NOVA NOTES

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THE NEWSLETTER OF THE HALIFAX CENTRE OF THE RASC

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INSIDE THIS ISSUE...

President's corner 1

December Meeting Report 2

Do-It-Yourself Planisphere 4
- Mel Blake

Barefoot Astronomy 5
- Mary Lou Whitehorne

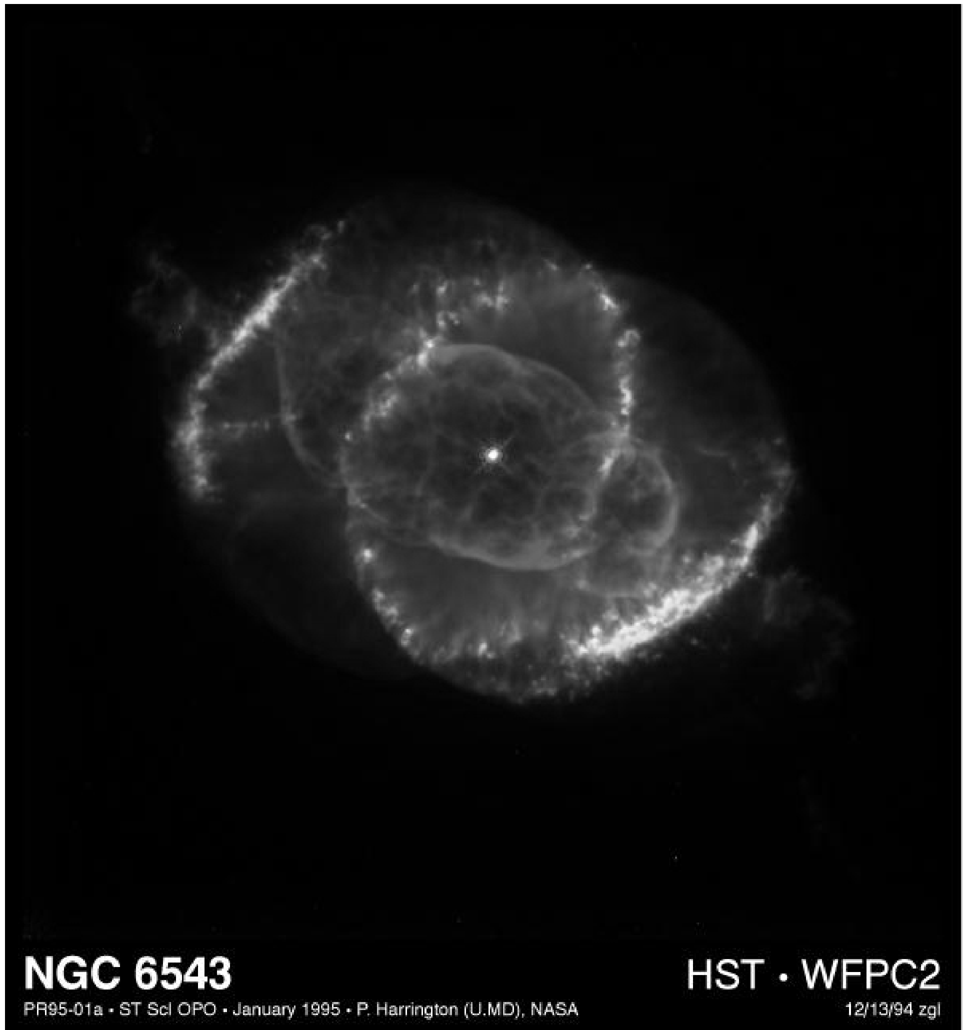
Occultation of Regulus 6
- Sherman Williams

What's Up 7
- Mike Boschat

The Sweden Solar System 7
- David Chapman

High Energy Groove 7
- Mary Lou Whitehorne

Notice of Meetings and Other Stuff



ASTROPHOTO OF THE MONTH

The Cat's Eye Nebula

Credit: J.P. Harrington and K.J. Borkowski (U. Maryland), HST, NASA

Three thousand light years away, a dying star throws off shells of glowing gas. This image from the Hubble Space Telescope reveals "The Cat's Eye Nebula" to be one of the most complex planetary nebulae known. In fact, the features seen in this image are so complex that astronomers suspect the bright central object may actually be a binary star system.

PRESIDENT'S CORNER: BY CLINT SHANNON

The Messier Marathon:

Once a year, near the time of the March equinox, the Sun is in a position to allow viewing of nearly all the Messier objects in one night. Some, however, will be near setting in the early evening and should be viewed first in the following sequence: M31, M32, M33, M74, M77, M79 and M110. Other objects which will not be visible until just before dawn are M2, M15, M30, M55, M72, M73 and M75. The rest of the objects can be viewed in a relatively leisurely progression as they cross the sky.

The new moon in March is on the 17th. A telescope of at least a 4" objective will be required (larger objective would be better) and a good west horizon in the evening and a good east horizon in the morning. The standard reference for Messier Objects is the RASC Observer's Handbook Messier Catalogue by Alan Dyer. Kenneth Glyn Jones' book, "Messier's Nebulae & Star Clusters", is also recommended as well as Burnham's Celestial Handbook.

NOVA NOTES, the newsletter of the ***Halifax Centre of the Royal Astronomical Society of Canada***, is published bi-monthly in February, April, June, August, October, and December. The opinions expressed herein are not necessarily those of the *Halifax Centre*. Material for the next issue should reach the editor by **April 16th, 1999**. Articles on any aspect of astronomy will be considered for publication. "Letters to the Editor" or to our resident expert: GAZER are also most welcome. Contact the editor at:

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Requirements for eligibility for the RASC's Messier Certificate are:

1. The applicant must have observed all 110 Messier objects.
2. The applicant must have located each of the objects without assistance from:
   a) other observers, and/or
   b) by use of telescopes which are pointed with the aid of computers.
2. The applicant must list on the application form: instrument used, observing site(s) used and time period over which the observations were made.
3. Members applying for the Messier Certificate must provide a signed declaration that he/she has observed all 110 objects, has met the above criteria and submitted either:
4. the declaration signed by two witnesses; or a log book record of observations which records the date and time of observation of each of the 110 Messier objects, telescope and magnification used for each observation, any remarks noted at the time of the observation.

An Application Form for the Messier Certificate can be had by requesting same from myself or any succeeding President of the Halifax Centre. The completed form with supporting documents must be submitted to the National Secretary, RASC. Clear skies (hopefully). Ω

DECEMBER MEETING REPORT
BY PAT KELLY

Members did not have to worry about missing a chance to observe on the night of the December meeting as there was a ice snowstorm in progress. While driving up Spring Garden Road to the museum, I saw a grand total of five people on the sidewalk, and four of them were shoveling snow. That was on Friday night of the last shopping weekend before Christmas, so I was not expecting a big turnout at the meeting. An even dozen showed up in total. In fact, there were so few there that we had to skip the executive meeting. Fortunately, Clint had come prepared and we enjoyed some absolutely exquisite chocolates that he had brought with him.

The reduced number of attendees did make the meeting go a bit faster as there were only long-standing members in the audience. That saved the need for introductions and for explaining the benefits of membership!

Those who braved the weather were treated to a very interesting presentation by Larry Bogan, who had arrived in the early afternoon, beating the bad weather. The topic of his presentation was global positioning systems (GPS). His interest in this topic was spurred by his hobby of flying sailplanes, for which he purchased a GPS system so that he could produce a ground track of where he had been. He soon found other uses for the GPS receiver, including hiking, and decided to learn about how they worked and to see if GPS could be applied to astronomy.

The basic concept of a GPS system is quite simple.

a) Each satellite that make up the network knows where it is with respect to the Earth's centre.

b) The GPS receiver is used to compute your position relative to the satellite. If you think of this in terms of vectors, you now have a vector from the Earth's centre to the satellite, and from the satellite to you. Now all we have to do is:

c) the difference between these two vectors is your location on the surface of the Earth. Simple, eh?

Obviously it is not quite that simple in practice. the orbit (and hence position) of each satellite is affected by many changing effects which include the uneven shape of the Earth, attraction by tidal bulges, solar radiation, solar wind, atmospheric drag, relativity, and both solar and terrestrial magnetic fields. These all must be allowed for so that the position of the satellite is known as accurately as possible.

The distance of the observer from a particular satellite is determined fairly easily, by measuring the time it takes for electromagnetic radiation (in the form of microwaves) to travel from the satellite to the GPS receiver.

We now run into a new set of problems. The clocks that are on the satellites are atomic clocks the one that is in a GPS receiver is not (otherwise they would be somewhat larger and a lot more expensive). The satellites are not only moving with respect to the receiver, but are further out of the Earth's gravitational field so both special relativity and general relativity must be taken into account. Even worse, the speed of the microwaves changes significantly while it passes through the ionosphere and the troposphere. It is possible to correct for this effect by having the receiver allow for a correction based on a mathematical model of the atmosphere. Still, at any given time, the real atmosphere may vary widely from the virtual one inside the receiver.

Once you have allowed for all of these, you can now determine your distance from a given satellite. The problem is that this will not tell you where you are on the Earth. Imagine that you have determined, by measuring the travel time of the signal, your distance from a satellite. That places you on the surface of a sphere, centred on the satellite. Obviously you will need more that one satellite to narrow things down a bit. Your distance from a second satellite will place you on the surface of another sphere which will intersect the first one in a circle. We are getting closer! Adding a third satellite will produce another sphere which will intersect the circle at two points. Usually one of these points will be on the surface of the Earth and the other one will be in space. The receiver will assume that you are not in orbit, thus your location is now known.

In order to get your altitude as well, a fourth satellite is needed. In a perfect system, each sphere would be a true sphere, but due to various errors (mostly from the difference between the time in the satellites, each of the three spheres is actually a thin spherical shell. Thus the two pairs, are not true points but are actually three dimensional volumes, hence the need for additional information.

The satellites themselves are fairly complicated pieces of equipment. Each one has a mass of almost a ton. There are, not one, but four atomic clocks in each satellite. Each clock is accurate to one part in 10^{14} per day. The satellites orbit at an altitude of 26,000 km (four Earth radii) and have a period of twelve hours. To cover the entire planet (and to ensure that there are always between five and eight satellites above the horizon at any given point) there are twenty-four satellites in all. They are placed in six different orbital planes, with four satellites in each orbit. The groups are separated by 60 degrees in longitude. To cover the whole planet, the orbits have a very high inclination, 55 degrees.

Depending on where one is located relative to a satellite the travel time for the signals varies from sixty-eight to eighty-six milliseconds. The signals are transmitted at frequencies of 1.2 and 1.6 GHz. There are other signals that are sent along with these main ones, a 1 MHz signal for public use and a 10 MHz secret signal for military use.

The entire system was built and launched by the US Department of Defence and cost about $12 billion. In addition to the initial cost of the placing them in orbit, each satellite has an expected lifetime of ten years, and there are also five tracking stations worldwide that are needed to fine-tune the satellites orbits, adjust their clocks, etc.

At this time, Larry showed us samples of various GPS receivers and pointed out some of the additional features that come with the more expensive models.

Each satellite is identified by a pseudo-random signature. Larry showed an animated GIF file which showed how the system works and the processing that was required. Older GPS receivers had to decode these signals one satellite at a time, and could only give a location once enough satellites had been identified. Newer models decode the signals from all available satellites simultaneously.

The conversion of the location of the receiver in three-space (x,y,z) to latitude and longitude requires the receiver to have a mathematical model of the shape of the Earth. Different models give different locations.

There are several different types of errors that cause inaccuracies in the positions that the receivers give. Bias errors are caused by things like clock drift, errors in the real position of the satellite compared to its ephemeris position and the random time delay in the signals caused by their passage through the troposphere. All of these sources produces small errors, on the order of one meter. The largest bias error is caused by the time delay in the ionosphere, which can be quite a bit larger that that caused by the troposphere and can result in an error of up to ten meters. Major errors can be caused by blunders in the information programmed into the satellites by their controllers and can give inaccuracies of one to 100 km.

In addition to these errors, the American Defence Department has added intentional errors so that civilian receivers can only be accurate to about 100 meters. They do this by randomly varying the time signals over a time scale of hours. If it was varied over a short period, the variation could be averaged out, allowing you to strap a $100 GPS receiver on a SCUD missile and actually have it hit its intended target. By knowing the time variation as well as by having access to both the 1 MHz and 10 MHz signals (allowing them to cancel out the ionospheric effect, the military can get an accuracy of a couple of meters.

Since one might think that only the military can get high accuracy, why bother with using a GPS system. As it turns out, there are ways to get highly accurate measurements. One technique, used by surveyors, is called **relative positioning**. In this case, two units are needed, a reference receiver and a mobile receiver. Initially the two receivers are placed side by side. They are sensitive enough to actually measure the profile of the microwaves that are being received and as the mobile receiver is taken away from the reference unit it measures the phase chance and literally counts the number of wavelengths that it has been moved. Since the wavelength of the signal is known, the distance **between the units** can be measured to within centimeters. This method is useful over distances of up to thirty kilometers but you must keep in mind that although it allows relative distances to be measured very precisely, it still does not give you any better accuracy in determining where you are in absolute terms.

To get a highly accurate absolute position you need to use **differential GPS**. The biggest problem with civilian receivers is the error produced the ionosphere. Over an area covering about 300 km, that error is essentially the same. Differential geometry makes use of this by using a fixed receiver that is placed at a fixed location whole latitude and longitude is already known. The receiver at this location then uses the GPS system and determines where the satellites thinks that it is. The difference between where the GPS receiver thinks it is and where it really is, gives one a correction that will apply to all GPS receivers within the 300 km area. This correction (which will vary over time) is broadcast on radio and allows anyone in the coverage area to correct the reading from their own GPS receiver to get a position that is accurate to one to three meters. Larry noted that there were plans available that would allow a person to connect a $10 radio directly to a GPS receiver so that the corrections are done automatically. The Canadian Coast Guard has eight of these reference transmitters covering the Atlantic Provinces.

More information on GPS systems can be found at Larry's web site. Ω

DO-IT-YOURSELF PLANISPHERE: BY MEL BLAKE

When asked to give a school talk, it is always good to have some interactive project for students to do, instead of just lecturing at them. I was thinking about this when I was performing a tour of our observatory here at York University. Once the students started asking questions, the evening started going much better. They were particularly happy with the monthly star chart I handed out. This sheet is created by a computer program I have written to make the round magazine style star charts like those in Sky News and the back pages of the Observers Handbook.

After the tour I thought, "Wouldn't it be a better thing to get the students to make their own star chart, and then teach them how to use it?" So it occured to me that even better would be to give them something they could use all year round - a planisphere they could make themselves. Something they make themselves would mean more than some chart just handed to them. I set to work on this, and after some trial and error, I had modified my monthly star chart program to create a planisphere for any latitude. I then made such a planisphere for 45 degrees north and placed it on my teaching website, *http://aries.phys.yorku.ca/~blake/teaching.html*

The planisphere consists of two parts. The first is the star chart itsself, containing all the stars down to 5th magnitude, and lines showing the position of the meridian at 8 pm on the 15th of each month. The second part of the planisphere is the mask covering all the sky but the portion visible. The mask also contains a brief description of its use. The planishere can be made in just a few minutes. First you cut out the sky and mask, and the interior sky portion of the mask. You then take a sheet of transparency and cut out a portion just big enough to cover the sky part of the mask. One sheet of transparency is enough for two planispheres. Then you can use tape to attach the transparency to the mask, align the mask with the sky and stick a small pin through the center. You then have a planisphere good for latitude 45 degrees north.

I have had the planisphere on my web site for about 18 months, and it is one of my most popular products. I get about 3 downloads per day, not bad for a non-commercial site. Interestingly, most downloads come from Europe, particularly France, and I get few from Canada! Recently I was asked to supply the chart to the London Center's newsletter, and so I thought I would make the members of my home center in Halifax aware of it. I invite you all to download my planisphere and use it as class activities or for learning the sky yourselves. Feedback is welcome.

Mel Blake
Dept. Physics and Astronomy
York University Ω

BAREFOOT ASTRONOMY: BY MARY LOU WHITEHORNE

HOW BIG IS A BILLION?

Have you ever wondered just how big a billion really is? Astronomy is full of really large numbers, and a big sandy beach in the summer time is a good place to think some astronomical thoughts. Begin by taking off your shoes and socks and digging your toes into the sand. How big are those grains of sand? Let's say that they're 1 millimeter across, on average. So, how big a pile of sand will it take to have a billion grains of sand?

1 BILLION = 1×10^9 (or 1,000, 000,000, or 1000 x 1000 x 1000).

Interesting. 1 meter = 1000 mm. So, 1 meter x 1 meter x 1 meter = 1000 mm x 1000 mm x 1000 mm, which happens to equal 1 meter 3 which equals $1 \times 10^9\ mm^3$, which equals 1 BILLION mm^3 !

Now we have a model of a billion: 1 cubic meter of sand.

Thinking a little bigger, lets make each grain of sand represent a star in our galaxy, the Milky Way. The Milky Way contains about 200 billion stars, give or take a few, here and there. 200 billion stars, represented by 200 billion grains of sand. We now need 200 cubic meters of sand and that will give us 200 billion sand grain "stars."

Go to your favorite beach. Start at one end of the beach and pace off 200 meters - it's a lot farther than you think! Now imagine a row of blocks of sand; 200 of them, each block being 1 cubic meter in size. There you have it, a model containing 200 billion sand grain "stars." Pretty impressive!

Returning to the stars: our Sun has a diameter of 1.4 x 106 km (1.4 million km) and the average separation between stars in the Sun's neighborhood is about 4 light years. (A light year is the distance that light travels in one year. The speed of light is 300 000 km/s, so a light year is equal to 10 TRILLION km!).

1 light year = 1×10^{13} km, average separation between stars = 4×10^{13} km.

In order to scale stars and their separations to grain-of-sand sizes, we must reduce everything to millimeters. The math looks like this:

Sun's diameter = 1.4×10^{6} km = 1.4×10^{12} mm

stars' separation = 4×10^{13} km = 4×10^{19} mm

To scale the separation between the millimeter-sized stars we divide the Sun's diameter into the stellar separation distance:

4×10^{19} mm / 1.4×10^{12} mm = 2.9×10^{7} mm = 2.9×10^{4} m = 2.9×10^{1} km

Therefore, at the scale of our sand grain model of the galaxy, the typical separation between stars is 29 kilometers! With a galaxy like the Milky Way, having a diameter of about 100 000 light years, at this scale a "sand grain" galaxy would be approximately 700 000 km across, almost 55 times the diameter of the Earth and 5 times the diameter of Jupiter! Interestingly enough, this is half the Solar diameter, which is roughly equal to the size of the Moon's orbit around the Earth. So we can take our 200 billion grains of sand and spread them evenly over the space contained within the Moon's orbit and we'd have a reasonable scale model of our own galaxy!

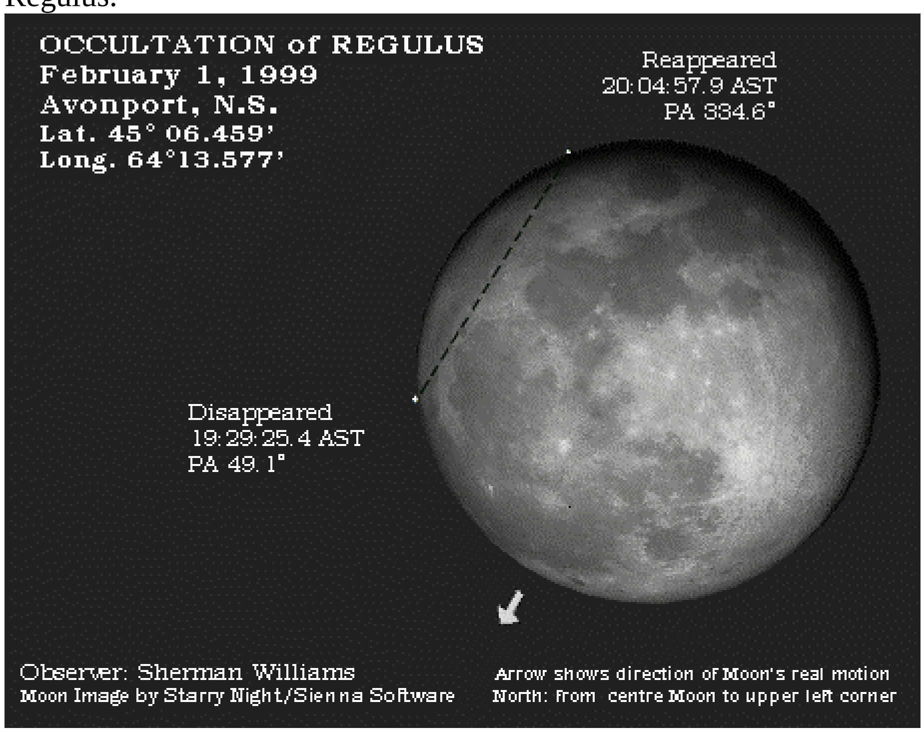
If the Earth could be placed at the centre of the Sun, the Moon would orbit about halfway to the Sun's surface. On the chances of stars colliding with one another: if there were four garden slugs cruising randomly around Canada, it is more likely that two of them will collide with each other, than it is for two stars to meet in a head-on crash! Ω

References:
Bishop. Roy: 1998 Observer's Handbook, Royal Astronomical Society of Canada
Tyson, Neil de Grasse: Merlin's Tour of the Universe, 1997, ASP

OCCULTATION OF REGULUS: BY SHERMAN WILLIANS

My February observations were launched on the 1st, just after 6:45 p.m.,with a beautiful moonrise over the mouth of the Avon River at Horton Bluff.

The moon was just a day past Full. By 7:15 p.m., with the moon not much more than 5 degrees above the horizon, I began observing the occultation of Regulus.



Regulus, the brightest star in Leo the Lion, shines on the brighter side of magnitude 0 from a distance of 85 light-years. As my observing began, Regulus was 5 or 6 minutes of arc from the leading edge of the Moon. Through the eyepiece at 40X, a few moments before the light of the star was cut off, the Moon's real motion became very obvious. Suddenly, poof, Regulus was gone! As I called out the progress of the event, my voice was recording the event on tape for later analysis against a time mark.

Perhaps more interesting was anticipating and experiencing the moment when Regulus popped into view again. It would happen just beyond a sliver of the darkened edge of the Moon. One moment Regulus was not there, then suddenly, pop! there it was in all its brightness. The contrast of the intense point of starlight popping suddenly into view from behind the darkened edge of the lunar night made the sight quite dramatic. Within minutes the distance between Moon and star grew wider as the Moon pulled away.

Later, from the voice record on tape, specific times associated with the observation were obtained. These are the results:

Disappearance on the bright edge of Moon: 19:29:25.4 AST
Reappearance from behind dark edge of Moon: 20:04:57.9 AST
Later in the evening I took another look up and by eclipsing the Moon with my thumb, I could easily see Regulus. The Moon had moved eastward from the star by about 3 of its own diameters. My observations ended, satisfied in the thought, "I've just witnessed what delays the next tide." Ω

WHAT'S UP: BY MIKE BOSCHAT

March

Wed 3 - Mercury at Greatest Elongation East – 18 degrees, good for north latitude observers.
Fri 5 - Zodiacial Light visible n west at end of evening twilight for next 2 weeks.
Sat 20 - Venus 5 degrees North of Moon at 9 pm. Saturn 3 degrees North of Moon at midnight Venus 3 degrees North of Saturn at 5 pm.
Sun 21 - Spring begins - 9:46 pm.
Mon 22 - Albebaran occultated: Disappearance dark limb at 1:01 pm. Reappearance at bright limb at 2:06 pm.

April

Sat 3 - Zodiacial Light visible in west after evening twilight for next 2 weeks.
Sun 4 - Daylight Savings Time begins.
Sat 10 – Venus is near M45 the Pleiades at 6 am.
Fri 16 - Mercury at Greatest Elongation West – 28 degrees good for southern observers.
Sat 24 - Mars at opposition 3 pm.
Regulu occultated: Disappearance at dark limb at 4:46 pm. Reappearance at the bright limb at 5:54 pm.

Planet Roundup

Mercury is visible low in the west early in the evening.
Venus is in the west about 10 degrees at end of evening twilight.
Mars rises late in the evening, about 30 degrees off horizion.
Jupiter is difficult early in month, very low in west southwest. Lost by mid-month.
Saturn is low in west, sets 3 hours after sun. Ω

THE SWEDEN SOLAR SYSTEM BY DAVID CHAPMAN

If you are looking for heaven on Earth, you may not find it, but Sweden has made a pretty good start by creating a 1:20,000,000 scale model of the Solar System, the world's largest model of the system of planets circling the Sun. The Sun is represented by the Globe Arena in Stockholm, an 85-meter diameter spherical building. The inner planets will lie within the city limits: Mercury (2.9 km distant), Venus (5.5 km), Earth and Moon (7.6 km), and Mars (11.6 km). The outer planets will be considerably more distant: Jupiter (40 km, near Arlanda airport), Saturn (73 km, in Uppsala), Uranus (146 km, near Gavle), Neptune (229 km, near Soderhamn), and Pluto and Charon (300 km, in Delsbo). There already exist scale models of Venus (62 cm), Pluto (12 cm), and Charon (6 cm). Sculptor Bergsteinn Asbjornsson depicted Pluto and Charon as crystal orbs revolving around one another in sandstone and basalt boats. Amazingly, $750,000 (US) has been raised for this project, plus volunteer labour. In the words of Professor Gosta Gahm, one of the project leaders, "At this scale, one gets the direct feeling of how empty and desolate space is, how small and far away the planets are." The other leader is physicist Nils Brenning, who conceived of the project while preparing a talk at his daughter's grade school.
By David M.F. Chapman (based on an article in Physics Today) Ω

HIGH ENERGY GROOVE BY MARY LOU WHITEHORNE

From the 9 January 1999 issue of New Scientist -
The crowd was wowed at the annual Christmas party hosted by the National Academy of Sciences in Washington by a group calling themselves the Chromatics. Chromatics group members are NASA astro-physicists, engineers and computer programmers who offered up this song as part of the evening's entertainment:

Point your X-ray specs to the Sun's location
You'll notice along with its slow rotation
You'll see active loops and plasma arcs In a Solar dance producing X-ray sparks
The X-ray Sun isn't serence and smooth
It's a dynamic and changing high energy groove.

NOTICE OF MEETINGS AND EVENTS

REGULAR MEETINGS

Date: **Regular Meeting — Friday, March 19 at 8pm**; 7pm for the council meeting.

Place: **Saint Mary's University, Room 255 Sobey's Building.** Access is from the Robie Street parking lot (see maps) and follow the signs.

Topic: **Main Speaker**: Dr. Roy Bishop
"Time"

Date: **Regular Meeting — Friday, April 16 at 8pm**; 7pm for the council meeting.

Place: Lower Theater, Nova Scotia Museum of Natural History, Summer Street, Halifax. Access is from the parking lot.

Topic: **Main Speaker**: Blair MacDonald
Technical Aspects of Image Processing

Date: **Regular Meeting — Friday, May21 at 8pm**; 7pm for the council meeting.

Place: Lower Theater, Nova Scotia Museum of Natural History, Summer Street, Halifax. Access is from the parking lot.

Topic: **Main Speaker**: Mary Lou Whitehorne
Microvariability and Oscillations of Stars

BECOME A ST. CROIX OBSERVATORY KEY HOLDER

For a modest key fee, members in good standing for more than a year who have been briefed on observatory can gain access to the centre's new Observatory, which is nearing completion. To become a key holder, contact Observatory Committee Chair, Shawn Mitchell.

ASTRO NOTICE

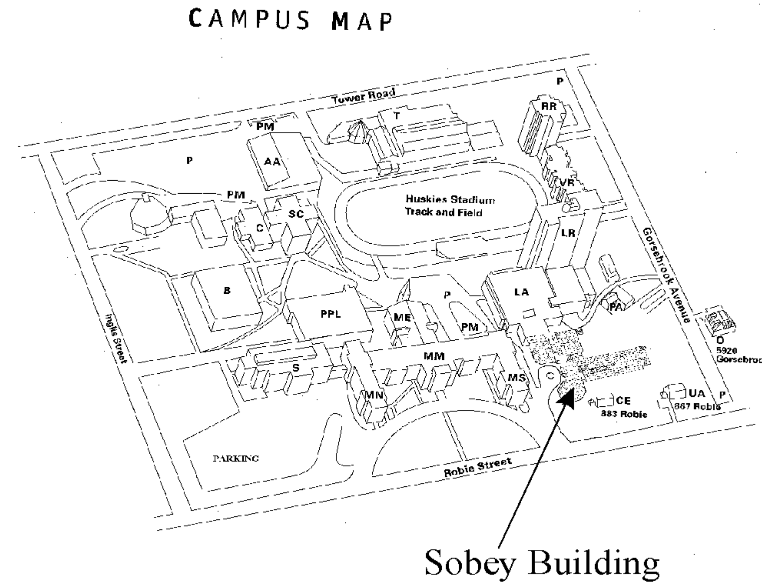
Joe Yurchesyn requests that the member who borrowed his 2" threaded diagonal for a Meade Schmidt Cassegrain Telescope please contact him. His telescope is unuseable without the diagonal and he wishes to have it returned ASAP.

JUST WHERE IS THE ST. CROIX OBSERVATORY?

The Centre's Observatory is located in the community of St. Croix, Nova Scotia. To get there from Halifax (Bayers Road Shopping Centre), follow these simple instructions.

1. *Take Hwy 102 (the Bi-Hi) to Exit 4 (Sackville).*
2. *Take Hwy 101 to Exit 4 (St. Croix).*
3. *At the end of the off ramp, turn left.*
4. *Drive about 1.5km until you cross the St. Croix River Bridge. You will see a power dam on your left.*
5. *Drive about 0.2km past the bridge and take the first left (Salmon Hole Dam Road).*
6. *Drive about 1km until the pavement ends.*
7. *Drive another 1km on the dirt road to the site.*
8. *You will recognize the site by the two small white buildings on the left.*
9.

LOCATION OF THE MARCH MEETING



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