NOVA

NEWSLETTER OF THE VANCOUVER CENTRE RASC

VOLUME 2002 ISSUE 5 SEPTEMBER/OCTOBER 2002

Looking Ahead

Remember, you are always welcome to attend meetings of Council, held on the first Tuesday of every month at 7:30pm in the G.S.O.

Sept. 10: *Our Copernicus*. UBC English professor Dr. Dennis Danielson presents a detailed look at the man and his accomplishments.

Oct. 8: Lee's Amateur Hour.

Nov. 12: TBA

Next Issue Deadline

Material for the November Nova should submitted by Monday, Nov. 4, 2002. Please send submissions to:

Gordon Farrell
(gfarrell@shaw.ca)

The Absolute Minimum You Need to Know About Lunar Libration

by Dan Collier

During the 17th century, J.D. Cassini published three laws that govern the aspect of lunar dynamics known as *libration*. The word was coined from the same root as Libra, and is applied to phenomena of chaotic oscillation—as suggested by the waggling of a merchant's balances. Cassini's Laws were educated guesses insofar as the theory was not worked out until the 18th century. Libration lets us see about 9% more of the Moon's surface than the 50% we would be otherwise limited to. In effect, the Man in the Moon ceaselessly *nods* up and down, left and right.

The longitude and diurnal terms of libration are well explained in textbooks, but the other terms are almost always treated incorrectly. Readers are led to believe that the tiny physical libration is the only nontrivial factor in the orientation of the Moon.

Consider Cassini's Second Law. The plane of the Moon's orbit is inclined 5° 8' 43.4" from the ecliptic. When the Moon is above (below) the ecliptic, we can glimpse the forbidden side over its south (north) pole. This is libration in latitude. At the same time, its axis is canted 1° 32' 30" out of perpendicularity with the ecliptic. The reader might conclude that this cant adds to the libration in latitude, which is true. But while the *magnitude* of it is constant, Cassini's first two laws say nothing about its *direction*, so it is tempting to consider it fixed relative to the stars. In reality, the Moon's axis *precesses* to stay aligned with the inclination.

This is addressed by the puzzling Third Law, whose terms will now be defined. It is well known that the Sun's attraction induces disturbances in the Moon's orbit, the most important being the *regression of the nodes*. Because the Sun is constantly pulling on the Moon, its orbit wobbles like a spinning coin coming to rest on a table. One cycle of regression takes 18.61 years. Like the Moon itself, the Moon's orbit has a north pole, defined as the point on the celestial sphere 90° north of the orbit's plane. As the nodes regress, this

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Images

by Marc Verschueren

Once again, new fantastic images from the Hubble Space Telescope appear like glowing mysteries from far away on the pages of the astronomical magazines. The new Advanced Camera for Surveys gives us a better vision of the far away universe than ever before. There is probably no astronomer who is not impressed by this imagery. What makes it so beautiful? Their scientific meaning is far from clear from what you see. They look more like abstract paintings than astronomical objects, but the view is stunning. There is a grandiose beauty in them. They seem to have some mysterious meaning.

I heard a talk once, illustrated with majestic Hubble images, where the speaker wondered why we, humans on earth, have such a sensitivity for these unearthly objects. It was clearly suggested that we have some cosmic awareness built into us that gives us this sensation of beauty. I would like to suggest we come down back to earth. We find these objects beautiful because they have an intrinsic beauty in an abstract sense, just like a piece of art. Just like we can admire the shape of an arm in a sculpture or a curve in an abstract painting. And more so, these images remind us of purely beautiful earthly objects such as mountain scenes or cloud formations, especially cloud formations with special light effects created by the sun.

The Hubble photographs will always be exceedingly beautiful but when I hear about the Throne of God I do shake my head a little bit. This expression was used recently in one of the astronomical magazines in connection with the new Hubble photographs of the Cone nebula. Robert Burnham called it that in his Celestial Handbook, and he only saw black and white pictures! The aesthetic excitement is pushed a little bit too far here. Even if Burnham puts these words in the mouth of hypothetical ancient observers, calling for religious connections while commenting on astronomy is not the thing to do except when referring to personal beliefs. However, there are some very famous people in science who have fallen for the temptation. If I turn the magazine upside down, which I am allowed to do since the universe has no up or down, does it still look like the Throne of God? The Eagle nebula, also a Hubble marvel, was referred to once as the Pillars of Creation. There is no more creation in there than in our Sun—no less, either.

All this glamour, and I will admit I sometimes am somewhat saturated by it, obscures the fact that the Hubble telescope is so much more than the top fashion photographer of outer space. We had a fascinating example of this a few weeks ago when Professor Richer introduced us to his work on white dwarfs in M4. That is also work that Hubble does and what I presume Hubble does best. The raw data of this research do not look aesthetic at all, just some black spots on a white background or some graphs representing spectra. But the result of the interpretation is impressive. We find stars almost as old as the universe. Stars that just stayed alive since almost the beginning and gently still spread some light; witnesses to the age of the universe. And Hubble did not look to the edge of the cosmos—only a few thousand light years away in the environment of our own Milky Way.

When I open an astronomical magazine, it is hard not to immediately start looking at the latest parade of glorious galaxies and nebulae. They are great. But during this glorious summer this year I had the opportunity to look many times through the eyepiece of small telescopes at Messier objects or NGC members. The sensation of a real observation far exceeds the impact of a photograph. I can really see an object with my own eyes (well yes, with the help of some mirrors and lenses, but essentially with my own eyes). Standing for hours under a dark sky on a warm summer evening with a telescope, that is a true awareness of our universe. That is the beginning of my curiosity to go and look further in more abstract forms of our knowledge, such as photographs or scientific theories and

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President's Message

This summer has been one of the busiest that we have had in quite some time. Some of the highlights include a very successful Perseid Meteor shower event with the GVRD at Aldergrove Lake Park. We had over 300 attendees and the Park Interpreters were extremely happy. We had 11 scopes out and thanks to all the volunteers.

We also represented the Centre well for the two Rotary Club events. The recipients were quite pleased with the number of objects they got to see and we were blessed with good sky conditions both nights. This is a new method of spreading the word about our society and it seems to be working quite well. I am sure more of these will be arranged.

Upcoming events include a neighbourhood star party that will be held either September 21st or 28th. There is a bit of a problem with that event as the Vancouver school board says the original location is undergoing construction even though it will not be starting until October. A change of venue is being made right now and hopefully the event will be held at Windermere School on one of those nights. We would like to get a good number of scopes out for the event, so if you are interested please contact me.

We will also be holding a Sidewalk Astronomy on October 4th or 5th at the Inuit statue to the

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About RASC

The Vancouver Centre, RASC meets at 7:30 PM in the auditorium of the H.R. MacMillan Space Centre at 1100 Chestnut St., Vancouver, on the second Tuesday of every month. Guests are always welcome. In addition, the Centre has an observing site where star parties are regularly scheduled.

Membership is currently $51.00 per year ($26.00 for persons under 21 years of age) and can be obtained by writing to the Treasurer at the address below. Annual membership includes the invaluable Observer's Handbook, six issues of the RASC Journal, and, of course, access to all of the club events and projects.

For more information regarding the Centre and its activities, please contact our P.R. Director.

NOVA, the newsletter of the Vancouver Centre, RASC, is published on odd numbered months. Opinions expressed herein are not necessarily those of the Vancouver Centre.

Material on any aspect of astronomy should be e-mailed to the editor, mailed to the address on page 5, or uploaded to SpaceBase™ at 604-473-9358, 59.

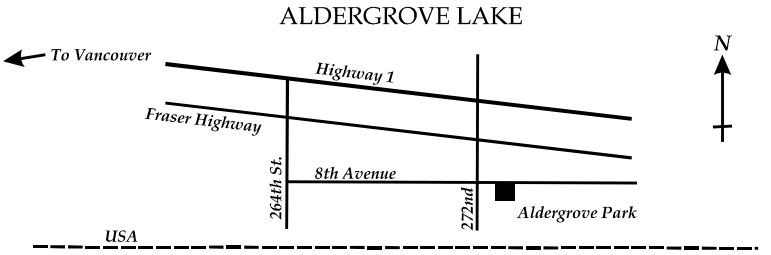
Advertising

Nova encourages free use of its classified ads for members with items for sale or swap. Notify the editor if you wish your ad to run in more than one issue.

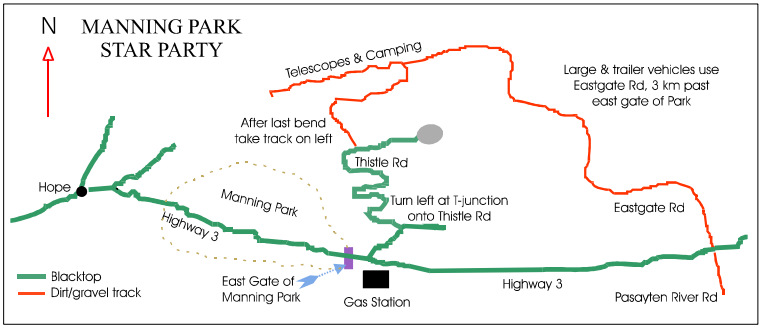
Commerical Rates

1/2 Page: $25.00 per issue
Full Page: $40.00 per issue
Rates are for camera-ready, or electronic files. Payment, by cheque, must accompany ad material. Make cheque payable to: RASC Vancouver Centre.

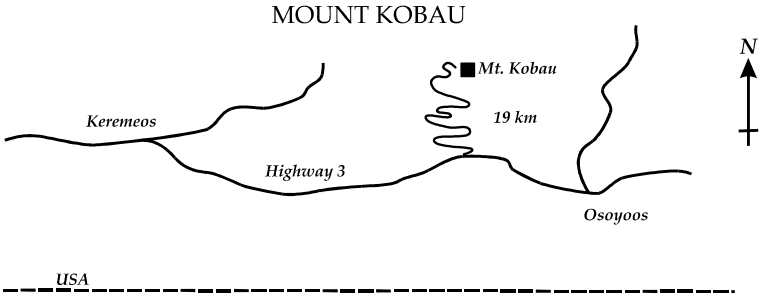
Observing Sites



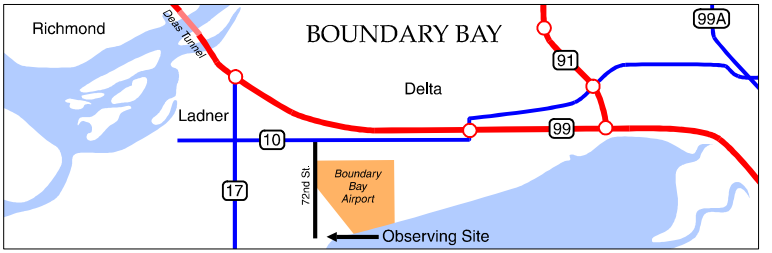
Dale McNabb Observatory in Aldergrove Lake Park (RASC Vancouver Centre's regular viewing site)
Contact Mike Penndelton (604-888-1505) or Howard Morgan (604-856-9186)



Site of the annual star party organized by the RASC Vancouver Centre



Site of the annual Mt. Kobau Star Party organized by the Mount Kobau Astronomical Society



Site of the regular Thursday night star party. On the dike at the foot of 72nd St.

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east of English Bay Beach. In June, we parked right on the grass beside our scopes and had quite a few people stopping by. We like the new location for the absence of direct lights so plan on joining us. If you are interested in helping out, please give me a call.

The 2003 General Assembly is less than a year away now and plans are starting to ramp up. We could use some more volunteers to help out on committees or to head them. There are a lot of tasks to perform and we could use committee chairs for things ranging from observing coordinators to door prize organizers. We will meet at 1:00 on the Saturday following the regular meeting every month from now until the event. We meet at the Billy Bishop Legion on Laburnum just a couple of blocks west of the Space Centre and ½ a block north of 2nd. Please join us, as many hands will help to make the workload easier.

Last but far from least is the approaching end of the year. The Nominating Committee is being formed now and will start soliciting people to hold positions on Council for the coming year. I will be concentrating on the General Assembly and will not hold a position next year. If you are interested in deciding the course of the Centre over the next year then please contact a current member of Council and they will point you to the members of the Nominating Committee. ✸

ASTROCOMPUTING

SpaceBase™ (604-473-9358,59). Affiliated since 1992 with RASC Vancouver, our link to RASC Net, RASC Members only chat area. Future data distribution hub for CARO Project. Features include latest HST images, current world space news and astronomy programs. Provides a file uploading facility for submitting articles and imagery to Nova.

LIBRARY

The centre has a large library of books, magazines and old Nova's for your enjoyment at the GSO. Please take advantage of this club service and visit often to check out the new purchases. Suggestions for future library acquisitions are appreciated.

RASCVC on the Internet

http://members.shaw.ca/rascvan/
or http://www.rasc.ca/vancouver

H.R. MACMILLAN SPACE CENTRE

The Pacific Space Centre Society is a non-profit organization which operates the H.R. MacMillan Space Centre and Gordon M. Southam Observatory. Annual Membership ($30 Individual, $65 Family) includes a newsletter, Discounts on Space Camps, special programs and lectures, Vancouver Museum Discounts, and free admission to the Space Centre. Admission to the Space Centre includes: Astronomy shows, Motion Simulator rides, multimedia shows in GroundStation Canada, and access to the Cosmic Courtyard Exhibit Gallery. For Membership information, call Mahi Jordao at 604-738-7827, local 237 for information. You can also reach them on the Internet at http://www.hrmacmillanspacecentre.com/

MEMBERSHIP HAS ITS PRIVILEGES!

New members, did you know? The Vancouver Centre has 6 telescopes available for loan free of charge! We have telescopes ranging from 3" to 10" diameter. For more information call Phil Morris, Director of Telescopes at 604-734-8708, or see him in the lobby of the GSO after the members meeting. The loaner period is for one month only. All telescopes are to be picked up and returned after the members meeting. No telescope will be allowed to circulate outside of these meetings!

Your greatest opportunity as a member of the R.A.S.C. is to take advantage of the company of other enthusiasts to increase your knowledge, enjoyment and skill in astronomy.

The best thing you can do to gain the most from your membership is to get active! Take in the club meetings; engage other members with questions; come out to observing sessions (also known as "star parties"), and, by all means, volunteer to take part in our many public events.

Observing takes place at the Dale McNabb Observatory in the Aldergrove Lake Park, located in Langley, on 8th Avenue, just east of 272nd Street. We are there most clear nights. Contact Mike Penndelton at 604-888-1505 or Howard Morgan at 604-856-9186.

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Summertime Observing

by Doug Montgomery

It seems I spend all winter finding excuses to not go observing. It's too cold; it might get cloudy; so on and so on. But this summer has been superb for clear nights.

I found myself going out several times a week to several different locations almost all summer long. My travels took me to English Bay, Boundary Bay, Aldergrove Lake, Macdonald Park, Derby Reach, Manning Park, and Mt. Kobau. Oh yes, also my Surrey backyard.

June started with a sidewalk astronomy night at English Bay. Craig Breckenridge, Marcellus Redmond, Bill Ronald and myself were parked on the lawn right by the Inuit statue. We could only get bright objects, but a good night nonetheless. On the day of the annular eclipse, I could not make Spanish Banks, but still watched from my backyard. I also made several trips to the Delta site with the usual suspects, Jason Rickerby, Mike Jensen, and Greg Price. We also did a night with the Young Naturalists—Sean Roddick and myself had a short night that night.

In July, we had the first Manning Park star party. It was well attended by the regulars, Mike Pendelton, John Sherrett, Gary Wolanski, Hoon Hui, and many others. One name from the past that showed up was Frank Marino; it was very nice to see him back. Later that month Mike, Hoon and myself went to Macdonald Park and observed with Victor Pollic, Paul Greenhalgh, Dennis Dening and the rest of the Fraser Valley Astronomers. I also spent several nights at Delta and a night at Aldergrove Lake.

In August I started at Delta looking at the southern horizon. The next night Bob, Pomponia, Marcellus, Angela, and myself gave a slide show and brought our scopes to Derby Reach for the Boy Scouts' Heritage adventure. From there, I went to Mt. Kobau where I camped beside Craig and his family. Many of our members were there including Lee Johnson, Nelson Teskey, Randy Klassen, Jason Rickerby, Riyad Abu-Ladan, Wallace Helter and many others. There was also lots of members from the Fraser Valley group. When we got back, we did a display at Aldergrove Lake Park for the GVRD with a slide show and many scopes. The regulars—Mike Jensen, Jason, Greg, Craig, and myself—were helped by Karl Miller, Howard Morgan, and Hugh Gregory.

In closing, I would like to urge everyone to take advantage of the weather this year and attend the upcoming events we have planned for the rest of the year. Clear skies! ✸

Smudges and Shooting Stars: A Neophyte on Kobau

by Val Stevenson

I only come up to the star party on Mount Kobau every two years for the same reason I only had a baby every two years. You forget the discomfort and remember the beauty of the experience.

We push the elderly 18-foot Frontier RV up the twelve vertical, twisting miles to the summit. No problem there. But the fresh-water lines that produced an occasional drip last night in Keremeos become a rivulet, then a cascade on Kobau. At the end of the first day, the holding tank and water tank both read empty. Alarming, and mathematically unlikely. Ahhh—but the view from my kitchen sink: sage-covered hills breaking away to the snow-dusted (fresh—in August!!) extinct volcano across the valley.

Our spot is a good one, near the summit with enough space to set up the 8-inch Dobsonian, borrowed for the occasion from the RASC, and a set of 10x50 binoculars on a tripod. These are for Mike, the serious astronomy buff. For the first time except on an airplane, we watch the clouds roll in around and below us. Off to bedlam then until after 10:00 p.m., when there is a break in the cloud cover. Mike is exultant with his view of Andromeda. "A smudge," I sniff, and settle in to watch the "bodies in motion" that I prefer: satellites and shooting stars. There is still room for me to set up a lounge chair and, bundled up in a heavy hunter's sleeping bag, I lie on my back and watch the beginning of the Perseid meteor shower. They do not disappoint—one every few minutes until they, and we, are defeated by another heavy cloud cover. And so, to bed.

The next twenty-four hours are glorious and clear. Our experiences

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Upcoming Events

September

6-7 – Manning Park Star Party #2

21 – East Vancouver Neighbourhood Party (rain day: Sept. 28) at Windermere School at Rupert and 22nd. starting at 8:30. See President's message for details.

October

4 – Sidewalk Astronomy #2 (rain day: Oct. 5)

November

18 – Leonid meteor shower peaks

December

10 – Annual General Meeting

FOR SALE

Miscellaneous telescope parts for sale:

1 8" mirror in cell	$15.00
1 1.25" rack and pinion	$15.00
1 6" mirror in cell	$10.00
1 3" secondary holder and spider	$10.00
1 1.5" secondary mirror	$5.00
1 1.5" secondary holder	$5.00
1 barn door camera mount	$2.00
1 14.75" mirror-unfinished	$30.00

The 8" mirror is at the bottom of a poor quality sono-tube and is of need of some love. The rack and pinion are attached to the tube. There is no secondary but may have once taken the 1.5" secondary noted above.

If any or all of these items interest you, call David Dodge, 604-739-3281, or email me at: daviddodge@shaw.ca

FOR SALE

The perfect stargazers vehicle! 1984 GMC 2500 Vandura 'Starcraft'. Newish 350 engine - 24,000 miles. Cruise control, tilt steering, power windows & locks. Excellent sound system/Pioneer radio/cassette. New front tyres, towbar. 4 Captains seats, bench seat converts to bed, rear telescope storage space/2nd bed. No automatic lights - you are in control! Only selling as bought motorhome. $6000. 604 734-9726 Angela Squires.

WANTED

10 - 12 inch solid tube Dobsonian with excellent optics. 604 734-9726 Angela Squires.

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astronomical experiments. It puts it all in the right perspective.

When I had basically written this piece, I came across the article by Ray Villard and Zoltan Levay in the August issue of Sky and Telescope. It is so appropriate that they describe the complex techniques used to prepare these Hubble pictures for the way they appear eventually to us. These images are indeed creations in their own right. Some strict rules are followed and the basic black and white images are very real observations, but there is a lot of creativity in it as well. And it is a creativity we all deeply appreciate and that inspires us—inspires us to put the telescope out tonight and look for ourselves. ✸

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are shared with all the others at the star party that night—optimal viewing and the enjoyment of everything the mountain holds every summer. We shall return—two years from now. ✸

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pole sweeps around the *ecliptic north pole*, defined similarly. At the same time, the Moon's axis precesses around the ecliptic pole. By the Third Law, the orbital and axial poles remain on opposite sides of the ecliptic pole as they sweep around it. The key to the phenomenon lies here. Most textbooks leave out the vital insight that the Moon's axis precesses in step with the nodes. Any attempt to work out the ebb and flow of libration over time will go awry unless lunar precession is taken into account.

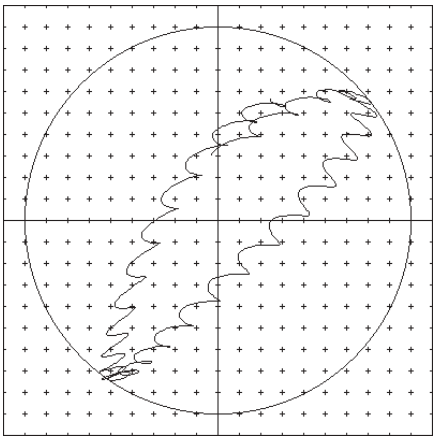

Figure 1. Lunar libration over 30 days. The curve shows the motion of the Moon's 0° longitude–0° latitude point relative to the centre of the disk with all terms included. Grid interval is 1°. Diurnal libration produces the small loops. The radius of the circle is 9°, the maximum value of libration in this period.

Why would the Moon precess? In general, a rotating body will precess if subject to a *moment*, or off-centre force. Since gravity acts through the centre of a body with spherical symmetry, it is correct to conclude that the Moon lacks that symmetry. This is already evident from how the Earth's attraction keeps one side in constant view. Astronomers have further confirmed it by timing eclipses and measuring the libration with lasers. But as the Moon *looks* as round as a billiard ball, the symmetry violation must be hidden inside. Why does the precession follow the regressing nodes? Roughly speaking, if it did not, the moment would not vanish when the Moon crosses the ecliptic.

It turns out that Cassini's Laws are not exact. The system can be likened to a pendulum that receives a regular impulse (the attraction of the Earth for the Moon's visible face is analogous to the pendulum action.). Although the free-running period of a pendulum may differ from that of the impulses, its oscillations come to be governed by them. But if the impulses come irregularly, the pendulum will undergo transients in which its

Cassini's Three Laws

I. *The Moon's rate of rotation is constant, and its period is equal to the sidereal month such that the same hemisphere constantly faces the Earth.*

II. *The tilt of the Moon's axis of rotation with respect to the ecliptic is a constant.*

III. *The pole of the Moon's rotation, the ecliptic pole, and the pole of the Moon's orbit always lie in the same plane, and therefore on the same great circle on the celestial sphere, and always in that order.*

The Four Terms of Libration

- *Libration in longitude:* caused by the varying speed of the Moon in its orbit (maximum 7° 57')
- *Libration in latitude:* caused by the inclination of the Moon's orbit out of the plane of the Earth's orbit around the Sun (the *ecliptic*) (maximum 6° 50')
- *Diurnal libration:* caused by the offset of the observer from the centre of the Earth (maximum 57')
- *Physical libration:* wobbles in the Moon's rotation (maximum 2')

natural period resurfaces. Similarly, the nodal moments that govern the Moon's libration are applied in a constantly evolving pattern. As it tries to follow them, the Moon quivers slightly out of compliance with the Laws. The tiny *physical* librations comprise the difference.

The sum of the inclination and axial tilt, 6° 41', is sometimes quoted as the angle between the Moon's equator and its orbit. If you've followed this argument closely, you might conclude that the maximum libration in latitude is also 6° 41', contradicting the value in the sidebar. The reason is that the Moon's orbital inclination is *not a constant*. Over a period of 173 days it varies about nine minutes of arc around its mean. Thus the libration in latitude can be as high as 6° 50'.

So exactly what do we *see*? Think of the Moon mounted on a spring, and imagine pulling at some point on its limb to bring some of the farside into view. On the real Moon, this point migrates around the limb, completing a revolution in about a month. During that period, the favoured point may move at a constant rate, speed up in spurts, or slow and dwell. The maximum amount of 'pull' that libration can impart varies around the limb. At the poles the limit is 6° 50', at the equator 7° 57', but in between it can be as much as 9.5°.

Looking at the calendar in *Sky and Telescope*, we see a red dot that represents this favoured point for each day of the month. If the dot is located on a bright limb, a little slice of farside comes into view. If the dot is larger, the libration is closer to the maximum of 9.5°.

The beginner is eager to look into the 'libration zones' of the farside, but soon tires of the novelty. What is more interesting is that libration *reduces the foreshortening* of features on *our* side of the limb, and greatly improves our view of them. For example, Mare Orientale, Mare Australe and craters Bailly and Grimaldi are best observed when *S&T's* red dot comes close to them.

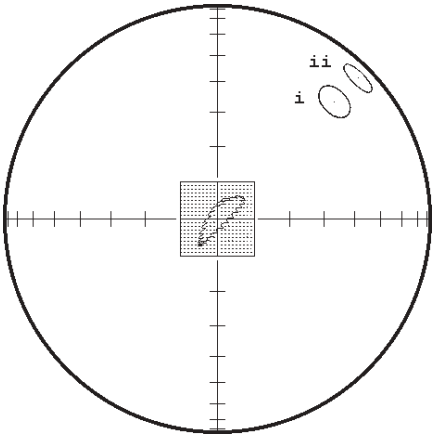

Figure 2. Foreshortening effect of libration. Figure 1 is reproduced at the centre of the lunar disk to scale. North is up, east to right. A 'crater' is depicted at the dates of greatest libration. This feature is 30° from the *mean* limb. (i) Libration 9° at NW limb; feature is less foreshortened. (ii) Libration 9° at SE limb; more foreshortened.

Libration affects the appearance of the rest of the Moon too. Imagine the tip of the nose of the Man in the Moon lying at 0° latitude, 0° longitude in the system of lunar coordinates. Lunar libration moves this point up, down, left and right from its mean position at the centre of the disk. Tycho, the rayed crater that marks the Man's chin at Full Moon, is carried up and down substantially by librations in latitude. Libration also affects the time of sunrise for a given feature, as well as the profile of the limb presented to the last rays of the Sun at the onset of a solar eclipse.

Perhaps the lunar feature most obviously effected by libration is Mare Crisium, the roundish 'sea' at the upper right limb of the Moon (the *northeast* limb, in current parlance). Mare Crisium is almost round, but our perspective foreshortens it into an oval. Moreover, the foreshortening is highly dependent on libration. When the northeast limb is favoured, Mare Crisium is less foreshortened than usual. When the opposite limb is favoured, Mare Crisium is more foreshortened and closer to the edge of the Moon. Try observing this effect without a telescope. Unfortunately, it is difficult to make comparisons on dates two weeks apart because the advancing phase of the Moon brings darkness to Mare Crisium!

Imagine attaching a pencil to the nose of the Man in the Moon

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Scope Stuff

by Steve Whitehouse

The Schmidt Cassegrain Telescope has garnered an unfair reputation as a mediocre instrument. There was a time in the early to mid 1980s that the two biggest producers of these scopes did in fact turn out their share of lemons. This was largely due to the rush to produce large quantities of telescopes for the return of Halley's comet. Since then, optical production has seen some major changes, resulting in tighter optical control and a better product for the end user.

True, there are better telescopes for deep sky work (large Dobsonions), and there are better telescopes for planetary work (apochromatic refractors), but the Schmidt Cassegrain Telescope has held on as the best selling telescope in the world. The reason for this is simple: the Schmidt Cassegrain Telescope is capable of doing many things very well. Having eight generous inches of aperture combined with an f/10 focal ratio will give you enough power to cruise through the solar system and beyond to the outer galactic realms of the universe.

The SCT works well in typical suburban locations due to the long focal length and the well designed baffle systems that provide images of celestial objects with nice dark backgrounds. The real key to performance on the SCT (as with all telescopes) is collimation. Schmidt Cassegrain Telescopes are extremely sensitive to misalignment. In fact, just a simple car trip to an observing site may be enough to degrade the images seen in your telescope.

The typical SCT has an f/2 spherical primary mirror and a convex secondary mirror that magnifies the image of the primary mirror five times. The corrector plate has no role except to correct for spherical aberrations and to hold the secondary mirror. Just a minor miscollimation of the secondary mirror will prevent the telescope from performing at its best. Small festoons on the equatorial belts of Jupiter would fade into non-existence with only the smallest misalignment of the secondary mirror. This is why collimation should be checked every time you observe. You would not want to play a musical instrument that was not in tune, so why observe with a telescope that cannot perform at its best? For many SCT owners, the collimation of these instruments has long been an issue avoided, and this is why the mediocre reputation of theses modern classics has persisted. However, the collimation procedure is very easy.

The secondary mirror holder of your SCT will have one screw in the centre and three screws around the outside. Never touch the centre screw. This screw holds the secondary mirror in place and will have no effect on the collimation procedure. Only make adjustments to one of the three outside screws. Never over-tighten any of the screws. If one of the screws is too tight, loosen the opposite screw. Make sure your telescope has cooled to the ambient outside air temperature. Internal heat plumes can provide false readings and make collimation much more difficult.

The first step involves aiming the scope at a bright star, say magnitude 2 or brighter. Polaris works very well, and also has the advantage of being relatively stationary. Some people feel that the star diagonal should be removed during collimation, however I feel that if you plan to observe with this star diagonal in place you should leave it in, as long as it does not introduce any additional aberrations.

Use an eyepiece that would give you about 100 to 125 times magnification. Centre Polaris in the middle, and defocus the star. As long as Polaris is very well centred in your eyepiece, you should see an image like a doughnut—a bright set of concentric rings with a black spot in the middle. This "black spot" is your secondary mirror. It should be perfectly centred. Follow the rings all of the way around. Do they seem even all the way around? If not, you will require some adjustment to your secondary mirror. Remember to use very small increments when you make the adjustments. A fraction of a turn on a collimation screw is all that is required. You may have to experiment to find out which screw adjusts in which direction. Moving your finger in front of your scope near the part of the collimation ring that does not seem concentric will give you an idea as to where to start to make the adjustments. Always remember to re-centre the star after you make an adjustment.

The second step requires an eyepiece that will provide about 250

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to 300 times magnification. Don't be afraid to defocus the star large enough to discern any errors in the collimation pattern. Once again, centre the star in the eyepiece and defocus. Look at the rings again. Are they uniformly spaced all the way around the secondary mirror? If not, more adjustments are necessary. Remember to make minute adjustments, and re-centre the star after each adjustment. Once this step is completed you should be fairly well collimated.

The third step will require steady seeing to accomplish. You will need an eyepiece (or Barlow combination) that will give you 350 to 400 times magnification. However, this time you will **not** defocus the star. You will want to focus the star as best as possible. You will be looking for the first diffraction ring on the outside of the **focussed** star image. Does this diffraction ring appear to be uniform all the way around the airy disk? If not, a few more tweaks to your secondary mirror maybe in order.

Please note that if you have gotten the first two steps correct, then the adjustments required at the third step will be very small. In fact, even just some pressure on the adjustment screw is all that may be needed. If you have trouble seeing the diffraction rings around the focussed star, you may need to wait for a night with better seeing conditions.

With practice, this procedure will become very easy, and a well collimated SCT will reveal many more details on celestial objects that you may have previously missed.

Clear skies. ✸

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to let him draw his librational motion. Such an exercise can be carried out with an ephemeris, and Figures 1–3 are typical outcomes. Figure 1 shows the behaviour of the total libration over 30 days. During this period, the Moon 'nods' in every direction, although the motion peaks toward the upper right and lower left. Note how the curve almost returns to its starting point after 27.3 days, the sidereal period of the Moon (count the loops to see this).

Figure 2 shows how the appearance of a hypothetical 'crater' (representing Mare Crisium) varies with libration.

Two years of libration are plotted in Figure 3. At times the curve describes roughly circular arcs, with the libration remaining close to 6° at a point that moves smoothly around the limb. At other times the curve is more eccentric. This is indirectly due to the fact that New Moon can occur at any time between lunar perigee and apogee.

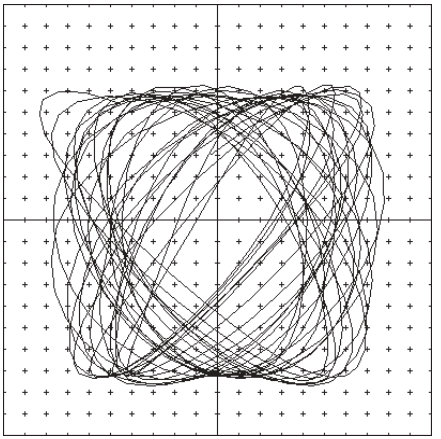

Figure 3. Lunar libration for two years, diurnal term suppressed. (All figures plotted with data from *GSO Moon*.)

The RASC *Observer's Handbook* lists dates of minimum and maximum librations in latitude and longitude. These correspond to dates when the curve is farthest from the horizontal (or vertical) axis in Figure 3. The *Handbook* uses the term 'minimum' to mean *maximum in the negative direction*. For example, a 'minimum' libration in longitude of –6° exposes the west limb to view. In *Sky & Telescope*, the format is somewhat different. The dates when the curve is either farthest from or closest to the centre of the graph are given, along with the name of a prominent crater. In both publications the diurnal term is ignored. Take care to understand the format in use!

Further readings from your Centre library:

V.A. Firsoff, *The Old Moon and the New*. CCN:66

Zdenek Kopal, *The Moon*. CCN:43 ✸

RASC MERCHANDISE

Available for purchase after meetings:

Calendars	$12.00
Beginners' Guides	$15.00
Observers' Guides	$20.00
Star Charts	$10.00
Cloth Crests	$11.00
Lapel Pins	$ 6.00
L.E.D. Flashlights	$22.00