

## Meade DSI Pro Camera Deep Sky Images “Your First Night Out”

by *Jim Thommes*

This is a great time to be an amateur astronomer. Technology has brought us superior and affordable optics, computer controlled GOTO motorized mounts, and sensitive CCD sensors. Now Meade has developed their Lunar and Planetary Imager (LPI), soon followed by their Deep Sky Imager (DSI), and now available is the Meade DSI-Pro. This latest DSI-Pro offering from Meade makes a very sensitive astronomical sensor available to the amateur astronomer at a price pretty much unprecedented for the features offered. So how is this DSI-Pro performance wise? What does it present to the introductory or intermediate astro-photographer? Read on to see if this review can answer these questions.

### What you get

The DSI-Pro comes in two price flavors (at the time of this review). There is the DSI-Pro for \$399 and the DSI-Pro with filter set for \$499. The only difference between the two is the set of four filters (Red, Green, Blue, and Clear) of the filter set. Assuming you get the DSI-Pro with filters, you get the filters plus the following:

- DSI-Pro Monochrome Camera
- DSI-Pro filter slide
- 1-1/4 inch male nosepiece to male T-Thread
- USB cable
- Parfocal ring
- Serial DB-9 PC connector and RJ-style serial cables to connect to Meade Telescopes.
- Autostar Software Suite.

The last item, the software suite includes a planetarium program, a camera management and image capture program, and imaging processing software. This should be enough to get most people started as long as they can bring a telescope and a computer to the party. Will you need anything else? Well, like many things regarding astronomical equipment one seems to always find things to buy to “improve” their setup.

### What you still need

As indicated, you need to bring a telescope and a computer to the setup to begin taking astro-photographs. A little understanding is needed about what these need to bring to the party. First, the computer minimum requirements as given by Meade in the manual is:

*“PC running Windows 98SE with 96 MB and 100 MB free disk space.”*

Well, you also need a USB port. Meade says you can use a USB1.1 or a USB2 interface. I have used a USB1.1 with disappointing results and it seems many of the more experienced DSI users have recommended a USB2 interface. (The consensus seems to be that USB2 is pretty much a requirement.) If you are using a laptop computer that does not have a USB2, you can purchase a powered USB PCMCIA card to install in one of your Laptop’s PCMCIA slots. It is important that this card is “powered” either from a separate external supply or external cord to the mouse port to pick up 5 volts. If not powered, the camera electronics will likely be recognized by the computer, but the CCD systems in the camera will not be powered properly and image data will not result. If you run with a desktop PC that does not have a USB2 interface, I believe there are USB2 interface cards you can purchase to install into your PC.

We will get more into the camera specs later, but one thing to know is that the CCD used in the DSI-Pro is somewhat small. As such when used with a Schmidt-Cassegrain for example with a focal length of 2030mm (8 inch f/10 instrument), the horizontal field of view will be about 8 minutes. This will be quite small for many deep sky objects and quite challenging for someone just starting out. So many would do well imaging with a shorter focal length to begin with. Meade has 0.63x and 0.33x reducer correctors for their Schmidt-Cassegrains. Others make focal reducers that screw onto the nosepiece like a filter. Or a small refractor may be used as the optical instrument. The message here is to try to select telescope system with a manageable focal length for your first images – 400mm to 800mm would be good fist time choices. A purchase of a focal

reducer may be needed for your system.

Finally, this may not fall into the “need” category per se, but it may be a good idea to look up the experiences of others with the DSI-Pro. This series of cameras is looking to be pretty popular for Meade, so there are other reviews to look at. Notable ones are the Sky and Telescope review of the DSI and DSI Pro in the October 2005 issue, the Weasner site DSI Pro review, and our own Cloudy Nights Suk Lee review of the DSI. The Suk Lee review is at: <http://www.cloudynights.com/documents/ds1.pdf> and while it is not on the DSI Pro model, there are very helpful insights on the use of the software. In addition to the reviews, there is an active Meade DSI Yahoo Group. There are many experienced users willing to answer your questions. The files section contains lots of detailed information about the DSI cameras. Finally, the Camera Information and Specs

**Meade offers the following information about the DSI Pro camera:**

## SPECIFICATIONS

<b>CCD Sensor</b>	High Sensitivity Sony® ExView HAD™ Monochrome CCD Sensor
<b>Pixels</b>	510 x 492 pixels (250,000 pixels)
<b>Pixel Size (in microns)</b>	9.6 microns (W) x 7.5 microns (H)
<b>A/D Conversion</b>	16-bit (greater image depth and contrast)
<b>Min. – Max. Exposure Time</b>	1/10,000 of a second to one hour
<b>Housing</b>	Anodized die-cast aluminum
<b>USB Compatibility</b>	High Speed 2.0 and 1.1
<b>Size / Weight of product</b>	3.25" x 3.25" x 1.25"/ 10 oz.

The CCD used is the Sony IXC254AL. The image area size as given by Sony is a 6mm diagonal (type 1/3 size CCD). The horizontal by vertical imaging area is approximately 4.8 mm x 3.6 mm. This is the size that along with focal length will determine the field of view of the image taken. There are FOV calculators available on the internet.

Also, not specified by Meade anywhere I could find, the back focus distance from the T-Thread mounting surface to the CCD surface is 24 mm. This distance is needed when setting up the correct distance from CCD surface to a focal reducer. It is not the scope of this review to go into detail on focal reducer setups and calculations, but this back focus distance is needed for focal reducer calculations.

There is no binning with this camera.

## Software Installation and Setup

I was particularly interested to see how well the software installed on an “almost” minimum system since, like me, many may choose to use a dedicated astronomy laptop of an earlier generation. I do this to avoid subjecting my state of the art laptop to the dew, dust, and dark foibles in remote site imaging. I installed the Autostar software suite over a network (no CD in the laptop) on a Dell Inspiron 400 (128MB Ram 850 MHz PIII) system operating with a Windows ME OS. The install took about 12 minutes over a 10 Mbit network. There are the non – Microsoft certification warnings that Meade warns about as well as a little confusion over finding the driver location when plugging in the camera. All of this was easily resolvable by someone

with rudimentary computer skills. So in all, the installation went well on a minimum system. I also made an install on a Desktop PC (256MB RAM 2.8GHz) operating with Windows XP without any difficulty.

There is one finding subsequent to the install that is worth noting. On the laptop, the display is 1400 x 1024 pixels and for my old eyes, I had the fonts set to "large" rather than "normal". Autostar software does not seem to handle this font size well (at least with the Dell video system). Many of the dialog boxes were not sized right for the font and needed to be bigger – only they would not resize, magic eye focus window was truncated, and various other difficulties related to font size were experienced. The good news is that when I made the font setting "normal" then there were no further difficulties with font size – Autostar software did not need to be re-installed.

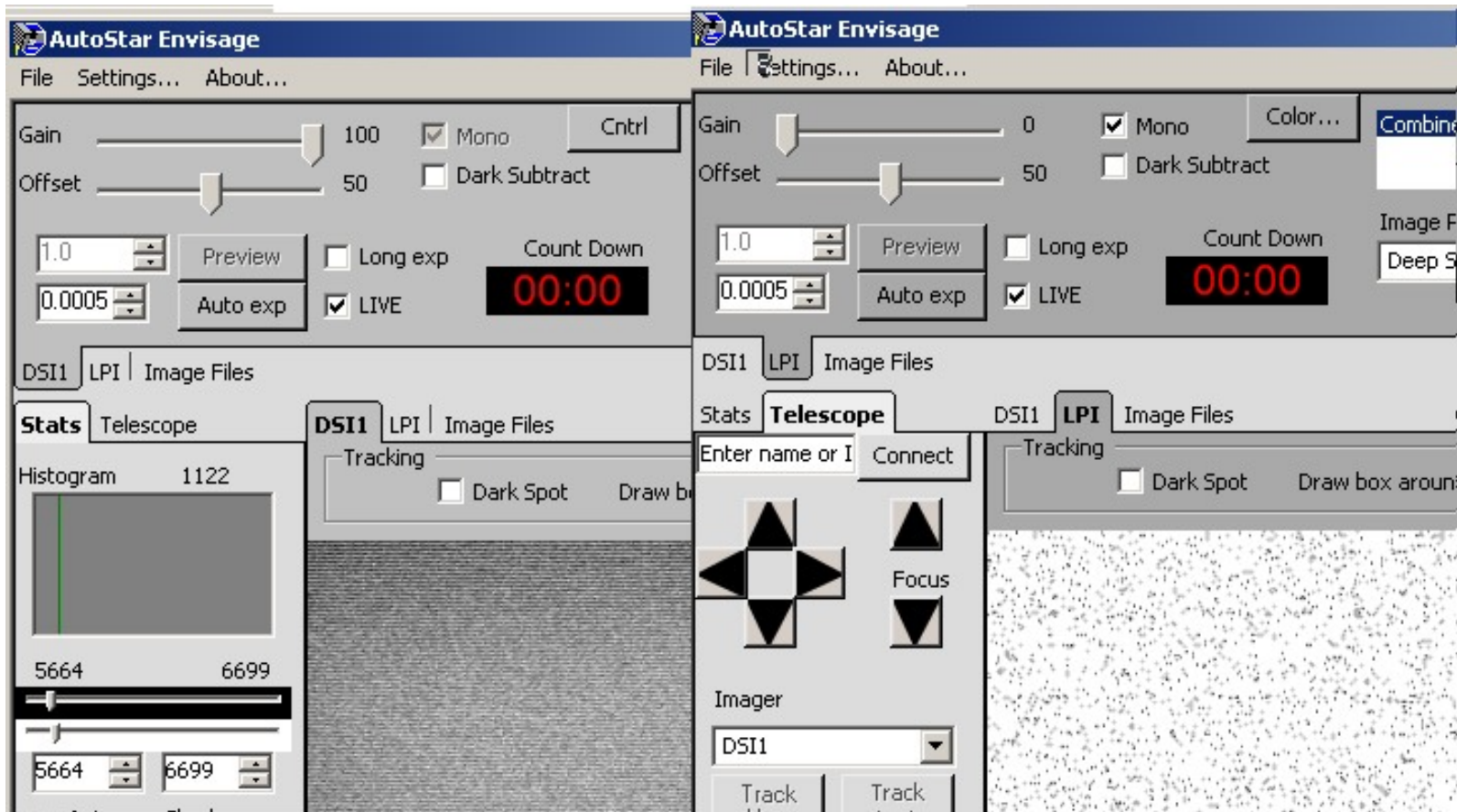
When complete, the programs installed are:

1. Autostar Suite – Planetarium and telescope control application. This can be used to locate and frame objects. Eyepiece and CCD FOV windows can be used.
2. Autostar Envisage – Camera control and image capture application. This is used to capture your images and autoguide / focus. Needed camera drivers are also installed.
3. Autostar Image Processing – Image align / stack processing software. This is to process exposure data to prepare for further processing.
4. Updater – Autostar updater application. This is used to update Autostar Suite data or version upgrades.
5. Manuals – basis manuals for these applications.

### Multiple cameras

I was also interested to see how well the software worked with multiple cameras. If one was interested in taking deep images of faint objects and nebulae, auto guiding becomes an important consideration. With the Meade cameras, a separate camera and guide scope or off axis guiding pick up is used for auto guiding. Auto guiding function is built into the Autostar software Meade has designed their software to be compatible only with Meade telescopes and since I do not have a Meade mount / telescope, I could not test this feature fully. I could, however, verify the operation of two cameras, a DSI Pro and an LPI. There are external emulators that can be built from kit form for the "do it yourself" or complete external interfaces that will convert the Meade Serial signals to the 4 drive directions signals for auto guiding common to many other mounts. The interested reader can find needed information with an internet search for "LX200 emulator".

I set up the DSI Pro on a separate USB PCMCIA card and the LPI on the laptop native USB port. This setup worked perfectly with the Autostar Envisage camera software. The application comes up with tabs for each camera, the DSI Pro and the LPI. The figure below illustrates the two tabs and in the LPI screen, the "telescope" control for auto guiding is shown rather than the "stats" settings.



## The Manuals

I will take this opportunity to suggest that a thorough reading of the manuals is in order before trying that “first night out” image. In fact it is probably best to spend a few daytime hours or nighttime inside hours to develop a full understanding of the camera and the software. I found that the software is not inherently intuitive, but once you get used to it, it is fairly serviceable. The controls seem somewhat complex. By Meade’s own manual, the Autostar Envisage main screen has 40 control settings – many of which have multiple sub control settings underneath. So the best advice here is to study and understand the operation of the camera thoroughly before getting out in the dark and not getting desired results.

The controls area is where I am somewhat critical of the DSI system. I feel these controls could have been better thought out and organized. For example, including taking darks, there are four different locations for setting exposure time of the image (for each camera). Several time I found myself exposing for a duration that I had not intended.

The “Magic Eye” focus is also an area of uncertainty. Focus is a critical element of astrophotography. It is important to get this as accurate as possible – if its not, then everything else afterward to the finished image is compromised. I did seem to get some results from the “MagicEye” however, in the review I mentioned earlier, Suk Lee found magic eye “not to be useful”. I believe I achieved some degree of focus quality using it, but it was hard to be sure – particularly with 1 sec and longer preview times. It is unclear what the focus algorithm is. Most programs use a star point spread analysis or Full Width Half Maximum (FWHM). With FWHM, one isolates a star (usually with a box or double click) and the capture software reads out the maximum and the pixel width at half the maximum. The objective is to increase the maximum and decrease the width. Coupled with a zoom feature in the image window, FWHM can be very effective. At least Meade would do better with a zoom feature in the image window. As an alternative, some operating systems or video set ups may have a “magnifier” feature that may help.

Finally, it was not apparent that any changes should be made to gain and offset for the DSI Pro. It seemed to me that gain was set to pretty much utilize the full well capacity of the ICX254AL CCD. Setting it lower did not really give more range as the pixels would be full anyway. The offset would shift the range around somewhat but generally not serve to increase it. I felt it was best to leave the gain at 100% and the offset at 50%.

Other than these areas of constructive criticism for Meade I will have to say that I found the software to be useful and it faithfully recorded every image exposed.

## Formats and pixels

It is useful to have a discussion about pixels, formats, and CCD geometry. The DSI Pro CCD has non square pixels – they are 9.6 x 7.5 microns. This means that a horizontal pixel really cover about 128% of the horizontal dimension. If pixels are read directly from the CCD the resulting image is scrunched horizontally by about 78%. In order to give the image the correct aspect ratio (1:1 vertical:horizontal) the image must be resized horizontally by 128%. Meade Envisage does this internally when combining images.

Autostar Envisage software gives the user the opportunity to save not only combined images but all the individual exposures for later processing. Two options on saving individual exposures are saving “all uncombined images” (these are aspect corrected and 648 x 489 pixels) saving “all raw images” (these are uncorrected aspect and 508 x 489 pixels- scrunched horizontally to 78%). In order to get the full dynamic range of the CCD system, it is advisable to select one of FITS file formats rather than the others. Although, if one is uncomfortable with the FITS format, the TIFF format is a go alternative. Envisage software allows saving in file formats of BMP, GIF, JPEG, PNG, TIF, FITS, FITS3P, and FITSINT.

It is important for the user to select the appropriate file type and save option if subsequent processing of the individual exposures is desired. It is also important for the user to know that the Dark frames that Autostar Envisage saves when it takes darks are the Raw format with the scrunched horizontal scale. This means that if the user wants to save individual exposures already scaled horizontally, he cannot use the DSI darks to calibrate the exposures. Instead, a series of Dark exposures saved with the same process must be used. In this case the user must combine their own darks for a calibration dark frame.

In the demonstration images I made of M38 and M42, I chose to use the raw images (un-scaled horizontally). I also used a set of dark frames I later combined rather than the darks made in the “Taking Darks” mode of operation. I felt this would provide the most accurate results using post processing methods.

## Issues I found

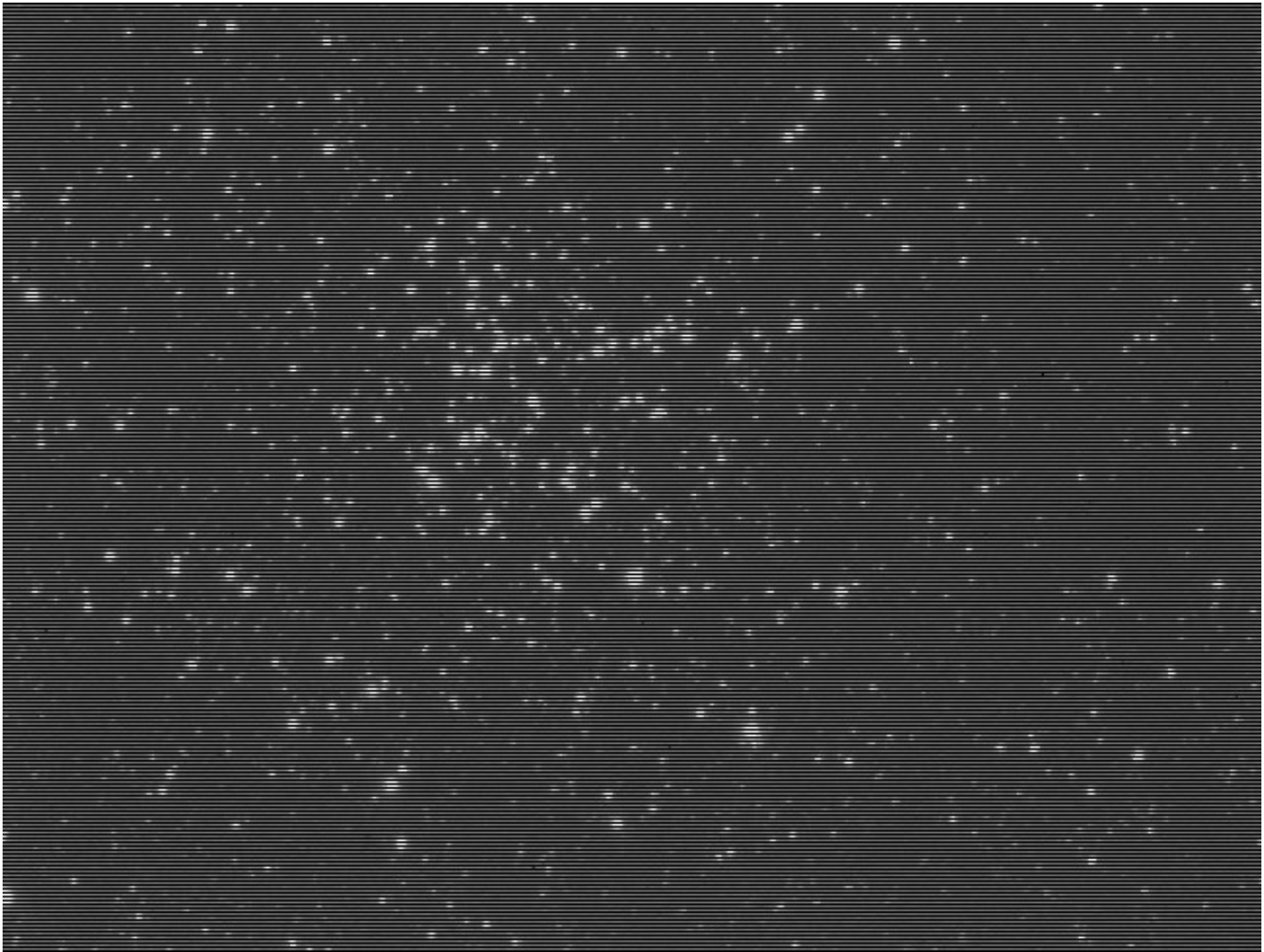
One item of note – when I was imaging, I received a dialog error box saying :  
“File save error status = 412”

I do not know it’s meaning, but it did not prevent me from saving data. I could not get this message in the daytime experiments and it would not appear if the image did not pass quality minimum and as such was not combined into the image. For reference, I was using FitsInt file type and a “save all raw images” procedure. The software versions I tested were:

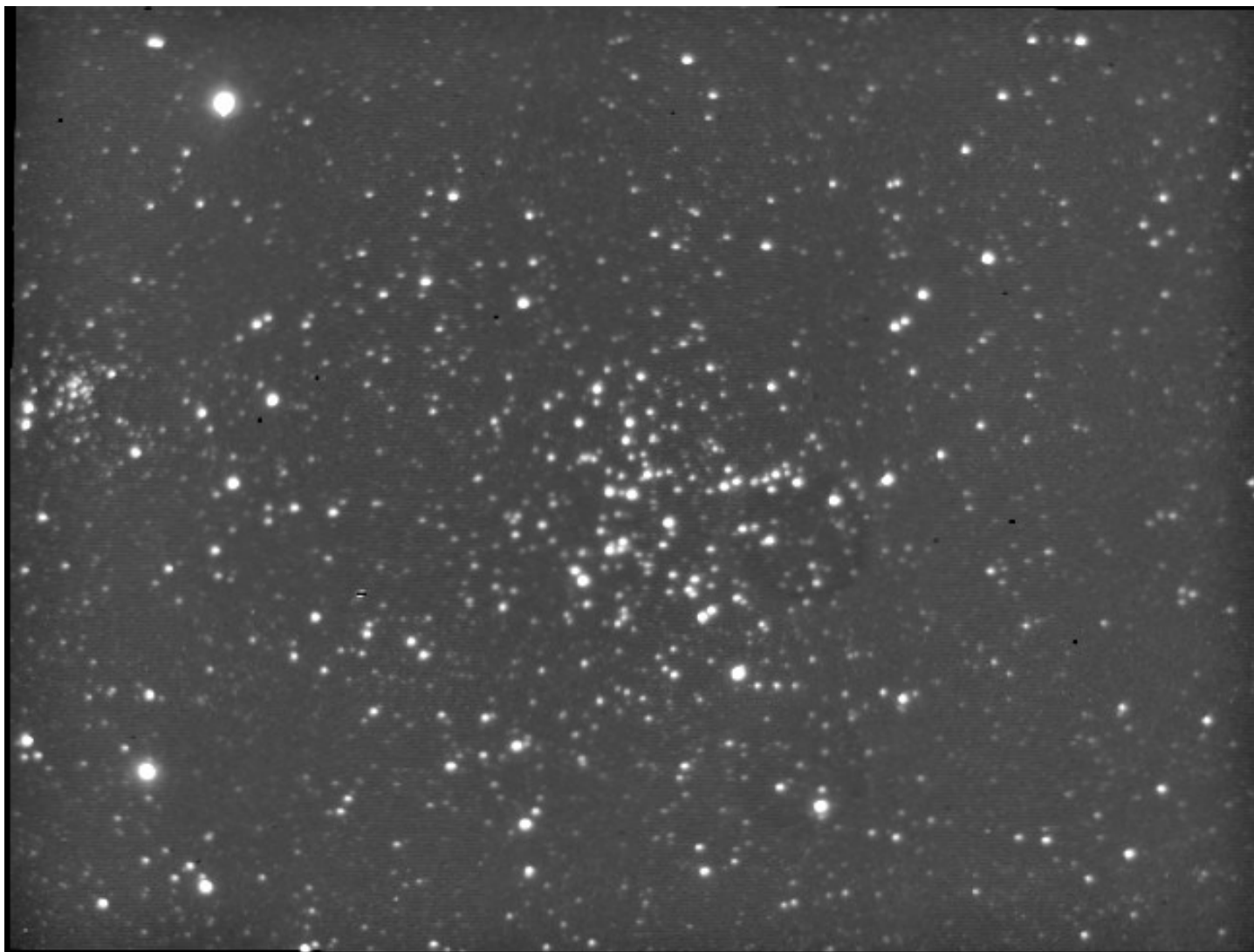
Autostar Suite	v3.18
Image Processing	v3.21
Autostar Envisage	v4.00

I understand that the latest version of Autostar Envisage on the Meade website is v4.12. I do not know if this error dialog would appear on that version. Regarding USB1.1 vs. USB2 that I had mentioned earlier, I found that I was not able to get “great images the first night out”. I was foiled by USB1.1. As I had mentioned earlier, even though Meade says that the DSI Pro will work with USB1.1, I found that for my particular set up the results were disappointing. Indeed many of the experienced DSI users for the Meade\_DSI Yahoo group recommend USB2. I have provided results below, illustrating the different results I got with USB1.1 and USB2. These are 15 combined images with the background excessively lightened to illustrate the horizontal bands with USB1.1.

### My Experience with USB1.1



*Image of M38 with USB1.1*



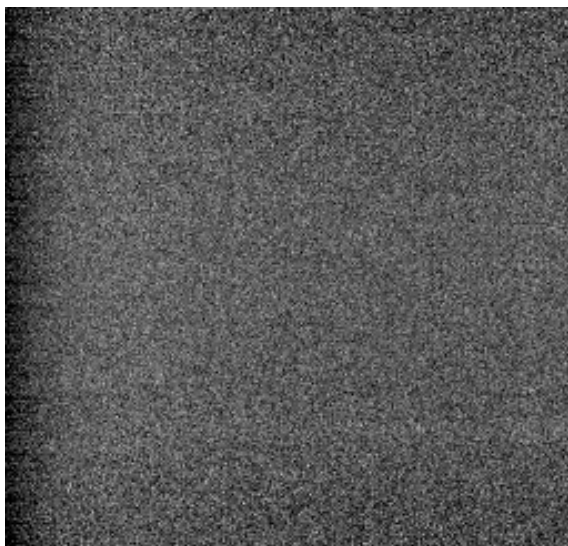
*Image of M38 with USB2*

### Some Specific Tests and Findings

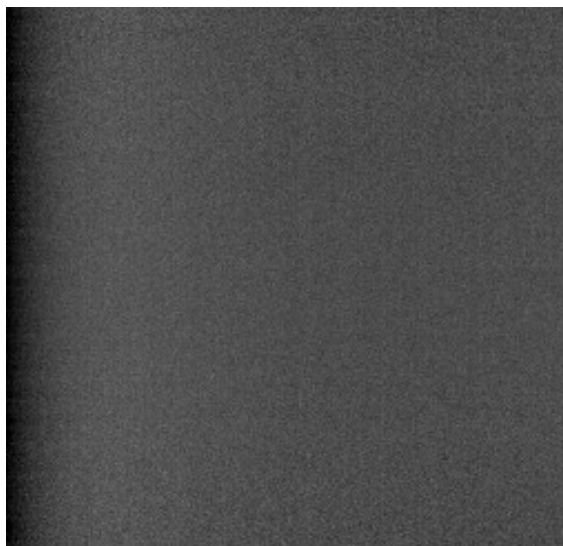
**Read Noise** - Before actually going out for my first night or my second night, I wanted to make some specific tests with the DSI Pro indoors. Read noise measurements were taken (in terms of Analog to Digital Units – ADUs). Read noise frames were taken with an exposure time of 2 msec at approximately 22C degrees ambient temperature. Standard deviation for the single exposure was 24.2 ADU (out of 65,535 at 16 bits). When 16 similar frames are averaged, one would expect the Standard Deviation to go down by a factor of 4 (4 is the square root of 16 and noise will reduce roughly with the square root of the number of frames stacked.) in this case the Standard Deviation of the stack was 5.2 (close to the predicted 6). Resized and equal stretched example images are shown below:

This read noise is on the high side for a 16 bit camera. But this noise is very manageable. The implications (true for any camera really) is that one wants to expose long enough such that the signal is significantly greater than the single frame read noise and then stack enough images to improve signal to noise. Remember, all other things equal, the signal to noise ratio will improve with the square root of the number of stacked frames. To get a 2X improvement in signal to noise the ratio, stack 4 frames; to get 4X, stack 16; but to get 8X, stack 64!

READ NOISE



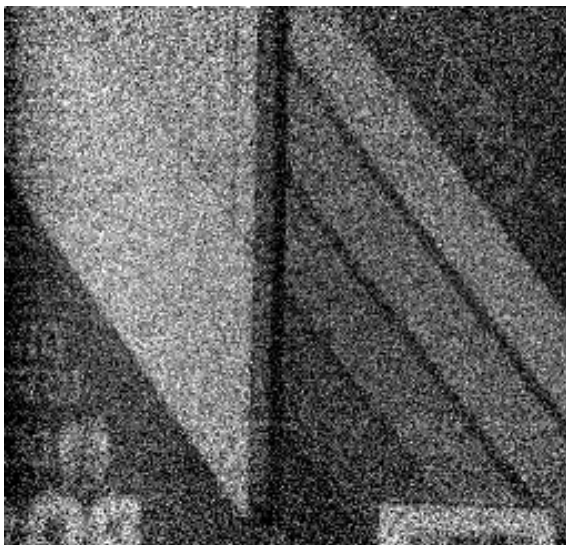
*Read Noise Single Exposure*



*Read Noise 16 Stack*

The objective for the DSI Pro user will be to expose long enough to get the weakest desired signal well above 2x to 3x of the 24.2 ADU read noise and stack probably a minimum of 12 to 16 frames. The effect of read noise is illustrated in the set of images below. There is an image of a single frame taken at .5msec and the 16 frame average. To compare there is a single frame image of 4x exposure time - 2.0msec and its corresponding stack of 16. In comparing the images, it is clear that the 4x exposures minimize the read noise relative to the signal even though the stack depth is the same.

#### READ NOISE IN IMAGE



*Single Shot 0.5msec Raw (508x489)*



*16 stack 0.5msec Image (648x489)*



*Single Shot 2.0msec Raw (508x489)*



*16 stack 2.0msec Image (648x489)*

**Dark Frames** - So based on read noise, one should take really really long exposures - right? There are of course limitations to this strategy. Sky background, mount tracking and stability are the typical limitations. For the DSI, being an un-cooled camera, thermal effects may be a factor. However, one could experiment with their own cooling or try third party coolers (such as the Mogg Outback Cooler). For reference, I have included below three dark frames of 30, 60, and 120 seconds at about 22C degrees ambient temperature. They are just JPGs but the visual comparison shows the effect. These were fits files linearly stretched from 0 to 15,000 ADUs (out of a theoretical 65,535 16 bit system). The estimates on the internet for the Sony ICX254AL CCD is a well depth of 55,000 electrons, so there is an approximate match of electron to ADU for 50 offset and 100 gain settings. At 2 minutes, 6,742 (about 2.7%) of the pixels were above 20% filled. At this temperature, limited dynamic range may begin to degrade results at longer exposure times. One other point regarding the darks taken by Autostar Envisage, it appears that a bias level is removed from the darks. Stacking my own darks showed higher background levels than the Meade darks and indeed the very short read noise frames above showed a background level of about 4,500 ADU; the Meade darks were 560, 750, 1450 for 30, 60 and 120 seconds respectively. One may want to consider using a bias frame if one uses the Meade darks for calibration in the Image Processing application.

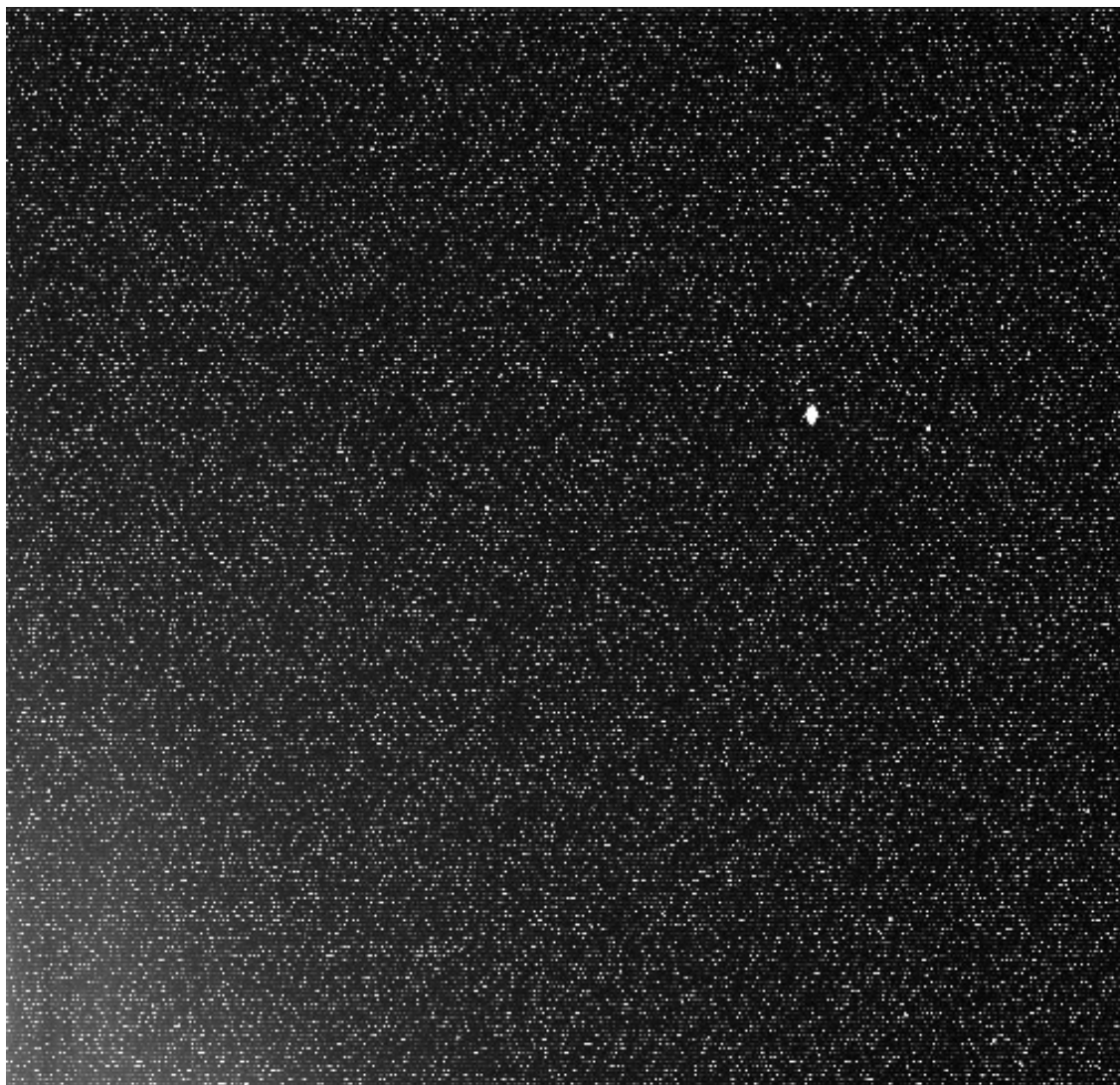
## DARK FRAMES



*30 Second Dark (0-15,000 ADU linear stretch)*



*60 second Dark (0-15,000 ADU linear stretch)*



*120 second Dark (0-15,000 ADU linear stretch)*

### **Image Results M38 and M42**

So after some study of the camera system and an unimpressive “first night out”, I did get a chance to get out on a second night and put the camera through some of its paces. I used an 80mm Megrez II refractor with a .63 focal reducer attached to the camera’s 1-1/4 inch nosepiece. This set up yields about a 60 arc minute horizontal field of view. With this set up I was able to take some image data for the open cluster M38 and the Orion Nebula M42. The results of this session are the images below. For each image, a set of 20 second subs (between 16-20) of clear IR block and RGB filters using the DSI Pro filters. In the case of M42 a set of 6 second clear IR Block subs was also taken in anticipation of trying to capture some detail in the bright core.

Regarding the Meade supplied RGB filters, I am told that these filters are not IR blocking and the advice of some experienced users is to use the clear IR Block filter on the front of the 1-1/4 inch nosepiece to shoot through on the RGB exposures as well. The fourth slot in the filter slide is left open for a straight IR block only luminance exposure. I had not used this technique for the M38 and M42 images and in hindsight, I realize it likely caused some color balancing issues in post processing.

As previously mentioned, I chose to save all raw images. I made my own Dark calibration frames for these exposures. I used the Autostar Image Processing software to calibrate, align, and combine the raw frames. The software was very convenient and easy to use for this part of the post processing. I was left with R,G,B and Luminance master frames which I took to my normal image workflow process in Photoshop. I originally intended to try to use the Image Processing software to achieve a final image, but it is unable to handle color channels with a separate luminance channel. My personal judgment of the images and the camera was that I had a successful “second night out”. I am fairly sure that with some experience with this system better images could be obtained. And in fact the conditions with a moon and some light clouds drifting were not the best.

Overall, the camera performed and respectable images were obtained.



*M38 DSI Pro, 0.63 focal reducer, 80mm Megrez II refractor*



*M42 DSI Pro, 0.63 focal reducer, 80mm Megrez II refractor*

### **What Can You Do After Gaining Experience?**

Neil Fleming, an experienced DSI and DSI Pro user, has offered a sample of images for this review that he has made with the DSI and DSI Pro. Notice that Neil has taken substantially more frames than the 16 or so that I have recommended. In some cases up to 100 frames. Also, Neil has used color data from a DSI and Luminance or narrowband data from a DSI Pro. Some exposure data ranges up to 6 minutes. See the captions below the images for more details.



*Televue NP-127, Meade DSI-Pro, Unguided, L 49x2min,*

*R 40x1min, G 39x1min, B 37x85secs, Saved as TIFs*

**M101 - Courtesy of Neil Fleming**



*Color: - Meade DSI-C - 78x60 second exposures*

**M27 - Courtesy of Neil Fleming** - *OIII - Meade DSI-Pro - 54x60 seconds*

*- Luminance: - Meade DSI-Pro - 104x42.4 seconds plus 96x1 minute*



**NGC 2264 – The Christmas Tree Cluster, including the Cone and Foxfur nebulae - Courtesy of Neil Fleming** *30x6min exposures, Astrodon Ha filter, with the TV-60IS and the DSI-Pro*

## Conclusions

During my experience with the DSI Pro and related software, I was able to understand the camera's capabilities and obtain image results the first night out. It was the second night out that was the more rewarding experience though. There are a few practical issues worth pointing out at this time that were noticed during my nights out. The first is that I noted that the filters in the filter slider are exposed while other filters are in use. I was out on fairly dry nights and did not have a problem, but on other nights I know there would be issues with dewing. The other item I noticed is that the 1-1/4 inch nosepiece Meade supplies with the camera is recessed nearly the full length of the barrel making it unsuitable for use with compression focus tubes like that used in my Megrez II refractor – it must be used with a screw lock holder. The USB cable provided is short - 5ft long. While I did not have any difficulty with this length due to the position my mount was in for these objects, I can see that normal usage or any mount slewing while the USB cable is attached to a mounted camera can run the risk of pulling the camera off the telescope or the laptop off the table.

I have found the DSI Pro camera to be a great camera for the introductory Astrophotographer or for one interested in stepping up from webcam imaging. This camera is available at a great price that does not empty your bank account - \$499 with RGB filters and \$399 without filters. This is an extremely attractive price for a 16 bit camera. Along with the 16 bit pixel depth resolution, you get a sensitive CCD whose QE is approaching the higher end cameras. The software, while a bit of a challenge to noodle through, provides the image data in a format that allows it to be used in all the professional image processing software. If one ever transitioned from a DSI to a higher end camera, all the principles learned with the DSI Pro would apply to your new system.

In addition to these features, there is the Meade Drizzle process, which I did not go into in this review. It seems interesting though perhaps unconventional. But it is an area that the DSI Pro user can investigate at leisure. In fact there are many areas that can engage the DSI Pro user for many seasons to come. Or the DSI Pro user can hone their skills on the DSI Pro before moving to a higher-grade camera system. Either way, it seems hard to go wrong with this camera purchase. Finally, no review is complete with out the list of likes and dislikes.

### **What I liked about the DSI Pro**

- Great features at a great price
- Comprehensive system including Planetarium, Camera Control, and Image Processing software.
- Multiple camera use and potential for auto guide function (Meade mounts only)
- Rich choice of data save formats and procedures.
- Lightweight, simple package and USB interface.
- Multiple Internet help resources for DSI Pro users.

### **What I disliked about the DSI Pro**

- Seemingly overly complex or poorly laid out camera control software
- Lack of information about “magic eye” focus – would have preferred a FWHM algorithm.
- Lack of zoom capability in preview mode (would aid focusing)
- Poor performance on USB1.1
- Inability to auto guide with other than Meade mounts without needing to invest in external converters.

I would like to thank the experienced DSI and DSI pro users whose help in putting this review together was absolutely essential. Thanks a lot guys!!

- *Alan Clitherow*
- *Neil Fleming*
- *John Graham*