Double Star Imaging and Measurement with Unconventional Cameras, Part II: Binary Imaging with the Meade LPI and DSI Cameras

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Abstract: The Meade LPI and DSI cameras are inexpensive imaging solutions for double star workers. They are both capable of obtaining high-quality, low-noise data suitable for use in astrometry. Double star images are easy to obtain with the LPI and DSI due to the cameras' noteworthy, innovative software "suite."

There's no denying the humble webcam has transformed amateur astrophotography. While its impact has been most profound in planetary imaging, it has changed (and improved) the way we take pictures of everything, including deep sky objects. Admittedly, its effect on deep sky imaging has been mostly indirect—advanced astrophotographers aren't going to use tiny webcam chips to capture M31—but its influence is felt even there in the form of innovative software and techniques. No, a Toucam pro, even one modified for long exposure, is not really suitable for imaging Andromeda, but the incredible software webcam users have been developing, wonderful applications like *Registax*, can improve the images delivered by any camera.

We in the double star "business" are caught somewhere in-between. Many of us use or have used webcams like the Toucam Pro or Quickcam as our primary tools, but, while the webcams have generally given results superior to anything we could accomplish with film, and have some advantages over "traditional" large-chip integrating CCD cameras, webcams are not without their problems for our application.

What problems? There are several. First and foremost is chip size. The tiny (about ¼ inch) CCD chips used by the Toucam Pro and other popular "astronomy" webcams can make image acquisition tedious. Even if your telescope is placed on a highly accurate goto mount, getting a double star centered on the chip at the long focal lengths we must use to provide good image scale for imaging close doubles can be a pain. A flip mirror is *de rigueur* if you want to keep your sanity (and hairline) intact when hunting pairs at f/20 or f/30. Noise can be a problem, too. I'm not talking about thermal noise—the relatively short exposures we use tend to keep this at bay—but about the "noise bars" and other electronic artifacts evident in webcam images taken under low light/high gain conditions. Finally, webcams are not exactly robust construction-wise, being designed to sit on a computer monitor in a nice cozy den rather than on the rear cell of a telescope on a damp observing field.

Until recently, there was no good alternative for the double star imager who found webcams less than ideal, but who certainly didn't want or need to invest 1500 US$ or more in a "real" CCD camera. Many of us have experimented with low light video cameras, but these, while workable for double star imaging (especially the "deep sky" video imagers like the Stellacam), are analog devices. You'll have to provide a means of getting your images into the computer, which adds cost and inconvenience to a setup.

Things finally began to look up for the penny-pinching double star imager about two years ago when Meade Instruments Corporation introduced their first new camera following the phase-out of the

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Figure 1: The LPI, Lunar and Planetary Imager from Meade

Pictor series of CCD imagers. This new webcam-like device, the LPI, the "Lunar and Planetary Imager," had some significant advances over the off-the-shelf Quickcam or Toucam, and, despite its name, signaled the beginning of a small revolution for double star photography.

The LPI, seen in Figure 1, actually looks a lot like a webcam. In fact, it's made for Meade by a far eastern manufacturer of these devices, Sonix. There are some significant differences between the LPI and the average webcam, however, both in hardware and software. In the former category, most important is that the 1/3-inch (775x525 pixels) detector used in the LPI is slightly larger than the typical ¼ inch webcam chip. You wouldn't think this relatively small increase in area would be enough to make much difference when searching for targets, but, in my experience, it does seem to make acquiring stars noticeably easier. On the downside, this chip, an Elecvision EEVS350A, is a CMOS device (the Toucam and Quickcam feature genuine CCD sensors). The principal drawback of CMOS detectors for the astronomical imager is their lower sensitivity when compared to CCDs. In practice, however, this doesn't have much effect on the LPI's suitability for use in binary imaging. Its CMOS chip is easily sensitive enough to provide good signal data under most conditions. Like all currently available webcams, the LPI is a USB device.

The main hardware advantage that attracted many webcam users to the LPI was not its larger chip, however. It was the camera's built-in *long exposure capability*. The LPI as delivered can expose for as long as 15 seconds, which is a considerable advance over the second-or-less maximum exposure times of most off-the-shelf webcams. 15 seconds, while not sufficient for serious deep sky picture taking, is more than good enough for the Lunar and planetary (and double star) work for which this little camera is best suited. Actually, I don't often find the need to expose for longer than a second when imaging doubles with the LPI, but the capability is there when needed, and tends to somewhat offset the CMOS detector's middling sensitivity.

The body of the LPI is something of an improvement over the run of the mill webcam too, if more an incremental than exponential one. As seen in Figure 2, the LPI is very small in size, which is a Good Thing if you use an alt-azimuth mounted SCT and a flip mirror (despite the LPI's larger chip, I still use a flip mirror to speed the object-centering process). When used with a flip mirror, some webcams extend so far out from the back of the scope that they will contact the drivebase of my Nexstar 11 SCT long before the scope is pointed to the zenith. This is not a problem with the

Figure 2: The LPI attached to an alt-az mounted SCT with a flip mirror.

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LPI; I can concentrate on the computer monitor and allow the NS11 to track unattended without worrying about a "camera crash." The LPI is also considerably sturdier in build than the Quickcams and Toucams—my LPI has been dropped to the observing floor more than once with no ill effects.

Another plus for the LPI is that it includes a 1.25-inch adapter, an extra expense for the webcam user. While this 1.25-inch "nosepiece" is removable, the threads revealed by unscrewing it are non-standard. There are no T threads to allow easy use of the camera in the prime focus position. This is not a problem, though, since you'll almost always want to insert the LPI into a Barlow via the nosepiece in order to increase the focal ratio of your system when imaging doubles. Like many webcams, the LPI features a non-removable IR filter (glued in place). This helps the user achieve proper color balance (like all current webcams, the LPI is a "one shot color" camera), and keeps star "bloat" down and sharpness up. Since the LPI is mostly useful for relatively bright subjects—stars and Solar System objects—the presence of the filter doesn't create sensitivity issues.

Yes, the LPI hardware was an incremental if welcome advance over the webcam, but the Meade software, their "*Autostar Suite*" program, was and is a huge breakthrough for imagers of all types. *Autostar Suite*, seen in Figure 3, builds on some of the concepts pioneered in applications like *K3CCD Tools* and *Registax*, but also adds some significant advances of its own. This program is, frankly, nothing short of amazing. What makes it so revolutionary is that it can expose individual frames, evaluate their quality, and stack and process them *on the fly*. All the user must do is center the target of choice, focus using the program's "live" mode (while the software has a "magic eye" focus indicator, the fact that you can focus using live 1/30 second video means it's very easy to achieve a sharp image by merely observing the displayed stellar image), set the exposure, draw a "tracking" box around a medium bright star in the frame, and push the "start" button.

Once "start" is pressed, Autostar Suite takes over and does all the work. First, the program takes several frames in order to establish a baseline for image quality. The user is allowed to select how many

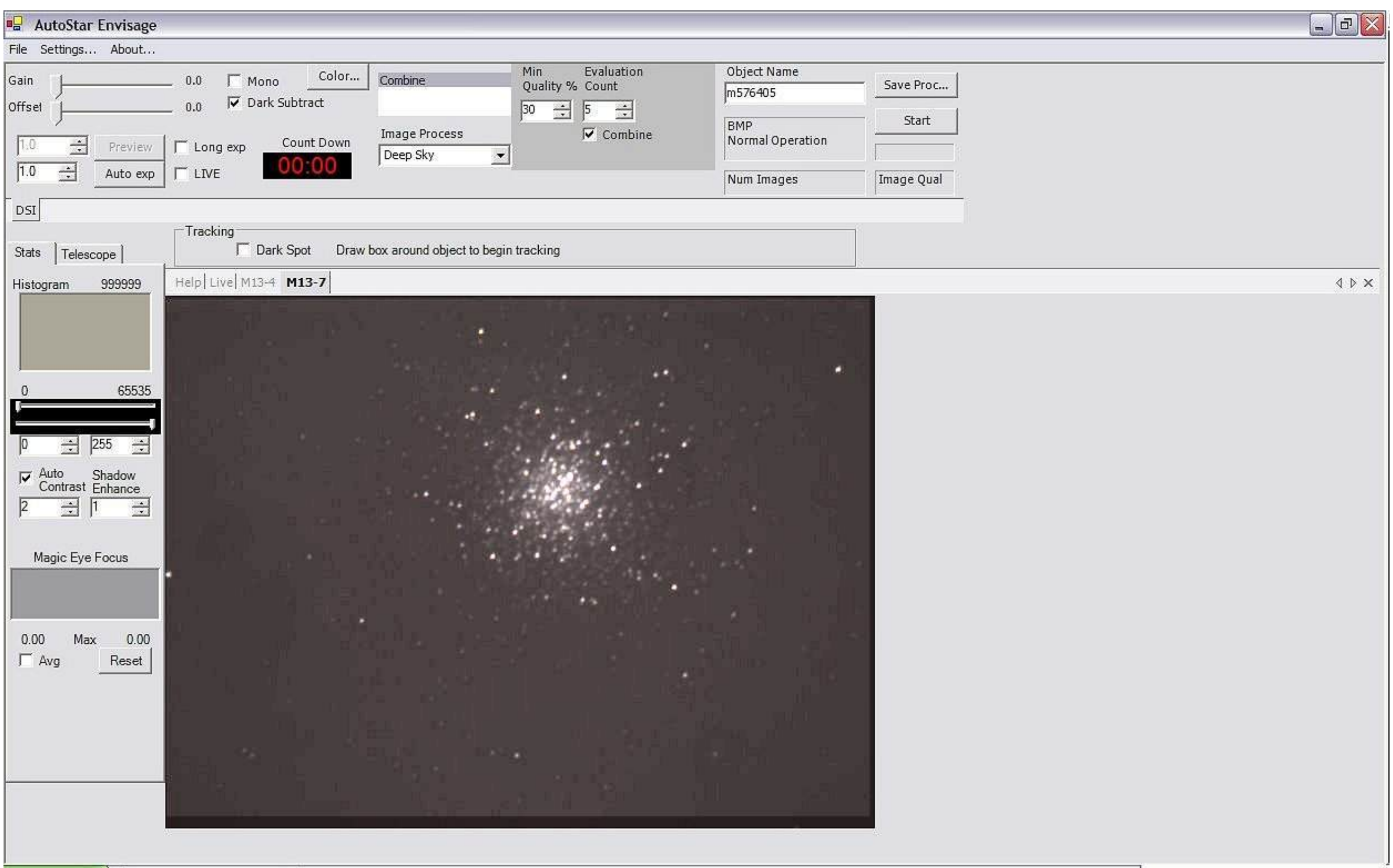

Figure 3: Screen shot from *Autostar Suite*.

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frames will be used in this evaluation process, typically five, and what quality standard successive frames must meet to be used in the final image. The program examines the evaluation frames, picks the best one, and uses this to judge whether the frames that follow will be used. If, for example, the user selects "80%" as the quality standard, all exposures must have a quality "factor" of 80% of that of the reference frame to be used in the final composite image.

Once the reference frame is obtained, the program continues taking images. If a frame is of sufficient quality (the manual does not spell out how image quality is evaluated, but seems to do a pretty good job of it), it is added to the stack. As with Registax, stacking multiple short-exposure frames both reduces noise and tends to counteract the effects of poor seeing. As mentioned above, unlike Registax, the image frames are aligned on the fly as they are taken. The tracking box the user draws around a bright star in the live frame is used to align successive images during stacking. At the 10th frame, the program applies an image processing/sharpening filter if desired (user selectable) and continues to evaluate and stack frames into a composite image until the user presses "stop." I've found that a stack of about 50-60 frames will yield an excellent final image.

While the above "stack on the fly" method is the way the program is normally used, it can also be instructed to save each exposed frame rather than stack the exposures into a composite image, allowing the user to process the frames later using *Registax* or another program if desired. The file type of the final image is selectable by the user, with a large number of alternatives including .bmp, .jpg, and FITS being available. The program can also automatically expose and apply dark frames (for noise reduction), but this is seldom necessary with the LPI.

How well does the LPI work? It works very well on double stars, as can be seen in Figure 4. Is it perfect? No. At heart, this is still a webcam, and some electronic noise is evident. However, this camera is quite sufficient for imaging brighter double and multiple stars. Certainly it is more than usable on many pairs down to *at least* magnitude 8 with a C8. In fact, the only major complaint many binary-star-oriented users will have is the lack of astrometric facilities in *Autostar Suite*—tools for measuring separation and position angles. While the software does have some rudimentary photometry features, astrometry functions are conspicuously absent.

Autostar Suite is a "suite," by the way, because the program is actually composed of three separate applications. The camera control/image acquisition/stacking program, called Envisage, is accompanied by a fairly effective if less than feature-laden image processing application, Meade IP. While Meade IP pales beside something like Adobe Photoshop, it will perform most basic image processing tasks, and has the advantage of allowing the user to load FITS files without the use of the "plugins" required by Photoshop. Finally, there is Epoch 2000, a rudimentary planetarium program that will mainly be of interest to owners of Meade telescopes. If you're equipped with a Meade goto scope, you can control most of its functions (of Autostar scopes, anyway) with the program. It should also be noted that Autostar Suite will allow the LPI (or the DSI) to be used as an autoguider if desired, but only (easily) for Meade telescopes (a serial connection to the scope is required).

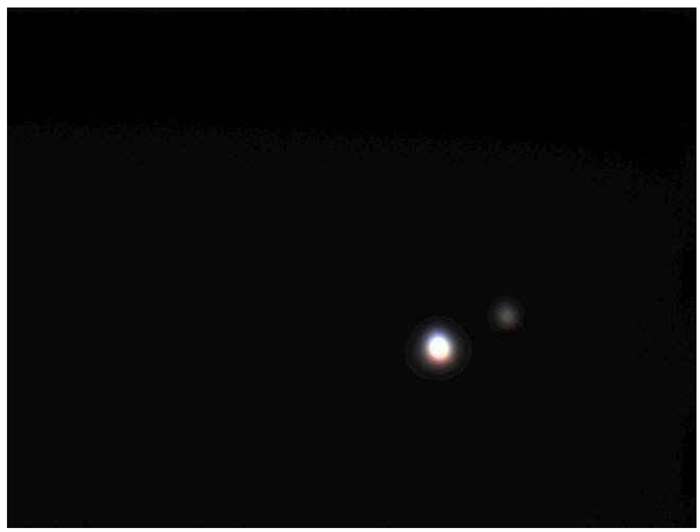

Figure 4: LPI image of a double star.

Are there any major criticisms to be leveled at the LPI? It's hard to think of any, as this 99 US$ camera and software can open the whole world of double star (and Lunar and planetary) imaging to the amateur almost painlessly. "Almost" painlessly. Problems for beginning LPI users have been twofold: difficulty getting the software installed, and difficulty understanding the program's operation once it's running. Meade had some problems with the software early on, but they have continued to update *Autostar Suite*, and real problems—bugs, that is--are now few. The current reason for most failed installations, those where the camera is not recognized by the software, is usually that the user has plugged-in the LPI before the

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software is ready for it. Doing so prevents camera drivers from being loaded properly. Luckily, the installation instructions are pretty clear, and, if followed to the letter, the camera should install without difficulty.

As far as complaints about Autostar Suite's user friendliness, well, some of that is justified. The user interface could be better, but remember, this is a program that is required to do a lot; it must be able to do anything from applying image filters to exposing dark frames. There is a limit to just how "simple" it can be. At least Meade has provided some fairly understandable manuals for the programs: one for Envisage, one for Meade IP (a thick one), and one for Epoch 2000 (all on the included CD). Print 'em out and read 'em a couple of times if you want to be completely ready for the LPI experience. If, like me, you hate reading manuals, though, be prepared for at least a night or two of frustration. One noteworthy feature of the documentation is that the Envisage manual includes a "quick-start" guide to taking images. If these pages are read and their instructions followed carefully, the new user may be able to start getting pretty good images the very first night (as Meade gushes in its ads).

Just don't like the Envisage software? Can't get friendly with it? The LPI is now supported by K3CCD Tools, so you do have an alternative. In my experience, however, the camera still works better with the Meade program.

Final caveats? Autostar Suite needs at least a 566mhz (Windows) computer to work well. It may function with slower processors, but you really won't be happy with it. This USB camera works with either USB 1.x or 2, and I don't, in fact, notice any improvement with USB 2. As is the case with webcams and other CCD cameras, don't expect quality pictures unless your scope has a smooth drive with manageable periodic error.

The release of the Meade LPI caused some initial excitement amongst astrophotographers, but it quickly subsided. While the Meade camera was the first webcam-type device to be tailored especially for astronomy by a major manufacturer (Celestron would soon release a competing camera, the NexImage, but, unlike the LPI, it really was just a repackaged webcam), but it was still basically very similar to the Toucams and Quickcams. No one expected Meade to stop with the LPI, however. They had discontinued their cooled Pictor CCD cameras, and it seemed likely that a replacement would be forthcoming. In 2004 we found out what that replacement would be: the Meade DSI, the "Deep Sky Imager."

If amateur imagers were excited by the full-color DSI ads that appeared in *Sky and Telescope* and on the Internet, it was not because the DSI *looked* exciting. Despite being a little larger than the LPI, the DSI still looked like, yes, *another* webcam. There was a tip-off that something was different, however. Eagle-eyed Internet surfers quickly noticed the large heat-sink at the camera's rear (see Figure 5).

What made the DSI special? Meade's advertisements claimed this inexpensive, uncooled, one-shot-color camera didn't need a Peltier to keep thermal noise down. The heat sink and some other tricks (like turning off power to camera electronics during exposures) made active cooling completely unnecessary. Uh-huh. Most amateurs have tended to take a wait-and-see attitude toward Meade's advertising claims. While the company has produced and continues to produce some excellent products, Meade is well known for the dollops of hyperbole their advertising department heaps on everything.

This was one time, however, when we had to put aside our initial skepticism. Given its 299 US$ price tag, the Meade DSI turned out to be incredible. No, it wasn't completely noise free, but its frames were very comparable to those produced by cooled CCD cameras.

Figure 5: The Meade Deep Sky Imager with heat sink at the camera's rear.

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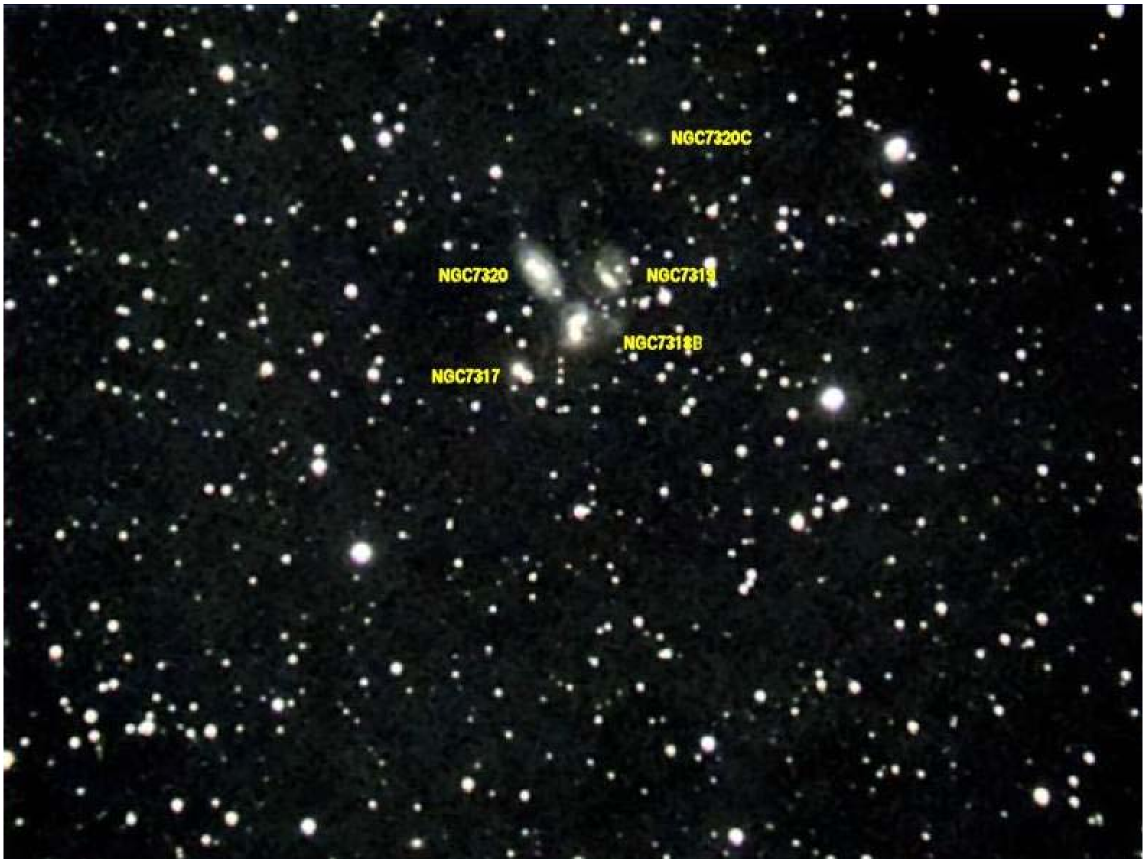

Figure 6: Stephan's Quintet imaged by a Meade DSI attached to an 8" SCT.

This is possible both because of the passive cooling techniques mentioned above, and because of the way the camera is usually operated.

While it's possible to take very long exposures with the DSI—up to one hour—the fact that it uses a small chip, a ¼ inch detector just like many webcams (a genuine CCD chip, a Sony ICX254AL interline device), means that mount-tracking problems will be exaggerated. For this reason, most users operate the DSI in the same manner as the LPI, taking multiple short exposures (30 second – 1 minute for deep sky objects, usually), allowing Autostar Suite to stack them into a final image. The use of these short exposures helps keep thermal noise down, just as with the LPI. Despite our initial skepticism, this camera has proved that it is capable of going very deep (see the image of Stephan's Quintet in Figure 6) and producing very attractive images even in the hands of novices.

The DSI's hardware is relatively simple. The camera (seen attached to a scope in Figure 7) is delivered with a 1.25 inch nosepiece that can be unscrewed to reveal standard T threads. A removable 2-inch IR blocking filter is also found in the box along with a few other items (a parfocal ring to help center objects using an eyepiece, and cables to allow *Autostar Suite* to control Meade telescopes).

Like the LPI, and, indeed, almost all other amateur CCD cameras today, the DSI is a USB device. While Meade assures users that the camera will work with USB 1.x, early adopters found that, unlike the LPI, it does not work very well at all without USB 2.0. The program display is sluggish, and images poorer in quality with the older USB port standard. Luckily, reasonably priced add-on USB 2.0 cards are readily available for older computers.

As with the LPI, the *Autostar Suite* software is the key to the DSI's success. With the release of the DSI, Meade updated the software to operate the new camera, but continued support for the LPI with the same program. This means that *Autostar Suite* can guide a Meade telescope with an LPI camera and image with the DSI at the same time. Program operation for the DSI is almost identical to that for the LPI: the user sets the exposure time, focuses, draws a tracking box around a bright star, and begins stacking short exposures by pressing "start." A couple of additional steps are required if longer exposures are needed (30 seconds and above): acquiring dark frames and combining them with images. Don't worry if you don't know a dark frame from a light frame; *Autostar Suite* handily automates this process, even reminding the user to "please uncover the telescope aperture" after the DSI finishes taking a series of darks. Image calibration with dark frames is automatic; simply check the,

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Figure 7: The Meade DSI attached to an SCT.

"subtract dark frames" box.

The Meade DSI has proven itself quite capable as a deep sky camera, but what does it have to offer the double star imager? Why pay nearly 300 US$ for the DSI when the 99 US$ LPI works just fine? In part, because of the DSI's lower noise profile. At both shorter and longer exposures, DSI images look "smoother" and less noisy than LPI pictures. But the main reasons to choose the DSI are its greater sensitivity and versatility. The DSI's high sensitivity, amazing for a color camera, means it can be used for just about any project you can dream up. How sensitive? When imaging the galaxy NGC 7331 in Pegasus with the DSI and a C8, I found that the camera easily revealed 15th and 16th magnitude PGC field galaxies in a 20-minute (total time) exposure. Versatility? Not only is it capable of bringing home nice images of galaxies and nebulae, it does a credible job on the Moon and planets—though it doesn't do as well on them, frankly, as a Toucam does.

When it comes to double star imaging, this little thing is, I'm not hesitant to say, *just right*. Once I'm set up in the field, I can quickly image any double I desire with the DSI. It's not unusual for me to come home with 20 different stars "in the bag." While my procedure is identical to that I used with the LPI (Barlow lens for image scale, flip-mirror for star locating, 50 – 60 short exposure frames stacked per image), my results (see Figure 8) look better, and, because they are cleaner, measurements are easier to make.

The catches? The problems with the DSI are essentially the same as those with the LPI: installation difficulty and a fairly steep learning curve for *Autostar* Suite. Also, many of us were surprised that Meade's new deep sky camera didn't feature a larger chip. The LPI had been at least a small step up from ¼ inch world, but with the DSI we were right back down in webcam territory. Finally, as was the case with LPI users, some DSI owners simply can't stand *Autostar Suite/Envi*sage.

Unfortunately, the DSI hardware is even more "different" than that of the LPI, and third party imaging program vendors have been slow to support the camera. *Maxim DL*, *Astroart*, and *K3CCD* are now DSI compatible, but I've seen few examples of DSI images taken with these programs. I suspect that most users of an expensive piece of software like *Maxim DL* are more interested in using the DSI as a guide camera than in taking pictures with our humble camera. You can, of course, load your images into non-Meade image processing programs once capture is complete.

Figure 8: Beta Monocerotis imaged with a Meade DSI.

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This is required, in fact, in order to do measurements of your stars, as the updated *Autostar Sui*te still does not offer astrometry tools.

I've been very happy with the DSI, and find it both effective and easy to set-up and operate (though it didn't *become* easy until I'd had about three evenings with the camera under my belt). Though I also have an SBIG ST2000 at my disposal, it's nice to be able to get out and shoot a few doubles without worrying about power supplies, camera cooling, and hanging counterweights on the scope because of the massive SBIG on its rear. I just plug-in the DSI and snapshoot my doubles to my heart's content.

Addendum

Meade, driven by the success of the DSI, released a more sensitive monochrome version of the camera, the *DSI Pro*, a few months after the original one-shot color camera debuted. For about 100 US$ more than the original, the Pro offers considerably better sensitivity. For the double star imager, however, giving up the easy color of the original DSI for monochrome (or color-shooting via tricolor imaging) for usually unneeded sensitivity may not be a very attractive prospect. Also, the camera tends to "bloom" on bright stars (they look more like footballs than stars even with fairly short exposures), and this may be problematical when making measurements of brighter pairs.

Meade being Meade, they haven't stopped with just two cameras. In the last month, they've announced *two more*: the DSI II cameras. The new camera line currently includes both a one-shot DSI II color camera and a DSI II monochrome camera (the "Pro II"). In addition to still *more* sensitivity and a further reduction in noise, this pair offers larger chips, 1/3 inch rather than the ¼ inch detectors used in the original DSIs. Despite its better sensitivity, I'm told the Pro II does not suffer from star-blooming problems to the extent the original Pro does. I have not yet been able to try either of these new DSIs, but when I can, I'll report on them here.

In my opinion, however, the original color camera is still the most cost-effective DSI for us. Alas, though, unless you rush out and buy the original DSI *immediately*, you may not be able to get one. It appears Meade is discontinuing the camera, and I believe the original monochrome Pro won't be far behind. Sadly, double star imagers will probably soon wind up paying 300 dollars more for sensitivity they really don't need (the one shot color DSI II goes for 599 US$). There's always Astromart of course. The Original DSI is simple, effective, and just the thing to get your binary imaging-measuring program off the ground for a *pittance*.

Next Time: Measuring Double with Unconventional Imagers

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