

# Nova Notes

The Newsletter of the Halifax Centre of the Royal Astronomical Society of Canada



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## Front Page Photo:

Mat Nightingale "Lyre and the Swan".  
Unmodified Canon Rebel XS DSLR  
124 seconds, F/5.6, ISO1600. Camera piggybacked on a manually operated Scotch mount.



## From the editor

*Quinn Smith*

The December meeting is the Halifax Centre's Annual General Meeting and, as such, possibly the most important meeting of the year. It is a time to hear how the Centre progressed over the last year, and more importantly hear the Centre's plans for the next. It is an opportunity to thank your Executive for a job well done, or to criticize them for things you didn't like. It is a time to vote in a new Executive and perhaps more importantly offer your services and stand for one of the available positions. In short it is a time to participate in the running of your Centre.

There is always much discussion on astrophotography both on the Halifax "list" as well as at meetings. The RASC Halifax Centre will be holding an astrophotography workshop at Saint Mary's University, January 22, in the Atrium Building, room AT305 starting at 1 p.m. The workshop will cover the basics of equipment, image acquisition, calibration, stacking, and processing, with the goal to produce an image suitable for framing (not scientific imaging). The event is hosted by Halifax Centre, and sponsored by Atlantic Photo Supply, and Saint Mary's University (BGO).

I'll end by wishing you all a wonderful season, the enjoyment of family, and friends, and as always, clear skies!

## St Croix Observatory

Part of your membership in the Halifax RASC includes access to our observatory, located in the community of St. Croix, NS. The site has grown over the last few years to include a roll-off roof observatory with electrical outlets, a warm-room and washroom facilities.

Enjoy dark pristine skies far away from city lights, and the company of like minded observers searching out those faint "fuzzies" in the night. Observing nights (Fridays close to the New Moon) are open to members and guests.

If you are not a key holder and would like to become one, or need more information please contact the Observing Chairman, John Liddard (see below).

### Upcoming Observing Nights:

January	7th	2011
February	4th	2011
March	4th	2011

## Meetings begin at 8 p.m. at Saint Mary's University Please note room changes for 2011

NOVA program begins at 7:00 p.m. in the same room

The Atrium is located in front of the Patrick Power Library, between the Burke Building and Science Building

### December 17th 2010 - Sobey - SB 160

The Halifax Centre's Annual General Meeting. What could be more fun than watching your Executive make complete fools of themselves?

Guest speaker: Charles O'Riley - the "Saxby Gale".

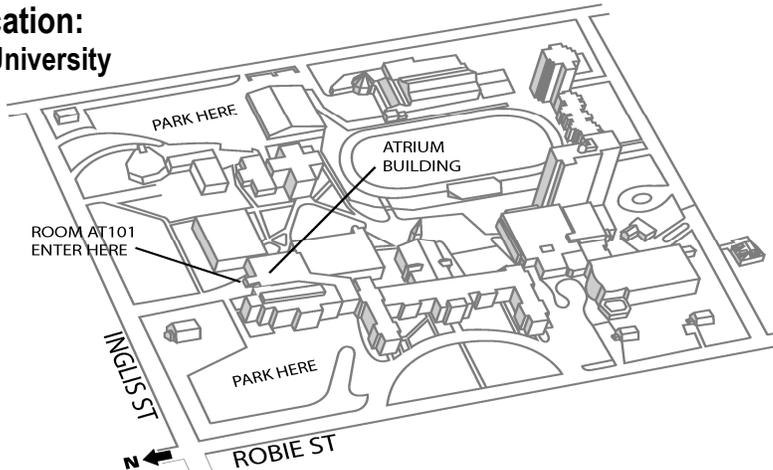
### January 21st 2011 - Atrium - AT 101

A regular meeting - speaker and topic to be announced

### February 18th 2011 - Atrium - AT 101

A regular meeting - speaker and topic to be announced

## Meeting Location: Saint Mary's University



Meetings are usually held on the third Friday of the month, except for the months of July and August, when there are no meetings.

The Nova program (an introductory course in astronomy) starts 1 hour before the main meeting, in the meeting room.

Executive meetings begin at 7:00 p.m., in room SB159 (room AT 306 in 2011), and all members are welcome to attend.

## Halifax RASC Executive, 2010:

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## Old Tricks (for new observers)

Chris Young

Learning and remembering the sky is a challenge for the new and part time observer. This is an old task and there are memory aids passed on to us from earlier observers. Timothy Ferris in his book "Seeing in the Dark" (a good read and audio book) repeats the verse:

*"Follow the arc to Arcturus  
And on to Spica go;  
Then turn northwest to Regulus,  
The foot of the lion, Leo.*

*It's just that far to Gemini,  
Where Castor and Pollux glow,  
Near Rigel, and Capella,  
And Sirius, down below."*

Following this verse around the sky, or on a planisphere on cloudy nights, implants the pattern. Once this framework is established you can add constellation names and star information and the sky becomes a more familiar place. You may note the verse gets you to the winter hexagon.

If Spica isn't visible then take a short cut from the big Dipper:

*"A hole in the bowl  
leaks on Leo."*

This is how I learned the Zodiac. I have no idea where it came from - Ed

*"The Ram, the Bull, the Heavenly Twins  
and next the Crab, Lion, and Virgin*

*To the Scales and Scorpion we go  
and on to the man who carries a bow*

*And last the Goat who drinks  
from the Water  
And sees the Fish whose never  
been caught"*

OK, OK it's a stretch!

## Dr. Brian Marsden

### In Memoriam

It is with sadness that we must report the passing of astrophysicist and astronomer Dr. Brian Marsden.

To quote Roy Bishop:

"Brian Marsden was a great friend of the RASC. As a contributor to the Observer's Handbook, he faithfully provided data on asteroids and comets for 38 editions, including the upcoming 2011 edition. A pleasant aspect of my involvement with the Handbook was corresponding with Brian for 19 years. Like the asteroids and comets

he knew so well, his Handbook material was characterized by precision and timely arrival."

Dr. Brian Marsden was born in Cambridge, England in 1937 and died on November 18th 2010. He specialised in celestial mechanics and astrometry, collecting data on the positions of asteroids and comets, and computing their orbits. It was Dr Marsden who correctly predicted that long period comet Swift-Tuttle would return in 1992 and not in 1981 as was previously thought.

Again quoting Roy Bishop:

"David Levy featured Marsden in his Star Trails column in Sky & Tele-



scope (June 1993, p. 98) under the heading: "Brain Marsden: Cosmic Cop". Levy wrote: "More than anyone else, Marsden knows what's new in the sky, where it's located, and what it's probably going to do."

**H**ALIFAX  
CENTRE

**Nova Notes: The Newsletter of the Halifax Centre of the RASC**

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Nova Notes is published 5 times a year, in February, April, July, October and December.

The deadline for the next edition is January 20th 2011

The opinions expressed herein are not necessarily those of the Halifax Centre.

Articles on any aspect of Astronomy and Allied Sciences will be considered for publication.

## A tour of the St Croix Dam

Quinn Smith (thanks to Roy Bishop)

With the rain storms of early November (over 6" of rain in 4 days!) many Halifax Centre members were concerned about the St Croix Observatory, nestled, as it is, on a lake.

This promoted much discussion about the location and safety of the SCO, and eventually lead to a tour of the upstream dam that protects the Observatory.

The Observatory sits on land owned by the Minas Basin Pulp & Power Company. It is located downstream from Panuke Lake, a little south of the village of St Croix in Hants County.

Panuke Lake is a 30 km long "ribbon lake" formed by a dam at the north end of the lake.

The dam was completed in 1938. Its role is to convert gravitational potential energy of the stored water into electrical energy, at a rate of about 2 megawatts. The water exiting the big dam is used a second time, via the

canal beside SCO and the pipeline, to generate an additional 3 megawatts at the turbine by the bridge in the village of St. Croix. The 5 megawatts is carried on a dedicated power line to the Minas Basin Pulp & Power recycled paper mill in Hantsport.

There are, in fact, two dams. The upper and larger dam forms and holds back Panuke Lake. The lower diversion dam, known as the "Parsons Dam", not only protects SCO but holds a reservoir of water to be fed via a pipe to the 3 megawatt lower generating station.

As Roy Bishop said of the concerns about flooding, "That immense, little-known dam does indeed protect St. Croix Observatory. It caught and stored all the rain of a week ago that fell in the watershed above SCO, and together with its older sibling, the diversion dam immediately above SCO, are responsible for the idyllic, safe setting for SCO. Both dams are spilling a small amount of water, but 99% of the recent rain in the watershed is being stored behind the big dam (like charging a battery)! There is room behind it for another two or three metres on Panuke Lake".

The upper dam is actually hollow and Roy Bishop arranged with Jamie Carmichael (supervisor of the dams) for a tour of the upper dam. This tour took place on November 13th 2010 and was attended by approximately 16 members and guests of the Halifax Centre.

Due to a lack of time, the tour did not include a stop at the diversion dam (which is not hollow!), but anyone can drive the half kilometre (+/-) above SCO and have a look at it.



*Inside the upper dam*

The diversion dam catches the "exhaust" from the big dam/powerhouse and diverts it into the canal that flows past SCO to the pipeline for the lower turbine by Highway #1.

By way of a "report" on the tour Paul Heath submitted "Guardian" which may be read on page 5. Thank you Paul—I think you really captured the feel of walking inside a 75 year old power dam.

*All photographs: Blair McDonald*



*The lower 3 megawatt generator*



*Dam astronomers*

## Guardian

Paul Heath

Ed: Paul Heath was one of the Halifax members who participated in the St Croix Dam tour. This is his report.

### Guardian

You stand in Strength . . . In Solitude.  
You Guard the Stars . . . We're drawn too.  
You stand astride a quiet stream, The forest held, upon each hand.  
You guard the wonders, That each clear night we seek.  
Your strength has kept a place . . . For Stars to come, while others sleep.

Unsought your Strength has stood above,  
Unheard your Heart has beat within,  
Unknown to but a few  
You've kept OUR gentle glade and quiet pool.

And then the Torrents ripped our skies apart,  
On came the rush of FEAR,  
Of Stars awash and wonders drowned,  
Of loss of One whose strength, undone,  
Could wash our dreams away.

We climbed the trail, through forest's leafless boughs  
In fear for whom we sought,  
A trepidation of what the Torrent's wrath had wrought.

And there YOU stood, in Solitude  
A mirrored tarn behind,  
So calm, So deep.  
A quiet place for our Sun to sleep.  
You stood in Strength astride the gorge  
And high upon the bank afar, a spring sang crystal clear,  
A testament that truth was here.  
And swift upon your feet, a forest river, far below  
No torrent here, for fears to grow.

And Those who knew and led the way, Each step below away from day,  
Within the depths of strength and thew, To pass to us what they knew.

Voices echoed from deepening walls,  
As Power's hum grew and grew,  
And step by step  
Your Strength and Vitality came to view.  
Within the warmth your heart exudes, We feel the power  
Of Waters deep, of Waters calm,  
Of Torrents changed from causing harm.

But stepping forth to caverned halls  
We hear the echoes off distant walls, and feel the chill and dampish air  
That speaks of Caves, and earthly deeps.  
And stepping forth between the voids, we see below,  
Stone melded to stone, and learn the Strength,  
Of Waters deep, of Waters calm.

With silent listening, we begin to hear  
The echoed DRIP of time, The DRIP, DRIP, DRIP echoes of time.  
And fast upon deep earth's sky,  
Slim fingers descend, marking out the years,  
Marking the DRIP, DRIP, DRIP echoes of time.

And turning now towards the Sun,  
We pass again through caverned halls,  
And looking round at stone on stone,  
Holding waters deep, holding waters calm,  
We fear no longer Torrents wrath,  
For we KNOW your Strength, your Power now.

Climbing step by step towards the Sun,  
We hear of Siblings along the run, Who guide the forest river's flow  
To form our pool and star lit glade  
Of a Brother fed anew, Whose Power comes from Strength,  
Of Waters calm and Waters deep.

And now you know of Strength in Solitude,  
and a Power whose Heart is true.  
So when you seek the STAR lit skies,  
To record the wonders and Dream anew,  
Come to the Guardian whose Strength and Power are TRUE,  
And Who holds in trust the STARS for you,

In a gentle glade, by a quiet pool.

By Paul Heath

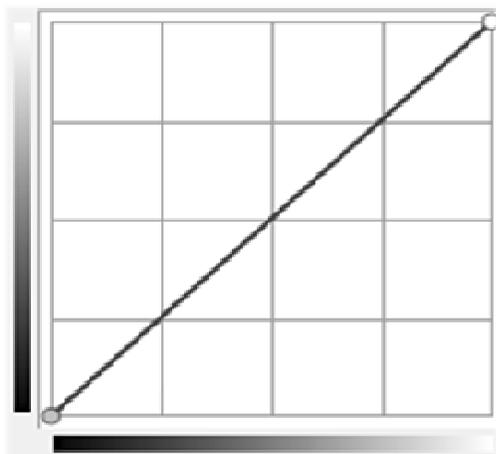


***Blair McDonald***

This edition begins a group of Imager's Corner articles that will focus on a few techniques that are useful in processing astrophotos. Over the next several editions of Nova Notes I'll attempt to give a guide to image stretching, background correction, SIM processing, and any other technique that I happen to find useful. All the techniques discussed will be useable with nothing more than a standard image processor that supports layers and masks. No special astro-image processor is required.

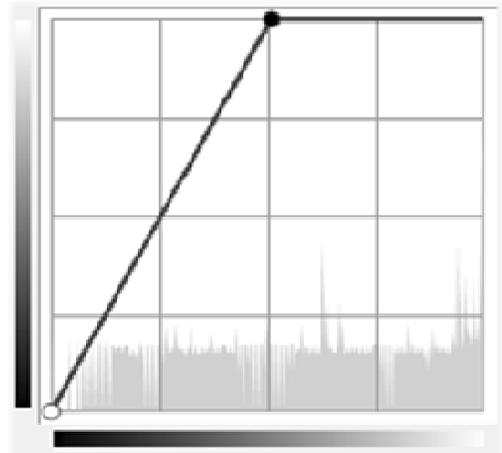
This edition will deal with image stretching using the curves adjustment function. While there are many built in image processing functions that stretch or brighten an image, none of them provide the control and flexibility of the curves adjustment.

The curves adjustment allows you to specify a transfer function that will be applied to your image data. A transfer function is just the relationship between the input (usually the x-axis) and the output (usually the y-axis). As an example, consider the following curves adjustment.



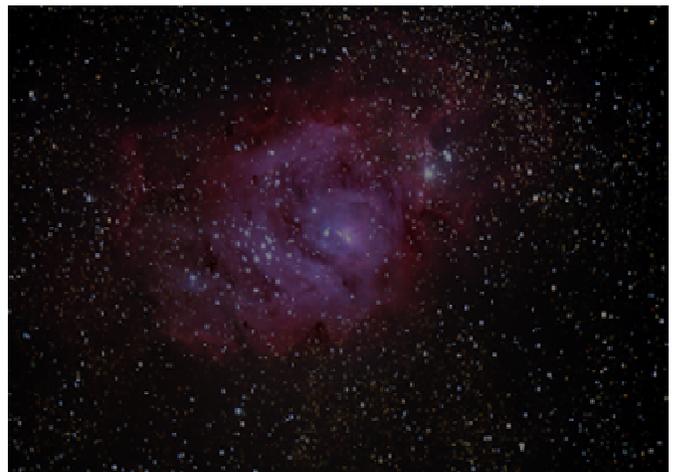
***Simple Curve Adjustment***

Here there is no change in the image as for every point on the line the output value equals the input value. For reference the bottom left has the coordinates 0, 0 while the top right is 255, 255. Now let's look at a curve that brightens an image.



***Increasing Brightness with Curves***

Here the input and output values are quite different. The scale is the same as the previous example so you can quickly see that the output value for any input above zero is significantly increased. In fact, the image saturates (has an output of 255) for any input value greater than 128 and brightens all values between 0 and 128. This type of stretch is the equivalent of using the brightness and contrast adjustment. The effect of applying this adjustment to an image can be seen in the views of Lagoon Nebula as shown below.

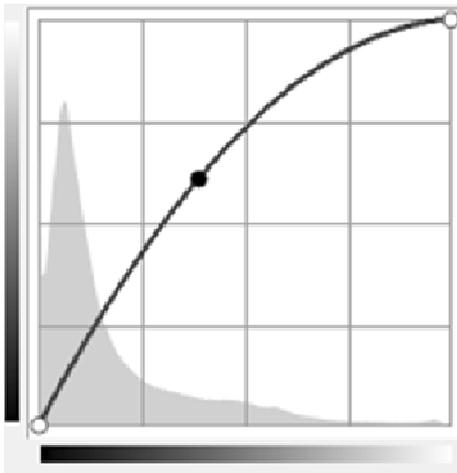


***Lagoon Nebula before stretch***



*Lagoon Nebula after stretch*

The problem with this simple brightening is that the brighter areas of the nebula have saturated and lost all detail. A simple modification of the stretch will help substantially.



*Highlight Preserving Stretch*



*Lagoon Nebula after Highlight Preserving stretch*

This approximates a log stretch that will compress the brighter data but limit saturation.

The result is a more pleasing image of the nebula. The faint outer areas of the nebula are now visible and the central core is less washed out than in the example produced with a simple, linear stretch.

You can apply multiple curves adjustments to your images to precisely control the results. You can even apply them to each of the RGB colour channels individually to change the colour balance of the image. When used as an adjustment layer, curves can be combined with masks to provide the ultimate in control. The adjustment can be applied only to sections of the image leaving the rest untouched.

The ultimate image stretching method is a pseudo HDR technique called a layered, masked stretch or LMS processing.



*LMS Processed Image*

This can produce stunning images by brightening the dimmest areas while preserving all the detail available in the bright ones as shown below.

But that's a column for another time.

Remember, this column will be based on your questions so keep them coming. You can send them to the list at [hfxrasc@lists.rasc.ca](mailto:hfxrasc@lists.rasc.ca) or you can send them directly to me at [b.macdonald@ns.sympatico.ca](mailto:b.macdonald@ns.sympatico.ca). Please put "IC" as the first two letters in the topic so my email filters will sort the questions.

## October Meeting report

Dave Chapman

President Richard Vanderberg assembled the crowd—many of them NOVA students from the same room who stayed on—promptly at 8:00 p.m. Several free items were announced for distribution, and Blair MacDonald flogged some leftover T-shirts from the Nova East That Never Was - truly collector's items!

The benefits of RASC membership were duly touted and a plea was made for new blood on the Executive (some things never change!) Dave Chapman reported the highly successful International Observe the Moon Night events (300+ people!) and the Fall series of astronomy talks at the Halifax Public Libraries.

The main event was a presentation by Prof. Roy Bishop (Acadia, retired) who also happens to be the RASC Halifax Centre Honorary President. Roy has a long and distinguished record of service to the RASC. His topic was "Subrahmanyam Chandrasekhar," the brilliant Indian-American mathematical physicist and Nobel laureate.

As I write this (October 19th), it is the 100<sup>th</sup> anniversary of Chandra's birth. It was Centre Treasurer Ian Anderson who had suggested the topic to Roy.

Chandra was something of a mathematical genius and had published two scientific papers in reputable physics journals by the age of 18 years. He earned a Government of India scholarship to Cambridge University and during the sea voyage to England in 1930, he worked out the essentials of the idea that eventually earned him the Nobel prize—53 years later!

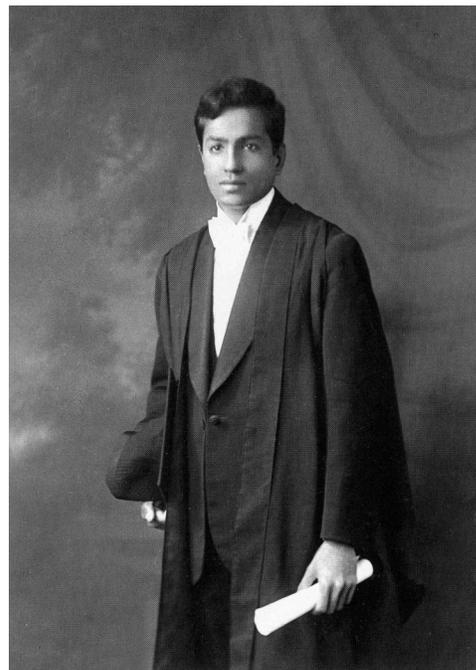
The idea is now called the Chandrasekhar limit and specifies an upper bound to the mass of a white dwarf star of 1.44 solar masses. Up until that time, it was thought that any star that finished converting its hydro-

gen to helium would eventually collapse into a much smaller white dwarf star in which the attraction of gravity is balanced by something known as "electron degeneracy pressure," a consequence of the newly minted quantum theory of matter. By combining the Fermi-Dirac statistics of the constituents of the star (supposedly electrons and protons) with The Special Theory of Relativity, Chandra predicted that the collapse of stars of mass above 1.44 solar masses would not be halted by electron degeneracy pressure, but that such stars would continue to collapse - into what, no one knew at the time.

It is not my intention to transcribe Roy's entire talk! The remainder of the story describes the difficulty Chandra had obtaining an academic position in England and how he continued his distinguished career at the University of Chicago. Every decade or so he produced a monumental book on some area of mathematics, physics, or scientific philosophy, following an intense period of study.

Roy also highlighted several "Canadian connections" including an interesting pair of letters Chandra wrote to Roy near the end of Chandra's life, when he was working on "Newton's *Principia* for the Common Reader." Chandra asked Roy for a copy of his famous rainbow photograph taken at Newton's birthplace, and paid him for it! (The title of this last book by Chandra is slightly misleading: one would need university-level maths to follow it!)

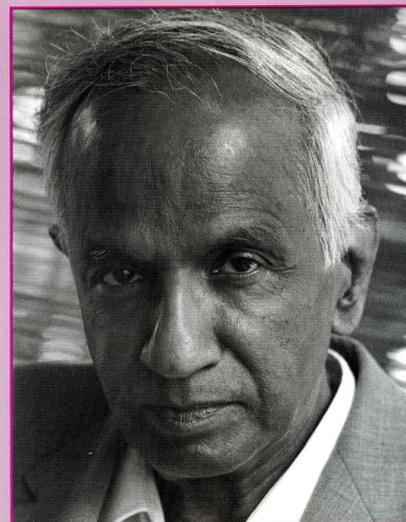
During the question period, Roy received a heartfelt accolade from an audience member, a mature junior high teacher who had first looked through a telescope only 2 years ago. She told Roy that his presentation was truly inspirational and that she now understood how the beauty of the world could be appreciated in different ways—even through mathematics! (It should be noted that Roy did not show a single equation.)



*Chandra after receiving the Ph.D. degree, Trinity Collage, Cambridge, 19 December 1933*

## CHANDRA

A Biography of S. Chandrasekhar



Kameshwar C. Wali

*By the time you read this newsletter the Halifax Centre library should have a copy of this biography*

Following that, there was nothing more to be done or said, so we broke for cookies and cold drinks.

## November Meeting Report

Chris Young

Richard Vanderberg, President, opened the meeting and greeted the 36 people in attendance, including 10 guests. These guests received Halifax RASC introduction package and a brief outline of the benefits of membership.

The RASC Calendars are in and available from Jim Dorey for \$15. Blair only has a few 2010 Nova East T-shirts left

Richard introduced the current Executive members and invited anyone with questions to speak with any member of the Executive. Our AGM is coming in December and a new Executive will be elected. Currently there are candidates for all the Executive positions with the exception of President.

The President is assisted by the Executive and anyone interested can contact any member of the Executive for more information.

Dave Chapman gave a brief report on

the Centre's public outreach programs that have occurred over the last few months. Chris Young put some photos on the screen of two of the recent outreach activities at SCO, the addition of 3 new concrete pads for observing positions, and sidewalk observing at the Mic Mac Chapters. Upcoming events include sidewalk observing, Burke Gaffney Observatory tours, and the Halifax Planetarium shows. See the [astronomynovascotia.ca](http://astronomynovascotia.ca) website for details!

Blair briefly described the upcoming Astrophoto Seminar at SMU scheduled for January 22nd, sponsored by Brian from Atlantic Photo Supply (they will soon carry Skywatcher dobs!). Further details at the December Meeting.

The December Meeting is planned for December 17th at 8:00 p.m. but is still being confirmed against the exam schedule. Confirmation of time and place will be on the Halifax e-mail list, Halifax Centre website and ANS website (see meeting notes on Page 2).

The December 17th meeting will be our Annual General Meeting with a

presentation by Charles O'Riley on the "Saxby Gale".

Our meetings may be moving in January! We are confirming a move of our regular meetings to a larger and better equipped meeting room at SMU. The library cart will be stored next door. Details will be provided at the December Meeting and maps, guided tours and sheep dogs will be used in January to get everyone to the new location.

Richard introduced the speaker of the evening and noted in his introduction that we often overlook the experience and knowledge resident in our own Centre. Last month we had an excellent talk from Roy Bishop. Tonight our own Dave Chapman will give the presentation.

Richard gave a quick summary of Dave's lifelong astronomy experience and accomplishments. Dave Chapman then gave his presentation "Astronomy Outreach in Cuba: My Adventure".

Following Dave's inspiring talk the Meeting adjourned about 10:00 p.m. for refreshments and discussion!

## Public Outreach Report

Dave Chapman

October and November have been very busy months for astronomy outreach in Nova Scotia. There is a long list below! (Please forgive the point-form style: the Editor gave me a word limit there is just to darn much to report! Details of individual events have been reported on the email discussion list <http://www.rasc.ca/mailman/private/hfxrasc/>)

- **Astronomy talks at libraries:**

Chris Young "Astronomy with Binoculars", Alderney, Oct 4 (10 people); Paul Bowman "Exploration of the Solar System", Woodlawn, Oct 16 (60 people, including kids); Jerry Deveau "Introduction to Amateur Astronomy", Weymouth, Nov. 5 (17 people).

- **Visits to youth groups:**

Theta Lubliner, Eastern Passage Brownies, Nov. 9 (40 girls); Tony Schellink and Wayne Mansfield, "Muin", StarFinders, and observing, Katimavik Group at Keji, Nov. 20 (13 youth).

- **Classroom talk:**

Dave Chapman "Constellations" Portland Estates Elementary, Grade 6, Nov. 9 (23 students).

- **Galileoscope workshops:**

Dave Chapman and Blair MacDonald, Bedford South, Grade 6, Oct. 21, 23 students; Dave Chapman, Theta Lubliner, Julie McEachern, and Perry Babineau, Discovery Centre, Nov. 20 (2 sessions, 15 people).

- **Public observing session (Oct.):**

Dave Chapman and Dale Clayton, Keji National Park, Oct. 7 (30 people);

Karl Penney, John McPhee, and Mark Dryden, Chapters Bayer's Lake, Oct. 14 (100 people).

- **Public observing session (Nov.):**

Jeff Donaldson and Robert Bussieres, Chapters Mic Mac, Nov. 12 (200 people); Karl Penney, Wes Howie, and Blair MacDonald, Chapters Bayer's Lake, Nov. 12 (125 people); Roy Bishop, Pat Kelly, Mark Dryden, and other MAG members, Grand Pré National Historic Site (40 people).

- **Dark Sky Preserves:**

John McPhee wrote another nice article about Keji in the Oct. 9 issue of the Chronicle-Herald.

And all I can add to that is that RASC Halifax Centre is blessed to have such a fantastic crew of volunteers!

## More Sketches

Michael Gatto

I started out looking for Comet Hartley with binos (ha!) and then with my 8" scope. Couldn't see it though. So I moved on to Jupiter, viewed it at low power then moved up to Uranus.

I did not want to give up on the comet, so I returned, and after 10 minutes or so of panning and scanning it came into view. Just a very faint diffuse glow – would be very easy to miss. I sketched the field so I could confirm it with Starry Night later.

Then I went back to Jupiter and studied it longer, this sketch was made at the eyepiece, between 1030-1050pm, with an 8" scope from Dartmouth (Cole Harbour) scanned and minimally cleaned up in photoshop.

The seeing was outstanding at times, but I found the best magnification was only around 120X. There was a prominent white oval in the equatorial belt. Also notable, the band below it (in this sketch) appeared as 4-5 dots strung together.

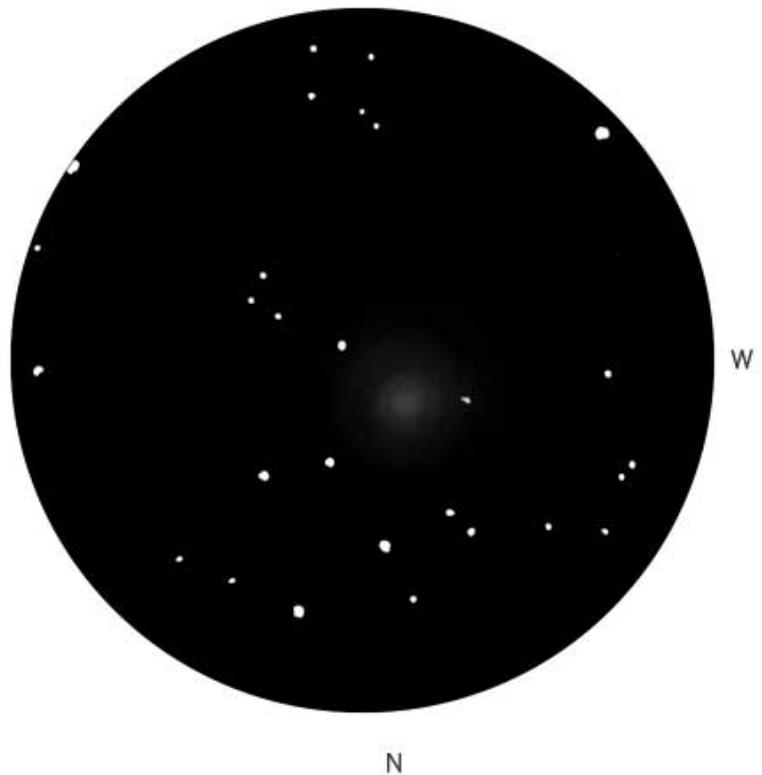
In the moments of best seeing the missing belt was 'visible' as a very low contrast band of tone. You could clearly see where it 'should' have been.

### Editors notes:

Thank you to Michael Gatto for allowing me to reprint this e-mail that appeared in the Halifax "list" on October 3rd 2010.

Michael has a wonderful ability of translating what he sees in the eyepiece into absolutely outstanding sketches.

For those of you new to astronomy and also to those who are not, sketching is an amazing way to train ones eye to seek out the hidden detail at the eyepiece.



**Photo: Chris Turner**  
**M42**

“Well, it took me maybe 1 hour of imaging and 20 hours of trying to figure out Deep Skystacker (thanks Blair for your help)... So after all was said and done here is one 30 sec. image (problems stacking).

Oh well, live and learn, I hope!”

An interesting fact of M42:

The Maya of Central America had a folk tale which dealt with Orion's part of the sky, known as Xibalba. Their traditional hearths included in their middle a smudge of glowing fire that corresponded with the Orion nebula. This is clear pre-telescope evidence that the Maya detected a diffuse area of the sky contrary to the pin points of stars ( WIKI).



**Photo: Michael Boschat**  
**Reappearance of Omicron Leonis**

I took this shot about 0845 UT on October 4th 2010. I was not really going to take an image but dragged the scope out and saw the star! It was just after the reappearance of Omicron Leonis!

I used my C8 with 40mm (50x) eyepiece for full shot with lens set at 18mm, exposure of 1/100 second, f/5.6, 800 ISO, burst mode, hand held camera over eyepiece, and used afocal method.

The inset image at upper left is same data, but set camera lens to 55mm with an exposure of 0.5 seconds (also hand held!)

## Cosmic Debris

### Odds and Sods from the World of Astronomy and Cosmology.

*NASA Press Release Nov. 18, 2010:*

NASA has just issued a travel advisory for spacecraft: Watch out for Comet Hartley 2, it is experiencing a significant winter snowstorm.

Deep Impact photographed the unexpected tempest when it flew past the comet's nucleus on Nov. 4th at a distance of only 700 km (435 miles). At first, researchers only noticed the comet's hyperactive jets. The icy nucleus is studded with them, flamboyantly spewing carbon dioxide from dozens of sites. A closer look revealed an even greater marvel, however. The space around the comet's core is glistening with chunks of ice and snow, some of them possibly as large as a basketball.

"We've never seen anything like this before," says University of Maryland professor Mike A'Hearn, principal investigator of Deep Impact's EPOXI mission. "It really took us by surprise."

"This is a genuinely new phenomenon," says science team member Jessica Sunshine of the University of Maryland. "Comet Hartley 2 is not

like the other comets we've visited."

The 'snowstorm' occupies a roughly-spherical volume centered on Hartley 2's spinning nucleus. The dumbbell-shaped nucleus, measuring only 2 km from end to end, is tiny compared to the surrounding swarm. "The ice cloud is a few tens of kilometres wide--and possibly much larger than that," says A'Hearn. "We still don't know for sure how big it is."

Data collected by Deep Impact's on-board infrared spectrometer show without a doubt that the particles are made of frozen H<sub>2</sub>O, i.e., ice. Chunks consist of micron-sized ice grains loosely stuck together in clumps a few centimetres to a few tens of centimetres wide.

"If you held one in your hand you could easily crush it," says Sunshine. "These comet snowballs are very fragile, similar in density and fluffiness to high-mountain snow on Earth."

Even a fluffy snowball can cause problems, however, if it hits you at 12 km/s (27,000 mph). That's how fast the Deep Impact probe was screaming past the comet's nucleus. An impact with one of Hartley 2's icy chunks could have damaged the spacecraft and sent it tumbling, unable to point antennas toward Earth to transmit data or ask for help. Mission controllers might never have known what went wrong.

"Fortunately, we were out of harm's way," notes A'Hearn. "The snow cloud does not appear to extend out to our encounter distance of 700 km. Sunlight sublimates the icy chunks before they can get that far away from the nucleus."

The source of the comet-snow may be the very same garish jets that first caught everyone's eye.

The process begins with dry ice in the comet's crust. Dry ice is solid CO<sub>2</sub>, one of Hartley 2's more abundant substances. When heat from the sun reaches a pocket of dry ice—poof!—it instantly transforms from solid to vapour, forming a jet wherever local topography happens to collimate the outrushing gas. Apparently, these CO<sub>2</sub> jets are carrying chunks of snowy water ice along for the ride.

Comet Snowstorm (jetmodel, 550px)  
An artist's concept of Comet Hartley 2 shows how CO<sub>2</sub> jets drag water ice out of nucleus, producing a 'comet snowstorm.' [larger image]

Because the snow is driven by jets, "it's snowing up, not down," notes science team member Peter Schultz of Brown University.

Ironically, flying by Hartley 2 might be more dangerous than actually landing on it. The icy chunks are moving away from the comet's surface at only a few m/s (5 to 10 mph). A probe that matched velocity with the comet's nucleus in preparation for landing wouldn't find the drifting snowballs very dangerous at all--but a high-speed flyby is another matter. This is something planners of future missions to active comets like Hartley 2 will surely take into account.

Comet snowstorms could be just the first of many discoveries to come. A'Hearn and Sunshine say the research team is only beginning to analyze gigabytes of data beamed back from the encounter, and new results could be only weeks or months away.



*This contrast-enhanced image obtained during Deep Impact's Nov. 4th flyby of Comet Hartley 2 reveals a cloud of icy particles surrounding the comet's active nucleus.*