Digital Astrophotography "On the Cheap"

By Dan Lessmann

If you're like me, one of the reasons you took up astronomy is not only to see all the beauty the sky offers outside, but to be able to take that beauty inside. As a life long space and photography enthusiast, astrophotography is the best of both worlds for me.

But burning film to capture the skies is tough to do. You never know what you've got until you develop the film so learning to do it well is a trial and error process that involves a lot of time between the trials and errors. This can be so frustrating that most people just give up. I did.

But there's hope for us impatient types! Higher demands for CMOS and CCD technology have opened up exciting alternatives to traditional film. Most of us have moved to digital cameras for our daylight photos and those of us that haven't are considering the switch. This has resulted in increased production of these devices and brought the costs way down in recent years.

Nevertheless, the best CCD astronomical cameras are still beyond the reach of most amateur astronomers. A typical setup; scope, mount and camera, for CCD astrophotography can very easily exceed ten thousand dollars. In fact, that's a conservative amount. The total investments can be much higher.

Fortunately there are alternatives available for those of us that are limited by budgets or would like to try out this side of our hobby before we commit that kind of pocket change to a top of the line setup.

I've taken my first baby steps into the world of digital astrophotography and would like to share my experiences and what I've learned along the way. I hope that I can help you take your own step into this exciting and enjoyable branch of our hobby.

Step 1
Study

I know this because this wasn't my first step and I paid for it. Unless you already know the difference between a light frame and a dark frame, the first investment you should make is for a comprehensive book on the subject. I can strongly recommend, *The New CCD Astronomy* by Ron Wodaski, www.newastro.com. This book is recognized as the bible of CCD astrophotography. It's also very easy and enjoyable reading even though it delves into very technical aspects of the subject.

Purchasing the book also gives you membership to the web site and web discussion group. This group is very active and helpful to newbies like me. But be warned, these folks are serious astrophotographers! They have made that ten thousand investment and more and produce beautiful images that are often comparable to those you've seen from the HST.

You'll also find that there are web discussion groups for just about any type and brand of camera you choose to use. These groups are valuable resources for improving your knowledge and skills.

Okay, now you've studied and you've asked questions and you've found out that all of the equipment you've got will work, sort of. But, it's not optimal, kind of. But, you still want to give this a try, maybe.

Step 2
An Inventory

Here are the minimums you're going to need if you're going to do this on your own:

- A telescope. (Duh) This can be anything from a Wal-Mart special to one of the club's reflectors to the best astrograph. The quality and specifications of the scope you use will determine only what you can shoot and how good your results will be.
- A mount. (Duh again) This can be anything from a Dobsonian to the best equatorial mount. They'll all work but the lower end will, again, limit what you can shoot and for how long.
- A camera. (I'm now going to stop saying duh) This can be anything from a cheap web cam to a top of the line SBIG CCD. It can also be your current digital camera if you can get the right adapters to fit it into your optical train. Again, the type and capability of the camera is going to limit you to certain types of objects

Europa, Ganymede and Jupiter at f/20, 10" LX200GPS, Meade LPI for certain exposure times.

Keep in mind that your daylight camera is not going to be as sensitive as a camera designed for astrophotography so your exposure times go up. This puts more demands on your mount's tracking.

- A computer. Most likely you'll want a laptop as you're going to want to get out in the dark boonies to try this. The choice of laptop will be based on the software you're going to use.

- Software. Both to run the camera during exposures and to process the images back at the house the day after.

- A hodge-podge of other items, Barlows, focal reducers, a power supply for the camera/computer and probably a separate one for the mount, adapters, filters… The list goes on and on. Go slow on this. Get what you need when you need it and *ask questions first.*

Unless you're very fortunate you now have a shopping list. So this is a good time to reevaluate just how interested you are in trying this. I can guarantee this. If you get hooked, you're going to start spending the kids' milk money.

Be warned! This can be a very expensive hobby!

Step 3
Accept That There Ain't Know Such Thing As The Perfect Scope

Actually that's not true. The perfect scope does exist and is available for you to rent over the Internet. There are web sites that will rent scope time to you and you can capture images via the Internet with top of the line equipment. Google it or here's one for starters:

www.newastro.com/remote/default.htm.

These services are a relatively inexpensive way to try this out.

But, if you're like me, you'll find you want to do this with your equipment under your own skies. Learning to use my own equipment is as much fun as using it and I like to get my hands dirty. If dirty hands aren't part of what you're after, renting telescope time is a great alternative.

Okay, let's assume you too want to get your hands dirty. The variety of objects you would like to image probably range from the very small, like comets, to the very large like the Andromeda Galaxy.

Unfortunately, the scope needed to image one is not the scope needed to image the other. I'll not go into the technicalities of focal ratios and fields of view here. Suffice it to say that if you're going to get serious about this, you're eventually going to want more than one optical tube assembly (OTA).

But, to stay within the realm of this particular subject, i.e., "on the cheap", let's assume you're going to use the OTA you now have or one of the club's tubes. Okay fine, just accept that you're not going to get images of everything you want with that one tube. There are still a number of targets out there and they'll teach you the basics of imaging and image processing. Also keep in mind that a few Barlows and focal reducers can expand the range of objects possible with your current setup.

Step 4
There Is Such A Thing As the Perfect Mount

And you probably don't have it. But the one you have will still work for you as long as you're ready to accept more limitations. Unless you've got an accurate Eq. mount, and know how to align it very precisely, you're going to be limited to short exposure times which means brighter objects.

If you're mount is a Dobsonian or an Alt-Az, you're going to have to deal with field rotation or no tracking capability at all.

Those of you with fork-mounted scopes can add an equatorial wedge for not a lot of money. These vary quite a bit in quality and price. One that comes very highly recommended is the Milburn wedge and it's in high demand so it holds its resale value well. I tend to believe in spending more for quality equipment initially rather than buying cheap and replacing later but, if your budget is a big issue, you can build an adequate wedge if you've got some woodworking skills.

Step 5
Processing Is The Key

When starting out, you're probably going to be disappointed with the quality of images straight off of the camera. Likewise you're going to be surprised by the beautiful results after processing. In fact, you're probably going to spend more time at your computer processing images than at the scope exposing them. Your family won't like this, but it does give you something to do when it's cloudy.

Before you start spending money on expensive processing software, first see what's available for free from the Internet. Here are a few free software applications that I can personally vouch for:

Registax

www.aberrator.astronomy.net/registax

This is an image processing software that does a good job of processing images. However the documentation is a bit weak.

Registax has the ability import and process common graphic file formats and AVI files if you're using a web cam. This allows you to stack and combine multiple short exposures to get something approaching the result of single long exposures possible with expensive cameras.

K3CCDTools

www.pk3.org/Astro/index.htm?software.htm

This application will operate a variety of cameras and will store the exposures in a variety of formats.

Adobe Photoshop

Not free but you may have received the light version with your digital camera or your computer. It's a great tool for enhancing and sharpening your images after stacking and combining them.

There are many others and, with a

little work, you can get everything you need for nothing but the time it takes to find it. Internet discussion groups are great for some hints on what's available.

Step 6
Get A Camera

There are a lot of inexpensive options out their and this is another place for a bit of study and discussion group questions.

As I'm new to this, I have personal experience only with one camera so I'll speak mostly about the choice I made.

For the relatively low price of about $150 you can do what I did. I added Meade's Lunar Planetary Imager or LPI to my LX200. New LX200 scopes are shipping with this camera as standard equipment. All of the images in this article were shot with the LPI on my 10" LX200.

I have to admit that I've spent more than this amount. I've added an f/6.3 focal reducer to open up more targets for imaging with my long focal length telescope. I also had much of the equipment on the minimum list prior to deciding to do this.

This camera will work with any scope that can accept a 1.25" eyepiece. Two inchers can get an adapter if they haven't already got one. So can the 15/16" crowd but you may not have enough back focus in your focuser to accommodate it.

The LPI features a 640x480 pixel array and a field of view more or less equivalent to a 6mm eyepiece. It interfaces to your computer via USB so image downloads are fast. It's also powered through the USB port so no external power supply is required.

Meade LPI

The LPI comes with all of the software you need to image. Note that I said image, not process. There are better options for processing than the apps supplied with the LPI, like Registax and Photoshop.

The LPI is a CMOS camera as opposed to a CCD like the Phillips Toucam or the SAC cameras. This means it's not as sensitive but it does have an advantage over the Toucam in that it can expose for up to 16 seconds and can save separate image files rather than AVI files. Its advantage over the SAC cameras is that it's less expensive than the low-end offered by SAC.

However the SAC cameras are more sensitive and the higher end models include Peltier cooling. If I were to start over again, I would give serious consideration to a SAC rather then the LPI.

The down side of the LPI is it is not cooled. However, since it's a CMOS chip, dark noise is not that much of an issue and the imaging software allows you to subtract dark frames. In cold weather, noise is not much of a problem and you should let the camera cool down to ambient temperature before you image. Noise is increased substantially in warmer weather and could be quite bad in the summer.

This camera is basically a web cam on steroids. Its primary use is for what the name implies, lunar and planetary imaging. With some patience and some practice, it does a great job with both. It can also image brighter deep sky objects although this is much more of a challenge. But hey, all CCD or CMOS imaging is a challenge. That's part of the fun!

Probably the greatest advantage of the LPI is its imaging software. The LPI comes with the Autostar Suite. This is a suite of applications including planetarium software, the imaging software and processing software.

I'm not terribly impressed with the planetarium or processing software and don't use either as I've got better. But the imaging software does a good job of operating the camera in a simple to use interface that is almost point and shoot for the beginner and can be manually adjusted for the more seasoned shooter.

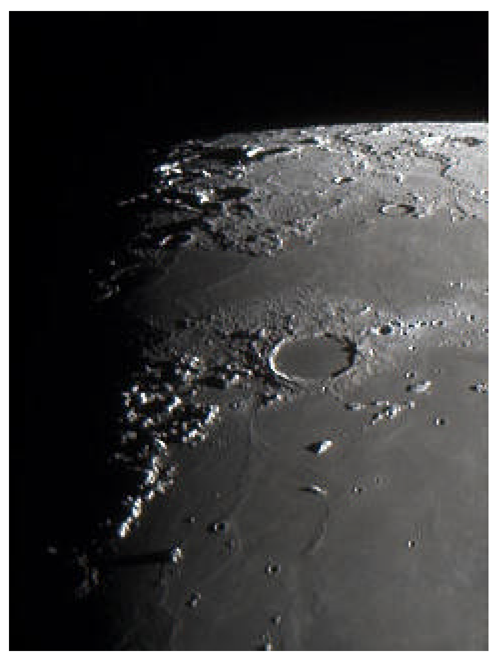
The one major deficiency in this software is the inability to adjust RGB (red, green and blue color) levels individually. However, you can work around this by adjusting them in K3CCD first then imaging with the LPI application.

Step 7
First Light!

My first light with the LPI was shooting the moon (no pun intended) and it was simplicity itself. The software automatically set everything up for me and I was able to shoot beautiful, high magnification images of the moon even though I was shooting through haze.

I was feeling pretty salty that first night but my smugness didn't last long. Anybody can shoot the moon with the LPI and that's a great way to get a feel for the software but everything else is much more of a challenge.

As with visual astronomy, seeing and focus techniques are the first two keys. If you're working with an OTA that has a shorter focal length, seeing will not be as much of an issue, but focus *always* is and it can be *tough!*



Plato Crater at f/10, 10" LX200GPS, Meade LPI

My LX200 has an electronic focuser and that helps a lot. Those that have rack and pinion focusers are going to have a hard time focusing accurately with any camera at long focal lengths. I would wait to see if I get hooked, but if I did, some sort of electronic focuser would be on my shopping list.

Consider this. Depending on the focal ratio of your scope plus any optical attachments, the critical focus zone, the range of positions the chip can be in to be clearly focused, is most likely no more than a few thousandths of an inch. It's very difficult to hit that zone with an R&P focuser.

For solar system images, I've found that I spend maybe three times the amount of time tweaking the focus as I do exposing. I cannot emphasize enough how critical good focusing technique is in any kind of astrophotography.

There are a variety of tricks you can use to improve focus and these are discussed in depth in most texts on the subject. Use them and practice, practice, practice! You'll soon find you can focus accurately with your setup within the limits of the seeing.

On those nights when you simply can't get good focus, you're dealing with bad seeing or, if you have a reflector or SCT, you may need to collimate your scope. Good collimation is critical. A CCD or CMOS chip is much less forgiving than your eyes.

One of the steps of my setup procedure is to check the collimation of my SCT. I do this every time I setup and I tweak the collimation if needed. Again, with practice, you'll find you can collimate your scope in just a few minutes.

If you still can't get good focus, go to visual for the night or switch to a lower power setup (a focal reducer or a different tube) to reduce the effects of the bad seeing. But go ahead and capture some light with your typical setup. These marginal images can be used for processing practice.

Step 8
First Processing

Assuming you go with the LPI, you will initially be using the software's built-in track and combine features to capture images. But you're very shortly going to realize that you can get better results by taking separate images and stacking and combining them after the fact.

Saturn at f/20, 10" LX200 GPS After Processing

The f/20 image of Saturn on this page is the result of over 100 separate images stacked and combined in Registax and then further processed for sharpness and contrast, again in Registax.

Does that seem like a lot of images? Well it's actually a rather low count. I exposed over 250 images for this single image and tossed out over half because of poor quality due to the seeing here in town. If I had done this with the LPI software, it would have gone ahead and stacked those poor images and ruined the shot.

On the other hand, the Plato Crater on the previous page was done entirely with the LPI. That image is only about 15 exposures stacked and combined. So it just depends on what you're shooting. Personally, I've found that I want separate images of everything but the moon to work with after the fact and sometimes even the moon if seeing is exceptionally bad.

I mentioned that when seeing is *really* bad you should go ahead and shoot a few cruddy images to use for processing practice. This f/20 Jupiter image shows just how much things can be improved with a little patience and practice.

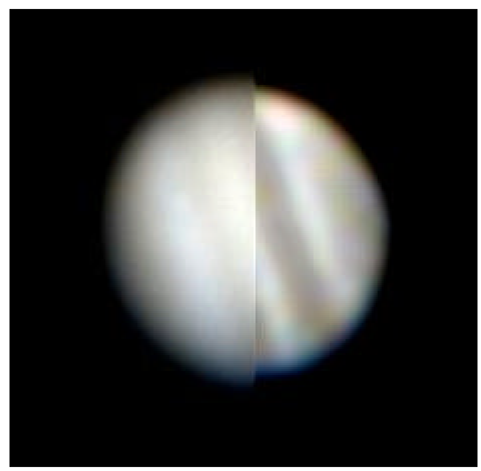
The left half of the image is the result of stacking over 100 images taken under poor seeing conditions (the individual raw images are even worse). The right half is the result of wavelet processing in Registax. Obviously, the image is still very poor but you can see how much post processing can improve the quality of an image.

Step 9
Recognize Your Mount's Limits

A common mistake, and one I made, is the assumption that because you shoot shorter exposures with these lower end cameras, the type of mount and its tracking ability doesn't really affect the final result. Nothing could be further from the truth.

My LX200 is still on its Alt-Az mount. I have a Milburn equatorial wedge on order and field rotation is the reason why.

The image of M42 at the top of the this page is the stacked and combined result of 75 exposures. Why only 75 when the Saturn image had over 100? Because, unlike lunar and planetary images, the time for each exposure required for DSOs is quite a bit greater. Each of the 75 exposures used in this image are 8 seconds long.



Results of Processing on a Poor Quality Image

Do the math, 75 x 8 seconds is 600 seconds or 10 minutes. I had many more images that could have been included in this but, depending on

M42 at f/6.3, 10" LX200 GPS, Meade LPI

where the object is in the sky, I've found that ten minutes is just about the maximum I can image before field rotation becomes an issue. Even so, there is some field rotation evident in this image. Take a close look at the dim star at the right center edge and you'll see there's a bit of elongation. The same is true of the brighter star in the upper right.

The image at the bottom of this page is 191 images stacked and combined. These were taken the same night as the M42 image above and at the same focal ratio.

I've monkeyed with the balances on this image to better show the field rotation.

Theta 2 Orionis (follow the arrow) was the star I used to track this image and the camera, mount and software did a good job of tracking on this nice, magnitude 5 star. But you can see that the image is not usable because of the field rotation inherent in my Alt-Az mount over the 26 minutes or so that it took to capture these images.

Even though each individual image exposure is only eight seconds long, the total time of all exposures to be stacked and combined is what matters.

Though I've not used them, you can use software to de-rotate images. Depending on how well this works, this would be less expensive than getting a wedge, or upgrading your mount, and is probably worth a try if you feel you're not going to step up to a more expensive camera later.

Of course a Dobsonian mount is going to be even more of a problem. Here you're limited to much less than even the ten minute limit I've encountered since Dobs don't sidereal track. Depending on your focal length, you would most likely be limited to only a few minutes worth of exposures. This most likely will put deep sky objects outside of the range of your equipment. That's okay. There's plenty to shoot within the solar system.

Adding a focal reducer can help with this. Since a focal reducer speeds up the optical system, you can use shorter exposures for the same amount of light. You'll sacrifice some magnification but most nebulae and many clusters don't require much magnification anyway.

Adding a focal reducer also hurts because it increases the field of view. The larger your field of view, the more field rotation will be evident. You can get around this by cropping the outer edges of your image.

You'll just have to see what you can do with your setup but that's also part of the fun!

You can also consider adding or building an equatorial platform for your Dob. This will give you equatorial sidereal tracking for not a lot of money and opens up those big light buckets to all kinds of objects in the way out there regions.

Field Rotation with Alt-Az Mount, 191, Exposures, 26 Minutes

How Many Steps Is That?

Only nine. Hmmm… Well that will have to do.

I hope I have shown you that you don't need to take out a second mortgage to have a go at digital astrophotography. This is a hobby that you can grow into as your skills improve and desires change.

I also hope I have shown you that you just might end up with that mortgage as this hobby is habit forming and you're going to need more and more to get your fix.

I find this branch of our hobby to be extremely fascinating. It appeals to my techie tastes and there's always a challenge for that latest and greatest image capture. As with astronomy in general, it's a hobby that rewards skill, dedication, practice, and study. But mostly, it's just *fun!*

I hope you too can enter into this fascinating branch of our hobby and until then, *clear skies!*