



Spring 2005: No. 8

# PULSAR

THE NEWSLETTER OF THE KITCHENER-WATERLOO CENTRE OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

## Imaging With Digital SLR Cameras An in-depth tutorial in three parts

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Guest speakers ask some really big questions in our quest to understand the cosmos.

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Magic happens when you bring kids and telescopes together.

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There'll be plenty of dining at Starfeast 2005, but not by astronomers!

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#### Taking Astrophotos The Digital Way

Film is dead! Join the revolution and learn how to do it digitally.



Globular cluster M3 by Brady Johnson. A composite of seven three-minute exposures at ISO 400 taken with a Canon 300D Digital Rebel through a SkyWatcher 8-inch f/5 Newtonian.

### Editor's Corner

Spring is a time of renewal and hope, bringing with it green grass and warmer weather. For amateur astronomers, it also brings anticipation of new celestial observations to be made. While the stars of spring shine modestly, they do so amidst seemingly countless far-flung galaxies begging for our personal discovery. Some enthusiasts would say there's no better time to observe the sky with a telescope.

It's also a great time to share the experience

with others. And that's exactly what the K-W RASC and its members have been doing. In this issue you'll read about several club events that occurred in the past few months, and about others that will happen soon, including the club's second annual star party. Many more activities will be taking place in the year ahead. If you haven't become involved already, come on out and join the fun!

Alen Koebel, Editor

RASC K-W Centre

<http://kw.rasc.ca>

ROYAL ASTRONOMICAL SOCIETY OF CANADA

## Centre News

## Of Black Holes And Aging Galaxies

At February's meeting, the K-W Centre's vice-president Mike Burns gave an entertaining talk on the subject of Black Moles. At least, that's what his first slide was titled; Mike could never be accused of lacking a sense of humour. The actual subject was, of course, *Black Holes*. Mike's talk was an abridged version of a presentation he gave a few days earlier at the Perimeter Institute for Theoretical Physics in Waterloo. Mike is well qualified to give such a talk, having graduated from UCLA with a PhD in astrophysics and currently the head of the Mathematics department at Waterloo Collegiate Institute.

Mike delivered his talk in an enthusiastic and rapid-fire style, accompanied by an impressive number of PowerPoint slides containing a mix of artistic renderings and arcane equations (it was *not* necessary to understand the latter). Much of the talk concerned the anticipated unification of general relativity, quantum physics, and string theory as they relate to our understanding of black holes.

String theory, for example, can be used to resolve the so-called "information paradox," which concerns the fate of information (e.g., the ordered structure of matter) that falls into a black hole. If the information that falls below a black hole's event horizon is truly lost, then the law of conservation of energy, a concept essential to quantum mechanics, is violated. String theory comes to the rescue by providing a mechanism to store the information, which stays visible at the event horizon to any outside observer.



Dr. Mike Burns striking a professorial pose.

Mike predicts that in the next two years our knowledge of black holes will increase exponentially. One thing is for certain; the insights on black holes provided by theoretical physicists can only continue to expand our meagre understanding of the universe.

April's meeting featured a talk by Dr. Michael Balogh, an Assistant Professor of Physics at the University of Waterloo, on the topic of the formation and evolution of galaxies.

While cosmology – the study of the evolution of the universe as a whole – gets most of the astronomy press nowadays, Dr. Balogh made it very clear that there is still plenty we don't know about the evolution of the individual galaxies that populate the universe. For instance, we don't know why the rate of star formation in our own Milky Way galaxy has been approximately constant for the last ten billion years since it was created, producing an essentially equal mix of old and young stars, while the rate for most other galaxies has been in steady decline over that same period. Other galaxies in our local group (which includes the Magellanic clouds, M31, M33 and a handful of dwarf galaxies) typically contain only younger (and in one case, older) stars. We also don't know why most galactic clusters are

primarily populated by elliptical galaxies, which are composed largely of stars at least ten billion years old.

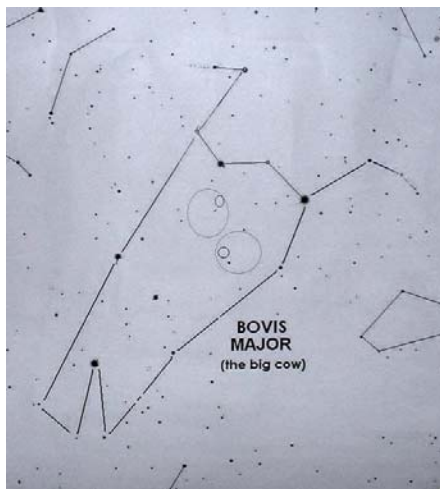
One tool that may help astronomers find the answers is the Sloan Digital Sky Survey. Using a 2-meter telescope, the SDSS will measure accurate photometry for 100 million objects and provide red-shift data for 1 million galaxies and 100,000 quasars. A host of other initiatives, including the Keck DEEP2, the Canada-France-Hawaii Telescope Legacy Survey (CFHTLS), the HST Ultra Deep Field (UDF) and the COMBO-17 spectrophotometric 17-filter survey are providing other levels of detail for differing numbers of objects.

A true understanding of how galaxies evolve is likely to remain elusive until astronomers account for all the missing mass and energy in the universe. What we can observe makes up only one percent of the total required to "close" the universe; the rest remains undetected. Perhaps the James Webb Space Telescope (JWST), which will be launched in 2011, and the Thirty Meter Telescope (completion date to be determined) will help crack the mystery. In any event, there are more than enough research questions to keep astrophysicists like Mike Balogh busy for years to come.



Dr. Mike Balogh of the University of Waterloo

## Centre News

Partying Till The Cows  
Come Home

Bovis Major, the forgotten constellation.

On April 9th, club member Jeff Collinson held a small gathering at his home in the country near Kenilworth, Ontario (north of Arthur) to celebrate the arrival of spring and to bid old man winter a rousing farewell. This private get-together, dubbed “The Big Cowland Event” because Jeff’s property is surrounded by farms, was the second in what may become an annual tradition. Since Jeff’s house isn’t large, he could only invite a few people. The invitees this year included a few K-W RASC members.

The event wasn’t just an excuse to eat, drink and be merry, although there was certainly plenty of that. It was also an occasion to observe. A total of six telescopes were set up that evening, including a 14-inch Celestron SCT and a 20-inch Obsession Dobsonian, the latter brought by Jeff’s good friend Brian McKillop from Peterborough. While most of the telescopes were used visually to hunt down the spring sky’s many faint fuzzies, the 14-inch was pressed

into service by its owner Darryl Archer for imaging, using both a webcam and a digital SLR. Unlike last year, when heavy fog destroyed any chance of observing, the skies remained clear all night and the seeing became exceptionally good in the wee hours of the morning.

Jeff’s house is nestled among stands of pine and cedar trees, so it’s easy to forget that it’s located in the middle of farm country. The property features a spring-fed pond in the backyard that occasionally attracts deer and other wild critters. This occasion it also attracted a few wild humans, namely Brian and Jeff who decided to plunge into the pond’s frigid water early in the morning. Everyone else, presumably retaining more active brain cells from the previous night’s revelry, enjoyed a few more hours of much needed shut-eye before eagerly attacking breakfast.

All-in-all, this year’s Big Cowland Event was an udder success. [*The staff of the Pulsar deeply apologises for this pun. In the future we’ll try to avoid puns instead of milking them for a few laughs.* – Ed]

## Kids And Telescopes

Bringing astronomy to the public is one of the prime mandates of the RASC. Nothing fulfils this better than reaching out to the children in our public schools, thereby introducing the wonders of astronomy to young, receptive minds. At the K-W Centre, Outreach Co-ordinator George Peer is responsible for organising these kinds of events. It’s safe to say that no one in the club’s history has ever taken on this responsibility with more enthusiasm or more professionalism.

George actually started organising outreach events about a year ago, but since joining the K-W RASC he has stepped it up a notch. He has even designed his own teaching program, composed of three parts. The first is an hour-long lecture delivered to a classroom of students. The second is a resource package, which he leaves with the teacher, consisting of book references, web sites and other materials. The third part, and by far the most exciting for the students, is an observing night, usually held on



Saturn proved an irresistible draw for imaging when the hunt for Bovis Major drew a blank.



Students of Empire Public School eagerly line up to snatch a peek through a telescope.

the school premises on some clear night after the lecture (the exact date depending on the weather). As George puts it, the lecture is the appetizer; the observing night is the dinner.

One particularly notable observing night occurred on April 18th at Empire Public School in Waterloo. Members of the K-W RASC brought a total of ten telescopes out to the event, ranging from a modest 4.5-inch Newtonian to a 10-inch SCT, setting them up in the school's playground. At least seventy students and parents lined up in long queues at the telescopes to take peeks at the moon, Jupiter and Saturn. The children displayed a high level of enthusiasm, but were nevertheless very well behaved for such a large group of youngsters, most of them 11 or 12 years old.

When asked by Grade Six English teacher Margot Gascon to write about what they learned at the "star party" one student remarked "I think it's cool that you can see the moon's craters when the moon is that far away." Another wrote "I loved seeing Saturn. I learned that Saturn looks really cool through a telescope, but looks like a regular star

without a telescope." The general consensus was that the star party was "awesome."

Not all of George's observing nights are as well attended, but what they all have in common is the enthusiasm of the children. Kids and telescopes just naturally go together. When a child sees a telescope aimed at the heavens, he or she just *has* to look through it. With suitable encouragement, the experience could very well spark an interest in astronomy that lasts a lifetime.

## Workshops At KW Telescope

by Brady Johnson

A couple of meetings ago I asked if anyone would be interested in participating in workshops held at my store, *KW Telescope*. There was a very positive response to this and so I have begun to prepare a schedule that I hope can start in July.

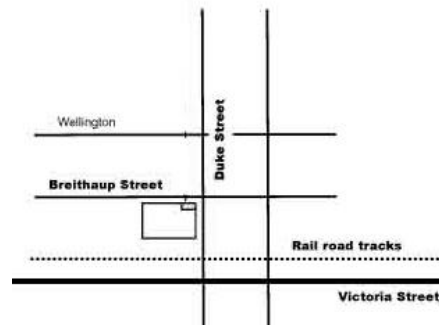
Up first, based on interest level, will be a workshop concerning methods for

doing astrophotography with digital point-and-shoot cameras. This type of astrophotography is one of the easiest to start with and will have you producing great results in a very short time. The workshop will cover the basics of the technique, hardware, camera and telescope requirements, and, weather permitting, an outdoor session where we can take a few solar images using either your own equipment or telescopes from the store.

I don't have a definitive date for the first workshop but it will very likely be on a Saturday morning between about 9:00 a.m. and noon (the store opens at 1:00 p.m.). If you are interested in attending this workshop please contact me at the store at (519) 404-0567 or by email at [brady@kwtelescope.com](mailto:brady@kwtelescope.com).

If you have a particular interest that you would like to see covered in a workshop please contact me about it. Future workshop topics may include astrophotography with a digital SLR, mirror grinding, planetary imaging techniques with web cams and commercial imagers, how to do a polar alignment, collimation, "hyper-tuning" your telescope, and digital image processing techniques, just to name a few.

There may be a small fee for attending the workshops. However, some or all of it will end up being a donation to the club.



*KW Telescope* is located on the corner of Duke and Breithaupt Streets in Kitchener, one block from Victoria Street (Highway 7).

## Centre News

## Club Receives Telescope Donation

by Brady Johnson

On May 25, 2005 I was contacted by the family of a Mr. Russell Newton Ebertt. Mr. Ebertt had passed away recently and amongst his personal belongings was a telescope which the family was planning to sell or give away. I went to look at the telescope to purchase it, but after talking to the family members decided that this 'scope belonged in the club.

Mr. Ebertt had a lifelong interest in astronomy going back at least to his mid teens growing up in Nova Scotia. He shared his interest with family and friends throughout his life and many times entertained everyone at the family cottage with discussions about the universe while they glimpsed it through his 10-inch f/6 reflector. He built a simple platform for the telescope at the cottage and, no doubt with tongue-in-cheek, dubbed it the "Russell Newton Ebertt Astronomical Observatory".

I thought it was particularly interesting that Mr. Ebertt, who was indeed named after Isaac Newton, should come to be so interested in astronomy, and eventually own a couple of Newtonian reflectors. But astronomy wasn't Mr. Ebertt's only hobby. He was also an accomplished banjo player. Many years ago he was one of the Conestoga Trail Riders, a band well known in our region and one that appeared on television frequently at one time.

His daughter Dianne told me that Mr. Ebertt worked as a draftsman at Uniroyal for 39 years. He had an extensive machine and woodworking shop in his garage and he loved to build and design

things. You can see that he was a very fine engineer and craftsman because he built many of the parts for his telescopes by himself, and they are very professionally done.

Mr. Ebertt had observed all of the planets within his lifetime, a feat that not many amateur astronomers ever match. Not long before he passed he was excited to share with his family that he had seen Mercury just off the western horizon. It was only the second time in his life he had seen the innermost planet, and he was very excited by it.

I am sure that the donation of his 10-inch Newtonian reflector to our club would make Mr. Ebertt very proud. I assured his family that the telescope would be well cared for, well used, and greatly appreciated by those who share Mr. Ebertt's passion for observing the night sky. The Ebertt Newtonian Reflector will be housed in the roll-off observatory at Ayr, and made available for shared use at public events and for member use at the Ayr facility.

## Starfeast 2005

July 7th to 10th

by Doug Bulgin

I am pleased to announce that once again I will be hosting a star party on my father's property on the Bruce Peninsula. It is located about three hours north of Kitchener-Waterloo, approximately halfway between Tobermory and Lion's Head.

Being so far north and lying between Lake Huron and Georgian Bay means the night sky is quite dark, noticeably better than at Starfest (Canada's largest star party held near Mount Forest). And last August, the Municipality of North Bruce Peninsula passed a proclamation to become a dark sky community, so the



Starfeast takes place in the Bruce Peninsula.

night skies should continue to be good into the foreseeable future.

This will be the second year for the event, unofficially called the *Bruce Peninsula Star Party*. The nickname "Starfeast" was thought up by a few of the people who attended last year's event. It is in reference to the plethora of hungry mosquitoes that were dining on us as we observed the heavens. In all, fifteen people came out last year and we all had a great time.

The dark skies are not the only reason to visit the area. Within a 30-minute drive there is plenty for you and your family to do during the day, no matter what your interests. Popular nearby site-seeing destinations include Cabot's Head, Flowerpot Island, The Bruce National Park, Fathom Five National Marine Park and the Chi Cheemaun ferry to Manitoulin Island.

You can shop for souvenirs in Tobermory, or take a glass bottom boat ride among the islands. If you enjoy more active pursuits you can swim, hike, fish, scuba dive, kayak or cycle.

For more information visit my site at <http://home.golden.net/~drbulgin> or email me at [dbulgin@johnsonite.com](mailto:dbulgin@johnsonite.com).

**Observing****The Eyes Have It****by Brent Spencer**

To improve your chances of discovering that first comet, or just being able to see more detail in an incredible globular cluster, you need to prepare your most important piece of equipment: your eyes! Dark adapting your eyes properly is the best way to be able to see fainter objects in more detail or see that faint fuzzy that would have otherwise eluded you.

Have you ever noticed that when you go into a dark room after being outdoors in bright sunlight, it is very difficult to see anything? After a few minutes you start to see outlines and the longer you are in the dark the more detail you can see. This is also true under a dark sky.

When you go out into the dark your eyes dilate, opening up like the aperture of a camera lens. But that only accounts for a small degree of dark adaptation. The larger effect is from a pigment called visual purple that accumulates in the eyes as they become dark adapted. The more visual purple, the more sensitive your eyes become to light. The longer you are in the dark, the better you will be able to see.

There are two different types of cells in your eye: rod and cone. Rod cells allow your eyes to see detail while cone cells allow you to see colour. There are far fewer cone cells than rod cells and they are inherently much less sensitive, so far more light is needed to see colour than detail. Most nebula and galaxies don't provide enough light to activate the cone cells, even with dark adapted eyes, so you don't see any colours in them (one exception is M42, which can appear green).



When your eyes are dark adapted, the gain in sensitivity is towards the blue end of the spectrum. So, using a red flashlight will not ruin your dark adaptation. A red filter over the lens of a regular flashlight will work fine, but one that uses a red LED is even better because it emits a more pure red light and uses very little current.

Decent dark adaptation for astronomical viewing takes time, anywhere from half an hour to as much as an hour, depending on the individual. To speed up the process, I sometimes use the "pirate" approach. I have found that a simple eye patch purchased at Shoppers Drug Mart for about four dollars works very well. Just place the patch over the eye that you usually use to view with and by the time you set up, dress warm and get your charts together, you're ready for a satisfying viewing experience. Just move the patch out of the way for viewing and replace it again to preserve your dark adaptation. Use your other eye to view maps and charts. Remember to keep the patch on at all times that you

are not actually observing, because you can lose your dark adaptation very quickly in the presence of any bright light that may be shined in your direction.

Not everyone's eyes dark adapt to the same degree. In addition, some common things can affect the circulation of oxygen in your blood and lessen what you can see at night. One example is caffeine, which is found in coffee and many teas. You might think that cup of coffee is keeping you warm, but it's really slowing down your circulation!

Another example is alcohol, which lowers by about 20% what your dark-adapted eye passes along to your brain. Smoking is yet another bad influence; it makes dark adaptation take longer.

One other little trick that will help in seeing faint fuzzies is "averted vision." Your eyes are really designed to see in the daylight; the centre of the eye is the least sensitive to low light levels. When viewing a faint object don't look directly at it, look slightly to the side and the object will appear brighter.

So in a nutshell, making sure that your eyes are totally dark adapted will ensure that you can use whatever size telescope you have to its full capabilities. Here's wishing you dark skies – and the dark-adapted eyes to see them with!

**Tired of sitting on the sidelines?*****No problem!***

We've got plenty of ways for you to get involved. Check the web site for upcoming activities and a full list of committees that you can join.

<http://kw.rasc.ca>

## Feature

## Digital Astrophotography Part I

by Brady Johnson

Digital imaging is quickly emerging as the best way to do astrophotography. Over the past few years we have seen a continued growth in the advantages of using digital imagers such as CCD and CMOS cameras, coupled with a decline in their main disadvantages (small receptor areas and big prices).

But even with the many advantages of the new digital technology, there is one thing that has not changed: Producing successful astrophotos requires skill, dedication and a considerable investment of time, learning and effort. While the end result of digital imaging is generally much better than what can be produced with a film camera, the effort needed to get it is at least equal – and in some cases, a whole lot more.

This three-part article deals with



Figure 1. The Canon Digital Rebel 300D – a very popular choice for astrophotography. This one has been modified to make it more sensitive to red wavelengths – an important modification when photographing emission nebulae.

astro-imaging techniques using digital SLR cameras, such as the Canon Digital Rebel, the Nikon D70 and others. In this first part, I will discuss the set-up and image acquisition phases of a standard workflow. In the second part, I will explain the need for and use of calibration frames such as “darks” and “flats” to calibrate the raw data (unprocessed pictures). In part three, I will show how to manipulate the calibrated images in an image-processing program to bring out the maximum detail.

There are a number of non-SLR digital cameras that are also very useful for astrophotography. However, the techniques that apply to these “point-and-shoot” style cameras are quite different. I will discuss astrophotography using non-SLR digital cameras in a subsequent article.

### The Digital Image

When we do digital imaging we refer to collecting data rather than taking pictures. The data is being gathered in the form of photons hitting light sensors and being converted into electrical charges. Because these charges add up over time we refer to the process as integration (which is just another word for summing values). At the end of an integration the charges are converted into digital values and passed on to a computer or storage medium. For most purposes, you can think of an integration in the same way you would an “exposure” as used in reference to film-based photography.

A collection of digital values makes up the picture. The dimensions of the sensor and its bit depth define the size of the collection. For example, the Canon Digital Rebel has a sensor that contains 3042 columns x 2048 rows for a total of over 6 million pixels. The pixels are only 7.4 micrometers ( $\mu\text{m}$ ) square – one tenth the diameter of a typical human hair – so the physical size of the sensor measures 22.7 x 15.2 mm, which is about 40% of the area of a 35-mm film frame.

The Digital Rebel has a *bit depth* of twelve, meaning it can represent the luminance continuum from dark to bright over a range of 4,096 values ( $2^{12}$ ). This is lower than most *bona fide* astronomical cameras, which have a bit depth of sixteen (and hence, greater luminance resolution). However, it is still much higher than the average computer



Figure 2. The Rosette Nebula, a combination of six five-minute exposures at ISO 400 using a Canon Digital Rebel attached to a Borg 76ED refractor. All photos in the article are by the author.

display screen, which has a bit depth of only eight. So, the images your camera produces will look just fine on any computer screen. They will also print well at high resolution.

Because we are now dealing with electronic signals instead of film emulsions, a whole new set of factors come into play. These include thermal noise, unevenness of the sensor sensitivity and other factors that will need to be corrected. The correction process involves taking additional pictures that will be used for calibrating the optical system and camera. I will discuss this in some detail in part two.

### Setting Up

What do you need to connect your digital SLR to your telescope? A digital SLR connects to a telescope in the same way that a regular SLR does. You need an adapter called a t-ring that is designed for your specific brand of camera.



Figure 3. Just *some* of the power and data cables that need to be connected. Additional power supplies and cables are needed for the laptop, the autoguider and the autoguider control box.

You also need a t-thread to mate to your t-ring and couple it to the telescope. Many telescopes are supplied with threaded components to make this straight forward. If your telescope is not so equipped, the additional parts you need are widely available and not terribly expensive (from about \$20 to \$40).

Let's talk now about what is involved in collecting your *light frames*. Light frames are simply the pictures you are taking – the raw data. The process to get set up and take a picture can be lengthy and demanding. Consider the following list of must-do's. It assumes you have an imaging setup that includes a GOTO mount, a laptop computer, electronic focuser and an autoguider (a camera/telescope combination that is used to correct errors in the tracking of the mount during the exposure) in addition to your imaging camera.

Before you can take your first picture you need to: Travel to your location; unpack your gear; assemble your mount; perform a rough polar alignment; add your counter weights, mount your imaging scope, guidescope and finderscope; attach your dew heaters; attach your focus motor; attach your imaging camera; attach your autoguider; attach all needed data and power cables; balance your telescope with the full photographic payload in place, co-align your imaging scope, guidescope and finderscope; and connect your camera, autoguider and mount to your computer.

Now you need to fine tune your polar alignment; initialize your mount for GOTO applications; and boot the software that controls your mount, your imaging camera, your autoguider, your focuser and possibly your dew control system. After you slew your mount to a nearby star you then note the temperature and proceed to achieve critical focus with both your imaging camera and autoguider. Now, you perform a



Figure 4. The Digital Rebel with T-ring, two-inch adapter and light pollution filter. This one's ready to slip into the focuser and go to work.

procedure to calibrate your autoguider; slew to your target location; preview the composition; fine-tune your pointing and/or camera orientation to get the right composition; set up your acquisition sequence; select a guide star and initiate autoguiding.

At this point, two or more hours might have passed since you arrived. But the good news is, you are now ready to start taking pictures!

As you can see from the above description, there is quite a bit more to taking a picture with a digital SLR than pointing the camera and releasing the shutter. In fact, almost every point in the workflow I just described is itself a procedure that consists of multiple steps.

It is highly recommended that you log all of the steps and follow your checklist each and every time you go out to take images. There is absolutely no point to starting an exposure until everything is in place and working. After the first shot is finished, it is highly recommended that you download it to your laptop and inspect it closely for composition and critical focus. If everything looks okay, check the temperature.

Check the temperature? Yes, indeed. If the temperature has changed by more than about a degree or so, it is likely you will need to refocus. So, keep an eye on the temperature throughout the evening and adjust focus whenever needed.



## Focus, Pocus

Possibly the greatest advantage of the digital SLR is that it provides you with instant feedback about focus. In the film days, you had to focus the best you could visually or with additional hardware such as a knife-edge focuser. You had no way of knowing if your focus was perfect or not until you got your film back from processing. That might be days, weeks, even months from the time you took the pictures to the time you had the developed images in your hands.

With the digital SLR you can look at the image immediately after you take it. Most cameras let you zoom in on the view screen, so you can take a very close look at the quality of your focusing. If it isn't up to par, you can refocus and try again. With suitably equipped systems and software, you can even let the computer auto focus the camera for you. With a digital SLR, there is no reason to end up with an out of focus image.

While you can often achieve good focus by looking through the viewfinder at a bright star, there are some focus tools that prove very helpful, too. I prefer to use a *cross mask*. It consists of two strings crossed at 90 degrees over the front of my refractor. When I am close to focus, the strings create diffraction patterns that look like four sets of double streaks emanating from the centers of bright stars. As you get closer to perfect focus, the streaks come closer together. At perfect focus they merge and you see four bright spikes emanating from the brighter stars.

Diffraction spikes are easy to see even through the viewfinder of the camera so you can even achieve critical focus visually. If your eyesight isn't quite up to that, you can always use the camera's preview window to look at your focus image and zoom in to be sure that the



Figure 5. The Great Nebula in Orion, a single five-minute exposure at ISO 800 using a Canon Digital Rebel attached to a Borg 76ED refractor.

diffraction spikes are indeed single and sharp.

## Taking The Picture

Assuming your focus is perfect and your autoguiding is nominal, you can start taking a picture, typically by doing a series of equal-length exposures that you will later combine or "stack" in the computer (more about stacking in part three). With a digital SLR you should allow some time to elapse between exposures to let the camera cool down. Otherwise, you get a cumulative heat build-up over the course of the sequence and this makes the subsequent calibration of your light frames less effective. For example, I set my interval between exposures equal to half of the exposure length for my light frames. So, when I use 10-minute exposures, I let five minutes elapse between exposures to let the camera electronics cool down.

Normally, it takes about one hour of total exposure time to get a nice result. To accumulate this much exposure you need to allow sixty minutes for collecting the light frames (e.g., six images exposed for ten minutes each), plus twenty-five minutes to let the camera

cool between exposures. If you don't have a library of dark frames (*darks*), you'll need to allow another hour plus interval time to create new darks that match the duration of your light frames. Finally, you might need to allow another half hour or so to collect a series of flat field images, or *flats*. I will have more to say about darks and flats in the second part of the article.

As you can see, you need to take multiple lights, darks and flats just to end up with one final image. If your final image represents a total of 60 minutes worth of accumulated exposure time, the true time spent collecting the data you need is more like three to four hours. In view of this, you should never plan to image more than about two objects in a given evening because there just isn't time to do much more than that. This is especially true in the late spring and through summer when the sun sets late and gets up early.

In the second part of this article, I will describe the process of taking dark and flat calibration frames and explain how to combine them with the light frames in the computer to produce fully-calibrated images.

## Cosmic Comics



### K-W RASC Executive

*President:* Brady Johnson

*Past President:* Dave Garner

*1st Vice:* Mike Burns

*2nd Vice:* Peter Clarke

*Secretary:* Brenda Purdy

*Treasurer:* John Beingessner

The K-W Centre of the Royal Astronomical Society of Canada usually meets on the second Friday of every month excluding July and August. Meetings are held in the Science Building at Wilfrid Laurier University in Waterloo, Ontario. All residents of the Milky Way are welcome but must supply their own transportation.

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## In Coming Issues...

### Want to join our club?

To become a member please call John Beingessner at 519-884-2425 or send e-mail to [johnbein@gto.net](mailto:johnbein@gto.net)

- Second and third parts of Brady's digital astrophotography article
- Completing a 25-inch telescope
- Tips and techniques for computer enhancing your astrophotos
- Equipment reviews

*and lots more...*

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ROYAL ASTRONOMICAL SOCIETY OF CANADA

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