CANON DIGITAL REBEL: DEEPSKY IMAGING MADE EASY?

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DISCLAIMER

I have no vested interest in any of the manufacturers, camera, imaging accessories, lenses and scopes discussed in this review. Everything reviewed here was obtained through normal commercial channels. My purpose in writing this review is to help other amateur astronomers make a more informed purchase and utilization decision. I would like to thank cloudynights for this opportunity to present my impressions about the Digital Rebel and its use for deepsky astrophotography from a beginner's perspective to the amateur astronomy community.

REASONS FOR WRITING THIS REVIEW

As of late, the price of the Digital Rebel a.k.a 300D from Canon has fallen to such an extent that is affordable by just about anyone. I see a lot of superb pictures of deepsky objects as well as the lunar surface and the planets, on the internet, and in the reader astrophotography galleries of sites such this one, taken using the Digital Rebel. It was sorely tempting to just go out and buy one. However, I curbed my enthusiasm long enough to ask myself the following question (**Figure 1**):

Can the Digital Rebel be used by beginners (case in point, yours truly) for deepsky astrophotography, or is its use so complicated that only experienced astrophotographers have any hope of obtaining decent (perhaps not publishable, but at least printable) deepsky images?

Figure 1: Canon Digital Rebel a.k.a 300D; deepsky astrophotography powerhouse?

I will attempt to answer this question in a comprehensive fashion in this review. However, let me cut to the chase right away, and say that the answer, at least for the Digital Rebel is a definite **YES, IT CAN, AND NO, IT ISN'T TOO COMPLICATED TO USE**. In my humble opinion, the title of this review is apt; The Canon Digital Rebel certainly makes deepsky imaging possible AND enjoyable for a novice such as myself. I therefore, wanted to share my personal experiences for the use of this camera for deepsky astrophotography with others like myself, and what better way to do that than to write a review on good old cloudynights?

ABOUT THE DIGITAL REBEL

Overview: The Digital Rebel (**Figure 2**) is a Digital Single Lens Reflex (DSLR) camera capable of taking very high resolution images. It is available from several retailers in the USA. I bought mine as the black-bodied limited edition EOS Digital Rebel kit with the 18 -55 mm EF autofocus lens from B&H Photo for $ 899.95 right before Christmas 2004. Canon had a $ 100 mail in rebate so the camera kit effectively cost me $ 799.95. At the heart of the camera is Canon's fabled Digital Trinity:

1. An extremely low noise, high resolution 6.3 Megapixel CMOS (Complementary Metal-Oxide Semiconductor) sensor for recording the image (**Figure 3**).
2. Canon's proprietary DIGIC chip for efficient sensor data handling and on-chip image processing.
3. Compatibility with dozens of EF lenses and EOS accessories such as speedlites, remote releases etc. for a wide variety of creative photography options available to the user.

Figure 2: The Digital Rebel has intuitive function buttons on the back and a nice LCD screen for image review.

Implications for astrophotography What this translates into for astrophotography is very low sensor dark current, which can be controlled for some time, with reasonably high sensitivity for recording faint deepsky objects, an approximately APS (remember this film format?) sized sensor at 22.7 mm x 15.1 mm, which can cover a reasonably large area of the sky (much more than those pea-sized sensors in modified webcams, although 1.6 times less than traditional 35mm film), and a variety of EF lens type (USM, non-USM, IS, L-series, zooms, primes and combinations thereof) and EF lens focal length options for piggyback astrophotography. Available shutter speeds are from 1/4000 – 30 seconds and a bulb mode, which is required for our purposes. Available ISO speeds on the camera (sensitivity) are 100, 200, 400, 800 and 1600. I found that all these ISO speeds are useable, **even** ISO 1600 for long exposure astrophotography, provided some post image processing is done. The sensor is rated by Canon as good for up-to 30,000+ pictures. While this may not sound like a lot, consider this; say you are going to take a hundred long exposure astrophotos every week. At 5 minutes per exposure, that's a reasoable 8.3 hours of imaging time per week. This translates to 5200 pictures a year, leading to a useful lifetime of the camera of just shy of 6 years. Now I don't know about you, but for me, that's pretty darn good performance from this $ 800 camera kit ($ 700

Figure 3: At the heart of the Digital Rebel lies this Hi-res 6.3 MP CMOS sensor.

after rebate if you want the body only), which translates to a camera cost per year of less than $ 200 to feed my new-found imaging habit.

Physical Dimensions, Fit, Finish and Weight Considerations The camera is geared towards the consumer market and is made of lightweight plastic material, but from personal experience I know that it is rugged enough to use out in the field for astrophotography. The camera dimensions are 5.6 x 3.9 x 2.8 inches, which translates to a reasonably compact camera package. The weight of the camera including battery is 645 grams, which makes it the lightest Canon EOS DSLR on the market today. In contrast, the 10D has a weight of 875 grams, and the new 20D has a weight of 770 grams both including battery. The lightness of the camera is a good thing for astrophotography applications, because in all likelihood you do not have to worry about adding additional counterweights, since it is probably only a couple hundred grams heavier than your diagonal and eyepiece configuration. The fit and finish of the camera is excellent, as we've come to expect from Canon.

The batteries used are the Canon BP-511 Li-ion rechargeable supplied with the camera. This battery typically lasts for the entire night with a full charge, which is not surprising since it is rated for 1100 mAH and you only consume battery power to lock the mirror up, to energize the sensor when recording the image, and when you review the images on the LCD screen. There is a re-charger supplied with the camera and it's adequate for the recharge process, although it does not have automatic shut off when the battery is fully charged, and overcharging is possible, necessitating checking on the recharge process. There is a plastic body cap supplied with the camera, which is good to protect the mirror and the underlying sensor, and it fits snugly without coming loose when subjected to vehicle vibration, if you wish to transport just the camera to the dark sky site, and leave the kit lens at home. There is a camera neck strap carrying the EOS logo on it. I use it to loop around the scope, as a back-up means to secure the camera to the scope during imaging. If in case the T-ring comes loose (highly improbable), the neck strap will prevent the camera from falling on the ground and smashing to bits (again, highly improbable). There is a threaded receptacle at the bottom of the camera which can be used to attach it to the piggyback mount, or to a fixed camera tripod for star-trail photography. Finally, the camera records the images on the familiar and ubiquitous CompactFlash (CF) card media. CF card prices are now excellently low. I use a Lexar Media professional 1GB 80X CF card, which I bought from eCost for $ 79 after a $ 20 mail in rebate. The read-write speeds of this card are FAST, and 1 GB translates to roughly 140 RAW format images. The placement of the function keys on the back of the camera is a logical arrangement and their use is extremely intuitive. I especially like the fact that you can backlight the information panel above the LCD screen to visually follow and perform changes to your exposure settings at night.

Other Considerations There is no mirror-lock up available for this camera (unlike the 10D and the 20D), but I typically use the "hat method" whereby I cover the objective of the lens or scope to which the camera is attached with a black cardboard piece, use the remote release to fire the shutter, wait a few seconds to let the vibrations die out, and remove the cardboard piece. After waiting the required amount of time for the exposure to be done, I put the cardboard piece back on the objective of the lens or scope and stop the exposure.

The provided LCD screen for image review is on the back of the camera and is a little too bright, even at its lowest brightness setting at night in a dark sky site. I made a filter out of several sheets of transparent red cellophane, which I used to cover the LCD screen to preserve my dark adapted vision. Why use the LCD screen during the night at all? Simple, it's a great aid to determine best focus. Usually, even with a fairly bright deepsky object the view through the viewfinder is usually too dark to judge best focus. I simply get the focus first to where I think it is good, take a 5 to 15 second exposure, and examine the image on the LCD screen, which can be magnified several times (10 X) using the magnification button provided at the back. If I'm not at best focus, at this high magnification, it'll be really obvious. I then tweak focus and repeat this process until I get satisfactory star images at the highest magnification. I can erase the images after I'm done to free up CF card space. Usually this process takes no more than five or six iterations (couple minutes). This is a zero cost alternative to the expensive focus aids available out there, such as Canon's own Angle Finder C accessory.

As a final important point, I always have the camera set to save the images in RAW format, not JPEG. I would advise everyone to do the same. The reason, as you'll see further down is to take complete advantage of Canon's supplied File Viewer Utility 1.0 software, which is a powerful "Digital Darkroom" and allows you full control over the digital enhancement of the images, such as push processing (Digital Exposure Compensation), white balance adjustment (bringing out those faint H-Alpha regions), color saturation, tonal variations etc. Only RAW format, which is essentially sensor data straight from the sensor (perhaps some minimal processing perfomed by the DIGIC chip), lets you take full advantage of the inherent power of this software. For astrophotography, what this means is that your images are recorded in full 12 bits per channel (as opposed to only 8 bits per channel for JPEG). This is extremely important for recording subtle variations in color shades in deepsky images, and for extracting optimal information per pixel during later image processing.

MY IMAGING RIG

My imaging rig (**Figure 4**) consists of a Nexstar 8i on an equatorial wedge-mount which is polar aligned. I have written a review on this scope previously, and in addition, I have written another CN report on how to equatorially mount and polar align this scope, right here on cloudynights. I am still learning the art of drift polar alignment, but as you'll see, even a rough polar alignment is good enough to minimize field rotation and collect several relatively short (2 to 3 minute) unguided decent quality images which can be stacked later to approximate the effects of a longer guided exposure. The Nexstar 8i is an 8 inch f/10 SCT instrument, with Starbright XLT optical coatings, and is a superb visual performer. I use a Celestron f/6.3 focal reducer/field flattener to reduce the f-ratio and get brighter images in a shorter exposure. In addition, I also have a Lumicon Piggyback adapter attached to the Nexstar, which I use to mount the Digital Rebel with a 50 mm EF lens for widefield long exposure (5 to 10 minutes or longer) shots, or a Meade 60 mm f/5.8 astrostar (read department store) scope, for telephoto piggyback shots which are shorter in duration, say 3 minutes or so. In this way, my imaging rig gives three useful configurations for astrophotography.

Figure 4: Three useful configurations can be achieved for astrophotography with the Digital Rebel and the Nexstar 8i.

Piggyback astrophotography does not take advantage of the large aperture of the main 8 inch SCT scope, but it has its definite advantages, namely that you're using the clock drive on the main scope to track objects as they appear to move across the sky, avoiding the purchase of a separate small equatorial mount. Also, since you're covering a much wider area of the sky using the piggyback technique with either the 50 mm camera lens, or even the 300 mm focal length of the spotting scope, you can take longer unguided exposures than you can through the main scope. In addition, since the sky coverage due to the wide field of view of either the 50 mm camera lens, or the 500 mm spotting scope is so much larger than the field of view achievable through the main scope, you can fit extended deepsky objects or entire constellations into a single exposure through these piggybacked lenses/scopes. You can also connect the camera directly to the main scope using a T-ring and either a T-ring to 1.25 inch nosepiece adapter, or a T-ring to SCT adapter. This allows you to take short unguided astrophotos or longer guided exposures, where you gain an advantage with the larger aperture and greater light gathering ability of the main scope. You can increase the narrow field of view of the main scope AND decrease photographic exposure times by using a focal reducer/field flattener. The use of a focal reducer is also advantageous because star images are brighter through the viewfinder making it easier to get the first good guess on the best focus point.

REQUIRED ACCESSORIES I would recommend the following accessories which I found to be essential for astrophotography with the Digital Rebel.

1. Canon Remote Release RS-60E3: This accessory (**Figure 5**) plugs into the side port of the Digital Rebel and allows you to fire the shutter without touching the camera, and locks the shutter open for the duration of your long exposure. Without this accessory, you are limited to 30 second exposures and the built-in 10 second camera timer. I bought mine from B&H photo for 29 bucks shipped and it is money well spent.

Figure 5: RS-60E3 remote release.

2. EOS T-ring: The EOS T-ring (**Figure 6**) is required for hooking the camera up to the either the main 8 inch SCT scope or to the 60 mm f/5 spotting scope for prime focus astrophotography. I bought mine as a cosmetically blemished unit from Agena Astroproducts for 9 bucks shipped. Agena Astroproducts is to be commended on this T-ring. It is an extremely well made fully metal unit, and works like a charm with my Digital Rebel. I still can't figure out why the T-ring which Manish Panjwani, the owner of Agena, sent me is called cosmetically blemmed. It looks brand-new and shiny to me. I didn't see any dents, dings, pecks or scratches on it when it arrived.

Figure 6: EOS T-ring from Agena Astro.

3. T-ring to 1.25 inch nosepiece: This unit (**Figure 7**)screws into the EOS T-ring, and can be attached to the visual back of the Nexstar, or into the back of the Meade astrostar scope using the set-screws on the visual back or the drawtube of the spotting scope. As before, I bought mine from Agena Astroproducts, as a cosmetically blemmed unit for I believe, 10 bucks shipped. I found it be an extremely well made fully metal unit in an attractive black finish, and threaded on the inside to accept filters. Kudos to Manish and Agena; these are both excellent products. Once again, I can't tell why it's cosmetically blemmed, it sure looks brand new.

Figure 7: 1.25 in. nosepiece.

4. Celestron f/6.3 focal reducer/field flattener: I bought this along with my Nexstar a couple years ago. It's great for both photographic AND visual use. It appears to be a fully multicoated and finely made optical piece, and simply screws onto the back of the Nexstar. The photographic field stays flat across the length of the image, and it increases the field of view substantially, which is a definite plus.

5. Lumicon Piggyback Adapter: I bought this accessory (**Figure 4**) used on astromart a while back for I believe 20 bucks. It is a solidly made piggyback adapter. It is low-form, and this keeps the attached camera, or spotting scope close to the main OTA, which is good as it doesn't shift the center of gravity away too much. Also, it is felt lined on the back and prevents nasty scratches to your OTA finish, while also providing additional frictional grip. Good product, and highly recommended.

IMAGING WITH THE DIGITAL REBEL After that loooong preamble, we get to the heart of the review. How does the Digital Rebel actually perform for astrophotography? Let's look at the three different imaging scenarios individually. The ambient temperature in all

three scenarios was steady at about 35 °F (yes, it sometimes cools down here in Southeastern Texas). Noise is a function of temperature in either CMOS or CCD sensors, but I did not have a chance to gauge the temperature dependence of sensor noise for the Rebel. I will probably follow up with either a separate review or an addendum to this one at a later date.

Scenario 1. Widefield Shots with Piggybacked Digital Rebel and 50 mm Lens

This example covers the use of the Digital Rebel with a 50 mm EF canon lens, piggybacked onto the main scope. This was done from my backyard in extremely light polluted skies. I set up the scope, equatorially mounted on the Celestron equatorial wedge and field tripod, and did a rough polar alignment. I used GOTO to point the Nexstar over to M42 (the Orion nebula), and the tracking was on. I then attached the Digital Rebel to the Lumicon Piggyback adapter which was pre-mounted on the back of the main OTA. I attached the RS-60E3 remote release to the Digital rebel. The digital rebel had the 50 mm EF lens mounted on it.

The Canon 50 mm f/1.8 EF lens was purchased from B&H photo for 69 bucks, and is a lightweight plastic housing lens. It is non-USM, but optically speaking, this lens is SHARP as a tack. I usually stop it down two f-stops to f/2.2. The optical elements are not glass, but are polycarbonate. However, it is one of Canon's highest resolution lenses. I would venture to say that it has an optical resolution exceeding 100 lines/mm, which is exceptional for a $ 69 camera lens. The Digital rebel was set to Manual mode using the mode selector dial on the top of the camera. The following settings were used on the camera: Manual mode, RAW image saving format, ISO 400, Shutter speed should be bulb, lens should be stopped down to f/2.2, and the focus selector switch on the lens should be set to MF (manual focus). I used the viewfinder and manually focused the lens on the bright stars in the constellation. Most of the Orion constellation was sharply visible in the viewfinder. I then used the hand controller to frame the shot within the viewfinder, and I then covered the front of the lens with a black cardboard piece. I used the RS-60E3 remote release, and locked the shutter open with it. An audible "click-snap" was heard. This is the sound of the exposure being fired and the mirror locking up. I waited for a few seconds (about 5 to 6 seconds) for the vibrations to die down, and removed the black cardboard piece. I used my wristwatch to time the shot which was only a few seconds long. I put the cardboard piece back on the front of the lens, and released the shutter lock on the RS-60E3. I reviewed the image recorded on the LCD screen, zoomed in to the maximum allowable magnification (10X) and examined the star shapes to determine the focus. It was not exactly in focus, so I gently tweaked the lens by a very small amount and repeated this step. When I found best focus within a couple minutes, I erased all these shots. Now, I took an exposure for 1 minute. The light pollution was horrible, and the image appeared to be completely washed out. I took a few more exposures, at various lower exposure times. No darks or flats were collected, but I could have easily done so. I then

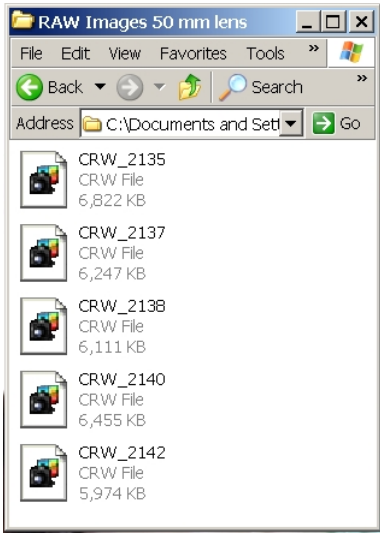

Figure 8: Raw image files are 6 MB each.

used a USB 2.0 card reader to transfer these RAW files onto my computer's hard drive, but you can also use the camera and the supplied USB cable to do this operation, without the need to remove the CF card. Then it was on to basic image processing. I opened up the folder containing the RAW image files. Each file was about 6 MB in size and had a CRW prefix as shown in the screenshot in **Figure 8**.

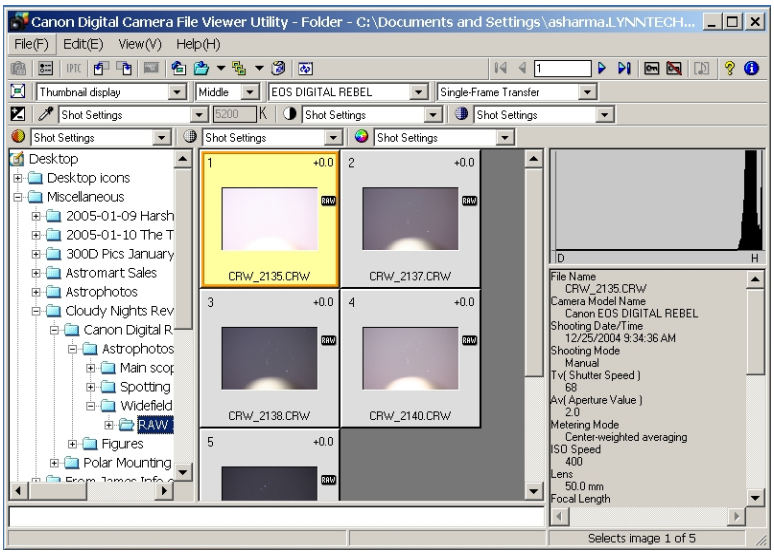

Figure 9: File Viewer Utility 1.0 RAW image thumbnail preview screen.

Double clicking on any of these files opens up the Canon FileViewer Utility 1.0 software which is supplied with the Digital Rebel. The RAW image files are displayed as thumbnails, and on the right hand panel, the histogram for the selected image is displayed along with exif information about the image, which includes exposure time, aperture, lens used etc as shown in the screenshot in **Figure 9**. This is extremely valuable information, which can be useful to gauge the quality and effectiveness of your imaging session.

The top menu bar of this program is extremely easy to understand, and rolling the mouse over each icon provides information about the function of the icon. You have options to perform digital exposure compensation on your images (akin to push and pull processing performed by film photographers). You can also adjust the white balance, the saturation, contrast, color-tone, sharpness and color space by using this program.

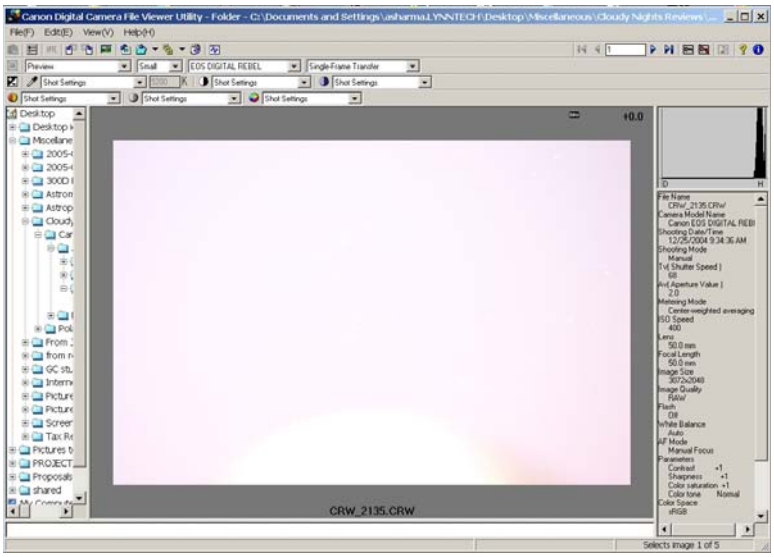

Figure 10: Double clicking the thumbnail opens up the image view. Exif information and histogram for the image is on the left panel and can be used to determine what preliminary processing needs to be done.

Note that the first exposure of 68 seconds from my light polluted skies is almost completely washed out based on both the visual appearance and the position of the image histogram. Double click this thumbnail, and the image is displayed (**Figure 10**).

On the top menu bar, double click on the digital exposure compensation icon which is the rectangular box icon with the + and – signs on it. This will open up the Digital Exposure Compensation dialog box (**Figure 11**).

I chose a -1 digital exposure compensation for this image only, and this shifted the histogram somewhat over to the left (**Figure 12**). I can now see the brighter stars which make up a portion of the Orion Constellation and the sword region with the Orion Nebula is visible too. Most importantly, the sky brightness has gone down considerably, and it will be possible to align these images and stack them using Registax easily.

At this stage I went back to the thumbnail view, and converted all images to jpegs. Click preview and select "thumbnails". Shift + right click to select all images. Then click on "File", select "Save File" and choose "Convert and Save In File". A dialog box pops up. Choose to save in the original folder and convert to Exif-JPEG with highest image quality (4). Check the do not modify file name box and click OK (**Figure 13**). Before doing this step, you can experiment with the other tools available on the menu bar, and you will see how powerful this software is in helping you enhance your images, and thereby your imaging session.

The converted files are now saved in the original folder as high quality JPEG files with minimal compression, WITH Exif information embedded within each image. For those of you who are

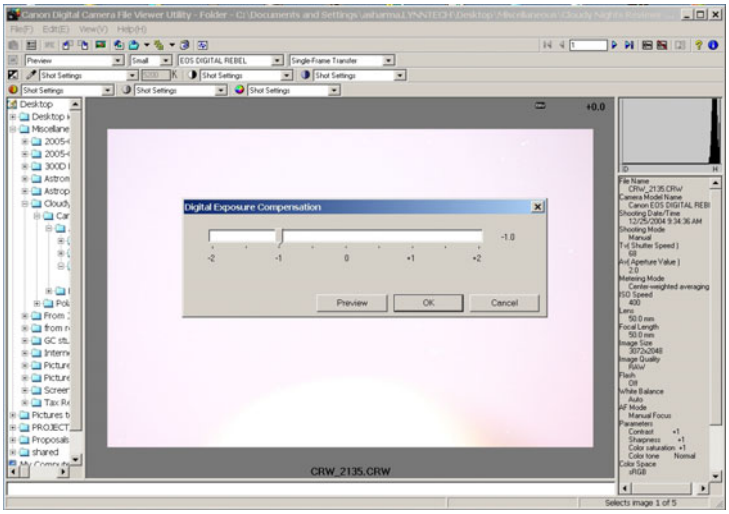

Figure 11: Digital Exposure Compensation preview.

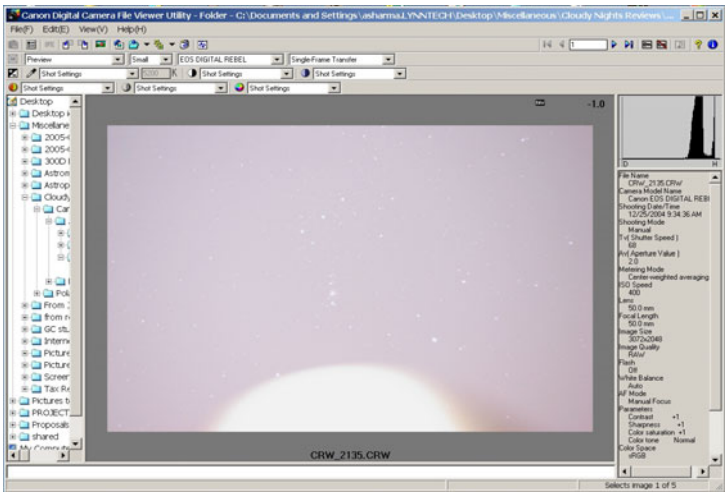

Figure 12: Digital Exposure Compensated (-1) image.

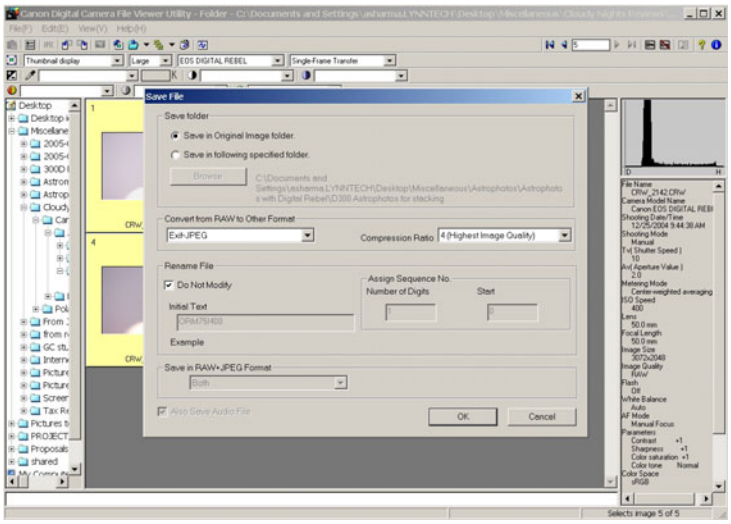

Figure 13: Save image options dialog box.

wondering, Exif information is also used by your photo printers to substantially enhance the look and feel of your printed pictures. All the following steps will cause you to lose this information, but it is unavoidable, because in order to obtain smooth, less noisy and visually pleasing images, further image processing is a necessary evil.

At this stage I began the image stacking process, using the freeware software Registax, to increase the signal-to-noise ratio (**Figure 14**). Since noise is random in every image, but the pixels corresponding to the actual stars occur in a fixed pattern, by stacking, you add the signal pixels up, in effect, decreasing the noise in your stacked image and obtaining a smoother image. For this operation, I use Registax since it is freeware and works wonderfully for the purpose of automatically stacking and smoothing my images.

When Registax is opened up, check the boxes for "Use Colour", "Automatic Processing" and 512 in "Alignment box". Click select and use the file select dialog box to navigate to the original image folder, choose still frame (jepg) to display the saved Exif-JPEG image files, and shift+right click on all of them to load them into the Registax queue. At this stage, the first image is displayed in original image size, with a 512x512 square pixel box to select the feature that Registax must use to align the images to each other, and them stack them up. Choose the middle belt star in the Orion Constellation region, and place the

Figure 14: Registax main window.

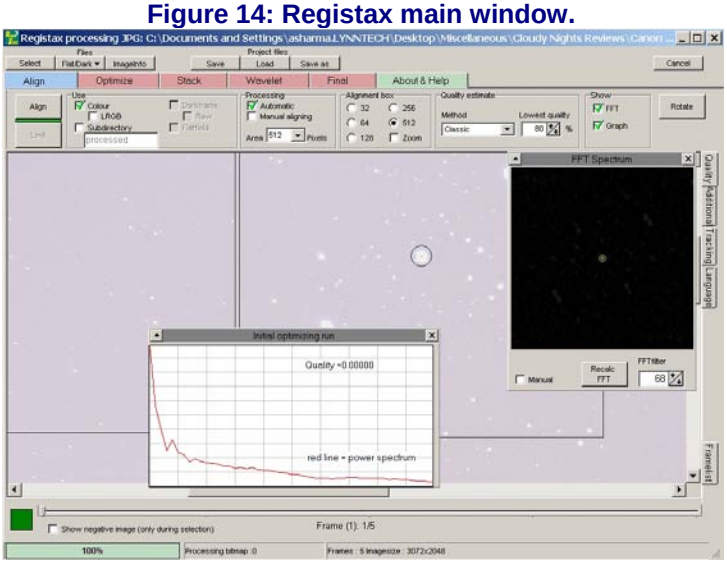

Figure 15: Initial alignment, FFT and power spectra.

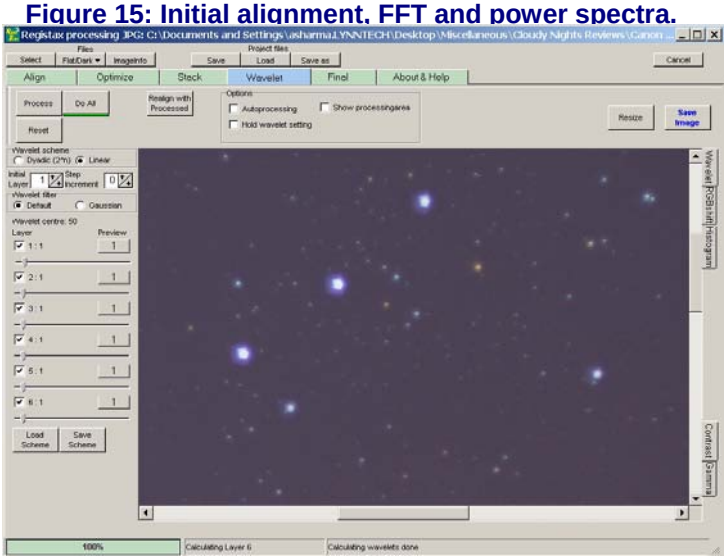

Figure 16: Optimized, Aligned and stacked result.

alignment box squarely over the center of the star image, and click once. The program calculates the FFT (Fast Fourier Transform) spectrum of the initial alignment feature, and displays an initial optimizing run window, depicting the quality of the graph and the power spectrum (**Figure 15**).

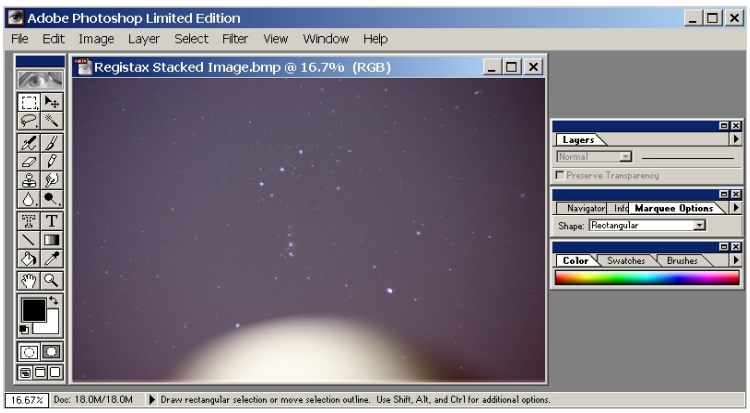

Figure 17: Stacked image in Photoshop main window.

At this stage I chose "Align" from the top menu, and the program automatically optimized the image orientations, automatically aligned the images for stacking, and automatically stacked the images on top of each other. It also automatically did the default wavelet calculations and finally displayed a very nice smooth image on the result screen. Some effects of the stacking were immediately evident; the washed out sky was replaced by a darker sky where several fainter stars were clearly visible, the bright stars which were visible in the starting images were substantially enhanced in brightness and had a lot more visual punch now, and the level of noise in this stacked image was SIGNIFICANTLY smaller than that in the individual frames. In addition, the image was turned from a horribly low contrast image into a nice smooth and higher contrast image now (**Figure 16**).

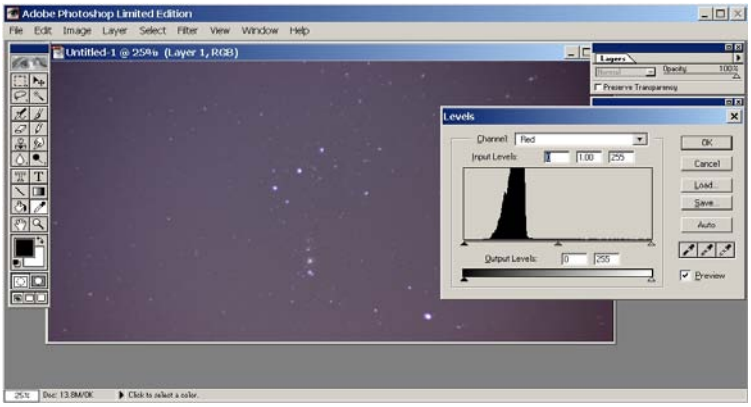

Figure 18: Levels adjustment in Photoshop.

At this stage, I elected to save the image into the original folder with a new name, as a bitmap file. If you do not have Photoshop, Registax does have the ability to allow you to perform Gamma corrections, levels adjustment using the histogram and clipping and stretching it, calculating RGB shift and adjustment of the contrast. You can then resize the image to a nice smooth JPEG or GIF or Bitmap file, for later viewing, or printing. I opened up the stacked image in Photoshop LE 5.0 (**Figure 17**). The first thing to do is crop out the annoying out-of-focus dew-shield on the front of the main OTA which was captured in the

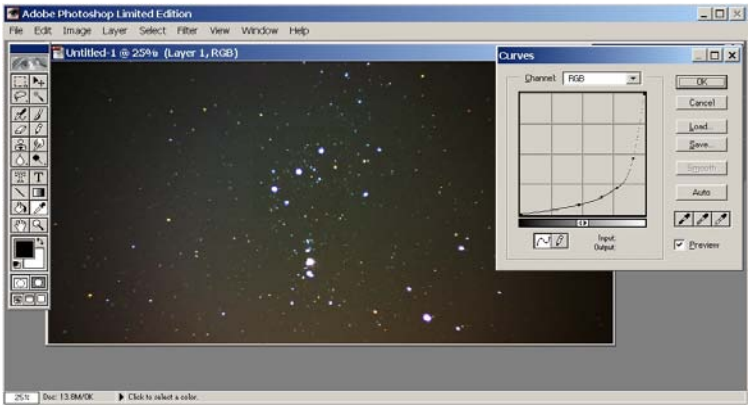

Figure 19: Curves adjustment in Photoshop.

images. Then from the top menu, choose “Image”, and then “Adjust”, and then “Levels”. This opens up a separate dialog box which has the RGB histogram and the histograms for the individual Red, Blue and Green Channels. Choose the red channel (**Figure 18**) and clip the histogram from the left and right by moving the tabs beneath the histogram to positions where the curve just begins to increase above the baseline on both sides. Move the central slider tab to the center of the clipped histogram curve. Repeat this process for the green and the blue channels. You will get a resulting image which looks extremely bright, with many stars visible across the field, with a slightly higher noise level. This image can be adjusted further by choosing Image, Adjust and Curves. A dialog box pops up and the displayed curve can be stretched from the linear shape to a nearly exponential shape in the combined RGB channel. The result: a very nice, smooth wide-field shot of a large portion of the Orion Constellation region, clearly showing a large number of faint stars across the field, the belt stars, the stars of the sword region, and of course a very bright Orion nebula, with some red emission displayed at the edges of this nebula (**Figure 19**). The image can be further cropped and saved as a JPEG, and is shown in **Figure 20**. I think that this image is pretty representative of what a novice astrophotographer should be capable of achieving the first night out with the Digital Rebel. The total combined exposure time for this image was (68 + 24 + 12 + 24 + 10) = 138 seconds, which is 2 minutes 18 seconds. Clearly with many more stacked images, and dark frame subtraction the final result will be even better. All this from my horribly light polluted backyard!!

Figure 20: Final image showing a large portion of the Orion constellation.

Scenario 2. Piggybacked 60 mm f/5.8 Meade Scope attached to the Digital Rebel

The Meade 60 mm f/5.8 astrostar scope is a typical example of a low cost (read department store) $ 40 all plastic construction scope. I bought this on an impulse from Ritz Camera, because the scope was "on-sale", and I liked the color. It's actually not bad looking, and at least the objective is a glass doublet (**Figure 21**), not plastic. It appears to be single coated with MgF_2 judging from the very light blue coating color, and the fact that I can see a lot of reflection off its surface (**Figure 21**). It has a fixed black plastic dew shield, which actually does function, in keeping dew off the objective for a substantial amount of time up-to an hour or more. There is a standard 1 ¼" mounting block on the underside of the scope, but the small supplied tripod which comes with it is practically useless. It comes in a padded carrying case, which is halfway decent, and the scope itself is quite short and lightweight. It has an erecting prism diagonal and comes with your typical Chinese plastic bodied Kellner oculars, a 17 mm and a 9 mm where the lens elements are fully uncoated but are made of glass, and an all plastic Barlow, including the lens. Is there any spurious color in this scope? Visually very little is noticeable, such as a thin yellow line across the limb of the moon, and a faint purple halo around Sirius and Vega. On fainter stars, there is none, visually. In large part it's probably due to the small aperture of 60 mm. Photographically, it is a different matter and lots of false color can be recorded in long exposures especially around brighter stars. The objective cover actually has a central screw-off aperture which lets you stop the objective down to 40 mm, and bring the effective focal ratio up to f/8.8. While you lose some light, the chromatic aberration goes down some on even the brighter objects. The drawtube and the focuser leave a lot to be desired, as there is a lot of slop and movement. However, it is possible to achieve sharp focus with this sloppy arrangement. Visually, this scope works well for open clusters in dark skies, clearly showing a whole bunch of faint stars along with the brighter stars in the Pleiades, and it can easily fit both cluster components in the field of view with a lot of room to spare on the Double Cluster. The Meade astrostar scope is mounted on the Lumicon Piggyback adapter on the Nexstar, and I use the Agena Astroproducts EOS T-ring and T-ring to 1.25 inch nosepiece converter to directly insert into the drawtube of the spotting scope. The arrangement is ungainly, but it works. As before, I roughly polar aligned the Nexstar, and pointed it towards the Orion Nebula with Tracking on.

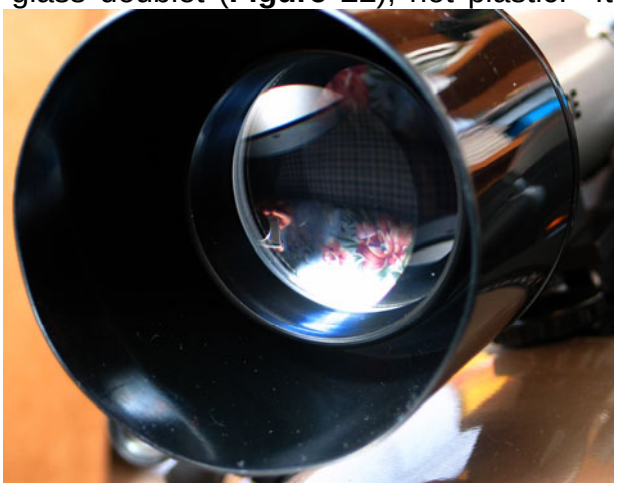

Figure 21: The objective of the Meade 60 mm astrostar is a single coated (MgF_2) glass doublet.

I took six images ranging from 1 minute to 3 minutes at ISO 400. The images were then all opened in the Canon FileViewer utility and digital exposure compensated +2 stops. Look at the raw image at 1 minute which has been pushed by +2 stops (**Figure 22**, top). I was pleasantly surprised, in that this small aperture challenged scope had not only recorded a nicely detailed image of the Orion Nebula as well as

DeMarian's Nebula (M42 and M43), but had also tagged the faint blue nebulosity in the Running Man nebula (NGC 1977) too, and the field of view was wide enough to cover both objects with lots of room to spare. The image is a tad noisy, but it's not too bad. I followed the procedure outlined above for the Registax stacking, and Photoshop processing and cropping, and obtained a really nice smooth image, which was well, quite nice IMHO (**Figure 22**, bottom). The total exposure time for the six images used for the stacking was slightly less than 8 minutes. Not too shabby at all.

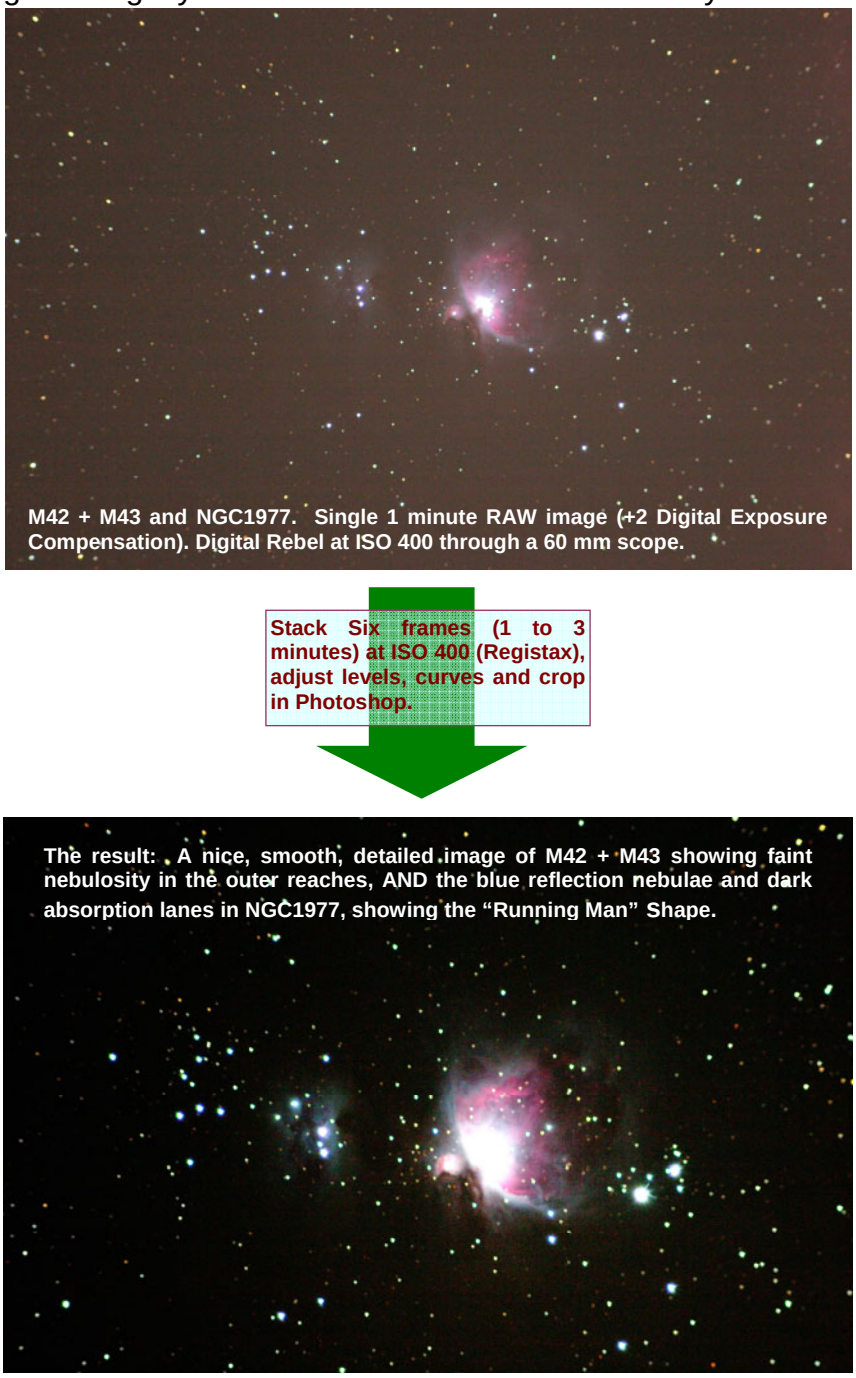

Figure 22: M42, M43 and NGC1977 region shot with a 60 mm f/5.8 scope and the Digital Rebel.

After seeing these results, I wanted to challenge this small 60mm scope and Digital Rebel combo even more. I figured that the Horsehead and Flame nebula complex would make an interesting fainter target for imaging with this combo. In addition, I wanted to see if ISO 1600 would be useable. I collected 14 separate images ranging from 40 seconds to 3 minutes with a total exposure time of 24 minutes. The exact same post processing was done on these 14 images. The resulting image is shown in **Figure 23**. Even though it's noisier than the ISO 400 shot of the Orion

Stacking, levels and curves adjustment

Figure 23: Flame and Horsehead Nebula complex using a 60 mm f/5.8 scope and the Digital Rebel.

complex, it clearly demonstrates that ISO 1600 is quite useable.

Scenario 3. Digital Rebel at prime focus of the Nexstar 8i SCT scope at f/6.3

The final scenario is prime focus astrophotography, with or without the use of focal reducers. I used an f/6.3 focal reducer on the main scope for this third scenario for images of the Orion Nebula which could be barely fit into the photographic FOV. A total of five unguided exposures ranging from 30 seconds to 2 minutes for a total exposure time of 5 minutes were +2 digital exposure compensated, stacked and processed as before. A starting 1 minute +2 exposure compensated frame (top) and the resultant image (bottom) are shown **Figure 24**.

Figure 24: M42 and M43 taken through an 8 inch SCT scope at f/6.3 using the Digital Rebel. Stack of five images (1-2 min) at ISO 400.

PROS AND CONS OF THE DIGITAL REBEL

Like any other imager, the Digital Rebel has its some desirable and not-so-great features. I'll try to list those which I noted.

DIGITAL REBEL PROS	DIGITAL REBEL CONS
• Lightweight • Low noise sensor (CMOS) for control of dark current • Large area sensor (APS size) for decent sky coverage • Power efficient • Quite Sensitive over the visual spectral range, with good Hα sensitivity • Standalone (no laptop needed) • Goodly number of practical accessories available • Capable of deepsky imaging "right-out-of-the-box" • Easy operation; usable by novice and experienced imagers alike • Powerful software included for basic image processing • Price (excellent for a 6.3 MP interchangeable lens DSLR) • Can be used for astrophotography AND regular photography	• Uncooled, so dark current can only be controlled for a short time • Not a full frame sensor so some cropping (1.6X) occurs compared to 35 mm film • No mirror lockup • LCD screen is too bright even at lowest setting at night • Price (three times a Meade DSI) • Hα sensitivity is good but not excellent

CONCLUSIONS

At the beginning of this review I posed the question, "Can the Digital Rebel be used by everyone for deepsky astrophotography?" The answer is a definite YES. The camera makes astrophotography reasonably easy. The supplied software is a powerful tool for basic image processing, and there is freeware available to further process the images to obtain very decent deepsky astrophotos by anyone, beginners and experienced imagers alike. This DSLR is doubly attractive, because unlike dedicated imagers, you can use it for both astrophotography and regular photography. And, it takes great daytime shots too. However, there a few things to be aware of before deciding to take the plunge. The sensor is low noise CMOS based one, so the dark current can be controlled for some time. Unlike a cooled imager, dark current will begin to accumulate to noticeable levels faster, especially at higher ambient temperatures. There are other small concerns noted in the cons column of the table above, but overall, in my humble opinion the pros of this camera far outweigh the cons, and it receives my enthusiastic recommendation, especially for beginners. In the end, I want to leave you with two examples of a daytime and a night-time shot taken with this camera to show that it is an excellent DSLR for astrophotography AND everyday use.

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