Nova Notes

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

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Front Page Photo: Roy Bishop

Here is a view at 02:13 ADT this morning (Canon XTi on a fixed tripod, 20 s, f/3.5, ISO 1600, 10 mm).

Minas Basin was illuminated by the aurora. The upper horizontal green band was pulsing. The vertical rays were faintly red to the eye and were changing structure on a time scale of several seconds. It was cool, especially in pajamas!

According to the Observer's Handbook (p. 32) the prominent colours are caused by excited oxygen atoms: the yellow-green at a wavelength of 557.7 nm, and the red at 630.0 and 636.4 nm.

In this issue:

From the editor *Quinn Smith*

This was the season for comets! At one point this fall we had four comets visible (with the aid of binoculars), namely ISON, Lovejoy, Encke and LINEAR. There was a lot of hype in the media as to ISON, where they were calling it the "Comet of the Century" (of course the century is only 13 years old!). Perhaps ISON should have been called Icarus, since, as it happened, it flew too close to the Sun and disintegrated during the close encounter. There is till lots of time for another "Comet of the Century".

As this edition goes to press the Halifax Annual General Meeting has already been held (despite the poor weather conditions) and our new Executive has be chosen. The new Executive comes into effect on January 1st and so the current Executive is still listed in this edition. A full report, including financials, of the AGM will be in the February edition of Nova Notes.

Thank you all for your contributions to Nova Notes, and I wish you all a wonderful winter solstice, and peace, joy, and clear skies, for the New Year.

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, use of the Centre's 437mm-dobsonian telescope and 100mm-binoculars, 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 both members and their guests. If you are not a key holder and would like to become one, or need more information, please contact the Observing Chair assistant, Alex LeCreux (for contact info, see below).

Upcoming Observing Nights:

January	31	2014
February	28	2014
March	28	2014

Meetings begin at 7:30 p.m. at Saint Mary's University in room AT 101 Note new meeting time.

December 13 2013

Our annual General Meeting. Come and help select your new Executive. "Who Want's to be a Gazer" following the AGM

January 17 2014

The first meeting of the new year. We will discuss the RASC resources available on the web.

February 21 2014

Meeting info to be announced

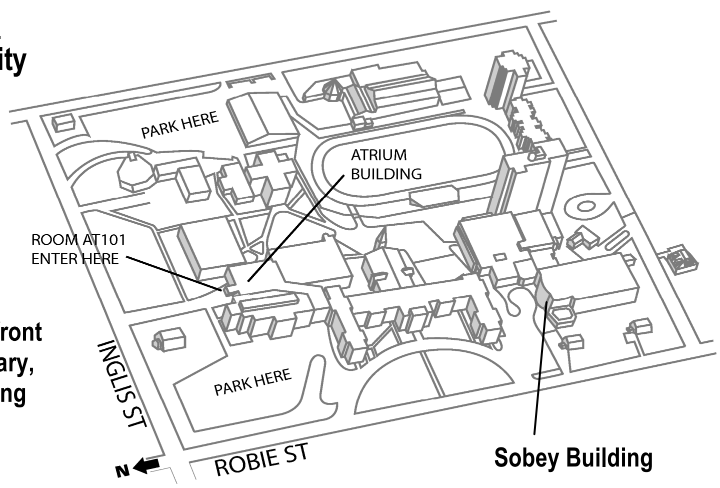
All meeting location and contents subject to change

Meeting Location:

Saint Mary's University

Atrium Building
Room AT 101

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



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) will not be held this year.

Executive meetings begin at 6:30 p.m., usually in room AT 306, and all members are welcome.

Halifax RASC Executive, 2013:

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Nathen Gray's Supernova

Dave Lane

Nathan Gray and I are pleased to report that we have discovered a possible supernova (mag ~18) in PGC 61330 (a magnitude 15.9 galaxy in the constellation of Draco).

It was imaged in the early morning hours of October 30, 2013 and discovered the next evening by G. Nathan Gray (age 10 of Greenwood, NS). The discovery is shared with Dave Lane who owns and operates the Abbey Ridge Observatory.

The skies were clear, so the dome was opened up and an image taken that confirmed that the new star was still there (ie. it was not an image artifact or an asteroid (which would have moved). After a few more checks, it was reported to the IAU's Central Bureau for Astronomical Telegrams late in the evening of October 30.

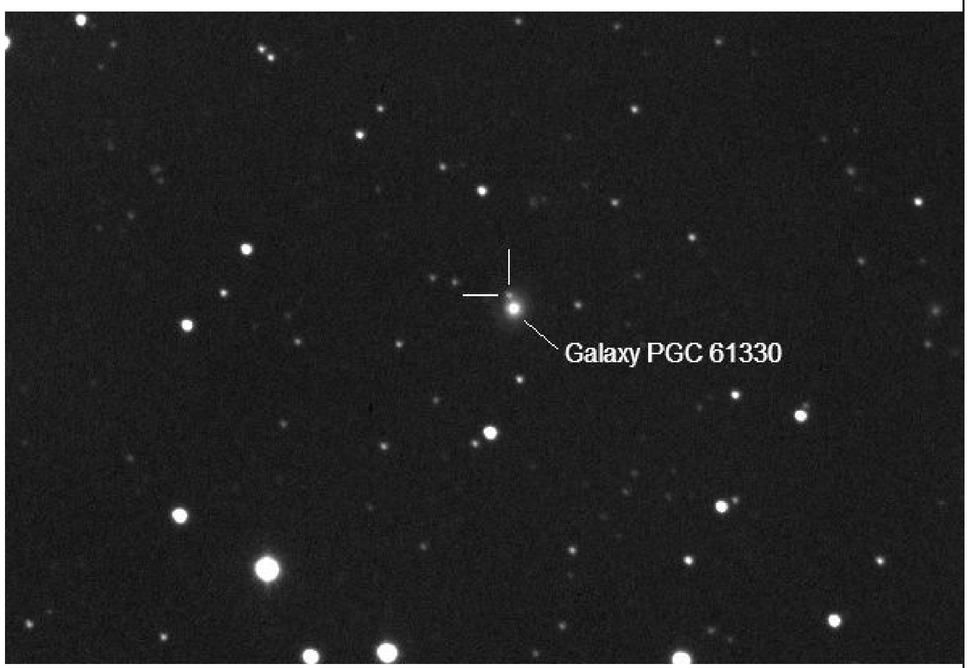
It was verified later the same night by another astronomer: the Maine-based amateur astronomer Doug Rich. The next step, before it is given an official designation, is to use spectrographic observations done by a very large telescope to confirm that it is a supernova and not something else (very unlikely) and to determine its type. This is usually done within a few days.

This is the fourth discovery from the Abbey Ridge Observatory, my fifth, and Nathan's first! So far was we know, Nathan's discovery at age 10 and a few days makes him the youngest supernova discoverer, by only 33 days before his sister Kathryn discovery of SN2010lt.

Editor's note:

Since Dave's report, the spectrum has been analysed and the supernova confirmed.

Nathan Gray (age 10) points to the image where he discovered asupernova on October 30th. Nathan is a (family) member of the Halifax Centre.
Photos: Dave Lane and Paul Gray



Provisional Designation: PSN J18032459+7013306
Discovered at 2013/10/330.179 by Nathan Gray and Dave Lane
Position: R.A.= 18h3m24s.59, Decl = +70o13'30.6"
Located 3" east and 7" north of the center of PGC 61330
Brightness: ~18 magnitude
SN Type: tbd
Galaxy Names: PGC 61330, CGCG 340-33, KAZ 180
Galaxy Position: 18:03:23.9 +70:13:24
Galaxy Helio. radial velocity: 13,280 km/s
Galaxy Approx. Distance: 580 million ly
Galaxy Size (arcmin): 0.3'
Galaxy Magnitude: 15.9

Polaris—More to it Than Meets the Eye

Pat d'Entremont

There's something very comforting about Polaris. On any clear night, any season, any hour of the night, you look up and there it is – right where it's supposed to be. It is always in the same spot, and no other star visible to the unaided eye does that.

Polaris, also called the "North Star", or "Pole Star", has been known to humankind for centuries precisely because it is almost exactly directly above Earth's north pole. It is like the Earth is dangling from a string tied to it. That is the reason Polaris remains in the same spot in our night sky. It always indicates true north. This has been of great value to mariners, who could tell which direction they were going simply by looking at Polaris.

Polaris is formally known as *Alpha Ursae Minoris*, the brightest star in the constellation Ursa Minor (the Little Bear). Polaris is actually more than one star: Polaris B which orbits it, can easily be seen in almost any telescope. Also orbiting the main star is a dwarf star that requires powerful telescopes to see.

Polaris is a fun star because it is one of the first things you show an amateur how to find in the night sky. Everyone recognizes the Big Dipper, and their first bit of "star hopping" is to draw an imaginary line from the two "pointer stars" at the end of the bowl of the Dipper, and trace a path to Polaris. This can be done even in a fairly light-polluted city.

If you're in a dark site, you can then point out that Polaris is the star at the end of the handle of the Little Dipper, so now they can stop thinking that the Pleiades or part of Sagittarius is the Little Dipper. From my backyard in peninsular Halifax, all I can see of the Little Dipper is Polaris and the two stars at the end of its bowl.

Polaris is important for another reason – it is the nearest and brightest Cepheid variable star. Cepheids are the most important type of variable star because they are an important link in determining the distance scale of the universe.

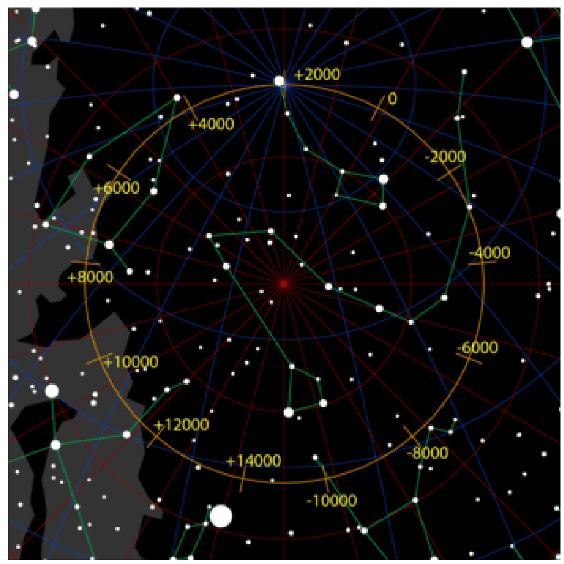
Many people think that Polaris is the brightest star in the sky. While it is quite bright, there are nearly 50 stars that are brighter. It is however, a very large star, some six times the size of our Sun, and *intrinsically* 3,600 times brighter than the Sun. It's a good thing it is far away.

How far away is a matter of some debate, but fortunately we have the foremost authority on Polaris right in our own city. Prof. David Turner of Saint Mary's University and his colleagues have used spectral analysis to determine that Polaris is 323 light-years away, as opposed to the 434 light-years determined by the Hipparcos satellite some 20 years ago.

Polaris hasn't always been, and won't always be, the North Star. The Earth's axis wobbles such that it points to a different spot over time, making a huge circle over a period of 26,000 years. And even today, it is still two-thirds of a degree from the north celestial pole.

Still, that's close enough to true north to keep us on course!

The author wishes to thank Dr. Roy Bishop for his invaluable contribution to this article.



The course of the Celestial Pole during a precession cycle

HALIFAX CENTRE

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The deadline for the next edition is Jan 15th 2014
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.

Moon Sketches

Michael Gatto

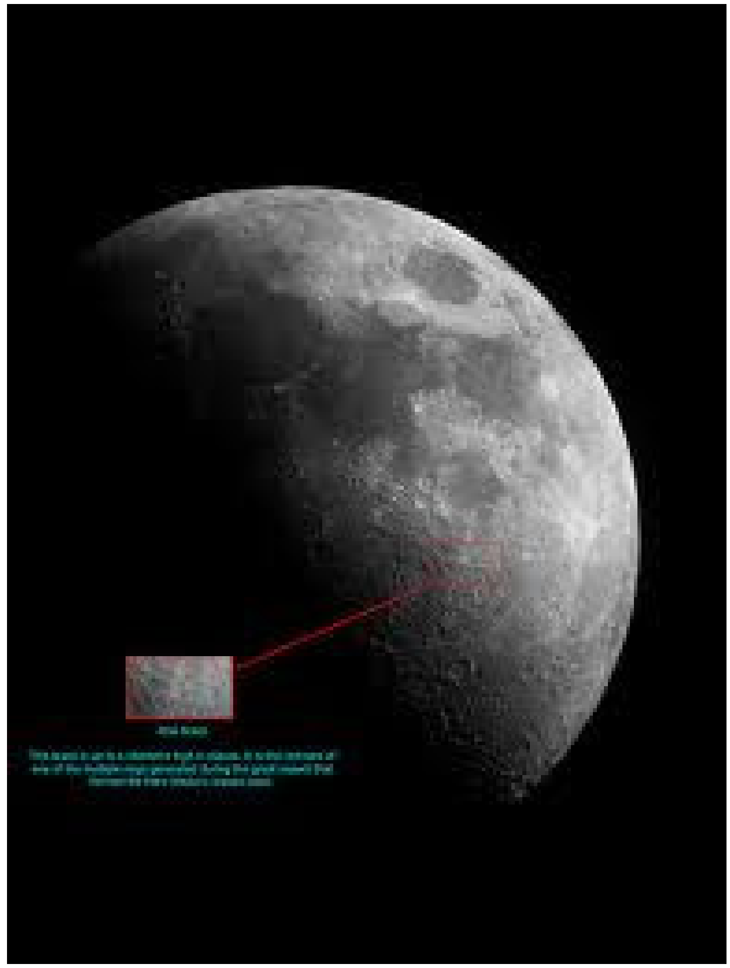
I guess I was inspired by Paul Evans and Dave Chapman, when I found myself last night with a few hours to kill.

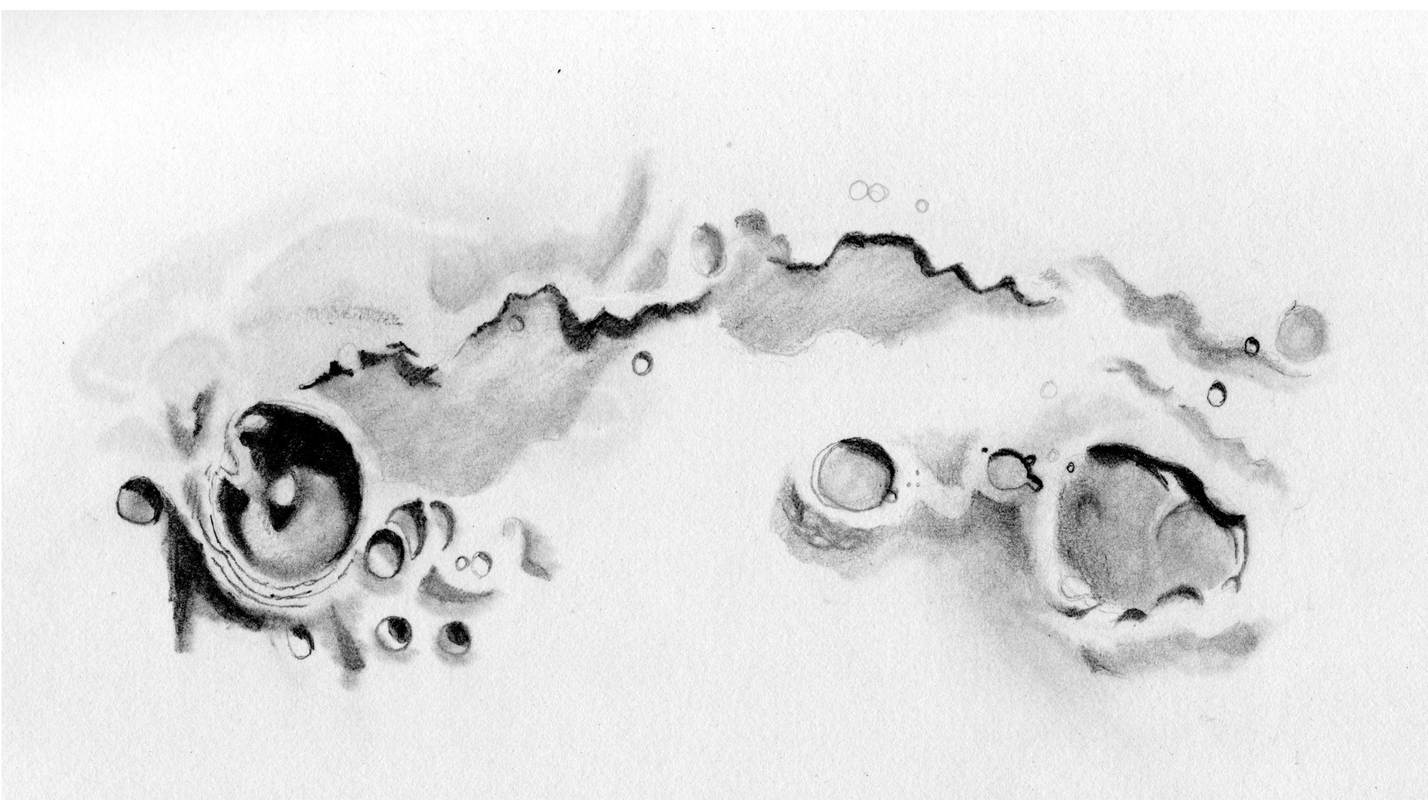
I took out the Explore the Moon files … and did some lunar observing. I think the key to this is going to be planning, but the provided files are very helpful!

My goal will be to sketch all these — but roughly!! I don't want it to take forever. That night I sketched crater Schiller, and crater Schickard. Another 2 nights of good viewing produced 7 more items captured, so I am off to a good start.

I did find that I am not really loosely sketching these like I had planned but taking a decent amount of time. The sketch here represents about an hour of time.

Here is one from November 21, it shows Crater Piccolomini (left) the Altai Scarp (arching across the top) and then on to the loosely formed crater Catharina (bottom right). Observed and sketched at through an 8mm EP in my 8" f/7.5 scope, hand tracked, under clear skies with poor to average seeing conditions.





October and November Meeting Reports

Editors note:
Normally the Centre meeting reports are written either by the myself or, when I can't attend a meeting, by one of the members of the Executive (usually Chris Young). In October and November we had students of Daniel Majaess. Daniel is a part-time instructor and researcher at MSVU and SMU (astronomy and physics), and the former student of two RASC members, Prof. David Turner and David Lane. Several students wrote meeting reports, and I thought it would be interesting for members to "see" the meeting from the viewpoint of a visitor to the meeting. Thank you to Daniel and his students for these reports.

RASC meeting - October 18 by Kae Lin Larder

I attended the RASC meeting this past Friday, and it was pretty interesting! The president opened the meeting with a poem about the sky - I didn't catch the title/author, but it was nice. They then did some society housekeeping business and talked about membership benefits, and then Art Cole did a presentation on iPhone astrophotography.

He first talked about his background in the aerospace industry (he worked on the CASSIOPE and RADARSAT missions) and how it informed his love of astronomy as a hobby. He decided one day to try to use his iPhone to photograph images from his telescope. He found it difficult to hold the phone still enough to get a clear image, so he designed and built an iPhone adapter that fits over his telescope eyepiece. Since the touchscreen was pressed up against the eyepiece and inaccessible, Art rigged it so that he could use the volume adjuster on the headphones to take pictures.

He said that he did some experimenting to figure out what the best method was for photographing various sky objects, and that he takes HD video and then uses frame-stacking software, a program called Registax, to get good planet images. He showed us an example of a video he took of Saturn - the planet looked shaky because of the atmospheric interference, but Registax is apparently able to compensate for that by detecting which frames of the video are the sharpest, and match up the best, discarding the others, and layering those good frames over each other to produce a sharper and more saturated image.

The reasons he gave for using an iPhone for amateur astrophotography are that it has a high-res camera, one-touch focus, high-rate video, and it's good for outreach. It's also good for getting new people involved in astronomy because so many people have an iPhone, and there are many helpful apps. It works for capturing planets, brighter stars and clusters, and very bright nebulae, but it's not so good for fainter or very deep sky objects because they are hard to frame, difficult to focus, and the iPhone doesn't have the capacity to take very long exposures. He described his process of getting an article about all this accepted to an astronomy magazine, and how he was invited him to Mount Wilson.

RASC Halifax Meeting Nov 15th by Amy Hillier

On November 15th I attended the RASC Halifax monthly meeting. This meeting discussed a few different topic including the recent supernova discovery, the building of a backyard observatory and the cultural stories connected with the sky.

First to present was Nathan Gray. He discussed how he came about finding a supernova. They (Nathen and his family) received batched of photos (taken by Dave Lane) and they used the computer workstation in their basement to go through the images. He and his sister take different photos and work through the batches. When he came across the one that he thought was a supernova, he went to his father (Paul Gray). From there they checked the IAU database to see if it was registered as a known supernova. It wasn't listed there, so they got in touch with Dave Lane where they checked the sky again, as well as older photos, to help confirm the observation was a supernova. From there a report was released (see page 3).

The part of sky he was looking at was a 10x10 arc minute square which is approximately 577million light years away. Unfortunately, until they can have a spectral typing done, they can't confirm that its a supernova. They said that it's starting to get harder to see as it becomes fainter, so time is of the essence in getting the spectral typing completed.
Nathan said that he was inspired to look for supernovas because of his sister Kathryn, who discovered her supernova when she was ten. He said that he wants to become an astronomer when he grows up

Next up was Jeff Donaldson who build an observatory, which he has named Belt of Orion Observatory (BOO), in his backyard. He discussed a lot of details that were very technical and over my head (I have a very basic knowledge of telescopes). Basically he build a deck in his backyard surrounding (but not touching) a cement pillar that held the pier plate which is what the telescope attaches to. Where he is located, he had to deal with some light pollution, mainly from the airport. Because of this, he mainly views the East sky and some of the South. The North is cut off by the trees and the

west is obscured by his house and the light pollution.

With this setup, he can go out and have everything ready in just minutes. He can set the telescope to track the object he wants to photograph, set the camera and software, and then go back in the house. Before it would take him up to 3 hours to get everything set up and in the summer that would leave him very little time to actually view the sky. He showed some of the images that he has been able to capture, which were beautiful and very detailed. He mentioned a few things that he would have changed if he could do it again, but would be more costly and what he has is working well enough.

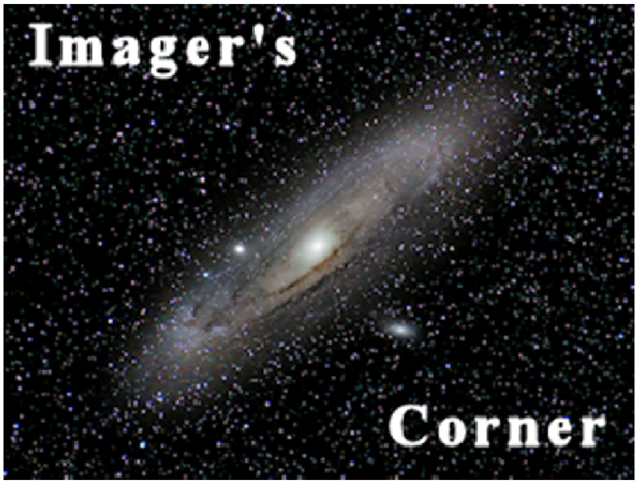
The final presenter was Chris Young. He talked about his dark sky weekend at Keji National Park in August. He then discussed the different stories and connections to the sky that difference cultures have created. He told a few different stories from locations all over the world. He started off talking about the Big Dipper and how the Inuit people believe that it is a story of 3 hunters (the handle) who are chasing a bear. He then discusses how Cassiopeia has been interpreted as either a whale’s tail or a spider. He told a really interesting story about the Pleiades, (the Seven Sisters) and The Navaho people.

He said they see them as seeds and that when they first see Pleiades in the sky, they know that it is time to start planting the seeds. This period of planting only last as long as the constellation is in the sky. They have the saying "never let Pleiades see you plant".

The last story he told was really interesting and was regarding the Milky Way. It was a about a woman and her husband in South Africa, before there were any stars. The story tells that during the night, when her husband was away hunting, she was sitting by the fire. She had looked down at the fire and grabbed the embers and threw them into the sky as a way of leading her husband back to her, guiding his way home. I thought that this story was very beautiful and when he showed a picture of the Milky Way it was easy to see how this story was imagined. Chris also discussed how one constellation, like Orion, can be interpreted many different ways across the world due to it orientation. They ranged from a hunter (how we see it), to a canoe in Australia (inverted).

Lastly the group went over the “What's Up” for November. They talked about the constellation Auriga and its bright start Capella which will be ideal to view this month. They went over the phases of the Moon, which include the Full Moon on Nov 17th, Last Quarter on Nov 25th, New Moon Dec 3rd and First Quarter Dec 9th. They also discussed 4 comets that are well positioned. They were ISON, Lovejoy, Encke and LINEAR. Lovejoy will be bright around the end of the month while ISON will near perihelion on Nov 28th. They mentioned that ISON may not make it to its perihelion because it is possibly disintegrating faster than was expected, but that everyone is very excited and hopes that this “comet of the century” will make it. Next they discuses the Leonids meteor shower, which will occur on Nov 17, but it is the same day as full moon so will be difficult to see, even though there will be about 1,000 per hour. Lastly they mentioned about the deep sky object alpha Persei and the double star delta Cephei.

Overall the meeting was interesting, there were many things that were over my head and beyond the knowledge of our introduction to astronomy class, but there were also times where I knew what they were talking about, which was a nice feeling.



Part #14 in a series by Blair MacDonald

This edition continues a group of Imager's Corner articles that will focus on a few techniques that are useful in processing astrophotos.

The Noise about Noise

WARNING: This edition of Imager's Corner will be a little more technical than usual, but after scanning emails from new astrophotographers in several Centres, I have found that few topics in astrophotography cause as much confusion as noise and proper exposure. In this column I will attempt to present some of the theory that goes into determining the "correct" exposure for a given scene and then show some simple guidelines that can make it easy – at least for the DSLR users in the society. As someone that works with a variety of signal processing systems in my day job, I've been well acquainted with noise and its properties. Noise, by its random nature can be confusing, but with a little knowledge we can quiet most of the *noise* about noise and take steps to control its effects in our images. The whole idea is to figure out the proper exposure to reduce noise as much as possible and produce good quality data ready for processing.

What is Noise

First let's get a working definition of noise as it relates to imaging. Officially, noise is any artifact in an image that is not present in the actual scene. For processing purposes, this is a little broad, as it would encompass any optical defects as well. Generally, noise is a random image artifact that is a function of a component in the data acquisition system or a function of the scene itself. In this case, the former means the camera excluding the optical system (scope or lens) and the latter means photon noise. As we will see, this random aspect of noise is very important in combating its effects.

Types of Noise Encountered in Astrophotography

There are generally two noise sources we are concerned about in astrophotography. Broadly the two categories are photon or image noise and camera noise.

Dark current noise, quantization noise and read noise are the usual culprits for camera noise Dark current noise is the one with which we are most familiar; it is the signal that builds up in the sensor even without any light falling on the chip. This noise is proportional to both the exposure time and the temperature. Dark current noise can be modeled as a combination of a fixed, deterministic value that is dependent on temperature and exposure time, and a random variation with a zero mean about this fixed value. In fact, it is because part of the dark signal is constant that we can remove it with a dark frame. If we look at just one pixel in a dark frame and plot its values over many images, we get a curve that looks like the one shown in Figure 1.

If we examine the plot in Figure 1, we see that the pixel has an average value (blue dashed line) of 4526 and a random fluctuation around that average. If we produce a similar plot for every pixel in the dark frame, we would find that each one has its own average value. A well-averaged dark frame is an image made up of these constant values. Subtracting a dark frame removes the average dark signal from the image producing a much less noisy picture. What remains is the actual image data plus the random variation in the dark signal collected during the exposure time. It is this random fluctuation that makes up the remaining dark current noise and it can be thought of as a zero-mean random signal. This remaining noise is proportional to the square root of the integrated dark current; it scales with temperature such that it doubles roughly every seven degrees.

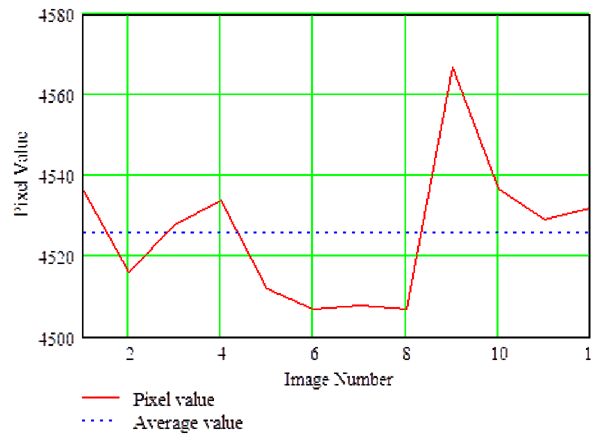


Figure 1 - Single pixel value over several images

Readout noise is caused by noise in the analog amplifier chain between the sensor and the analog to digital converter or ADC. This noise is fixed in level and unlike dark current noise is not proportional to exposure time.

Quantization noise results from the fact that the ADC outputs only discrete integer values. If the actual data falls in-between possible ADC values, an error or noise results.
For purposes of this discussion we will ignore the effects of

quantization noise, as it is small compared to the others in modern cameras with 12 to 16 bit ADC's. Instead we will consider only read and dark-current noise.

The remaining source of noise comes from the image itself. Quantum mechanics tells us that light itself is noisy; photon noise is inherent in light and has a Poisson distribution with an average value equal to the square root of the number of photons collected at each pixel.

The SNR Equation

There is a classic equation describing the signal to noise ratio of the data collected at each pixel in a digital camera:

$$SNR = \sqrt{n} \cdot \frac{s_{obj} \cdot t}{\sqrt{s_{obj} \cdot t + s_{sky} \cdot t + s_{dark} + n_{read}^2}}$$

Where:

n = number of sub-exposures and assumes an "average combine" in the final image.

S_{obj} = Object flux in electrons per unit time

S_{sky} = Sky background flux in electrons per unit time

t = Exposure time in units matching the units used for S_{sky} and S_{obj}

s_{dark} = Number of dark current electrons

n_{read} = Readout noise in electrons

From this we can readily see that the SNR improves with the square root of the number of sub-exposures. With a little more inspection we can also see that it improves with the square root of the exposure time. Now comes the interesting part.

From the definition of SNR we have SNR = signal / noise and the pixel SNR equation then tells us that the signal is $s_{obj} \cdot t$ and the noise is $\sqrt{s_{obj} \cdot t + s_{sky} \cdot t + s_{dark} + n_{read}^2}$.

The expression for the noise breaks down into two terms: image noise made up of $s_{obj} \cdot t$ and $s_{sky} \cdot t$ plus camera noise made up of s_{dark} and n_{read}^2.

Now if the image noise is much larger than the camera noise, we can ignore its effects and the pixel SNR simply becomes

$$SNR = \sqrt{n} \cdot \frac{s_{obj} \cdot t}{\sqrt{s_{obj} \cdot t + s_{sky} \cdot t}}.$$

This tells us that if we can make the image noise much larger than the camera noise then using n exposures of t seconds is identical to a single exposure of n times t seconds, assuming the short exposures are averaged. This conclusion is of great interest in astrophotography, because it is much easier to take multiple short exposures than a single long one. If something goes wrong, you lose a single short exposure rather than the whole thing! This all boils down to one question – how do we insure that the image noise is much greater than the camera noise?

The Noise Myth

The first thing we need to understand is that it is not necessary to keep noise to low values in our data. The absolute level of the noise, provided it does not cause saturation of the electronics or the image file format, is meaningless. It is only the ratio of the image signal to the noise that matters; everything else can be scaled and manipulated in your image processor. To demonstrate this point the following simulated star images were generated using mathematical modelling software.

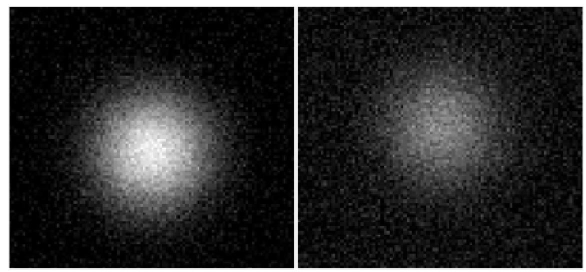


Figure 2 - Simulated star at different SNR's

The image on the left actually has a higher noise level than the image on the right, but because it has a higher SNR, it looks much better. Both images have been stretched in the same fashion to make the noise obvious.

Determining the "correct" exposure

The basic problem here is how to determine the correct exposure for a given image. First off I'd like to point out that there is no one correct exposure. Like all photography, this all depends on what part of the scene you are trying to capture. Many objects have a wide range in brightness, and you may want to choose a short exposure to better capture detail in the bright areas. The definition I'm using here is to give the best SNR over the whole of the image, even if it allows the brightest parts of the scene to saturate.

Our goal is to determine what sub-exposure will allow the image noise to dominate the camera noise and let us safely ignore the effects of camera generated noise. This is the very definition of a sky-limited exposure.

The first step in this exercise is to see how camera noise and image noise combine. There is a branch of mathematics (if you think of statistics as mathematics) that shows us that the average value of the summation of two or more random sequences is equal to the square root of the sums of the squares of the average value of the individual sequence. Using this relationship, we can examine how the total noise varies as the ratio between the image noise and camera noise changes. If we plot the ratio of total noise to image or sky noise against the ratio of image noise to camera noise we get the following plot.

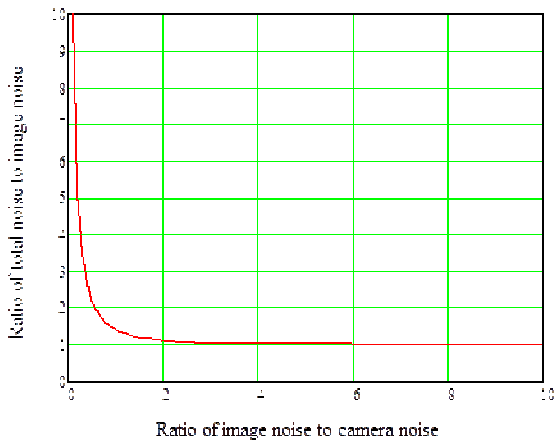


Figure 3 - Total noise ratio verses image noise ratio

As you can see from the plot, shortly after the image noise increases to twice the value of the camera noise, then for all intents and purposes the total noise is simply the image noise. Now if we zoom in on the area of the plot around the inflection point we can see things in better detail.

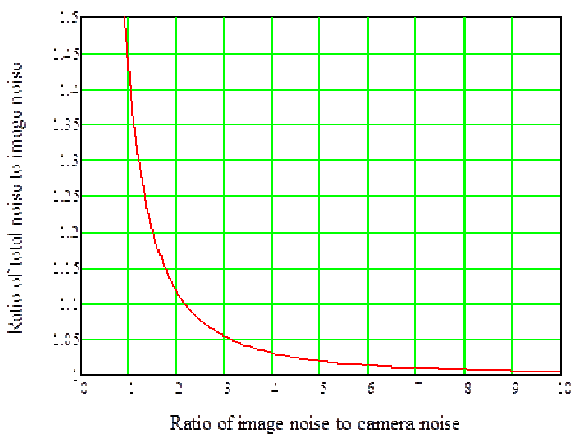


Figure 4 - Total noise ratio verses image noise ratio

An image is generally accepted as sky-limited if the total noise increases by no more than five percent due to the addition of camera noise. Using the plot in Figure 4, you can see that this occurs when the sky or image noise is approximately three times the camera noise. If we are averaging sub-exposures, then exposing each sub beyond this limit is of little value as seen from the pixel SNR equation.

So now we have a working definition of a sky-limited exposure; simply expose each sub until the sky noise is three times the camera noise. Now the problem becomes one of determining just how long an interval this is. To do this, we have to revisit the pixel SNR equation and make a couple of assumptions. Firstly we must assume that all the sub-exposures have been properly calibrated using a well-averaged dark frame. Secondly we assume that the sky signal is greater than the object flux, the case in most astrophotography. This means that the contribution of dark current to noise is greatly reduced and the SNR equation simplifies to

$$SNR = \sqrt{n}\cdot\frac{s_{obj}\cdot t}{\sqrt{s_{sky}\cdot t + n_{read}^{2}}}.$$

Here the background noise depends on the sky level assuming that it overwhelms the camera read noise.

Now we need to be able to measure the sky level and to do this, you need to know the system gain of your camera in terms of electrons per ADU (analog to digital converter units). You can find this in your camera manual, on the Web or you can measure it directly. Once you know this value, you can use a test exposure to measure the sky background. Take a short exposure, in which the sky is well below saturation, but where the histogram is completely separated from the left side of the plot. The number of electrons captured is calculated as follows:

$$s_{sky} = \frac{gain\cdot ADU}{t_{exposure}}$$

where s_{sky} is the sky flux and $t_{exposure}$ is the exposure time. Now remember the goal here is to make the sky noise three times the camera noise, so knowing the sky flux and the fact that noise adds as the square root of the sums of the squares, we just need to find the camera read noise and we can calculate the required exposure time. The read noise, like the gain, can be obtained from your camera manual, the Web or it can be measured. Finally the exposure time can be calculated

from

$$3\cdot n_{read} = \sqrt{s_{sky}\cdot t}.$$

After which, solving for t we obtain

$$\frac{9\cdot n_{read}^{2}}{s_{sky}}.$$

This is the exposure time required to make the image noise of the sky background equal to three times the camera read noise. This method gives us an accurate exposure time, but it is a bit of a pain to do each time you go imaging. It turns out that there is a short cut that uses the above method for calibration. Use the above method to determine the sky-limited exposure then take an exposure using the calculated time. Examine the histogram of this sky-limited exposure and note where the peak of the histogram is located.

The next time you want to know the sky-limited exposure time for any given conditions, take a test exposure and note where the peak of the histogram is located. Then simply figure out how much more or less exposure time is needed to move it to the position found above to obtain a sky-limited exposure. I've calibrated three Canon DSLR's using this technique and in each one, the sky-limited position of the histogram was one quarter of the way from the left hand side of the histogram plot.

Let's take a look at an example using my Canon 60Da. Suppose a test exposure of two minutes produces a histogram with a peak at the one-eighth point. Since CCD and CMOS sensors have a linear response with integration time, the exposure should be increased to four minutes to produce a sky-limited sub-exposure. That's all it takes; a calibration session to know where to place the histogram peak and a simple test exposure when you go imaging.

How many sub-exposures

Now let's go back to the pixel SNR equation. We notice that the final-image SNR scales with the square root of the number of sub-exposures. This means that each time the number of subs is doubled the SNR increases by a factor of 1.414 as shown in Figures 5 through 9.

Figure 5 - Single 5-minute exposure

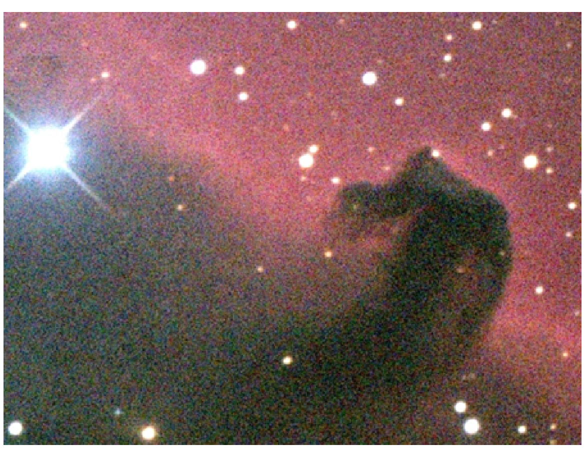


Figure 6 - Average of two 5-minute exposures

Figure 7 - Average of four 5-minute exposures

Figure 8 - Average of eight 5-minute exposures

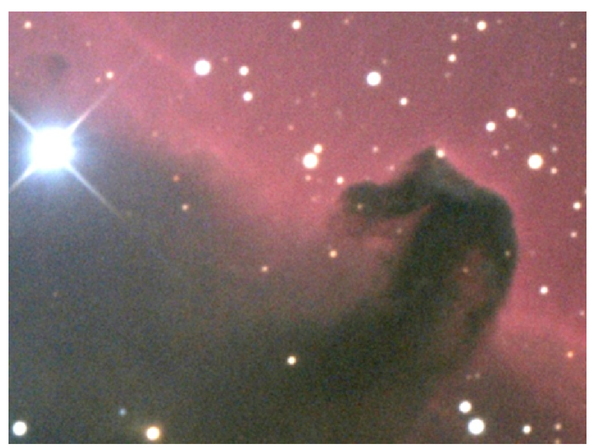


Figure 9 - Average of sixteen 5-minute exposures

As you can see from the above images the SNR improves each time the number of subs is doubled, but visually the improvement from eight to sixteen images is less apparent than between one and two. Even though the SNR has improved by the square root two at each doubling, the noise becomes smaller compared to the signal as the number of images is increased, and so the eye begins to lose the ability to distinguish the difference. We can determine how the SNR improves as the number of subs increases mathematically, but this doesn't really tell us much, as it does not take into account the way the human eye perceives changing SNR.

What you consider as a sufficient number of subs depends heavily on the imaging conditions and your setup. If, like me, you have to lug your equipment to a dark-sky site, then an hour or two of imaging is usually all you can achieve in one session. If you have a more permanent installation, then spending many hours on a target is not out of the question. There is a law of diminishing returns at work here; if you have collected three hours of data then six hours will offer only marginal improvement. If after three hours you are almost happy with the result then perhaps a little more noise reduction is better than another three hours of exposure.

Sometimes, especially if your imaging time is limited and you want to get several targets, it is nice to have a rough idea of how many subs are required to get a decent image. You can calculate everything you need with the help of a little integration, but I prefer to simply get a rough calibration for my optical and camera systems and use those to calculate the number of subs required. The goal is to measure the sky brightness, calculate the target brightness, then use the SNR equation to determine the required number of sky-limited sub-exposures to achieve the desired SNR.

First, calibrate your system. This can be done anytime and does not need to be repeated each imaging session. The calibration process will relate surface brightness and integration time to ADU values in your camera. We start by taking a sky-limited test image and measure the average level of the background with your image-processing software. Determine an average value from a few places on the scene to get a more accurate result. Divide the ADU value for the background of the image by the integration time in seconds. This gives us a value of ADU per second for the energy being received by your camera through your optics. Next we have to measure the sky background brightness. You can use a sky quality meter or simply use your test image and the technique developed by Samir Kharusi at:
http://www.pbase.com/samirkharusi/image/37608572.

Convert the result from magnitudes, which is a log scale, to a linear value by using the following:

$$\text{Linear brightness} = 10^{\frac{\text{magnitude}}{-2.5}}$$

Finally divide the ADU per second value obtained in the previous step by the linear sky brightness just measured to obtain a calibration value

When planning your imaging session, find the integrated magnitude of your target and its size in square arcseconds. Convert the brightness to its linear value and divide by the size to get the surface brightness of the target. Then multiply the result by the calibration value you have obtained for your system. This now tells you the number of ADUs per second you can expect from the target through your optical system. When you get ready to image, use an SQM or Samir's technique to measure the sky background. Convert the sky background to linear and multiply by the calibration constant then plug the calibrated object brightness and sky brightness into the SNR equation to calculate the sub-exposure SNR, with n set to one.

$$SNR = \sqrt{n}\cdot\frac{s_{obj}\cdot t}{\sqrt{s_{obj}\cdot t + s_{sky}\cdot t}}$$

The last step is to figure out the number of subs required.

Generally a SNR of 36 to 40 is required for a smooth image that can take an aggressive stretch without breaking down into a blurry noisy mess. The Horsehead shot shown in Figure 9 had a SNR of 36 when all 16 subs were averaged, and before any stretching. So I'll suggest that 36 is an acceptable SNR value. Using this we can estimate the number of sky limited subs required to be $(36/\text{sub SNR})^2$.

Now all this may seem like a lot of work, but keep in mind that it is very easy to put the math in a spread sheet that can be run in something like *Documents to Go* on a smart phone. All that is required is to fill in the object magnitude, its surface area and take a quick measurement of the brightness of the night sky. Plug those values into the spreadsheet and presto you have an estimate of the number of subs and how long each one has to be for a low-noise image. I've tested this technique on several of my older images and it agrees with the measured SNR of the stacked images to within a few percent.

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*** or you can send them directly to me at ***b.macdonald@ns.sympatico.ca***. Please put "IC" as the first two letters in the topic so my email filters will sort the questions.

Comets ISON and Lovejoy

Michael Boschat

I took these images from my balcony here in Halifax on November 14-16. I mounted my Canon 350D with a 75-300 mm telephoto lens to my old iOptron cube mount, that has GOTO and max. weight of 7 lbs, thus I was able to guide on the comets.

Being old it starts to trail after 1 minute so I kept my exposures short, all at 20 seconds with lens set at f/5.6,and 800 ISO. I put the lens to 300mm to get as much comet as possible.

Unfortunately the last 2 days, 15th and 16th November gave very poor skies with poor transparency, and I had to really enhance those images. I take 3-4 images then stacked them in Photoshop after which I messed with contrast, brightness, and color correction.

I was able to see ISON late in the month with 7x50 binoculars and C/2013 R1 (Lovejoy) was nice too. Comparing them, Lovejoy was bigger and looked like M13 but a bit bigger were as ISON was smaller: about half the size and fainter. In both cases I could not see the tails though the binoculars.

Comet C/2013 R1 (Lovejoy) - November 14th, 2013 at 2:33 a.m. AST

Comet C/2013 R1 (Lovejoy) - November 16th, 2013 at 12:47 a.m. AST

Comet ISON - November 14th, 2013 at 5:03 a.m. AST

Comet ISON - November 15th, 2013 at 5:52 a.m. AST

Outdoor Laptop Housing

Art Cole

I was looking for an inexpensive housing for a laptop computer for use with my telescope setup. I have an auto-guider coming, so an outdoor laptop became a necessity. I had a bunch of requirements for this, including:
- Dew/Ice protection
- Cold protection
- Ease of use
- Collapsible or folding
- WiFi-friendly (i.e., no metal boxes)
- Cable pass-thru
- No light leakage when closed

I thought about making something myself out of wood and Plexiglas with hinges & insulation, but it seemed like too much work. I checked for storage bins, but nothing met my requirements, and they all had weird shapes. Then while looking through my garage for something I noticed my collapsible fabric cooler I use for camping.

A quick check at Canadian Tire provided a great solution - a 96-can collapsible cooler with an access hole on the top, and a rigid (but folding) insert.

I bought some Velcro tape and a picture frame at the dollar store and stuck the clear plastic from the picture frame to the inside of the hole. So all I have to do is flip the cooler on its side, shove in the laptop, run the cables out through one corner, and bring both zippers to the corner. To use the laptop I open the flap on the front so I can see inside, and use a wireless mouse to control things. If I want darkness I just put the flap down.

In the summer if it gets too hot inside I'll just take out the plastic window. So there you go... a solution for star parties or just regular ol' parties!

Food for the Soul

Paul Heath

Editor's Note:
Paul Heath, our Centre President, opens each meeting with a poem. Since the reports for October and November were submitted by visitors to the Centre (see page 6 and 7) I have included Paul's poems for those two meetings here. Enjoy!

DREAMS EYE (October's meeting)

We gather the Eons, one by one
To hold within our EYE,
And collect our pictures from the air
With pencil guided photons, trapped with care.

And piece by piece the Dream we stitch,
As ages pass and vision mists.

We gather Treasures out of time
And hold them, mirrored circle bound.
As all the red lit wonders, found
Now drawn Images, caught with care.

And piece by piece the Dream we weave,
As ages pass and vision mists.

So when your distant lists complete
And all Images, in Mind's eye you keep
Step forth to darkness, there you'll find
A Tapestry of wonders, stretched firm across your Mind.

WINTER SKY (November's meeting)

One leaf holds firm,
Upon a frosted limb, now bare.
As zephyrs' twist and turn
And we watch 'til dusk becalms the air.

Then thrice cocooned, we step from portal warm
To wind swept stair
And crunch with measured pace a snow enshrouded field.

Eyes sweep up the calm and crystal air
As bundled within, our spirit stirs
To see the slivered, silver moon, rest gentle
On twilight's shoulders bare.

And thrice cocooned, with frosted breath
We stand and stare
While fires brighten, deep within the darkening air.

With myth and wonder, our spirit's draw
In frosted paintings across the air
Those timeless images, caught frozen there
And only seen, when breath drifts frozen on crystal air.

Now thrice cocooned, our spirits soar,
To see those brightest fires
Stand clear and high above, that frosted limb, now bare.

Photo:
Jeff Donaldson

Comet ISON taken on November 21st 2013

"Ignore the tails on the stars, a bit of a complicated stacking process. Just look at the detail in the comet.

You can see the outburst in the tail just past the comet head! I was fighting dawn at this point, was a considerable gradient."

The photo is a stack of 20 second and 10 second, unguided exposures, at ISO 1600.

Cosmic Debris

Odds and Sods from the world of astronomy and astrophysics

Comet ISON as captured by TRAPPIST on 15 November 2013

NASA Science News   Dec 4th 2013

Astronomers have long known that some comets like it hot. Several of the greatest comets in history have flown close to the Sun, puffing themselves up with solar heat, before they became naked-eye wonders in the night sky.

Some comets like it hot, but Comet ISON was not one of them. The much-anticipated flyby of the sun by Comet ISON on Thanksgiving Day 2013 is over, and instead of becoming a Great Comet….

"Comet ISON fell apart," reports Karl Battams of NASA's Comet ISON Observing Campaign. “The fading remains are now invisible to the human eye.”

At first glance this might seem like a negative result, but Battams says “rather than mourn what we have lost, we should perhaps rejoice in what we have gained—some of the finest data in the history of cometary astronomy.”

On the morning of November 28th, expectations were high as ISON neared perihelion, or closest approach to the Sun. The icy comet already had a riotous tail 20 times wider than the full Moon and a head bright enough to see in the pre-dawn eye with the unaided eye. A dose of solar heat could transform this good comet into a great one.

During the flyby, more than 32,000 people joined Battams and other solar scientists on a Google+ Hangout. Together they watched live images from a fleet of solar observatories including the twin STEREO probes, the Solar Dynamics Observatory, and SOHO. As Comet ISON approached the sun it brightened and faded again.

"That might have been the disintegration event," says Matthew Knight of NASA's Comet ISON Observing Campaign.

Cameras onboard the Solar Dynamics Observatory followed the comet all the way down to perihelion and saw … nothing.

“We weren’t sure what was happening,” recalls Knight. “It was such a roller coaster of emotions.”

The researchers were surprised again when a fan-shaped cloud emerged from the sun’s atmosphere. No one knows for sure what was inside. Possibilities include a remnant nucleus, too small for SDO to detect, or a "rubble pile" of furiously vaporizing fragments. By the end of the day, Comet ISON was nothing but a cloud of dust.

"It's disappointing that we didn't get a spectacular naked eye comet," says Knight, "but in other ways I think Comet ISON was a huge success. The way people connected with Comet ISON via social media was phenomenal; our Comet ISON Observing Campaign website earned well over a million hits; and I had trouble downloading images near perihelion because NASA's servers were swamped."

"So maybe ISON was the 'Comet of the New Century,'" he says.

Battams agrees: "The comet may be dead, but the observing campaign was incredibly successful.” Since its discovery in Sept. 2012, Comet ISON has been observed by an armada of spacecraft, studied at wavelengths across the electromagnetic spectrum, and photographed by thousands of telescopes on Earth. For months at a time, uninterrupted, someone or some spacecraft had eyes on the comet as it fell from beyond the orbit of Jupiter to the doorstep of the sun itself. Nothing was missed.

The two astronomers hope that the wealth of data will eventually allow them and their colleagues to unravel the mystery of exactly what happened to Comet ISON.

"This has unquestionably been the most extraordinary comet that Matthew and I, and likely many others, have ever witnessed,” says Battams. “The universe is an amazing place and it has just amazed us again."

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Credit: Science@NASA