. *MOST* has been able to measure this effect directly in a star other than the Sun for the first

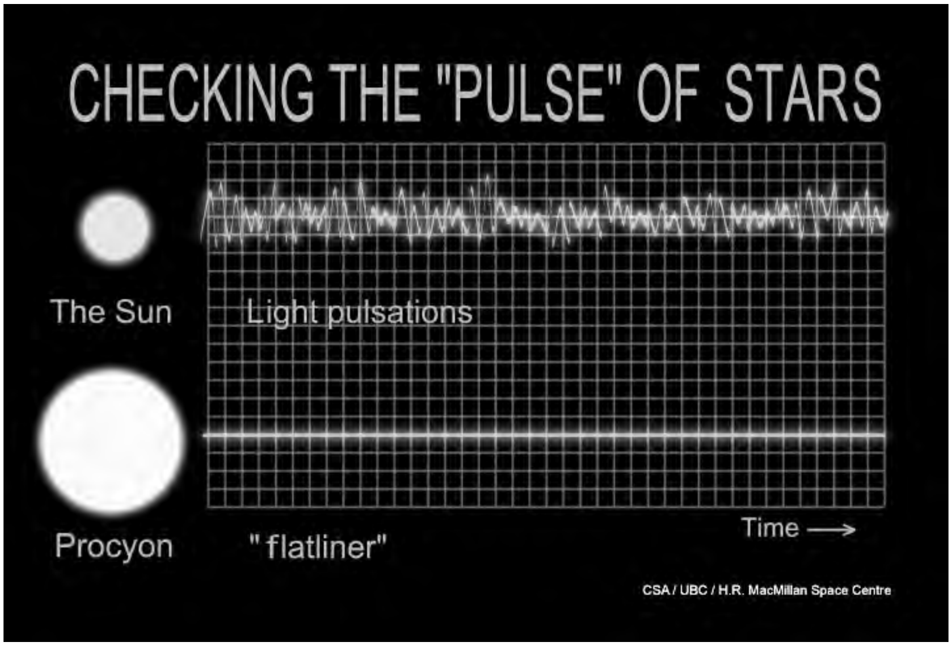

Figure 2. Comparison of the Sun's microvariability with that of Procyon (see `www.astro.ubc.ca/` *MOST* for further details). Image courtesy of CSA, UBC, and the MacMillan Science Centre.

time. These results are being prepared for submission to *The Astrophysical Journal*.

The *MOST* team has also studied the bright star Procyon, and was shocked to discover that this particular cosmic patient is a "flat liner." The star shows none of the pulsations predicted by over 20 years of earlier theory and observations from Earth. These results were published in the prestigious journal *Nature* in early July.

"The lack of a pulse doesn't mean the star Procyon is dead," explained Dr. Jaymie Matthews. "But it does mean that some of our long-held theories about stars like this need to be put on the critical list. And that future space missions following in the path of *MOST* will have to revise their target lists and observing strategies in light of this null result."

Future targets for *MOST* include other stars representing the Sun at various stages in its life, and stars known to have giant planets. *MOST* is designed to be able to register the tiny changes in brightness that will occur as a planet orbits its parent star. The way in which the light changes will tell astronomers about the atmospheric composition of these mysterious worlds, and even if they have clouds.

SHEDDING LIGHT ON DARK MATTER

Presenting their findings at the annual CASCA meeting in Winnipeg this past June, two University of Toronto (U of T) astronomers and a U.S. colleague report that they have measured the sizes and shapes of massive dark-matter halos that surround galaxies.

"Our findings give us the clearest picture yet of a very mysterious part of our Universe," says principal investigator Henk Hoekstra, a post-doctoral fellow at U of T's Canadian Institute for Theoretical Astrophysics. "Using relatively simple physics, we can get our first direct glimpse of the size and shape of these halos, which are more than fifty times more massive than the light-producing part of galaxies that we can see," explains Hoekstra, who collaborated with Prof. H.K.C. Yee (U of T) and post-doctoral fellow M. Gladders (Carnegie Institute of Washington) in the study.

In recent years ever more detailed observations have provided convincing astrophysical evidence for the existence of dark matter, although it has not been detected directly in ongoing experiments. Dark matter emits no light and, therefore, cannot be seen directly, Hoekstra explains. The only evidence for its existence comes from its gravitational pull on stars, gas, and light rays. Dark matter is believed to account for approximately 25 per cent of the total mass in the Universe, with the rest of the Universe composed of normal matter (5 per cent) and dark energy (70 per cent).

To date, most information about dark matter has come from measurements of the motion of gas and stars in the inner regions of galaxies. Other important data have come from computer simulations of the formation of the Universe's structure. However, scientists can explain their findings about dark matter only if it is true that galaxies are surrounded by massive, three-dimensional halos.

Using the magnifying-glass-like effect of gravitational lensing, the U of T scientists have found that dark-matter halos extend more than five times further into space than the visible stars in a galaxy. In the case of our Milky Way galaxy, the halo extends to a distance of some 150 kpc and contains approximately 880 billion solar masses of dark matter.

The new findings also provide strong support for the popular cold-dark-matter model of the Universe — a theory that suggests that dark-matter halos should be slightly flattened. Using the relatively new technique of weak gravitational lensing, which allows astronomers to study the size and shape of dark matter, the research team measured the shapes of more than 1.5 million distant galaxies using the Canada-France-Hawaii Telescope in Hawaii. "The small changes in the shapes of the galaxies offered a strong indication to us that the halos are flattened, like a rubber ball compressed to half its size," Hoekstra says.

Their findings can also be applied to a larger scientific debate about the nature of the Universe. Some scientists have developed theories about the Universe using the assumption that dark matter does not exist and, as a result, they have proposed changes to the law of gravity. However, Hoekstra is confident that his team's findings will refute these theories.

POLARIS: A CLOSER "FIRST CROSSER"

Astronomer David Turner (Saint Mary's University, Halifax, Nova Scotia), has discovered that Polaris (alpha Canis Minoris) is a probable member of a sparse cluster of stars never noticed before. Measurement of the cluster's distance puts Polaris significantly closer than previously thought. Furthermore, the unusual pulsating properties of this star suggest that it may stop pulsating soon. This new work on the pole star was presented at the Canadian Astronomical Society's annual conference held this past June in Winnipeg.

Polaris is the brightest and nearest member of a class of pulsating stars known as Cepheids, all of which obey a relationship between period of pulsation and intrinsic luminosity that makes them valuable gauges of distance to nearby galaxies. Polaris, however, is a peculiar member of the class. Its light variations have always been feeble relative to those of other Cepheids. In the early 1900s they were about a tenth the range of most other Cepheids. Over the past half-century they have dropped precipitously to about the 2% level, prompting a warning from some astronomers that the star might cease to pulsate prior to the turn of the millennium. That did not happen.

The manner of the star's pulsation is also mysterious. Most Cepheids undergo fundamental mode pulsation that produces skewed light curves. But the light changes in Polaris are smoothly sinusoidal, which many astronomers ascribe to pulsation in a higher order harmonic. The star's luminosity inferred from its distance established by the *Hipparcos* spacecraft mission permits such a possibility — yet several important and unanswered questions remain.

The poorly populated star cluster around Polaris allows us to derive an independent estimate of the distance to Polaris, explains Turner, since the luminosities of main-sequence companions are well established from stellar evolutionary models as well as from empirical studies of other nearby star clusters belonging to our Galaxy's disk.

The distance estimated for the cluster (276 ly ≈ 85 pc) is ~33 % smaller than the distance to Polaris obtained by the *Hipparcos* satellite from its parallax (431 ly ≈ 132 pc), although it is tied to the photometric data from the *Hipparcos* mission. The cluster distance may be the more correct value, in which case it implies that Polaris pulsates in the fundamental mode, not in an overtone.

Recent monitoring of Polaris confirms that it continues to pulsate, albeit at a very low level, and that its pulsation period is increasing at a rate of about 8 seconds per year. Although small, this increase is some 100 times larger than that observed in other Cepheids of the same pulsation period. The rapid-period change in Polaris can be explained by stellar evolution theory, and is the result of Polaris evolving from a hot, blue, main-sequence star into a cool, red, supergiant star. The evolutionary phase will take several hundred thousand years to complete. Most Cepheids have already evolved from the main sequence, and are presently in a slower stage of evolution following the red supergiant phase. Very few stars are ever caught in the act of evolving, and Polaris is one of a select group of five (in a sample of over 200 belonging to our Galaxy) known Cepheids that are "first crossers."

IMPROVED SERVICE

Beginning with the December 2004 issue, members will have early access to the current issue of the Journal on the RASC Web site at www.rasc.ca/currentjrasc. The latest issue will be posted immediately after the final production version is complete and removed from the Web once the issue begins arriving by mail. This service will give members immediate access to time-sensitive material in case the Journal is delayed in arriving. Each electronic version will be password protected with the password printed in the prior issue.

The access for the December issue (which should be available around December 6, 2004) is:):
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In Search of the *English Rose*, Robert Hooke's Lost Constellation

by Martin Beech (beechm@uregina.ca)

Introduction

Dr. Robert Hooke (1635-1703) F.R.S. was a thoroughly remarkable man[1]. History, however, has not served the memory of his extensive and innovative scientific career too kindly and, indeed, he is more often remembered in the modern era for his cantankerous (but arguably justified) "run-ins" with such other luminaries as Newton, Hevelius, Huygens, and Flamsteed. The topic of this essay, however, is concerned with an attempt to rediscover a lost remnant from amongst Hooke's astronomical works. Specifically, I have set out to recover some of Hooke's imaginative artistry and identify those stars that constitute the circumpolar constellation he defined and named the *English Rose*. "Discoverable only by a telescope," Hooke mentioned the *English Rose* in just one of his published works, where he described it as follows:

> "Consisting of six Stars in the Rose itself, and several others in the Leaves and Branches, one of these is in the Center of the Rose, and five in the five green Leaves of the Knob: This I have somewhere described about ten Years since, but have mislaid them at the present: the way of finding them I shew'd to Sir Chr. Wren, and some others of this Society at the time when my Instrument was fixed for that purpose."

The above quotation is from Hooke's *Discourse of Earthquakes and Subterraneous Eruptions*[2], read to the assembled Fellows of the Royal Society over several meetings starting February 9, 1687. Hooke became well known, if not infamous, in his latter years for asserting prior authority over many supposedly new scientific discoveries and/or mechanical innovations[1]. While some of his priority claims can be readily established, in the case of the *English Rose* his original description, presumably dating from *ca.* 1677, has not, apparently, survived to the modern era. The author is not aware of any references being made to the *English Rose* by contemporaries of Hooke, and likewise, no celestial cartographer appears to have explicitly incorporated it into any sky map.

The "about ten years since" comment relating to his initial description of the *English Rose* suggests that Hooke first identified it sometime between 1674 and 1680. A survey of Royal Society meeting notices[3] and Hooke's personal diary[4] indicate that he was actively observing the heavens and building new astronomical instruments in the time interval of interest. For example, we find from the published extracts of his personal diary that between 1674 and 1680 Hooke was making observations of the Moon, the Sun, sunspots, the planets, comets, lunar occultations, and lunar eclipses. We also find Hooke working on the design and construction of various quadrants, multiple numbers of helioscopes, a selenoscope, a new observatory turret at Gresham College, and the construction of numerous telescopes. Amongst the various telescopes that Hooke tried at that time, we find reference to objectives with focal lengths of 7, 8, 12, 15, 20, 24, 30, 50, and 60 feet[5]. Further, and again in the time interval of interest, Hooke published the first part of his *Animadversions* to Hevelius's *Machina Cœlestis,* and he delivered the Cutlerian Lectures on topics relating to the motion of the Earth, the construction of helioscopes, and the observational properties of comets[6]. And, all this astronomical work was being conducted in parallel with his many other experiments, investigations, and writings for the Royal Society, as well as in conjunction with his civic duties as City Surveyor of London.

It would seem that there are no specific reasons to doubt Hooke at his word concerning the discovery the *English Rose* sometime *ca.* 1677. Certainly Hooke was keenly observing the heavens at that time and he had numerous instruments with which to make his observations. We have not, however, been able to identify from his diary entries any specific time and experiment wherein Hooke might have discovered and/or described the *English Rose* to Society Fellows. In addition, it seems reasonably clear from his surviving works that Hooke made no great public advertisement of his "new" constellation prior to 1687, and we note that he made no mention of the *English Rose* in his *Lectures concerning Navigation and Astronomy*[7] read in 1683.

Polar Drift, The True Meridian, and Latitude

Hooke included a description of the *English Rose* in his *Discourse of Earthquakes* by way of making it an aid to the location of the north celestial pole (NCP). The relevance of identifying the pole position being that Hooke was describing in his *Discourse* the procedure known to all navigators since antiquity that the altitude of the visible celestial pole corresponds to the observer's latitude on Earth[8]. All that Hooke was encouraging at that time (1687) was that the meridian and latitude be measured with the greatest of possible accuracy. The reason why Hooke was advocating exacting precision, however, related to his belief that "the axis of its [the Earth's] rotation hath and doth continually by a flow of progression vary its position with respect to the parts of the Earth."[9] While Hooke knew that any such changes must be very small, on a time scale of say years, he argued that they should, nonetheless, be measurable with "modern" equipment. Just as precession can be measured by a shift in the position of the NCP against the background stars, so Hooke was suggesting that an additional motion might be present (and measurable) as a result of volcanically driven land mass shifting.

Hooke (rightly) believed that the accuracy required for his polar drift experiment could only be achieved through telescopic observations. His method suggested the use of a long focal length telescope first to determine the location of the NCP in the sky, and from the telescope he then proposed to mark out the meridian. To achieve this latter goal he suggested dropping two plumb lines from each end of the telescope tube or support, the line on the ground between the plumb bobs would then delineate the observer's meridian. In his reading[10] to the Royal Society on February 16, 1687, Hooke suggested that "six, twelve, or fifteen foot" focal-length telescopes might be used, although he later indicated (at the February 23 meeting) that a "two-foot glass" was adequate. In a moment of grandeur Hooke also suggested that perhaps extremely long-focal-length objectives might be employed, the objective being "fix'd at the top of some Tower or Steeple, and the Sights and Eye-glass at the Ground."[9]

The Royal Society meeting notices for 1687 indicate that Hooke first broached the subject of a changing polar axis in a lecture delivered on January 19, their raising the question "whether the earth's poles are fixed in the earth, or not?" He continued the debate on polar drift at the January 26 and February 9 meetings, and at the latter meeting outlined his telescopic method for determining the true meridian. Hooke introduced his method for finding the NCP via the *English Rose* at the February 23 meeting, and we find that an experiment to substantiate the method was postponed at the March 9 meeting due to cloudy weather. The Fellows returned to the discussion of the Earth's shifting poles at the March 23 meeting, it then being suggested that "the protrusion of mountains by subterraneous fire or otherwise may occasion some alteration of the poles of the earth, as well as the accession of new matter."

At the April 6 meeting Hooke introduced a new method for the determination of latitude; in this case advocating the use of a planisphere constructed according to a gnomonic projection. Hooke described additional methods for the determination of latitude at the April 13, April 20, April 27, and June 9 meetings. The method outlined at the April 27 meeting relied upon the placement of "the Pole Star [Alpha Ursa Minoris], and two other stars not far distant from the pole [NCP]" into appropriate location circles engraved upon a glass plate positioned at the focal plane of a telescope. At the April 20 meeting Hooke also showed a "reflecting telescope made to take in several degrees. This he proposed as a very proper instrument to discover the true pole-point among the telescopical fixed stars." Unfortunately no specifications for the telescope Hooke presented at the meeting were recorded. At the May 25 meeting of the Society, Hooke expanded his discussion on polar drift and raised a "suspicion of his, that the earth being made up of heterogeneous parts may have some inequality in the diurnal rotation from the different actions of the sun and moon." He further argued that any variations in the Earth's diurnal motion could be determined by measuring the crossing times of selected stars, all with the same declination, through a telescope's field of view, at various times during the same night. Hooke followed-up on the details of this latter "thought experiment" by presenting lectures at the June 8 and June 22 Society meetings on the topic of exact time measurement. While Hooke was prepared to raise the question of a non-uniformly rotating earth in 1687, we note that one of John Flamsteed's first research projects at the newly founded Greenwich Observatory was, in fact, to establish that the Earth did rotate uniformly[11]. Using pendulum clocks built by Thomas Tompion, Flamsteed made daily culmination measurements of the bright star Sirius, and concluded as early as 1680 that the Earth did, indeed, rotate at an even rate (to the accuracy measurable with the then available instruments).

The general trend in Hooke's discussions concerning latitude determination in 1687 is one of evolving practicality. The initial method introduced on February 23 involved the use of a very long-focal-length telescope and the identification of stars in a faint, poorly advertised "constellation." A refined, more utilitarian method using a shorter-focal-length telescope ("1 foot, or 18 inches in length") to locate Polaris and several other bright stars was introduced at the April 27 meeting. Alternate methods based upon azimuth, altitude, and zenith angle measurements of bright stars were introduced at Society meetings held in early April, May, and June. While all of the methods for latitude and true meridian determination outlined by Hooke would have worked in principal, there is no indication that he actually set out to perform, in any systematic manner, the measurements required to test the polar-drift hypothesis.

Identifying the *English Rose*

Finding patterns between the distributions of stars in the sky is an age-old human pre-occupation, and one that brings together both the visual acuity and the imagination of the observer[12]. We can not be certain which stars Hooke had in mind when he identified the *English Rose,* but there is no specific reason to suppose that we can not "find" them again for ourselves.

From Hooke's description in his *Discourse of Earthquakes,* we know that the *English Rose* is only discernible through a telescope and that it is close to the NCP. The meeting notes to the Society gathering held on February 23, 1687 contain the additional information:

> "[The] small telescopic constellation, called by him the *English Rose* (which he said, he had discovered just about the present pole-point, and wherein he formerly had marked the very point).... This method having the advantage of being [able] to be put in practice at all times of the night, when clear, and these small stars to be seen with a two-foot glass."

We have, therefore, that the *English Rose* actually encompasses the NCP, or, at the very least, the NCP is located close to some part of its imagined figure. Further, we may assume that most, if not all, of the stars in the *English Rose* are fainter than an apparent magnitude of +6, the typical clear-sky, naked-eye visibility limit. Likewise, we also assume that the stars in the *English Rose* are not so faint that a telescope with a large light-grasp is required to reveal them. Hooke, indeed, suggests a modest "two-foot" focal-length telescope is adequate to reveal the stars. This being said, the limiting magnitude of a telescope is determined by the size of its objective and not its focal length.

There are only a very few occasions in all of his written works when Hooke actually refers to the diameter of the objective being employed in his telescope. One such case relates to a 3.5-inch diameter objective, used *ca.* 1663, in a 36-foot focal-length telescope to study[13] both the Pleiades star cluster and the Orion nebula. A second instance can be found in a letter[14] written by Hooke to Hevelius *ca.* 1666. In this latter case, the objective of a 60-foot telescope is described as being "a piece of glass between 1/4 and 1/2 -inch thick, and between 5 or 6 inches over; it bears an aperture of about 3 inches, sometimes 4 or more." Hooke's observations on the Pleiades cluster were published in his famous *Micrographia*[13], and an inspection of the figure reproduced therein reveals that he was both a good observer and draftsman, and that his telescope could reveal stars down to an apparent visual magnitude of +10.5 (and possibly to magnitude +11). Certainly, the theoretical limiting magnitude achievable with a 3.5-inch objective is of order magnitude +14, but it is highly unlikely that any of Hooke's objectives were close to being "ideal."[15] It is probably safe to assume that the stars constituting the *English Rose* are much brighter than apparent magnitude +10. Indeed, if we set a limiting magnitude of +8.5 for the stars in the *English Rose* then they should readily fall within the light-grasp of a telescope with a 1 to 1.5-inch (20- to 30-mm) diameter objective.

Figure 1 shows those stars brighter than a limiting magnitude of +8.5 within 5 degrees of the NCP at the time Hooke was making his observations (epoch 1680).[16] The brightest star in the field is Polaris (α Ursae Minoris) with an apparent magnitude of +2.1. The stars in the figure are shown with equal weight (*i.e.* the same-sized positional dot is used in each case) in an attempt to enhance any figurative or spatial correlation. I have used the apparent magnitude as a secondary indicator (*i.e.* faint stars being less "prominent" than bright ones to the

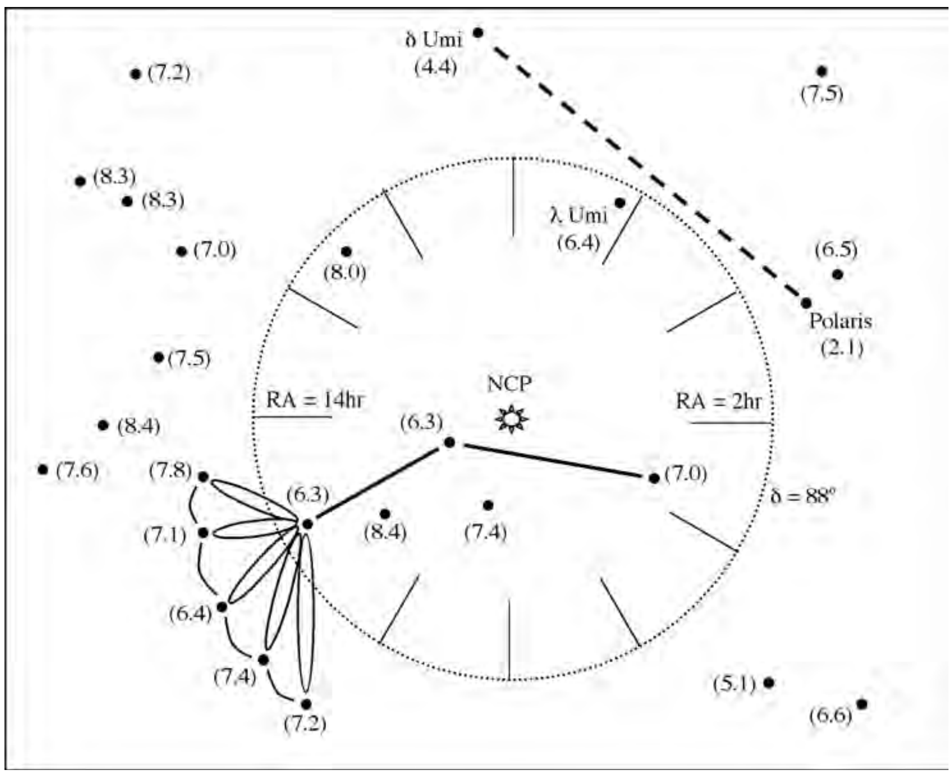


Figure 1. — The spatial distribution of stars brighter than apparent magnitude +8.5 located within 3.5 degrees of the north celestial pole (epoch 1680). The north celestial pole (NCP) is at the center and the circle (dotted) has an angular radius of 2 degrees on the sky. The star positions are shown with "dots" of equal weight (in order to enhance any spatial correlation) and their apparent visual magnitudes are given in the brackets. The dashed line in the upper right-hand corner indicates the "tail stars" of Ursa Minor. My suggested grouping for the stars in the *English Rose* is shown by the solid lines (the stem), ellipses (the five leaves), and arcs (the rose petals).

eye) in my search. The group of stars that most clearly "stand-out" to the author's eye and that apparently "fit" the description given by Hooke are joined by solid lines, loops, and ellipses in the figure.[17] In this suggested configuration, the *English Rose* is apparently seen "side-on," like a pressed flower, rather than from "above" as in the heraldic depiction of the Tudor Rose. The stars in our suggested *English Rose* configuration fall in the magnitude range +7.8 to +6.3, and the "constellation" stretches some 4 degrees across the sky. The NCP is located close to the "bend" in what we suggest is the "stem" of the *English Rose,* and the stars that constitute the "leaves and petals" are situated along what is now designated as the boundary between Ursa Minor and Camelopardalis. We also note that the stars SAO 1975, SAO 2012, and SAO 2010, the three brightest stars in our evoked *English Rose* all have approximately the same angle of Right Ascension (RA $\approx 12^{hr}$) and consequently they act as convenient guide stars that "point" directly towards the NCP. As a consequence of precession the stars in our suggested *English Rose* are now no longer close to the NCP. Indeed, the star in the *English Rose* that we place closest to the NCP, SAO 2010, is presently separated from the pole by 2.3 degrees, as opposed to a 0.5 degree separation in 1680. Polaris has experienced the exact reverse of this displacement; it presently being 0.7 degrees from the NCP, as opposed to 2.5 degrees in 1680.

Just as no clearly authenticated portrait of Hooke's likeness has survived to the modern era[18], so too has Hooke's original description of the *English Rose* been lost. I have here, however, sought to reconstruct the latter, and while we cannot be certain that the stars as specified by Hooke have been identified, I present the construction shown in Figure 1 as a possibility to what he might have had in mind.

Notes

1. See, for example, the recent books: Inwood, S. 2002, *The Man Who Knew Too Much* (Pan Books: London); and Bennett, J., Cooper, M., Hunter, M., & Jardine, L. 2003, *England's Leonardo: the life and work of Robert Hooke* (OUP: Oxford). See also, Chapman, A. 1996, England's Leonardo: Robert Hooke (1635-1703) and the art of experiment in restoration England, *Proc. Royal. Inst.* Gt. Brit., 67, 239

2. Waller, R. 1969, Ed., *The Posthumous Works of Robert Hooke* (Johnson Reprint Corporation: New York), 279.

3. Gunther, R.T. 1930, *Early Science in Oxford*, Vol. VII (Oxford Press: Oxford), 416.

4. Robinson, H.W., & Adams, W. 1968, Eds., *The Diary of Robert Hooke: 1672-1680* (Wykeham Publications: London).

5. I leave the focal lengths in their original units of feet; the conversion to metres, for those that will, being made through the multiplication by 0.3048. Hooke used long-focal-length objectives, as did all his contemporaries, as a means of minimizing the image-degrading effects of chromatic aberration.

6. Hooke outlines in this work a method by which an observer's meridian can be determined through the measurement of the extreme eastern and the extreme western positions of any circumpolar star. See note 2, pp. 505-506.

7. Hooke had been "charged" by the Royal Society, in June of 1669, to find a method for determining the "true meridian," but in spite of additional "reminders" in April and July of 1670, and in June of 1671, no practical method was apparently brought forward. The Royal Society meeting notices for April 14, 1670 do record, however, that Hooke "suggested a method for striking exact meridians by the North Star, and by observing the time of night" — see, Gunther, R.T. 1930, *Early Science in Oxford,* Vol. VI (Oxford Press: Oxford). In 1670, the North Star (= Polaris = α Ursae Minoris) was some 2.5 degrees angular distance from the NCP, and the method that Hooke appears to be advocating would require the determination of its times of upper and/or lower culmination. It seems clear, then, that Hooke had not identified the stars in the English Rose by June of 1671, which is consistent with his comments referenced in note 2.

8. See note 2, pp. 353-362.

9. Editorial comment by Waller. See note 2, p. 360.

10. Chapman, A. 1990, *Dividing the Circle: The Development of Critical Angular Measurement in Astronomy 1500 – 1850* (Praxis Publishing Ltd.: Chichester), 50.

11. There is typically only a slight or, at best, a passing similarity between the actual distribution of stars on the sky and the constellation figure that they are supposed to represent. Our assumption in this article, however, is that the stars that constituted Hooke's *English Rose* did have a distribution on the sky that would be generally "recognizable" as a rose, or at least a flower-like motif.

12. See note 8, pp. 279-281. The extract quoted is from an undated letter [but designated *ca.* 1666] by Hooke to Hevelius. Hooke continues in his letter, "It [the 60-ft glass] discovers many things not visible through a very good 36 [foot] glass; such as the shadows of the satellites, and the veracity of Jupiter and Mars on their axes." Hooke further designed and presumably experimented with variable aperture attachments. An iris-like diaphragm, for example, was described at the July 27, 1681 meeting of the Royal Society: "Mr. Hooke showed his new-contrived aperture for long telescopes, which would open and close just like the pupil of a man's eye, leaving a round hole in the middle of the glass of any size desired; which was well approved of." See note 3, p. 577.

13. The theoretical limiting visual magnitude of a telescope with an objective of diameter D(mm) is: $m = 2.7 + 5 \log D$. See *e.g.,* R. Gupta (Ed.) 2004, *Observer's Handbook of The Royal Astronomical Society of Canada* (University of Toronto

Press: Toronto). R. Willach (2001) [*The Development of Telescope Optics in the Middle Seventeenth Century,* Annals of Science, 58, 381] notes, however, that *ca.* 1610 Galileo could detect stars down to magnitude +8.5 with an objective glass of 20-mm diameter. Galileo was thus "losing" about one magnitude from the theoretical limiting magnitude of his telescope. This "loss" was caused by the poor optical quality of the glass available to Galileo in his experiments. Since the quality of optical glass hardly improved during the entire run of the 17th century [see *e.g.* Rudd, M.E., Willach, R., Stauberman, K., & Jaecks, D.H. 2003, *A curious Example of a Fraunhofer-Dolland Connection,* Bulletin of the Scientific Instrument Society, No. 79, 2] a one- to two-magnitude loss from the theoretical limiting magnitude of any telescope being used by Hooke would not be surprising.

14. The star designations in the Smithsonian Astrophysical Observatory Star Catalogue (SAO listings) are: SAO 2012 for the "central knob," with the five leaves being SAO 2122, SAO 2057, SAO 1975, SAO 1902, and SAO 1834. The "stem" is composed of the three stars SAO 2012, SAO 2010, and SAO 1401.

15. Chapman, A. 2003, *The astronomical works of Robert Hooke,* The Observatory, 123, 241. A portrait propounded to be of Hooke has recently been found, however, and this may be viewed at the MacTutor History of Mathematics Archive, maintained by the University of St. Andrews. The Internet URL is: `www-history.mcs.st-andrews.ac.uk/history/PictDisplay/Hooke.html.`

References

1. Gunther, R.T. 1930, *Early Science in Oxford,* Vol. VIII (Oxford Press: Oxford), 31.

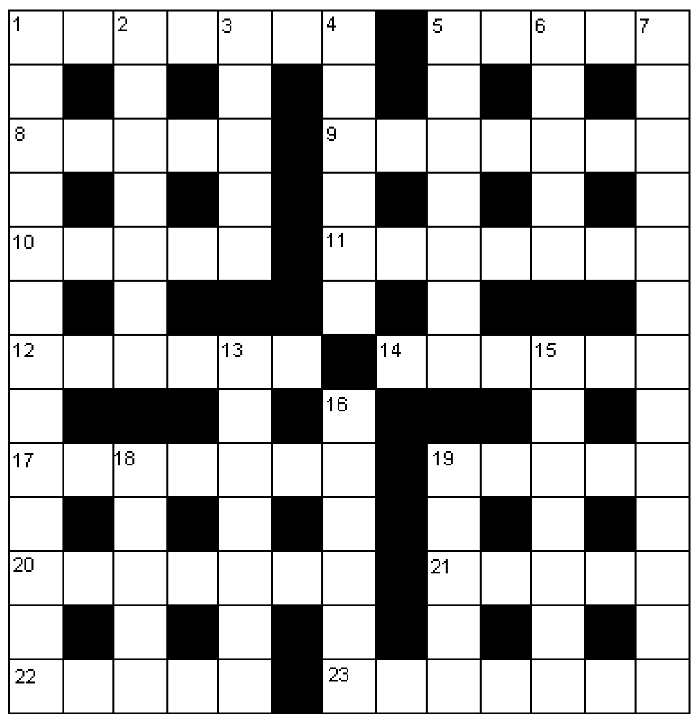
2. Gunther, R.T. 1938, *Early Science in Oxford,* Vol. XIII (Oxford Press: Oxford), 241. Hooke began his observations of the Pleiades cluster in April of 1663 — see, Gunther, R.T. 1930, *Early Science in Oxford,* Vol. VI (Oxford Press: Oxford), 128.

3. The figure has been constructed with the aid of the *Redshift 2* planetarium program (Maris Multimedia, 1995). The program incorporates both proper motion and precession adjustments to star locations in accordance to the prescribed viewing epoch.

Martin Beech teaches astronomy at Campion College, The University of Regina and would like very much to have known Robert Hooke.

Astrocryptic

by Curt Nason, Moncton Centre



ACROSS

1. Reflections journalized by two guys (7)
5. Endless love is complicated on Mars (3,2)
8. Not quite a maiden, not quite rain (5)
9. Foundation planet is right in Edgar's elephant (7)
10. Not very massive; massless, in fact (5)
11. Ain't it a funny place around Uranus (7)
12. Telescope mount in slow motion (6)
14. Beta version in test of unrecorded knowledge (6)
17. His nebular hypothesis transforms Capella (7)
19. Egyptians viewed Orion as hours wasted away (5)
20. Diffraction tool describes a family picture (7)
21. She embodies the Moon in Gassendi, a natural crater (5)
22. Early home computer used first at Tucson and Yerkes (5)
23. Sad, dour, convoluted tale of a swordfish (7)

DOWN

1. When stars appear at six below zero (5,8)
2. Are Lego pieces made to catch comet dust? (7)
3. Intended to obtain average temperature of stars (5)
4. Somehow attune the axis to change obliquity (6)
5. Mad one follows Saturn's lead to the impact cone (7)
6. The French can speak the language of scientists (5)
7. Brave tar sails off to observe Cepheids (8,5)
13. Calcium is replaced by oxygen in a star's capacity to absorb radiation (7)
15. He has a loop in the barnyard. Why not? (7)
16. Neptune ad goes awry (3,3)
18. Unfinished alpine crumbles to flatland (5)
19. Bright star seen reversed in a Telrad ahead of the finder (5)

In Search of Huygens

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

In *Reflections,* three issues ago (April), we commemorated the 375th anniversary of the birth of Dutch scientist Christiaan Huygens (1629-95), a giant of 17th-century science who made enormous contributions to mathematics, physics, and astronomy. Regular readers may recall that I was planning a July trip to The Netherlands to attend an acoustics conference and that I was hoping to make a pilgrimage to the home of this productive and influential man. Things did not turn out exactly as I had hoped, as you will hear, but I did enjoy an unexpected scientific surprise connecting Huygens, my acoustics conference, and Titan (Saturn's largest Moon).

The Tourist Story

My acoustics conference was held at the Technical University of Delft, in the small city of that name between Amsterdam and Rotterdam. Delft is known for blue porcelain china and as the home of the Dutch painter Vermeer. In fact, a recent book and film entitled *The Girl with a Pearl Earring,* inspired by a Vermeer painting, are both set in Delft, and some of the movie scenes were filmed in that city. The film opened in Halifax in a small theatre a few months before my trip, so my wife and I were able to get a sneak preview of the conference city!

Being so small, Delft did not take long to tour, and it was not long before the family wanted to venture further afield. Fortunately, this was not difficult, as Holland is a small country, densely populated, with an excellent train system. The next city along the train line is The Hague (*Den Haag* in Dutch), the home to many international organizations. It also happens to be the city in which Christiaan Huygens spent his first and last years. Since the art gallery there has some Rembrandts and Vermeers (including the above-mentioned painting), there were more than enough reasons to make the 15-minute train trip.

The tourist map of The Hague did not indicate any obvious memorial or museum dedicated to Huygens, so I enquired at the tourist information office near the train station. My first attempt was a failure, as the young man behind the counter gave me only a puzzled look when I asked about Huygens. Then I wrote down the name, and his eyes lit up. He read it back to me in Dutch, and to this day I have not been able to reproduce the sounds he made. I do not mean to be disrespectful of the Dutch language, but — to my ear — the first syllable of "Huygens" sounded like someone clearing his throat. There simply is not a sound like this in the English language, and I expect this would be a huge impediment to an English-speaker learning Dutch. In any case, once the language barrier was hurdled, I was on my way.

I was directed on the map to a suburb of Den Haag called Voorburg, where there is a museum dedicated to Huygens. Following my instructions, I returned to the train station and bought a ticket for that place, on the route to Gouda. I got on the train, and got some very funny looks when I got off only 5 minutes later at the very next stop. I think most locals would have taken the tram. Anyway, I found my way there. I was not sure where to go, so I wandered in the vicinity of the station along some very picturesque streets. I knew I was getting "warm" when I came across the "Huygens Pharmacy."

Figure 1. — The Huygens Museum in Voorburg, The Netherlands (photo by David Chapman).

Finally, I found a map of local attractions, and located the Huygens Museum, which turned out to be about a five-minute walk away.

The building was very unusual: small, almost a tower, surrounded by beautiful grounds, on the edge of a wide river. By this time it was late afternoon and a light rain had begun to fall. It looked closed, and I was perfectly correct, but I saw people coming and going all the same, so I went up to the door and knocked. A man answered, and told me it was closed, but he let me look around the ground floor for a few minutes…

…and here comes the punch line to the story: the museum had almost nothing to do with Christiaan Huygens, the scientist, and everything to do with his father, Constantijn Huygens, the Dutch poet and diplomat! The building was the family's "summer" home, about 45 minutes by horse from the Huygens mansion in town. In fact, although the Dutch scientists I met certainly knew about Christiaan, the Dutch generally know more about Constantijn. For example, in the same art gallery in which we viewed *The Girl with the Pearl Earring,* there is a portrait of Constantijn Huygens, but not of Christiaan Huygens.

Perhaps one day I will return to Den Haag and continue my quest for Christiaan Huygens.

For more about the Huygens Museum, go to www.hofwijck.nl/en.

The Science Story

At about this time, one of the former editors of *JRASC* would be grumbling, "where's the astronomy?" It's coming, be patient…

The scientific conference I attended in Delft was the 7th European Conference on Underwater Acoustics. My paper on the underwater measurement of aircraft sonic booms was in a special series on air/ocean acoustic interactions. One of the invited speakers in this series was Professor Tim Leighton of the University of Southampton, England, whose specialty is the acoustics of bubbles. He had prepared a scientific paper for the conference that appeared in the proceedings, but when he rose to speak, he declared his own paper "boring" and proceeded to give a fascinating account of several projects his group had undertaken. One of these had to do with the sounds of bubbles in extraterrestrial oceans and waterfalls.

At about the time the ECUA was held (almost coincident with the RASC General Assembly, which is why I could not attend) the Cassini-Huygens spacecraft arrived at Saturn for a long mission. The Cassini orbiter is a NASA craft, named after the Italian-French astronomer Jean-Dominique Cassini (1625-1712), known best for discovering the principal gap in Saturn's rings. (A *Reflections* column on Cassini appeared in the June 2000 issue of *JRASC*.) The Huygens probe is a project of the European Space Agency, named after Christiaan Huygens, who discovered Titan, the largest satellite of Saturn. In January 2005, only a few months after you receive this issue, the Huygens probe will separate from the Cassini orbiter and descend through the clouds of Titan, eventually reaching the surface. On board Huygens is a relatively inexpensive acoustic sensor (based on a hearing aid, I believe) that will record the sounds of the descent through Titan's atmosphere and — in the last few seconds — the impact of the Huygens probe on the surface, be it solid or liquid. Prof. Leighton's group will be analyzing the sounds from the probe, looking for clues about the surface environment. To this end, they have simulated the sounds of bubbles in the hypothetical ethane/methane oceans of Titan, so that they have some idea what to listen for. In my own mind, I imagine they will be listening for a "thunk" versus a "kersplash," but I know it is more sophisticated than this.

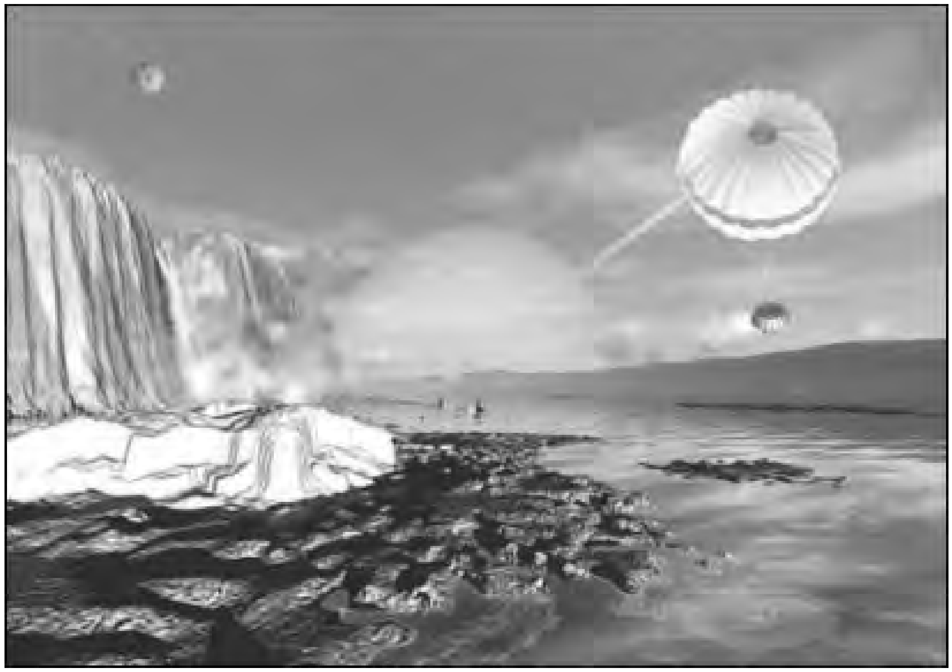


Figure 2. — Huygens descends through the clouds of Titan (image courtesy of ESA / artist: David Seals).

For more on the Cassini-Huygens mission, visit www.nasa.gov/mission_pages/cassini/main/index.html and www.esa.int/SPECIALS/Cassini-Huygens/index.html.

For more about "waterfalls in space," visit www.isvr.soton.ac.uk/fdag/uaua.htm.

It is a rare event when my interests in astronomy and acoustics coincide, and I certainly will be "listening" for news about the descent of Huygens in January.

David (Dave XVII) Chapman is a Life Member of the RASC and a past President of the Halifax Centre. By day, he is a Defence Scientist specializing in underwater acoustics at Defence R&D Canada — Atlantic. Visit his astronomy page at www3.ns.sympatico.ca/dave.chapman/astronomy_page.

ET: Don't Phone, Send a Book

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

For many years, it has been assumed that the best way to communicate with an extraterrestrial civilization was through electromagnetic radiation — typically at radio wavelengths. Chris Rose of Rutgers University and his colleague Greg Wright show that from the perspective of energy efficiency it actually is better to send physical artifacts, like the records sent on the Voyager spacecraft (see the September 2 issue of *Nature*).

The radio route has been driven partly by the interest in establishing two-way communication on a human timescale. If we decide that that is not important, then we can consider alternative slower mechanisms, which is what Rose and Wright have done. It turns out that a slower way of communicating could be strikingly more efficient. One way of demonstrating how this might be possible is to imagine sending the contents of a library electronically across town — even with a broadband connection, it could take a long time. On the other hand, if you load the books into a truck and drive them across town the effective baud rate is much higher than anything that could be achieved electronically.

But how does this relate to the cost of sending spacecraft out to other solar systems? You can quantify easily the energy needed to accelerate a given mass to a non-relativistic speed (just $\frac{1}{2}mv^2$), with the mass being determined by the number of bits you want to send in your message, along with the density of the storage medium. For simplicity, think in terms of number of words per kilogram in a book. It's also fairly easy to calculate how much energy you need to broadcast a radio message from (say) the Arecibo telescope. Rose has done this, and it turns out that energetically — bits transmitted per joule of energy used — it is generally more efficient to send "stuff," and this advantage increases with distance and length of message. As an example, the Voyager spacecraft carries about 10^9 bits of information, and had a launch energy of 6×10^4 J bit^{-1}. This makes it more efficient than Arecibo for distances beyond 17,000 light years. If Voyager had been carrying 3 DVDs, then it would be more efficient than Arecibo for distances above 1700 light years. Increasing the density of the stored information — say to biological density (DNA) — moves the break-even point to the outer edge of the Solar System!

Is it really that straightforward? Well, not quite. For example, you have the cost of building a launch vehicle (but on the other hand, it's fair to include the cost of building a telescope), and getting the spacecraft out of the gravity well of the Earth, as well as the cost of the storage material. But it is reasonable to use energy efficiency as a surrogate for some costs.

So it turns out that for short "we're here" messages, radio is fine, but if we want to send out a lot of information about our history and civilization, then sending the equivalent of books is better.

There's the added problem of getting such a spacecraft noticed — space is very big. One method would be to direct it towards a solar system that's known to have planets, and then have the craft orbit one of those planets. All maneuvering commands would have to be done on the spacecraft, requiring complexity, and there would need to be an engine and fuel dragged along. Or you could just aim it at another star and have it join the general orbiting debris such as comets and asteroids, but then how would you distinguish it from the rest of the junk? (But you'd still need the engine and fuel, or at least a solar sail to brake the spacecraft into an orbit.) Perhaps a radio beacon would help, though that would cost energy and eat into the efficiency.

Suppose that the engineering problems of message delivery can be surmounted. Maybe there are artifacts already in our Solar System, having been sent with copies of other civilizations' accumulated wisdom. What would you send, and how would you make sure that other life forms recognized the message?

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.*

TEKTITE DEBATE CONTINUES

A few years ago it was generally expected that when lunar samples became available for analysis there would be a definite answer to the long-standing argument about whether tektites — small, glassy objects found in four areas of the world — were formed by meteorite impact on the moon or on the earth (see these pages, vol. 61, p. 86, 1967). Lunar samples have now been studied for over two years but the tektite debate is still active. There has been a definite swing of opinion in favour of the terrestrial origin, due in considerable measure to more convincing evidence that the Ries crater in Germany is related to the Czechoslovakian tektite field and the Bosumtwi crater in Ghana is related to the Ivory Coast group of tektites. A long paper by Dr. Dean R. Chapman of N.A.S.A. in the September 10, 1971 issue of *Journal of Geophysical Research* supports the lunar origin of tektites while retaining the close connections just mentioned. The paper introduces some suggestions which are of definite astronomical interest and they are summarized here for this reason. Only time will tell whether these arguments in support of the current minority view are as significant as they are interesting.

by Ian Halliday
from *Journal,* Vol. 65, p. 296, December 1971.

THE FORMATION OF TEKTITES FROM A TERRESTRIAL RING ARC

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(received April 9, 2003; revised June 14, 2004)

ABSTRACT. Although tektites have been scientifically studied for the last 150 years, their origin still remains unknown. The presently recognized impact theory for their formation fails in many respects. The physical mechanisms that govern their formation, their characteristics, their distribution as a result of an impact, and their presence during only the last 35 million years have not been satisfactorily explained. In this paper, it is proposed that tektites were formed in a ring system circumscribing the Earth.

RÉSUMÉ. Quoique les tectites ont fait l'objet d'études scientifiques depuis 150 ans, leur origine demeure toujours inconnue. La théorie admise actuellement de leur formation par impact fait défaut à plusieurs niveaux. Le mécanisme physique qui régit leur formation, leurs caractéristiques, leur distribution résultant de l'impact et leur présence depuis seulement les dernières 35 millions d'années n'a pas encore été expliqué de manière satisfaisante. Dans cet article, nous proposons que les tectiques ont été formés dans un anneau autour de la Terre.

1. Introduction

Tektites are glassy objects with sizes varying from a few microns to about 10 centimetres, and they are distributed in specific areas of the Earth's surface known as strewn fields. The Australasian strewn field, covering one-tenth of the Earth's surface with an estimated mass of 2.7×10^{16} g (Schmidt & Wasson 1993), contains the largest distribution of tektites and was formed 0.75 million years ago. The North American strewn field, dated at 35 million years old, is estimated to be about 3.0×10^{14} g (Heinen, 1998). The two smaller strewn fields, namely the Central European and the Ivory Coast, have been dated at 15 million years and 1.1 million years ago respectively.

Of the four principal tektite types known, the splash-forms, shaped as spheres, rods, teardrops, and dumbbells, are the most abundant and are marked by sculptures or corrosion, most commonly systems of pits as well as grooves and furrows that meander over the tektite surfaces. The family of tektites known as flanged buttons, or australites, are lens shaped with a flange around the edge and with circular ridges on the anterior side, and were formed from the splash-form type by aerodynamic ablation. The microtektites are the smallest, with diameters of less than 2 millimetres; their shapes are similar to those of splash-forms, with some also showing corrosion. The Muong Nong-type tektites are blocky and are the largest tektites. They are tablet shaped and show a fine pattern of layers a few millimetres in thickness.

Compared to terrestrial rocks or impact melts, tektites have different chemical compositions, being homogeneous and deficient in water and containing very few bubbles. Tektites are known to have been present during only the last 35 million years of the Earth's history.

Present consensus on the origin of tektites and microtektites is that they are impact melt ejected from the target rock of a crater during an impact by an extraterrestrial object. Although geochemical evidence favours terrestrial sandstone as a source, many fundamental issues in relation to the physical mechanism of formation from an impact remain unresolved. As stated above, a distinct characteristic of tektites when compared with commonly formed impact glasses is homogeneity and a deficiency of water. Any theory supporting a meteorite-impact origin for tektites and microtektites must explain this "glass-making problem," as stressed by O'Keefe (1976), in which melting, refining, and homogenizing must all occur during the impact. Evidence suggests, however, that the physical processes and conditions required to remove water (refining) from common soils and rock are not created in an instantaneous impact event. Homogenizing requires diffusion, mixing, and a specific time period, and the instantaneous heating and melting seen in an impact event fails to create these conditions. The most significant piece of evidence against the impact theory is the mechanism of launch and passage of ejecta through the Earth's atmosphere, since the presence of atmospheric resistance retards the velocity of ejected material within a short distance. In order to explain the formation and the wide distribution of each strewn field (>10% of Earth's surface, for example, in the Australasian field) in relation to an impact crater, incredible and inconceivable conditions of impact are demanded (O'Keefe 1976). Also, the shapes of australites, produced by aerodynamic ablation, require atmospheric entry velocities in the order of 10 km s^{-1}, which cannot be realized by impact ejection due to air resistance. Another point against impact origin is the absence of target fragments and projectile contamination in tektites, both of which are characteristic features of most other impact melts. If tektites are formed by oblique impacts and/or jetting at the projectile/target interface as many argue, then tektites should be rich in these contaminants. In addition, in spite of the young age of the Australasian strewn field and the many geological expeditions to it and satellite images of it (Heinen 1998), the candidate impact structure (the smoking gun!), with a proposed diameter in the range of 90 to 100 kilometres, has not yet been found.

In the model described here, it is proposed that tektites and microtektites were formed in a terrestrial ring system. The evolution of this ring system is considered in relation to a past geological event on Earth, namely the assembly of the supercontinent Pangaea. This model, in addition to circumventing the constraints encountered in the impact theory of origin, can also explain the unique characteristics of tektites and their strewn fields.

2. Pangaea and Gravity

Beginning in late Devonian Period and continuing further into the Carboniferous Period, the continents Gondwana and Laurasia converged to form the supercontinent Pangaea. Within 200 million years it was completely assembled, and a single ocean, Panthalassa, stretched across the rest of the planet. It is estimated that this landmass, extending from pole to pole, encompassed about 40% of the Earth's surface during the Triassic Period (Figure 1). The presence of this continental cap would have had a significant influence on the thermal regime of the mantle and thus its convection pattern. Simulations done by Gurnis (1988) have shown that the heat accumulated under such an insulating continental plate could have changed the mantle flow, causing it to well up. The warmer mantle and the mantle upwellings could have caused thermal expansion and topographic uplift (Figure 2), which in turn would have created a long wavelength geoid high over the supercontinent Pangaea. Just such a geoid anomaly exists on the Earth, and Anderson (1982) has shown that the present-day long-wavelength geoid highs in the Atlantic-African region can be attributed to the pre-drift position of the supercontinent Pangaea (Figure 3). In the subsequent discussion, the geoid high so formed is referred to as the Pangaean Geoid High (PGH).

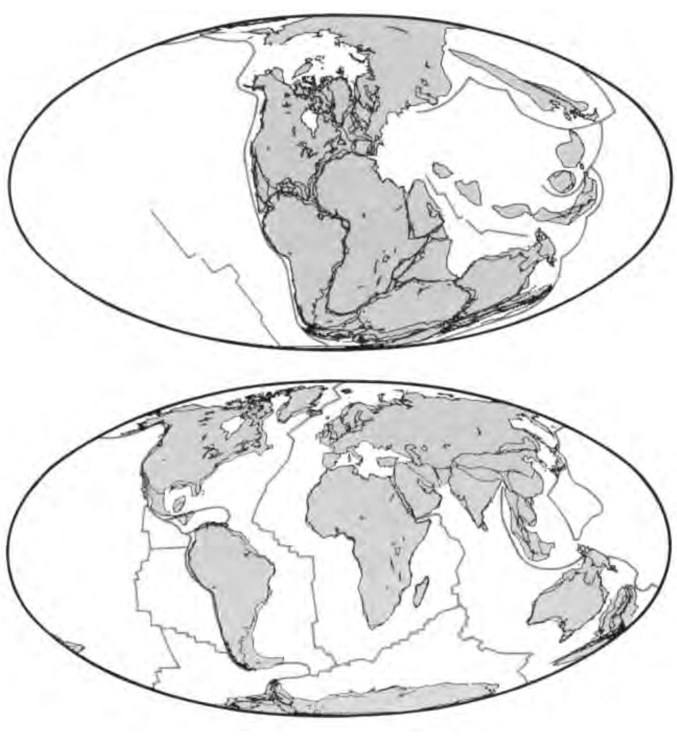

Figure 1 — The assembly of the supercontinent Pangaea during the Mesozoic Era and its breakup to the present configuration (Anderson 1990).

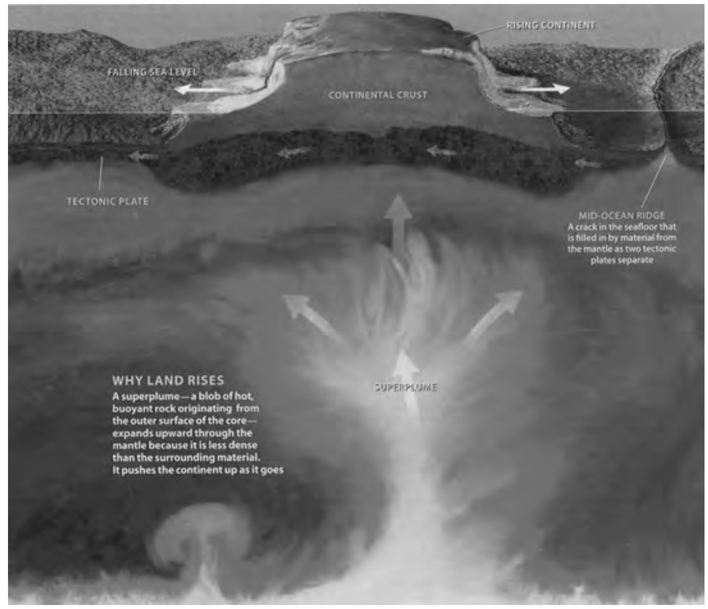

Figure 2 — A continent cap causes mantle upwelling resulting in topographic uplift and a positive geoid anomaly (Gurnis 2001).

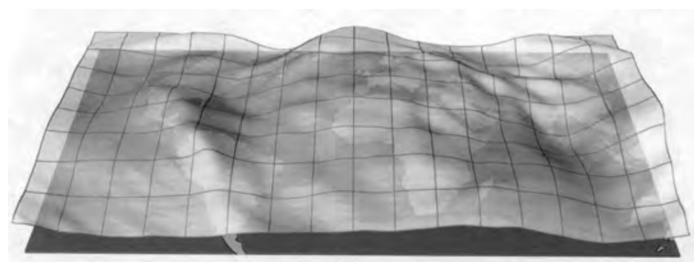

Figure 3 — Present day geoid showing the gravity anomaly caused by the Mesozoic Pangaea (Gurnis 2001).

3. Pangaea and the ring

The model described in this paper proposes that, prior to the assembly of Pangaea, a ring system of tektite particles circumscribed the Earth, a system that, by spreading inward and outward, was in a quasi-equilibrium state (Brahic 1977). As the supercontinent Pangaea was assembled, the PGH gravitationally perturbed these particles, which resulted in their orbital decay. The tektites in this decaying orbit fell into an orbital period that made a small whole-number ratio with the rotation of the Earth. At this location, the particles were in resonance with the Earth's rotation and thus with the PGH. The net effect of this resonant interaction with the PGH was to concentrate the tektites in a cluster or an arc at the perigee of their orbits. In such a resonant orbit, successive conjunctions between the tektite cluster and Pangaea would have always occurred over perigee. Such a cluster or arc at the perigee of a resonant orbit is considered to be a stable equilibrium configuration.

The formation of such a stable ring arc due to the resonance influence of an external gravity field can be observed in Neptune's ring system. The Adams ring of Neptune has three distinct arcs (Figure 4), and it has been proposed that this ring material is confined by resonance with the inner satellite Galatea (Murray & Dermott 1999). Orbital resonances of this nature are also a common feature in the Solar System. Regular satellites of Jupiter and Saturn as well as the asteroid belt exhibit similar resonances, and these are likewise considered to be stable configurations.

Thus the net effect of the assembly of Pangaea was to shepherd the previously circumscribing tektites into an arc. A swarm of tektites and microtektites formed, which eventually resulted in the formation of the Australasian tektite strewn field.

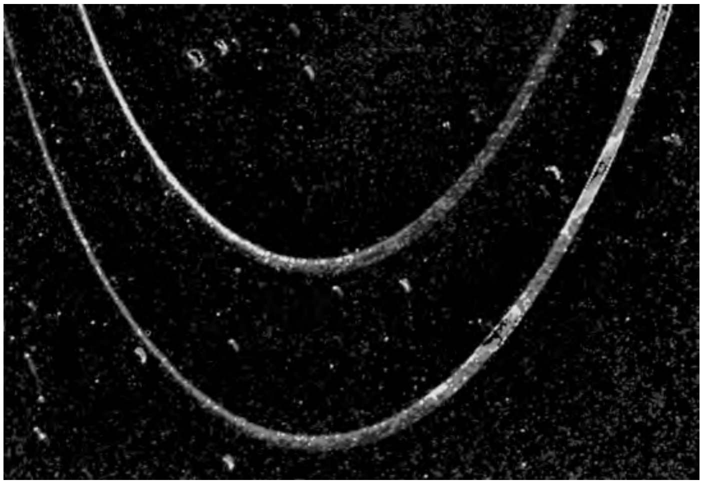

Figure 4 — Ring arcs of Neptune. The arcs are visible as bright areas in the outer Adams ring (The Planetary Report, 18, 6)

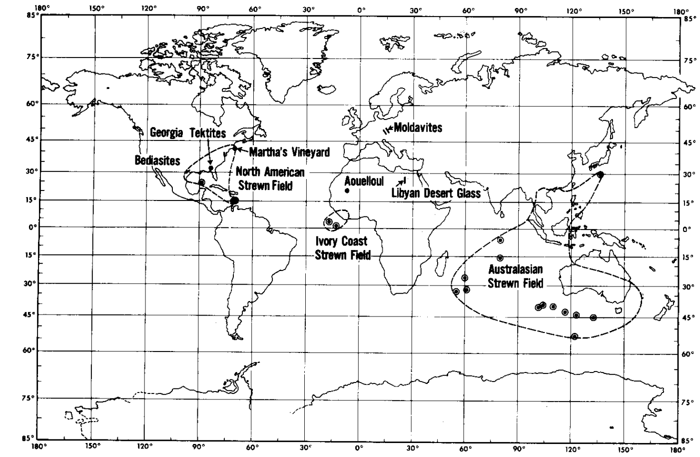

Figure 5 — The North American, European, Ivory Coast, and the Australasian tektite strewn fields Dotted circles indicate microtektites(O'Keefe ,1976).

4. Stability of the ring cluster

It is known that ring particles orbiting a primary will spread in radial and azimuthal directions due to interparticle collisions that arise from the different orbital velocities of the ring's components (Keplerian shear). Thus, it is important to investigate the long-term stability of the tektites in the proposed ring arc, both during its formation and also after Pangaea dispersed and the geoid high was dissipated. Several points argue in favour of the ring arc's stability. As discussed earlier, the cluster of tektites and microtektites located at the perigee of their orbits was in resonance with the PGH. This resonance capturing ensured that all the tektites had the same orbital period and thus the same orbital velocity. These necessary features of a resonant location are the key to the stability of the ring arc. Since the orbital velocities of all the tektites and microtektites in the ring cluster were the same, there would have been no interparticle collisions and no Keplerian shear as seen in normal planetary rings. Such a stable ring cluster is known as an epiton, and Fridman & Gorkavyi (1999) have described its stability in detail. Thus the tektites in the ring arc would not have spread either in radial or azimuthal directions, and its stability was ensured. Self-gravitation of the cluster would also have contributed to its stability.

With the dissipation of Pangaea, however, the geoid high gradually declined, the resonant lock was lost, and the orbit of the ring arc decayed at a slow rate due to tidal forces. Nevertheless, as shown above, the cluster of tektites and microtektites would have maintained its configuration until it entered the Earth's atmosphere.

5. the Ring arc and the Australasian field

Distribution. The subsequent passage of the ring arc from west to east and its collapse on the Earth's surface formed the Australasian strewn field of tektites and microtektites. The Australasian field forms a single unit distributed in a band of latitudes north and south of the equator (Figure 5), a configuration that would be expected from the decay of the ring arc in an equatorial orbit. The geographic location of the strewn field on Earth's surface would depend on the inclination of the ring arc to the equator, the eccentricity of the orbit, and the argument of perigee at the time of entry. All of these, as well as the apparent west to east deflection on both hemispheres that arises from Earth's rotation (the Coriolis Effect), are reflected in the present longitudinal position of the strewn field relative to the equator.

It is known that the external shapes of tektites in the Australasian strewn field form a continuous sequence from Australia to Indochina, with aerodynamically shaped smooth flanged buttons in the southeast, decorated splash forms in the centre, and blocky, layered Muong Nong types in the northwest (O'Keefe 1976).

Flanged buttons. This morphology of tektites could be attributed to heating due to atmospheric resistance as the ring arc passed through the Earth's atmosphere. The frontal part of the descending arc would have been exposed to greater atmospheric resistance and heating. Thus the tektites in the front of the cluster would have undergone aerodynamic ablation and would have descended to become the flanged buttons (australites) in the southeast end of the field. The extent of ablation found in these tektites (Figure 6a) is consistent with velocities on the order of 10 km s^{-1} and entrances into the atmosphere at low angles (O'Keefe 1976). The velocities of near-Earth satellites are in this range, and a ring arc circumscribing the globe would also have possessed corresponding velocities closer to the Earth's atmosphere. Thus the frontal portion of the cluster of tektites, when entering the Earth's atmosphere, would have had the required velocities to form the observed ablation. Also the tektites in front of the descending cluster, experiencing more air resistance, would have been accelerated ahead of the rest of the body. (This phenomenon is the well known "satellite paradox," where the drag force accelerates, rather than decelerates, a satellite descending through the Earth's atmosphere.) And, in fact, aerodynamically ablated tektites are located only in the frontmost southeast end of the field in

Figure 6 a — Three views of an australite, diameter 16-26 mm, showing lenslike form, flanges around the edge, and circular ridges formed by aerodynamic ablation (O'Keefe 1976).

Australia, where they are found separated from the main portion of the strewn field (O'Keefe 1976).

Microtektites. Collisions that occurred in the circumscribing terrestrial ring system would have resulted in the formation of particles of different sizes. As the ring particles aggregated into a cluster at perigee, further collisions would have resulted in the break-up of constituents into much smaller particles, which constitute the microtektites (Figure 6b).

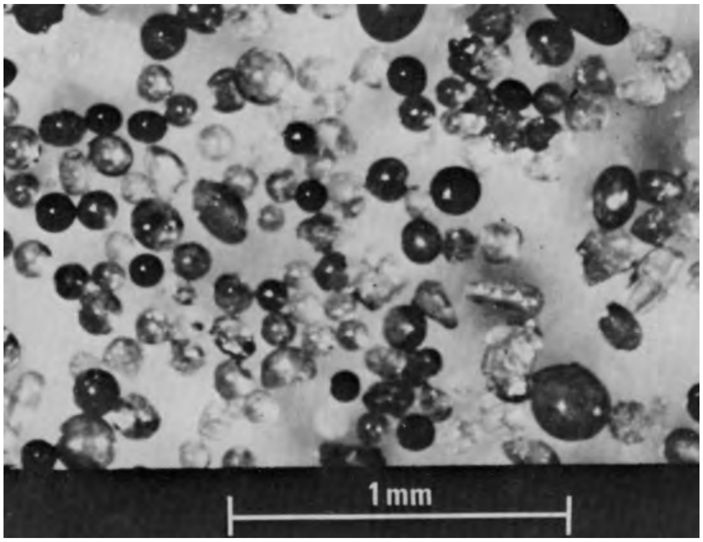

Figure 6 b — An assortment of microtektites from North American strewn field (O'Keefe 1976).

Splash form. Thus in the ring arc, the main mass of the body consisted of the larger splash-form type of tektites with microtektites embedded among them. The splash-form type would have constituted the most common tektite in the arc, and this type is, in fact, found in abundance in the Australasian strewn field. The splash-form tektites in the main body of the arc would have undergone less resistance and heating during entry than the tektites exposed in front. Thus, these mid-region tektites were not ablated, and some of the existing splash-forms even show signs of having been plastic only when arriving at the surface. The shapes of most of the splash-form types, such as dumbbells and teardrops (Figure 6d), could have resulted from rotation and break-up in the Earth's atmosphere during the descent. These tektites, as expected, are found next in sequence to the ablated australites towards the northwest, and are found widely distributed in the Philippines, Java, Indochina, *etc.*

Layered. The microtektites that were embedded and moving within the cluster of tektites could have accumulated sufficient heat to melt during the atmospheric descent, fusing together to form larger masses. This process could explain the formation of Muong Nong-type layered tektites. The chemical inhomogeneity of these tektites, which has been attributed to a differential mixing of glasses of different composition (Schnetzler 1992), and the presence of small glass particles (lenticules), confirm that these tektites are the result of the welding of a large mass of microtektites (O'Keefe 1976). As expected from the melting/fusion of the abundant supply of microtektites embedded within the ring cluster, these large masses are found as melt sheets or puddles in "layered-only" sub fields, and are located within the main field (Fiske *et al.* 1999). These are found as fragmented masses weighing up to several kilograms

Figure 6 c — Sphere shaped splash-form type tektite, diameter ~6 cm, with deep meandrine grooves (O'Keefe 1976).

towards the rear northwest end of the field, mainly in Thailand, Laos, and Vietnam.

The dispersal of tektites as the cluster descended through the Earth's atmosphere could explain the recent findings of tektites in Ganzu Province in northern China and in Tibet, which are considered an extension of the main field. The Tibetan tektites are of special interest since the Tibetan Plateau could have been in the path of the descending ring arc. If their presence is confirmed, these tektites could represent the tail end of the ring arc. The microtektites on the outer boundary that were loosely held to the ring cluster would have been dispersed over a large area during atmospheric entry, and deep-sea sediment samples have shown a wide distribution of microtektites in the Indian and Pacific Oceans and the South China Sea.

Sculptures & homogeneity. Interparticle collisions occurring during the aggregation of tektites to form a ring cluster can explain existing tektite thermal/chemical characteristics and sculptures. These collisions would have resulted in the formation of microtektites in the cluster, and further collisions could have occurred between tektites and microtektites. The accumulation of heat caused by these inelastic collisions could have resulted in the observed melting and homogenizing of the tektites and also in the loss of water and other volatiles.

The sculptures seen in splash-form tektites, such as pits and meandering grooves and gouges (Figure 6c and 6d), could be the result of direct and grazing low-speed collisions with smaller microtektites during the accretion of a ring arc. This scenario is in agreement with the view that these sculptures were formed before the tektites reached the Earth's surface (O'Keefe 1976). Specimens of embedded tektites, where one has plunged into the other while in plastic form, could also be the result of low speed collisions and adhesion occurring during the formation of the cluster. Thus, it is seen that a swarm of tektites and microtektites, undergoing inelastic collisions during its formation, would provide the ideal thermal environment required to explain the melting, refining, and homogenizing of existing tektites — the "glass making problem" as mentioned by O'Keefe (1976) — and also a variety of their sculptures.

Figure 6 d — Two dumbbell shaped splash-form type tektites, length 8-10 cm, showing sculptures such as pits and grooves (O'Keefe 1976).

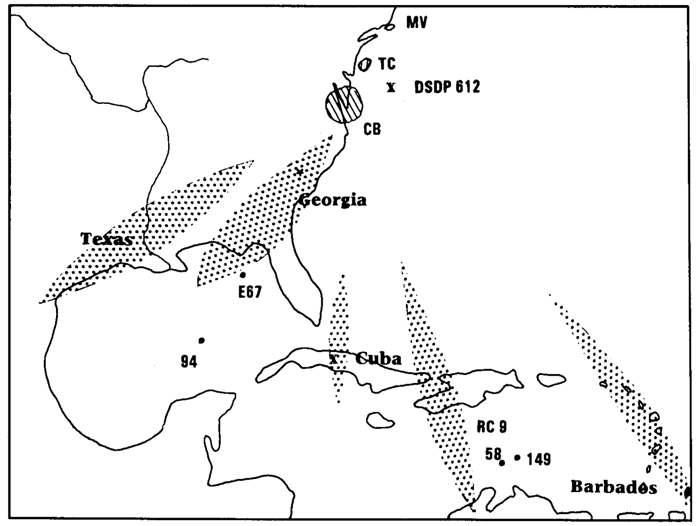

Figure 7 — The distribution of tektites (checked areas) in relation to the Chesapeake Bay crater {CB} in the North American strewn field (Heinen 1998).

6. Formation of the North American, Central European, and Ivory Coast fields

The common characteristics that exist among the four tektite-strewn fields indicate that all originated from a single source. All are dated to within the last 35 million years of Earth's history, and all strewn fields have splash-forms and microtektites as a common morphology. In petrology they differ from terrestrial rocks; they are non-crystalline, homogeneous, and deficient in water and volatiles; and all have a low ferric/ferrous ratio, similar isotopic properties, and identical corrosion patterns. Analysis of the chemical composition of the tektites in the strewn fields shows that a first-order trend exists among the oxides of silica, magnesium, and calcium (silica is negatively correlated) and that the range from one field to another is less than the range within a field (O'Keefe 1976). Also a linear trend can be observed in neodymium/strontium values in the tektites of all four strewn fields (Glass *et al.* 1998). These common characteristics, which encompass both chemical and physical domains, indicate that the tektites in all four strewn fields belong to a single family and thus originated from a common source.

The North American, Central European, and Ivory Coast tektites are chronologically (though not necessarily in chemical composition) linked to three impact craters, namely Chesapeake Bay for the North American, Ries Kessl for the Central European, and Bosumtwi for the Ivory Coast. The distribution of the tektites is asymmetrical in relation to these craters, and aerodynamically shaped tektites, similar to australites, have not been found in these three strewn fields. These fields consist mostly of splash-forms; layered Muong-Nong type tektites are scarce. Only one georgiaite and some layered-type tektites in deep sea cores are found in the North American field, and a few layered moldavites are known in the Central European field (O'Keefe 1976; Heinen 1998).

In the North American field, the tektites are distributed south of the crater and fan out towards the equator (Figure 7). This strewn field covers a wide area stretching from New Jersey to Barbados. All tektites here are found north of the equator converging on the crater, and none are found further north of the crater (Heinen 1998). Based on these observations, it is possible to model the formation of the North American field in relation to the orbiting tektite ring cluster at the time of the Chesapeake Bay impact event. The impactor, moving from southwest to northeast, either collided or gravitationally interacted with the orbiting ring cluster. The bolide then entrained the tektites and microtektites from their orbit and dispersed them in a southerly direction before impacting on the Earth's surface. Since the ring arc was in an equatorial orbit, the strewn field would extend north of the equator and converge towards the impact crater.

The distribution of the tektites in the Ivory Coast field in relation to Bosumtwi crater also gives credence to this proposition. In this case, the impactor moved from west to east, passing the ring arc along the equator, with the resulting tektite field stretching west of the crater in an equatorial direction; tektites in the existing field have not been found east of the crater. Microtektite distribution in the Atlantic Ocean also shows a large strewn field west of the Bosumtwi crater along the equator (Figure 8).

In the Central European field the distribution again is asymmetrical in relation to the relevant crater; the tektite strewn field is found east of the crater, and none are found towards the west, indicating that the passage of the impactor within the gravitational domain of the ring arc was from southeast to northwest. Unlike the tektites in the other two fields mentioned here, these tektites are found in close vicinity to the crater, about 200 km east, and constitute a small strewn field in mass and distribution (O'Keefe 1976).

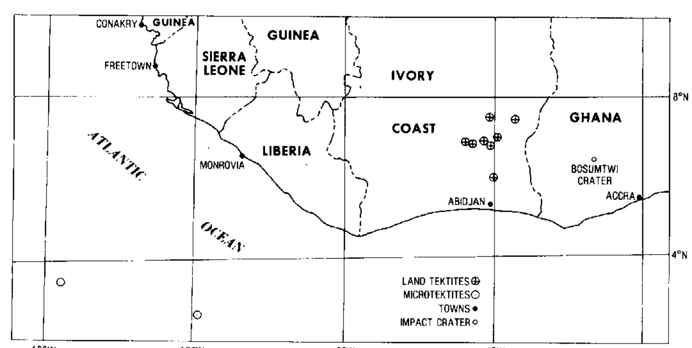

Figure 8 — The distribution of tektites in relation to the Bosumtwi crater in the Ivory Coast strewn field (O'Keefe 1976).

These three fields mostly contain splash-form tektites and microtektites, which are the main components of the proposed ring cluster. In this impactor scenario, the entrained particles in the ring arc did not undergo natural decay through the Earth's atmosphere as in the case of the Australasian tektites. Thus, this model explains the absence of aerodynamically ablated tektites and also the scarcity of layered tektites in these three strewn fields. It is to be noted that these passing bolides would have gravitationally drawn away less than 1% of the total mass of the ring arc.

7. Ages of tektite strewn fields and cosmic-ray exposure

The ages of tektites and microtektites since arrival at the Earth's surface have been determined by potassium-argon (K-Ar) and fission-track analysis. The former yields an age since the tektites were thoroughly outgassed by heating and the latter gives a time since the latest heating episode. During the passage of the tektites through the Earth's atmosphere, friction with atmospheric gas molecules produced strong heating, which could result in partial melting and degassing of argon. Evidence of such melting and melt flow is seen in tektites. Considering the small unit sizes of tektites, both in mass and diameter, atmospheric heating could produce sufficient heat for complete degassing of argon and thus reset the K-Ar clock and the fission tracks. Thus the age-on-earth of tektites and microtektites determined by these methods is the same as the stratigraphic age of the geological formations on which the tektites are found. As expected, the impact craters associated with the North American, Central European, and the Ivory Coast strewn fields also have the same ages of formation as the respective tektites.

It is known that the primary cosmic-ray signatures seen in meteorites are absent in tektites (O'Keefe 1976). This observation could be related to the fact that the orbiting tektite cluster was enveloped within the Earth's magnetic field. The paths followed by primary cosmic rays are strongly influenced by the Earth's magnetic field. Depending on their mass, speed, direction of travel, and the field strength, they can be deflected or follow spiral convoluted paths as they descend towards lower altitudes. Thus the Earth's magnetic field attenuates the energy of the incoming particles and also results in energy-cut-off values that increase towards low latitudes. The predominance of low-energy particles and the minimum cosmic-ray intensity at the magnetic equator attest to this shielding influence of the Earth's magnetic field (Friedlander 1989). Thus, it is seen that tektites and microtektites orbiting along the equator would not have been exposed to high-energy cosmic rays such as those observed in meteoroids in interplanetary space. Thus, the primary cosmic-ray encounters in space that cause nuclear spallation reactions, resulting in radioactive isotopes, or nuclei fissions yielding fission tracks, are not found in tektites.

Figure 9 — The tektite ring arc as seen during the assembly of the Mesozoic Pangaea (Image credit: Walter Myers/www.arcadiastreet.com).

Conclusion

As described in this paper, the ring arc model provides a framework to scientifically explain the well-known characteristics of tektites and their strewn fields. An orbiting ring arc provides explanations for the geographic distributions, morphology, and sculptures of tektites. Aggregation into a ring arc also furnishes the required conditions for volatile loss and homogenization. The orbiting ring cluster can act as well as a source for the formation of the three fields related to the Australasian. A special feature of this model is that the terrestrial ring system provides a rationale for the existence of a unique family of natural glasses during a 35 million year period of the Earth's history.

Acknowledgements

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Jay Jayawardena has shown a lifelong interest in the fields of planetary science and geology. He has researched for many years the nature and origin of tektites.

Society News/Nouvelles de la société

by Kim Hay, National Secretary (kimhay@kingston.net)

National Council Meetings & RASC Happenings

So much has happened since our last *Journal,* and by the time you read this our summer will be over — well, by calendar dates anyway. Oh, I am sure that some of you made it to star parties, where it wasn't always raining, cloudy, or a mosquito's haven, but it would be nice to hear from you about your summer activities. Why not write a short article to be included in the *Journal*? Send in your adventures to `editor@rasc.ca`.

Of course the big event of the summer for the RASC was the General Assembly 2004 held in St. John's, Newfoundland. If you ever get the chance to go and visit the East Coast, you must make it to Newfoundland. Its terrain is unlike any other, with pieces of three continents in one island, making it a geologist's heaven.

Garry Dymond, Chair of the GA Committee, and the following people — Florence McNeily, David Bourgeois, Fred Smith, Gary Case, Randy Dodge, Mike Crawford, Robert Babbs, Brian Payton, Doug Grouchy, Joe English, and Chris Stevenson — are the ones who worked so hard on the General Assembly to make it a great event and showed everyone a great "Screeching" time. Thank you all for your hospitality and warm welcome.

Figure 1 — Captain Screech, Garry Dymond (Image Credit: Kim Hay).

For those who could not attend the GA, visit `www.rasc.ca/ga` to view the pictures of how much fun we had, and what you are missing at a General Assembly. Thank you to those members who let the RASC use their links for photos, Jim Low, Patrice Scattolin, Kevin Kell, Kim Hay, and members of the St. John's Centre (Robert Babbs) who put a whole CD together.

Figure 2 — The traditional pyramid. Our new President on the right cheering on the group (Image Credit: Kim Hay).

There was the traditional human pyramid by members, group photo, and social evenings; everyone had a great time, and we hope you will someday be able to come to a GA. Of course we had our business meetings, both National Council Meetings and the Annual Meeting, but we also enjoyed old friends' and new friends' company.

At our Annual Meeting held on July 3, 2004, two motions were voted on. Proxies were used by those members who could not attend, and votes were counted from members on the floor of the meeting.

Motion 1: Motion 04129: That Council approve a $6 per member fee increase bringing the fee for a regular member to $50, and that this fee increase proposal be brought to the National Membership at the Annual Meeting in St. John's in June 2004.

When the $6 increase approved by Council in Motion 04129 for ordinary members is applied proportionally to all memberships, it also results in the increases in fees for youth and life members given in the motion that will be presented at the 2004 Annual Meeting. The effect of this motion would be to increase the Society's fees to $50 per year for ordinary members, $31.25 per year for youth members, and $1000 for life members (all Canadian funds).

This motion passed, and new prices will be in effect as of September 1, 2004 for people whose memberships expire in September and onward. Also, in order to reduce postage costs, there will be an email renewal coming to those members who have provided an email address. If you have not supplied an email address, then your renewal will be mailed to you. Toronto Centre and Centre Francophone du Montréal members are not included in this email renewal.

Motion 2: Bylaw Number One, Article

4.08(3) deals with the terms of National Council Representatives. It currently states the following:

(3) The term of office of a National Council Representative is one year. No person may hold the office of National Council Representative for more than three consecutive terms, but such person may be re-elected after a lapse of one year.

The motion is to change this to:

(3) The term of office of a National Council Representative is two years. No person may hold the office of National Council Representative for more than three consecutive terms, but such person may be re-elected after a lapse of one term.

This motion also passed, and will take place when the terms are up for this year at the Centre Level.

Tinkham and Associates were accepted as our auditors for the coming year.

The RASC also has a new Executive for the years 2004-2006. Our new President is Peter Jedicke (London Centre), 1st Vice President Scott Young (Winnipeg Centre), 2nd Vice President Dave Lane (Halifax Centre), National Secretary Kim Hay (Kingston Centre), and Treasurer Dave Clark (London Centre). Our Past President is Dr. Rajiv Gupta (Vancouver Centre). Let's wish our new Executive well as they guide the Society through the next few years.

On another note, the National Secretary term will be coming up at the next General Assembly 2005, being held in Kelowna, B.C. I have served 2 terms as National Secretary, and my time is up. The term is for 3 years, and if you know of anyone who might be interested in the position please contact the Nomination Committee at nominations@lists.rasc.ca. If anyone has any questions about the position, you can contact me at kimhay@kingston.net, and I will gladly answer your questions.

There were also reports given by the Executives and the Chairs of the committees, which summed up the events over the year.

There were paper talks on July 2 and 3, ranging in topics from the Venus transit past and present, the history of Kepler in Quebec City, and the planetary brightness of Saturn to CCD imaging innovations, and an excellent educational workshop, which included an insight into a new board game by Ted Dunphy of the Moncton Centre, called "The Constellation Quest Board Game."

The Helen Sawyer Hogg Public Lecture, was presented by Dr. Sara Schechner from Harvard University. Her topic was "Politics and the Dimensions of the Solar System: John Winthrop's Observations of the Transits of Venus."

This was an excellent talk on the history of John Winthrop's work and travels to St. John's to observe the 1761 Venus transit. This talk tied the present day Venus transit, which was June 8, to the 1761 transit, and made us all see and feel what John Winthrop might have seen and felt.

Sara Schechner, Ph.D. is the David P. Wheatland Curator of the Collection of Historical Scientific Instruments, Harvard University, and is the Secretary of the Scientific Instrument Commission of the International Union for the History and Philosophy of Science. She is an active member of Commission 41 of the IAU and chair-elect of the Historical Astronomy Division of the American Astronomical Society. She is the only person twice honored with the Pollock Award of the Dudley Observatory.

Later on in the weekend, a special plaque was unveiled by Dr. Fred Smith to commemorate the 1761 Venus transit, and the location from where John Winthrop saw the event. This will be placed in the centre courtyard by the Rose Garden at Memorial University. On Saturday night, July 2 at the Banquet we were exposed to some of the many observing experiences that Alan Whitman (Okanagan Centre) has made over the years, along with some of his observing friends. He had a very emotional solar eclipse he shared with us (via video tape and commentary) that made us all feel as if we were there sharing it with him and Jim Failes. He shared with us what you could observe from the Okanagan region and other places around the world, and I think a lot of us are making retirement plans for the interior of BC, as the skies are so clear and dark; we can only wish we could have these locally.

The RASC Awards were also handed out at the banquet to many fine members of the RASC who have devoted time and effort at the local level and the National level, and these awards are our way of expressing our appreciation for their dedication.

The Service Award is for contributions to the RASC over a minimum 10-year span. This year's winners of the Service awards are David Clark (London Centre), Jim Failes (Okanagan Centre), Art Fraser (Ottawa Centre), Guy Nason (Toronto Centre), and Stan Runge (Winnipeg Centre).

Figure 3 — Dave Clark, Guy Nason, and Stan Runge are presented the Service Award by Dr. Rajiv Gupta (Jim Failes and Art Fraser are absent; Image Credit: Kevin Kell).

The Simon Newcomb Award is for literary achievement. This year's winner is Mary Lou Whitehorne (Halifax Centre) for her work in the production of *Skyways: Astronomy Handbook for Teachers.*

Figure 4 — Mary Lou Whitehorne (Simon Newcomb Award winner) and Dr. Rajiv Gupta (Image Credit: Patrice Scattolin).

There were no nominations for the Chant Medal or the Ken Chilton Prize this year.

Remember, if there are members in your Centre or within the RASC who you feel should receive these awards, please visit www.rasc.ca/awards to view the requirements and have the nominations sent into the Awards committee by December 31, 2004 at awards@lists.rasc.ca. Also, see the article by Rajiv Gupta below.

Dr. Rajiv Gupta was also presented with many gifts from the Society and its members for his years of hard work as a member of the executive. We wish Rajiv well with his possible few extra moments of spare time, but we know where to find him when we need his advice.

We had some sun, rain, cloud, and St. John's fog, and we saw whales, puffins, and dolphins (for those who stayed a few extra days), but it's the memories of good times and friends we will bring home with us. There was so much that happened that I may have left out some details, but there will be stories for you to hear about the St. John's GA.

Plan your vacation now as the next GA will be held from May 20 to 23, 2005: visit www.rasc.ca/ga2005 for an early preview of what is in store.

Our next National Council meeting will be October 30, 2004 at the JPR Arbitration Centre, 390 Bay Street, 3rd Floor, Toronto.

On an ending note, as the summer winds down and there is a cool nip in the air, put your coat on and go outside and observe. Observe the morning sky and the evening sky, and remember what our hobby is all about. Look up and you will see...

RASC Awards: 2004 and 2005

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

The RASC has a multitude of talented and committed members. Each year, the Society honours a few of them with an award. These awards are approved by National Council, usually at its first meeting of the year, based on the recommendations of the Awards Committee. As the current chair of this committee, I'm asking for your help by submitting nominations to me.

Not including observing certificates, which are administered by the Observing Committee, there are four different distinctions a member can receive from the Society: the Chant Medal, the Ken Chilton Prize, the Service Award, and the Simon Newcomb Award. A member can win more than one of these awards, but generally not more than one in a given year. Details on each of the awards are given below.

The Chant Medal

This is the senior member of the Society's award offerings. At most one medal is awarded each year, to an amateur astronomer resident in Canada. The award is granted on the basis of the value of original work in astronomy or a closely allied field.

The award was named in honour of Professor C.A. Chant (1865–1956), who was President of the RASC from 1903–1907 and founder of the *Observer's Handbook* (of which he edited a remarkable 49 editions). It was established in 1940 and has been awarded to 26 members since then (an average of once every 2.5 years). The most recent recipient, in 2002, was Dr. Roy Bishop.

The Ken Chilton Prize

This award was established in 1977 in remembrance of Ken Chilton, an active member of the Hamilton Centre. It is awarded at most once a year to an amateur astronomer resident in Canada in recognition of a significant piece of astronomical work carried on or published recently. The award has been granted 13 times in its 27-year history, most recently in 2003 when it was given to a group of members, Paul Boltwood, Jon Buchanan, Peter Ceravolo, Doug George, and Glen LeDrew of the Ottawa Centre (this was the second time a group of members won the award). Four recipients of a Ken Chilton Prize have subsequently also won the Chant Medal.

The Service Award

The Service Award is the most often-given of the RASC's awards. It was established in 1959 and has been granted to 108 members in its 46-year lifetime and to 9 members in the past 5 years. The award is presented to a member who has provided substantial service of a well-defined nature to the Society and/or a Centre over a period of at least 10 years. The number of recipients from a given Centre is restricted to at most one per three years on average.

The Simon Newcomb Award

This award specifically recognizes astronomical writing by a member, either for a general audience or for an astronomical audience. It is named in honour of astronomer Simon Newcomb (1835–1909), who was born in Nova Scotia and served for 20 years as superintendent of American Ephemeris and Nautical

Almanac Office at the U.S. Naval Observatory, and has had 13 recipients since coming into existence in 1978 (roughly one recipient every two years).

Current Winners

The following six members won awards in 2004; five received a Service Award and one a Simon Newcomb Award.

1. *Dave Clark, London Centre, Service Award:* A member since 1990, Dave has provided service to the Centre as its treasurer, its public-education coordinator, and its National Council representative. He is also registrar of the RASD (Royal Astronomical Society of Daves) and is known to many of his friends as Dave II.
2. *Jim Failes, Okanagan Centre, Service Award:* Through his 24-year membership in the Okanagan Centre and its predecessor, the Okanagan Astronomical Society, Jim has served as President and also held numerous other offices. He has reached a wide audience in the B.C. interior with a CBC radio spot and has been a key organizer of the popular Mount Kobau Star Party.
3. *Art Fraser, Ottawa Centre, Service Award:* Art has given long and varied service to the Ottawa Centre. A member of the RASC since 1963, he has administered the Centre's membership since 1981 and since 1980 has, together with his wife Ann, provided refreshments at Centre meetings. He has also served as a Centre councillor and recorder.
4. *Guy Nason, Toronto Centre, Service Award:* Guy first served as a councillor for the Toronto Centre in 1987, and then continuously in various other capacities, culminating in a three-year term as President from 2000–2003. He has also been actively involved in the Centre's public-education program and observing activities.
5. *Stan Runge, Winnipeg Centre, Service Award:* Stan has been one of the driving forces behind the Winnipeg Centre for over two decades, having served in every office of the Centre Council. He has been active in public events and is also considered by many members as their sky-watching mentor, encouraging countless members to become active observers.
6. *Mary Lou Whitehorne, Halifax Centre, Simon Newcomb Award:* Mary-Lou has devoted great energy and many years to education in astronomy involving young people. This effort culminated in the recent publication by the RASC of her book *Skyways,* a unique teacher's guide for astronomy that contains a multitude of well-researched and self-contained astronomical activities for school children.

Figure 1. Recipients of RASC awards presented at the 2004 General Assembly in St. John's are, from left to right, Dave Clark (London Centre, Service Award), Guy Nason (Toronto Centre, Service Award), Mary Lou Whitehorne (Halifax Centre, Simon Newcomb Award), and Stan Runge (Winnipeg Centre, Service Award). Not shown: Jim Failes (Okanagan Centre, Service Award) and Art Fraser (Ottawa Centre, Service Award). Photo Credit: David Lane, Halifax Centre.

For the names of all winners in the previous 10 years, see pp. 39–40 in the 2003 *Annual Report.*

2005 Nominations

The deadline for nominations for recipients of awards in 2005 is December 31, 2004. Nominations can be submitted by any member or group of members, but in the case of a Service Award, approval of the nomination by the Council of the nominee's Centre is encouraged, if the nominee is attached to a Centre. Please help the Society recognize outstanding achievement by its members by sending your nominations to me, by email, before the submission deadline.

Fading Foursome

by Bruce McCurdy, Edmonton Centre (bmccurdy@telusplanet.net)

As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality.

- Albert Einstein

With these words, Einstein eloquently paraphrased, on the grandest scale, the Incompleteness Theorem of his Princeton colleague and frequent walking companion, Kurt Gödel. Simultaneously a breakthrough in mathematics, philosophy, and logic, Gödel's insight has forever changed humankind's approach to understanding all this. Simply put, we now know we can't (Hofstadter 1979).

That we *can* understand the Universe to the remarkable extent that we do, can surely be credited to the cosmic science of mathematics. The most fundamental laws of physics are paved with elegant and profound statements such as Einstein's own $e=mc^2$, Newton's inverse squares, and Kepler's equal areas.

Occasionally, numerical relationships arise that can't be easily explained. Why, for example, should a favourite plaything from the wonderfully weird world of (pardon the oxymoron) "recreational mathematics" appear across nature, from the structure of sunflowers to spiral galaxies, from the growth of honeybee populations to the description of eclipse cycles?

"Eclipse cycles?" you ask. Let me explain.

Solar and lunar eclipses are fundamentally different, to the degree that the 16th century astronomer Jean-Pierre de Mesmes proposed two unrelated terms, namely "obstructions" and "fades" (Brunier & Luminet 2000). Alas, his common-sense suggestion fell on the deaf ears of those responsible for scientific terminology, presumably the same people who permitted such paired terms as "immersion" and "emersion" to test our collective sanity. The result is a dizzying array of eclipse types: solar and lunar; total and partial; central and non-central; annular and hybrid and penumbral. Some of these categories apply to only one of the types, some to both. To give obstructions and fades the same name is as dumb an idea as splitting the day into two 12-hour clocks. Grrr...

However, both types rely on the alignment of the same three bodies, and do share some characteristics, particularly common cycles. Each eclipse season features at least one of each, separated by a *Fortnight.* For eclipses of similar type - and here we'll primarily focus on lunar eclipses - the most obvious period is that of six months (the *Semester*), at which interval series of about 8 eclipses can be found. The true period, however, is 5.87 lunations per half eclipse year, so the Semester series soon phases out to be replaced by another, one month "early." These calendar shifts are critical to short-term eclipse cycles.

Each Semester series begins and ends with penumbral and partial fades, and has a central "sweet spot" of 2-4 total eclipses some seven or eight Semesters after its predecessor. From these intervals come the *Hepton* and *Octon,* of 3.3 years and 3.8 years respectively. The two bracket the true ratio, so one of each combines to form a more-accurate period known as the *Tzolkinex,* so named because its 7.1-year period very nearly equals 10 Tzolkins (a mysterious 260-day period on the Mayan calendar). Octon and Tzolkinex together make a 10.9-year period called the *Tritos,* presumably named because it includes three calendar shifts. Each of these periods can be used to predict eclipses with increasing degrees of certainty (Meeus 1997; www.phys.uu.nl/~vgent/calndar/eclipsecycles.htm).

But all shrivel in comparison to the next periodicity, the mighty *Saros.* After 18 calendar and 19 eclipse years, an immense lap has been completed. The Sun, Earth, and Moon all return to very near their original positions after 6585.32 days - 18 years plus 10 (or 11 or 12 days) plus 8 hours - after which eclipses "repeat" with a high degree of similarity. The period of 223 lunations can be considered as 19 eclipse years of 12 months, minus 5 calendar shifts forward. Thus the "magic" number 5 is a key contributor; the shorter-term cycles described above merely subdivide the Saros into fifths.

A Saros cycle consists of 69-87 eclipses, covering an average period of some 1300 years. Yet that is small potatoes compared to the lesser-known *Inex*. This was the name given to the period of 29 years less 20 days by George van den Bergh (1955), who did seminal work in the field of eclipse cycles. He laid out the 8000 solar eclipses from the immense *Canon der Finsternisse* of von Oppolzer (1887) in a gigantic Solar-Inex panorama, essentially a spreadsheet where each row represents eclipses at intervals of 18 years, and each column intervals of 29. The Inex is the more extended of the two families by an order of magnitude; van den Bergh calculated an average of 780 members extending over 22,600 years!

Van den Bergh didn't stop there. He determined that it was possible to describe the interval T between any two eclipses by the equation $T = a\mathrm{I} + b\mathrm{S}$, where I and S are the durations of Inex and Saros, and integers a and b are relative coordinates on the panorama. And in the short-to-medium term, the best cycles occur when a and b are consecutive terms from the famous Fibonacci sequence!

Surprised? Not me. I had noticed right away the key numbers 18 and 29 years are consecutive members of Fibonacci's underappreciated doppelganger, the Lucas sequence (1, 3, 4, 7, 11, 18, 29...). The two sequences are linked as intimately as yin and yang. The relationship between any two consecutive numbers of either sequence is very close to the Golden Ratio, Φ. A pair of terms from either sequence tends to force more members of the sequence; for example, consecutive tetrads in the current century will occur at intervals of 11, 18, 11, 7, 11, 11, and 18 years. Very frequently, one of the sequences forces a cross-reference to the other, as indeed happens in this case (see Tables 1-3).

So why does nobody ever hear of the Inex? Saros is composed of (near) integers: 242 draconic (node-to-node) months, 239 anomalistic (perigee-to-perigee) months, 223 lunations, 19 eclipse years. Therefore all variables of an eclipse, including relative sizes of both Sun and Moon, change only slightly from one family member to the next, as the eclipse path slowly migrates from one pole to the other. The biggest wild card is the rotation of Earth, as those eight hours affect the eclipse visibility path. For example, I saw the "Eclipse of the Century" at the zenith near Mazatlan, Mexico on July 11, 1991. The next member of Saros 136, on July 22, 2009, will also touch down near the Tropic of Cancer but in India and China, a third of a world away. It will be the longest eclipse of the 21st century; even in decay, Saros 136 offers by far the best circumstances for long eclipses in the coming decades. This predictive capacity is what makes Saros so valuable.

Inex, on the other hand, features an extraordinarily precise mean interval of 388.500 draconic months to 358 lunations, with the Moon shifting extremely slowly with respect to the node. Inex is therefore an excellent forecaster of whether an eclipse will occur, and of the approximate centrality of the event. However, the anomalistic month is a non-integer, meaning the Moon's distance varies from one event to the next. So Inex is a poor predictor of the character (total or annular) and duration of a solar eclipse.

Another key difference is the "extra" 0.5 draconic month, which means that consecutive eclipses in an Inex occur at opposite nodes, in effect two complementary series of events starting at opposite poles and eventually crossing near the equator.

Inex is particularly useful for lunar eclipses, where consecutive events occur at similar ecliptic latitudes (the sign flipping between north and south). While significant, the Moon's distance is not so critical in establishing the character of a fade as for an obstruction. Consider: the Moon at perigee appears larger than at apogee, but is passing through a larger slice of earth's shadow cone, with the two effects offsetting each other to a large degree.

It stands to reason that the Inex plays a role in repetitions of such events as the lunar tetrads. As discussed last October in this space, the recent fade of October 28, 2004 was the last in a series of four consecutive total lunar eclipses at intervals of one Semester. Table 4 shows the distribution of tetrads in a Saros-Inex panorama in the style of van den Bergh. The just-completed tetrad was the last of four belonging to Saros cycle 121, but the first of twelve belonging to Inex period I-17. This cycle will remain active through this and the next two tetrad-rich eras and into the 31st century, proving the longevity of the Inex. However, it cannot predict with certainty; unlike Saros tetrads, which are in all cases consecutive, there are gaps in the Inex columns. One might anticipate a tetrad in, say, 1938-39; however, after three total eclipses the fourth fade was a near-total of magnitude 0.992; therefore, no tetrad officially occurred.

The beautiful mathematics of the Golden Ratio are certain, a vision of unattainable perfection, and therefore as Einstein suggests have an *im*perfect reference to reality. The geometry of Φ is a perfect logarithmic spiral, self-similar at all scales (Livio 2002). It is infinite in both directions, as it never achieves its true centre or its outer limits — whereas the solar system is finite and evolving. The Moon's orbit around Earth is inexorably increasing, so its periodicities cannot be considered absolute. Indeed, according to Meeus (2002), in some 1.21 billion years, total solar eclipses will no longer be possible. Even the best relationships gradually phase out.

In the case of eclipse periodicities, the Inex represents the pinnacle, with further Lucas iterations of 47, 76, 123 years representing still good but diminishing returns. (Many examples of these intervals can be found in Table 4.)

To my surprise and great pleasure, I have now found echoes of Fibonacci in the fundamental relationships Earth-Mars, Earth-Venus, and Earth-Moon-Sun (McCurdy 2002, 2004). Rest assured I do not ascribe any sort of metaphysical "meaning" to this; I have merely concluded it is a mathematical fact that when a relationship approximating the Golden Ratio chances to occur, it will persist through a greater number of iterations and decay more slowly than any other ratio. It is called “Golden” for a reason.

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Bruce McCurdy is active in astronomy education with the RASC Edmonton Centre, Odyssium, and Sky Scan Science Awareness Project. He currently serves the National Society as Astronomy Day Coordinator. An ardent lunar observer for one Saros, Bruce has in recent years faded ever deeper into his astronomical armchair.

Table 1.

VdB formula	Lunations	Draconic	Days	Years	Cycle	Reps
5I - 8S	6	6.511	177.18	0.49	Semester	~8
-3I + 5S	41	43.493	1210.75	3.32	Hepton	~14
2I - 3S	47	51.004	1387.94	3.80	Octon	~22
-1I + 2S	88	94.497	2598.69	7.12	Tzolkinex	~36
1I - 1S	135	146.501	3986.63	10.92	Tritos	~60
0I + 1S	223	241.999	6585.32	18.03	Saros	~72
1I + 0S	358	388.500	10571.95	28.95	Inex	~780

Table 1. The best short-term eclipse periods identified — and mostly named — by van den Bergh. Interestingly, his formula $T = a\text{I} + b\text{S}$ shows a logical sequence of consecutive terms from the famed Fibonacci sequence (0), 1, 1, 2, 3, 5, 8... Note that as with the Fibonacci sequence itself, each period is the sum of the two periods immediately preceding it. Furthermore, the output rounded to the nearest year yields the Lucas sequence, 1, 3, 4, 7, 11, 18, 29... The increasing accuracy of each period can be seen by the diminishing mantissa (remainder) in the draconic months column, which also reveals a faint echo of the Lucas sequence as it spirals in towards 0.000 (or 0.500), namely +0.011, -0.007, +0.004, -0.003, +0.001... (Table adapted from user.online.be/felixverbelen/cycles.htm)

Table 2.

Half draconic months per lunation:

2.170391... =		
2+1/	2/1	(Nova)
5+1/	11/5	(Pentalunex)
1+1/	13/6	Semester
6+1/	89/41	Hepton
1+1/	102/47	Octon
1+1/	191/88	Tzolkinex
1+1/	293/135	Tritos
1+1/	484/223	Saros
1+1/	777/358	Inex
11+1...	9031/4161	

Lunations per half eclipse year:

5.868831... =		
5+1/	5/1	(Pentalunex)
1+1/	6/1	Semester
6+1/	41/7	Hepton
1+1/	47/8	Octon
1+1/	88/15	Tzolkinex
1+1/	135/23	Tritos
1+1/	223/38	Saros
1+1/	358/61	Inex
11+1/…	4161/709	

Table 2. One method of determining ever-more-precise ratios is continued fractions, where the consecutive terms converge on the true ratio. Here two related periods are shown, with the number of lunations the denominator and numerator respectively; the development of the fraction is identical after the first term. The consecutive terms, known as convergents, first yield the poor, but possible, intervals of 1 and 5 months between eclipses, followed consecutively by the same eclipse cycles as in Table 1. Of particular interest are the several consecutive terms of ...1+1/..., which can be interpreted as "one of each of the previous two terms." The "purest" irrational number, Φ= 1.6180339887... can be expressed by a continued fraction consisting of *all* 1s, convergence in its most natural, recursive state. Eclipse cycles mimic this sequence for several iterations, thus yielding some temporary similarities to the mathematics of the Golden Ratio. However, Inex is an order of magnitude more accurate than Saros; the last row reveals that the next improvement in the period is 11I + 1S = 336 years, breaking the recursive relationship. (Table adapted from `www.wordiq.com/definition/Inex`)

Table 3.

Φ^n	decimal	algebraic	"rounded"
Φ^{-5}	0.09016994	5Φ - 8	
Φ^{-4}	0.14589803	-3Φ + 5	
Φ^{-3}	0.23606798	2Φ - 3	
Φ^{-2}	0.38196601	-1Φ + 2	
Φ^{-1}	0.61803399	1Φ - 1	
Φ^{0}	1	0Φ + 1	
Φ^{1}	1.61803399	1Φ + 0	(1*)
Φ^{2}	2.61803399	1Φ + 1	(3)
Φ^{3}	4.23606798	2Φ + 1	(4)
Φ^{4}	6.85410197	3Φ + 2	(7)
Φ^{5}	11.0901699	5Φ + 3	(11)
Φ^{6}	17.9442719	8Φ + 5	(18)
Φ^{7}	29.0344419	13Φ + 8	(29)

Table 3. Powers of Φ show a remarkable self-referential relationship, generating Fibonacci and Lucas sequences. Each power can be expressed algebraically as $a\Phi + b$, where a and b are consecutive terms from the Fibonacci sequence. Remarkably, the first seven terms shown above have the identical coefficients a and b, as the first seven van den Bergh eclipse periods from Table 1. The last seven terms, when rounded to the nearest* integer, yield the duration in years of those same eclipse periods, namely the Lucas sequence. In the special case of 1*, it should be noted the "rounding" process is in fact a specific operation combining reciprocals in the formula $L_n = \Phi^n + (-\Phi)^{-n}$, which yields precise Lucas values, in this case (L_1 = 1.618... - 0.618... = 1).

Table 4.

	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21
*****	*****	*****	**(329**	**Year**	**Gap)**	*****	*****	*****
S-119		1909	1927					
S-120								
S-121	1949	1967	1985	2003				
S-122			**2014**	2032	2050			
S-123			2043	2061				
S-124			2072	2090				
S-125			2101	2119	2137	2155		
*****	*****	*****	**(293**	**Year**	**Gap)**	*****	*****	*****
S-137			2448	2466				
S-138			2477	2495				
S-139			2506	2524	2542			
S-140					2571	2589		
S-141			2564	2582	**2600**	2618		
S-142				2611	2629	2647		
S-143				2640	2658	2676		
*****	*****	*****	**(311**	**Year**	**Gap)**	*****	*****	*****
S-155				2987	3005			
S-156				3016	3034			
S-157					3063			
S-158					3092	3110		
S-159					3121	3139	3157	
S-160						3168	**3186**	
S-161					3179	3197		
S-162						3226	3244	3262
*****	*****	*****	**(293**	**Year**	**Gap)**	*****	*****	*****
	I14	**I15**	**I16**	**I17**	**I18**	**I19**	**I20**	**I21**

Table 4. Tetrads for the period 1600-3500, distributed in a Solar-Inex panorama in the manner introduced by van den Bergh. Tetrads are currently clumped in groups of 17-19 within a period of about two-and-a-half centuries, followed by gaps of a further three centuries where no tetrads occur. The official Saros numbers — which are formally assigned at intervals of one Inex — correspond to the first event of the tetrad; the *un*official Inex numbers were assigned by the author starting from -2000. Each tetrad-rich era generally involves events from seven or so consecutively numbered Saros cycles, with no tetrads whatever occurring in the next dozen or so cycles. The progression through Inex cycles is much slower, as active cycles routinely make the jump from one tetrad-rich era to the next. The three events shown in **bold** are examples of the "Tetradia," an inferred eclipse period of 586 years (19I + 2S) — note their relative placement 19 rows down and two columns to the right. This is one defined but hardly definitive interpretation of the (changing?) interval between tetrad-rich eras, grist perhaps for a future column. (Tetrad data obtained courtesy Jean Meeus (2003) and Fred Espenak; `sunearth.gsfc.nasa.gov/eclipse/`)

Dr. Michael Dixon

by Philip Mozel, Toronto Centre (philip.mozel@osc.on.ca)

The pictures adorning Dr. Michael Dixon's University of Guelph office give strong clues as to his interests: Earth, Mars, astronauts, and — tomatoes. There actually is a common thread here, for Dr. Dixon's research involves feeding the first people to set foot on the red planet.

Hailing from New Brunswick, Dr. Dixon obtained Bachelor and Master of Science degrees in plant physiology from Mount Allison University. He earned his Ph.D. from Edinburgh University in Scotland. Following a post-doctoral fellowship at the University of Toronto, Dr. Dixon went to the University of Guelph where he is currently the Chair of the Department of Environmental Biology and Director of the Controlled Environment Systems Research Facility (CESRF) there.

His curiosity about space dates back at least as far as Apollo 11. Dr. Dixon remembers watching the mission on a black-and-white television with lengths of wire strung up as an antenna to improve reception. In the mid 1980s he responded to a Canadian Space Agency survey. The Agency was determining interest in space science among Canadian scientists. Dr. Dixon proposed research in the field of plant biology but, at the time, more attention was being shown in *Canadarm,* satellite communications, and the like. Years later, the space community took notice as the importance of biological life support became increasingly recognized. Now, Dr. Dixon is working with the European Space Agency and NASA (whose scientists have made use of the growth chambers at CESRF). It boils down to this: just how do you keep a Mars-bound crew fed? This is where plants come in.

Dr. Michael Dixon

It is simply too expensive to haul all necessary food to Mars due to the large quantities required. Growing the food will be necessary but this presupposes that useable water is accessible on the planet. Finding such water is a major part of the rationale for current robotic exploration. But finding water is only the beginning because Earth plants cannot simply be shipped into space to face very un-Earthlike conditions. On Mars they will encounter, for example, reduced levels of light, gravity, and atmospheric pressure. Furthermore as Dr. Dixon says, "There is no such thing as garbage on the way to Mars." Everything must be recycled so all parts of the plants must be useable in one form or another. Taken together, these factors argue for plants specially developed for the purpose. In other words, "We are not getting off this planet without genetically modified plants." Dr. Dixon's research aims to provide them. Such plants, besides providing food, will act as natural filters for the crew's air and water and provide essential vitamins and minerals. Having something green to look at and care for inside a spacecraft or surface habitation is likely to be a stress reliever as well.

But what kind of plants? The best crop to grow is one that has small hardy seeds, a short germination period, enjoys low light levels, is easily pollinated, and has a high yield of food energy. Ideally the crop should grow well in a wide variety of soil types and have modest requirements for water. Tomatoes are well on their way to filling the bill. And to encourage interest among young people in this research, there is *Tomatosphere*.

Tomatosphere is an experiment, overseen by Dr. Dixon, where students across Canada germinate seeds from three sources, one experimental and two controls, and report their results via the Internet. The originally experimental seeds were flown aboard the *Space Shuttle* courtesy of Marc Garneau. Current experimental seeds have been treated by exposure to simulated Martian conditions. One place where severe conditions may be created at will is at CESRF where such variables as lighting, temperature, and air pressure can be manipulated. Future experiments may be conducted on the half million seeds presently on the *International Space Station*.

Dr. Dixon is also involved in the Haughton Mars Project that involves a greenhouse, containing many species of food plants, built on Canada's Devon Island. Onsite researchers monitor internal environmental conditions and plant growth in July and August, and remotely at other times. Except for a short period in June, the intensity of sunlight on the island never exceeds that found on Mars (it is actually similar to what one would experience on the Martian equator). How must the greenhouse environment be manipulated to grow food crops, such as tomatoes, in a Mars-like environment on Earth? What accommodations will be needed to do something similar on Mars itself? Dr. Dixon would love to see in the near future a miniature growth chamber sent to Mars on a robotic spacecraft. Soil would be dug up, seeds planted, and the results monitored as Earth-bound scientists manipulate the growing conditions.

Not all of CESRF's research is directed at Mars; there are terrestrial applications as well. The development of efficient lighting, shade-tolerant plants, nutrient recycling sensors, *etc.* can all be applied to greenhouses on Earth and may revolutionize that industry. Plants and microorganisms are being developed to clean the air in enclosed environments other than spacecraft, such as office buildings. For example, a "breathing wall," a very large, indoor tropical garden acting as a biological air filter, is located at Humber College in Toronto: it is four stories high! Dr. Dixon believes that by putting huge technological challenges (*e.g.* growing plants on Mars) in front of Canadians, there is a large trickle-down effect that will benefit people across the country and around the world.

On the first piloted mission to Mars there will be, of course, pilots, engineers, geologists, and the like. If Dr. Dixon has his way, there will also be a horticultural mission specialist. And he or she will have studied in his labs in Guelph.

Philip Mozel is a past National Librarian of the Society and was the Producer/Educator at the McLaughlin Planetarium. He is currently an educator at the Ontario Science Centre.

The Skies Over Canada Observing Committee News

by Christopher Fleming, Chair, Observing Committee (observing@rasc.ca)

The 2004 General Assembly was held in St. John's, Newfoundland and I extend our thanks to members of that fine Centre for presenting such a well organized and memorable GA. The coastline of Newfoundland is very scenic and I thoroughly enjoyed standing on top of Signal Hill, an almost mountain-like structure that overlooks the historic City of St. John's, and taking in the view. To the east the scene spans out over the Atlantic Ocean as far as you can see and at the bottom of Signal Hill you can watch ships come in and out of the picturesque channel that leads into St. John's harbour.

Several productive meetings were held at the General Assembly and a lot of new ideas were put forth and discussed. Among these was a proposal to initiate joint observing programs with the Astronomical Society of the Pacific and possibly to share resources and publications with them. This may be a good way to extend our presence beyond Canada and in return reap benefits from another well-respected astronomical society. Another great idea coming from the meetings and that we plan to implement is to provide a significant amount of space on the national Web site for posting astronomical images that RASC members have taken. We think that providing one central location for posting the best of our members' images will be an excellent way to use the national site and it will be an important resource for all to enjoy. A specific email address for this may be in place by the time this article is published so, if you are an astro-photographer or imager, we invite you to send your best pictures and we will indeed post them. Our role will not be to judge the best images but to provide a vehicle for them to be shared with other RASCals.

As a result of preliminary returns from the membership survey we have learned that many observers are interested in the planets and so we will be developing more resources in that regard and hopefully we can create a complete Planets Section in the not-too-distant future. There was also a strong interest shown for lunar observing and that is good news since we are introducing a new lunar observing certificate program that will be named in honour of Isabel K. Williamson, a legendary astronomer from the Montreal Centre.

To show our appreciation for the superb way that the RASC has embraced the Explore the Universe Certificate program the committee was proud to present two prizes in a draw at the 2004 General Assembly for those who had received the certificate up to that date. The first prize was an 80-mm *SkyWatcher* refractor that was donated by O'Neil Photo Optical of London, Ontario and it was won by Emma MacPhee of the Moncton Centre. The second prize was a *SkyAtlas 2000* that was donated by Sky Optics of Burlington, Ontario and it was won by Gail Lorraine Wise of the Winnipeg Centre. Congratulations to Emma and Gail and many thanks to Joe O'Neil and Steve Barnes for donating those fine prizes.

There have been three Explore the Universe Certificates awarded since our last report and they are listed in Table 1.

There has been one Messier Certificate awarded to June 2004, as listed in Table 2, plus other applications that could not processed in time for this article.

The Asteroids Section features charts containing the orbital position of several bright asteroids that will be visible in 2004, and during November and December you will be able to print charts for the asteroids (8) Flora, (27) Euterpe, (192) Nausikaa, and (532) Herclina. They will all be brighter than tenth magnitude during this time and the charts will display nearby stars to tenth magnitude on a five-degree vertical field layout. Dates for the position of each asteroid will be listed at three day intervals and nearby bright "finder stars" will be highlighted. In many cases the finder stars are bright enough to be seen visually and therefore a *Telrad*™ or similar device can be used to find the star field printed on the charts. Otherwise a typical finder-scope will be sufficient to find the brightest star in the field.

The Variable Stars Section features direct links to genuine American Association of Variable Stars Observer's (AAVSO) magnitude estimate charts for Mira-type Long Period Variables that will reach maxima in 2004, and that will be brighter than magnitude 8.0. For November and December you will be able to print charts for R Leonis, V Monocerotis, R Geminorum, R Serpentis, R Pegasi, R Leporis, and S Virginis. We also have

Table 1. Explore the Universe Certificate Recipients

Name	Centre	Date Awarded
Ted Bronson	Thunder Bay, ON	June 2004
Doug Stuart	Thunder Bay, ON	June 2004
David Mooney	London, ON	June 2004

Table 2. Messier Certificate Recipients

Name	Centre	Date Awarded
Andrew Beaton	Toronto, ON	June 2004

direct links to charts for several other variable star types and you will find them on the Sample Charts 2 page. Many of the most interesting variable stars in the night sky are listed there as well as the positions of possible nova outbursts.

The Special Projects Section regularly posts Web pages containing information about upcoming, noteworthy astronomical events and we will have a page posted for the total lunar eclipse on October 28, 2004. If that date has passed by the time you are reading this I would still like to encourage you to visit that page since there will be lots of information there that you may find interesting, and we may also post a round-up of the event as seen from Canada as well as some images taken by members of the RASC.

A Comets Section has been in the works for several months and it may in fact be completed by the time this article reaches you, so if you are interested in this type of project, check the Observing Section's main page on the RASC site to see if it has been launched. I sincerely thank well-known comet hunter and Canadian David H. Levy for writing a wonderful introduction to the Comets Section. The section will feature information about currently visible comets and we hope to have sample finder charts available that are ready to print and use in the field. I also thank Michael K. Holzer of the Regina Centre who has contributed a great deal of the content for the Comets Section and who was instrumental in getting the project started.

If you would like to start and contribute to a project like that about your favorite observing category then contact the Observing Committee with your ideas and we will do our best to help bring your proposal to life. It is also possible that a project could be organized and run from your own Web site and we will simply link to it. It has always been great to see active participation from RASC members at the Centre level and it would be even more fantastic to see this extended across the National Society.

Christopher Fleming is Chair of the RASC Observing Committee and Observer's Chair in the London Centre. He enjoys all types of observing especially Deep-Sky, Lunar, Double Stars, and Variable Stars. Chris is also a musician and Webmaster of the London Jazz Society's Web site.

GA 2004

St. John's is an unforgettable city no matter what the weather — clear and bright or fogged in!
(image: Kim Hay and Kevin Kell

The 2004 General Assembly meets in St. John's Newfoundland
(image: James Edgar)

Bird-watching at the Witless Ecological Reserve
(image: David Lee)

GA 2004

The GA was enhanced with visits to the Cook monumet (above, left); the Johnson Geo Centre (above), and the Armillary Sphere (below, left). (images: Jim Low, left, David Lee, above and below left)

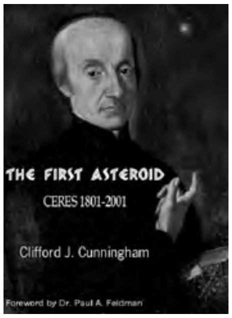
Another year, another GA! (image: Jim Low)

GA 2004

The changing of the guard proceeds as the new President directs the human pyramid (above left and right) while the Past-President defers to his new boss… (left) (images: Jim ow)

Gary Dymond hosts the Screeching Ceremony (image: David Lee)

Reviews of Publications
Critiques d'ouvrages



The First Asteroid: Ceres 1801-2001. Historical Studies in Asteroid Research, Volume 1, by Clifford J. Cunningham, pages 488 + vi; 21.5 cm × 27.5 cm, Star Lab Press, 2002. Price $120 US softcover (ISBN 0-9708162-2-7).

Canadian readers will recognize Clifford Cunningham from his many contributions to the astronomical literature. He is one of the world's experts on asteroids, having been fascinated by asteroids from his youth. In 1988 he published an *Introduction to Asteroids,* followed in 1990 by a comprehensive *Minor Planet Index to Scientific Papers*. The year 2001 marked the bicentenary of Giuseppe Piazzi's discovery of asteroid number 1, Ceres, and Cunningham has assembled a wide variety of materials to celebrate it. The result is clearly a labour of love; the author says it required more than ten years of research. Readers must be warned at the outset that the book is not an historical monograph with a sustained argument; rather, it is more like a scrapbook.

Piazzi and his contemporaries believed that the discovery of Ceres vindicated Bode's Law, which suggested that a planet should inhabit the region between Mars and Jupiter. We already know, from the work of scholars such as Stanley Jaki, that Johann Bode had little to do with his "law," and that the law has no scientific basis. Cunningham takes us through the steps of how the "law" came to be known. That the asteroids Pallas, Juno, and Vesta were discovered in the same region of the solar system soon after the discovery of Ceres was something of an embarrassment. Cunningham shows how the discovery was not something "out of the blue," but rather part of a systematic search on the part of several notable European astronomers, co-ordinated by Baron F.-X. von Zach. Controversy over the nature of the new object (was it a comet? a planet? how large was it? what was its origin?) brought contributions from many astronomers, including Bode himself, Heinrich Olbers, William Herschel (who proposed the term "asteroid," though Piazzi disliked it), and Johann Schröter. By calculating the best orbit for Ceres, the young Carl Gauss came to the attention of the international astronomical community.

The early chapters explore different aspects of the story, accompanied by poems, contemporary quotes, and pictures of various artistic renderings of the mythological Ceres. There is even a chapter on G.F. Hegel's philosophy, though its inclusion seems unnecessary. More valuable are short biographies of the key players in the story. The heart of the book — about two-thirds its length — is an excellent collection of source materials, including extensive and translated correspondence (Piazzi's with Barnaba Oriani, Olbers' with Gauss, and letters by other Italian and British astronomers), along with translations of Piazzi's 1801 and 1802 monographs on Ceres, parts of Bode's 1802 book, and Schröter's 1805 text. Also included are translated papers by Herschel and others that appeared in several journals of that epoch. Documents and parts of texts that do not appear in this volume are expected to be published in the next two volumes of the series. At the end are several appendices on disparate topics. It is not a book that you can read in a linear way, as it is not assembled in a traditional format; dipping in from time to time is more enjoyable.

While the author has done part of the job of unraveling the story of the discovery of Ceres, along with its aftermath, future historians will have an opportunity to extend the work. What Cunningham has provided in terms of documentation will be of tremendous value to others interested in studying the period of time associated with the discovery of the first asteroid.

Richard A. Jarrell

Richard Jarrell is an historian of astronomy at York University, and the author of The Cold Light of Dawn. He is currently part of the editorial team for the Biographical Encyclopedia of Astronomers.

Janet Akyüz Mattei (1943 – 2004)

Janet Akyüz Mattei (1943–2004).
Photo by Mike Mattei, provided by the American Association of Variable Star Observers.

I vividly remember meeting Janet Mattei for the first time. It was on a Winnipeg city bus, on a tour that was part of the 1974 RASC General Assembly. That General Assembly was a joint meeting with the American Association of Variable Star Observers (AAVSO). Janet had become Director of the AAVSO in October 1973, after serving for a year as assistant to Margaret Mayall. Margaret's were large shoes to fill: the AAVSO has had only three Directors in its 93-year history: Leon Campbell, Margaret, and Janet. I remember Janet as being young, bright, short, and — being Turkish — slightly exotic. Little did I know that she would become one of my closest colleagues and friends.

Despite her age, Janet was eminently qualified. Born in Turkey, she had received a scholarship to attend Brandeis University in the U.S., receiving a BA there in 1965. After working in a hospital laboratory for a year and a half, she returned to Turkey, where she was a high-school science and math teacher. But the heavens called, and she entered a graduate program in astronomy. A seminal event in her life occurred in 1969 when she was accepted into the summer program of the Maria Mitchell Observatory (MMO) on Nantucket, as one of "Dorrit's girls." "Dorrit" was the Director, Dorrit Hoffleit (who is still actively involved in astronomy at the age of 97). MMO provided summer research opportunities for women undergraduates in astronomy who, at that time, were insignificantly under-represented in the science. Dorrit became Janet's lifelong mentor and friend. MMO also hosted an AAVSO meeting that summer, and it was there that Janet met her future husband Michael Mattei, an optical technologist and amateur (and professional) telescope maker. Mike was a tower of strength for Janet throughout her life and career. Janet completed an MS degree at Ege University in Turkey in 1970, and another MS at the University of Virginia in 1972. Later in her career she completed a Ph.D. at Ege University with a thesis on cataclysmic variable stars.

The purpose of the AAVSO is to coordinate variable-star observing, primarily by amateurs, to evaluate, compile, process, and publish the observations, and to make them available to astronomers and educators. One way to demonstrate Janet's impact on astronomy is to compare the AAVSO at the beginning and end of her career. At the beginning, it was an important but simple organization. It collected visual observations, mostly of long-period and irregular variable stars, hand-plotted these on graph paper, and published descriptive information on the star's behaviours. Occasionally professional astronomers, for one purpose or another, would request observations of specific stars. During her directorship, the number of observations submitted each year increased three-fold, to almost half a million; they now total over 11 million. But there is an even more remarkable statistic: in the three decades of Janet's career, the *demand* by astronomers for AAVSO data and services *increased* by a factor of 25! Since this coincided with the first three decades of space astronomy, one might have thought that visual observations of variable stars by amateur astronomers would become obsolete. Quite the opposite! Many of the requests were for monitoring of unpredictable stars such as novae and dwarf novae, so space telescopes could observe them when the stars began to "perform." Janet co-ordinated over 600 projects of this sort. These projects benefited from her organizational skills, judgment, and diplomacy, as well as from her expertise in variable stars. She was equally at ease with senior NASA administrators, leading astronomy researchers, amateur astronomers, teachers, and students.

The AAVSO also became much more international. Observers in many countries now submit their observations to the AAVSO's "International Database." About two-thirds come "from abroad" (as Janet put it). In 1990 the AAVSO held its first European meeting in Brussels, Belgium, and in 1997 it held its second in Sion, Switzerland. Janet formed collaborations and friendships with astronomers around the world. Of course, the AAVSO met jointly with the RASC on many occasions. Janet and I were deeply involved in planning the 1999 "Partners in Astronomy" meeting in Toronto, which was a joint meeting of the RASC, the AAVSO, and the Astronomical Society of the Pacific (ASP).

One component of that meeting was a three-day symposium on *Amateur-Professional Partnerships in Astronomy Research and Education,* resulting in a book that is the ultimate guide to the subject. Janet played a major role, both nationally and internationally, in encouraging and supporting pro-am collaboration. She was the first Chair of the American Astronomical Society (AAS) Working Group on Pro-Am Collaboration, and she served on many other boards and committees.

In 1973 the AAVSO's observations were almost all visual. Now there are photoelectric and CCD programs, search programs for novae and supernovae, and even programs to search for the visible afterglows from gamma-ray bursts — the most powerful explosions in the Universe. These developments were enhanced by the workshops on CCD Photometry, and on High-Energy Astrophysics, which Janet organized with the help of experts who were keen to use these new AAVSO services. Janet was always insistent that any AAVSO data published or disseminated should be as reliable as possible. It was tempting to put the AAVSO observations immediately on the Web but Janet was reluctant to do so. The conflict between quality control, volume of data, and speed and ease of dissemination was a challenge. But Janet and her staff developed a system that resolves this conflict, and there is a project underway to verify *all* of the AAVSO's data, back to 1911 or before, and make it available on the Web by 2005. This remarkable database will be a monument to Janet's high standards and leadership.

In 1973 the AAVSO disseminated many of its results through a bi-monthly column in the *JRASC*. Janet's first column was in *JRASC,* 68, 48-52, 1974. She also contributed a section to the RASC *Observer's Handbook* and, in 1976 (when I was Editor of the *Observer's Handbook*), we introduced a *Variable Star of the Year*. At that time, there were also mimeographed (remember that technology?) newsletters for members. In 1972 the *Journal of the AAVSO* began as a refereed journal for disseminating the results of AAVSO observations, and recording the business of the Association. Janet's annual report was always a highlight in the *Journal,* and at the annual meeting, because it conveyed both the scientific and human side of the AAVSO's work; it was delivered straight from the heart. Now, the AAVSO also has a comprehensive Web site, which disseminates not only data and charts, but also excellent information about all aspects of variable stars and variable star observing. I particularly recommend the *Variable Star of the Season* — both the current issue and the archives. All of this progress was possible because of the team of able, loyal staff, which Janet developed and led.

My closest collaboration with Janet was the education project *Hands-On Astrophysics*. Janet and I had both been school teachers in our previous incarnations. We both had a deep interest in formal and informal education. We both realized that the observation and analysis of variable stars would be an excellent way for high school and university students to develop and integrate their skills in science and math, motivated by the excitement of doing real science, with real data — AAVSO data. With support from the U.S. National Science Foundation, we developed software, datasets, charts, slides, and prints (for indoor practice), three instructional videos, and a 600-page students' and teachers' manual for the project. Another of my vivid memories of Janet is of spending 10 hours with her and AAVSO staff member Mike Saladyga in a video-editing studio in Toronto one rainy Easter Sunday (the only time that studio time was available) helping our video editor/producer Todd Hallam create three short videos from about 24 hours of tape. For several years thereafter, Janet delighted in working for a week each year with school teachers, as part of the *TOPS (Towards Other Planetary Systems)* program in Hawaii.

Janet's work was internationally recognized by a dozen major awards, of which the AAS Van Biesbroeck Award, the Astronomical League Award, and the Royal Astronomical Society's Jackson-Gwilt Medal are but three. Asteroid 1998 FA-74 was named in her honour. But Janet was more than just an award-winning professional. Her warm, caring, and generous personality endeared her to everyone she met. She discovered that my wife had a liking for Turkish Delight, so every Christmas a predictable package would arrive by courier at our door. In return, I delivered or sent her a Canadian wildflower calendar, because her other passion in life was flowers. The obituary on the AAVSO Web site begins "Flowers are the stars of the earth; stars are the flowers of the Universe." Janet was often compared with a star — not the superficial stars of entertainment or sport, but the enduring stars that illuminate the night sky, as she illuminated everyone who knew her.

Janet Mattei passed away on March 22, 2004, after several months' brave battle with acute leukemia. Through the AAVSO's on-line discussion group, and other channels, condolences, remembrances, and appreciation poured in from around the world. Much of this is preserved on the AAVSO Web site `www.aavso.org`. She will live on in the memories of those who knew her. Her contributions to astronomy and education will outlive us all.

— John R. Percy

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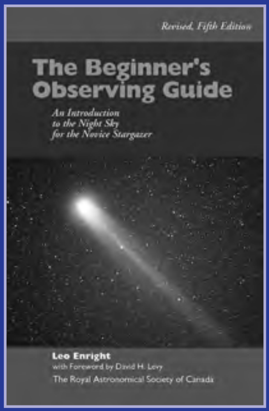

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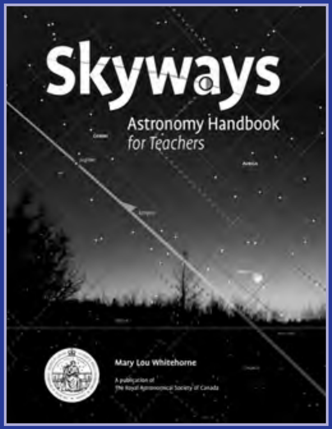

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