

A Pair of Planetary Performers

Tim Easterday

Over a year ago I finally had the opportunity to purchase a decent astrophotography rig. This was after more than two decades of enjoying this hobby with just my eyes, and sometimes a pair of binoculars. Like many of us, I spent a long time obsessing over what items to purchase while still keeping within my budget. It was truly “analysis paralysis” for a while, but I eventually came up with a list of equipment that would serve my needs both in deep-sky photography and planetary imaging. One of these items was a dedicated planetary camera. My criteria required that this camera be not only a good imager for the planets and the moon, but also a good guide cam for long-exposure work with my DSLR. Therefore, I needed a camera with a high frame rate, good sensitivity, and longer exposures than typically found in PC webcams. At the time (summer of 2006) there was a lot of talk about these little “blue cubes” from The Imaging Source that delivered a 30 fps frame rate with good sensitivity and exposures up to 30 seconds. About the same time they announced a firmware upgrade to 60 fps – even better! Given my budget, this seemed like the perfect choice for my needs, as the next step up in planetary cameras was much too expensive to consider.

The next choice was between the color “DBK” version or the monochrome “DMK” version, with the edge in sensitivity obviously going to the mono version. For long-exposure photography I would need maximum sensitivity in the guide camera because of my light-polluted skies in Atlanta. With that in mind I called up the nice folks at TIS and placed my order for the DMK 21AF04. I figured I could later save up enough money to get a filter wheel and some good-quality filters for color planetary imaging. The choice in resolution was strictly a budgetary concern for me. The DMK 21AF04 resolution of 640 x 480 pixels is plenty for the planets and adequate for guiding at longer focal lengths when using a reducer.

The Imaging Source DMK 21AF04

At the time I purchased my DMK 21AF04 they were not including the C-mount to 1-1/4” adapter that is necessary to use this device in a telescope. No big deal – these are easily found on Ebay and cost \$20. Since then TIS has started including the adapter. They have also created a website and blog dedicated to astronomical use of these cameras (the website can be found at <http://www.astronomycameras.com/en/products/> and the blog can be found at <http://www.astronomycamerasblog.com/>). The cameras are available directly from TIS or from many different resellers. One other required accessory that is not included is the FireWire cable that connects the camera to your computer. Here’s where you need to be careful: most laptops have a 4-pin FireWire port. The cameras from TIS have 6-pin ports on the back. What’s the difference? Power. Laptops do not usually have the extra 2 pins that supply DC power to the device. Fortunately there are power supplies and special cables with a DC power jack available from TIS. Another route, the one I chose, is to purchase a powered FireWire hub, a 6-pin to 6-pin cable, and a 4-pin

continued ⇨



Figure 1 — The DMK 21AF04 FireWire Camera

to 6-pin cable. The hub allows for future expansion in case more astro devices come out in the future that support the IEEE 1394 FireWire standard. Recently TIS has introduced a line of USB 2.0 cameras on their main website. This should simplify the computer connection for those who don't have IEEE 1394 ports on their computer, or don't want to spend the extra money on power supplies or FireWire hubs.

The DMK 21AF04 camera is one solid piece of equipment. When it arrived I was impressed by the quality construction. It feels heavy and well built. Isn't it funny how the heavier weight of an object somehow translates to better quality in our perception? In this case it's true. The camera comes with a thick metal base that is tapped for a tripod mount. The 5mm thick C-mount ring unscrews to allow the use of CS-mount lenses. This is necessary because of the 12.5mm backfocus requirement of CS-mount lenses, while C-mount lenses require a 17.5mm backfocus. Connection to a telescope is made via the (now included) C-mount to 1-1/4" adapter. After using the DMK for a few months I purchased a C-mount to T-thread adapter that I now prefer to use. I find this method of connection more solid and easier to change from my photo adapter/reducer combo for guiding to my filter wheel for color imaging (yes, I finally purchased that filter wheel + filters!).

This camera uses the Sony ICX098BL CCD sensor with 640x480 pixels, each measuring 5.6µm square. The same ICX098 family also includes the ICX098BQ sensor used in the DBK/DFK 21AF04 models as well as the Celestron NexImage, older Philips ToUcam pro webcams, and the newer Philips SPC900NC webcam (more on that later). If the convenience of a color camera is something you prefer, go for the DBK model camera. The DBK series does not have an internal IR-cut filter, so you need to supply your own. The DFK series does have the IR-cut filter but it cuts off steeply at the 656nm wavelength of H-alpha emissions - just in case you ever want to do some deep-sky imaging. If more pixels are your fancy, step up to any 31AF03 model which features 1024x768 pixels each measuring 4.65µm square, or the 41AF02 models which feature 1280x960 pixels also measuring 4.65µm square. Keep in mind the slightly larger pixels of the 21AF04 models will offer higher sensitivity over the larger resolution models.

As the cameras go up in resolution, the maximum frame rate decreases. The 60 fps frame rate is only available in the 640x480 resolution models. High frame rates are necessary to freeze the turbulence in the atmosphere. Moments of good seeing can then be captured more effectively amid the shifting & shimmering image we typically see when viewing a planet or the lunar surface under high power. Even though the DMK 21AF04 is capable of 60 fps, I find myself rarely using such a high frame rate. It takes a pretty bright object to get a good exposure at 1/60 second or faster. I usually only use

those short exposures for lunar imaging. When using color filters a longer exposure is normally required so the frame rate drops.

Speaking of exposure, not long after I got my DMK camera TIS came out with a long-exposure upgrade designated as the "AS" version. This upgrade extended the maximum exposure time to 60 minutes – more than enough for just about any deep-sky imaging. It was about this time that I was fighting an issue of some very bright stuck pixels on my DMK. TIS was nice enough to exchange my camera for an "AS" version. Now my camera was a real "triple threat" – capable of great planetary work, long-exposure deep-sky imaging, and a pretty darn good guide camera too. The long-exposure mode presented a new challenge, and yet another opportunity to buy more stuff (which we all love doing, right?). Now I needed a guide camera to have any chance of actually using the DMK's long exposures. Enter the Philips SPC900NC color CCD webcam, which at less than \$60 at the local Sam's Club seemed like a good bargain-priced guide camera.



Figure 2 — The Philips SPC900NC with telescope adapter

The SPC900NC webcam was the successor to the very popular ToUcam 840K and shares the same Sony ICX098BQ color CCD sensor used in the older ToUcam model. As I mentioned earlier, you'll also find this sensor in the 21AF04 color versions from TIS, as well as the Celestron NexImage. I never owned the ToUcam but I did own the NexImage for a few months and had a chance to compare it briefly with the SPC900NC. Even though the two cameras used identical CCD sensors, there was something different in the electronics. The AVI files and final stacked images from the NexImage always looked noisier to me. Within a week of purchasing the SPC900NC, I put the NexImage up for sale. This Philips webcam has already been replaced by newer models with larger CMOS sensors, but you can still find them online.

This webcam comes ready for mounting on your laptop or PC, complete with a focusable lens assembly and a large bracket to clip on a notebook screen. None of that is useful for planetary imaging and must be removed. The

continued ⇨

lens is pretty easy to remove and reveals the Sony CCD sensor sitting on a small pair of stacked circuit boards. An adapter is required to mount the camera in a telescope's focuser tube. Just like the DMK adapter, you can also find these on Ebay for around \$20, or a little more expensive elsewhere.

The Philips SPC900NC has a resolution of 640x480 pixels. The pixels are covered by a Bayer matrix which filters red, blue, and green to separate pixels. In this configuration, each 4x4 square of pixels contains one red, one blue, and two green filters. Naturally this camera has the strongest response to the green portion of the light spectrum. Overall you can expect this type of camera to be less than half as sensitive as a monochrome model. However, the convenience of one-shot color imaging and the price are hard to beat for anyone just getting started with planetary imaging.

Beware of the advertised specifications you'll find on many websites. Many online stores are using the default specs straight from the manufacturer. This can be misleading for the beginning astronomer. The camera is often labeled as a "1.3MP camera" capable of "90 fps." Obviously 640x480 does not equal 1,300,000 pixels. That is an interpolated mode specifically for snapshots – useless for webcam imaging. The 90 fps frame rate spec is also misleading. You will never realistically want to use more than 30 fps in AVI mode and even then you are pushing it for this less-sensitive camera on a slower USB 1.1 connection. It's better to start off around 15 fps and see what kind of image you can get.

A Little Bit about Bit Depth

It should be mentioned that both the Philips SPC900NC and all the DMK/DBK/DFK models are 8-bit cameras. This means that there are 2^8 , or 256 possible levels ranging from pure black to pure white. Higher-priced planetary cameras can output 12 bits, or 4,096 possible levels. However, that kind of resolution is best for solar H-alpha imaging or extremely detailed lunar imaging. Eight bit data is acceptable for typical planetary images and the results will make most of us very happy. You'll find 16-bit resolution on the typical deep-sky CCD imagers such as my newly acquired Meade DSI Pro, but these cameras just aren't made to deliver high frame rate video. They excel at what they were made for – very dim objects. The TIS cameras with long-exposure capability are capable of some decent entry-level deep-sky work, but the 8-bit images will never be able to compare to a true 16-bit camera.

The Cameras in Action

The DMK 21AF04.AS is very easy to setup and get running for the first time. Many great products suffer from being bundled with poor software, but that is not the case here. The camera comes with a licensed copy of IC Cap-

ture.AS. The more I use this program, the more I love it. All the controls are laid out very sensibly across the top of the screen and you can enable only the controls you need and hide the rest. You can setup a particular configuration and save it for future use. Toggling the Recording Control Dialog pops up the Record Video File window where you setup the file format, location, and naming convention. IC Capture can automatically increment the filename when recording multiple video files. Time stamping is also available if you don't mind your filenames getting longer. I would suggest that you go into the filename menu and type in something meaningful every time so you can remember later what was recorded.

At first the choice of recording format may seem quite daunting but it's really simple. Clicking on the Codec Setting button in the Record Video File window brings up a choice of media container type and video compression type. Choosing media container is easy – AVI is the only choice and the format needed when opening the file in Registax. Choosing the video compression method can be confusing because of the different settings and the sheer quantity of codecs available. For best image quality, compression of any kind should not be used. While compression saves on file space, it can degrade the quality of the file and may introduce artifacts. I tried every codec I had on my system and most would not even allow video recording. Those that would were not compatible with Registax. Therefore, I always choose an uncompressed format. You'll eat up a lot of hard drive space but it's necessary to get the best results. For monochrome imaging the only format needed is Y800. This is an 8-bit per pixel format. The other uncompressed formats are RGB24, RGB32, and UYVY. These are color formats and only applicable to a color camera like the DBK & DFK models. Below the uncompressed format selection, there's another choice labeled "Unspecified" which I believe defaults to Y800. I compared files taken with the Y800 format and the Unspecified format and for the same number of frames both had the same file size. Both worked in Registax as well.

Before you begin recording you must set up the proper exposure. This is where my favorite feature comes in - the live histogram. The histogram indicates the number of pixels at each of the 256 available levels. I always have "Visualize Zeros" checked and the graph scale set to logarithmic. What you are looking for here is an image that is neither underexposed nor overexposed. With the Visualize Zeros option, keeping a bit of yellow at each end indicates a good exposure level (Figure 3). I then adjust gain and exposure until I get a good-looking image and a properly exposed histogram. At that point it's time to begin recording. It's important to always go back and adjust the histogram when changing filters, moving to different objects, or even just moving to a different part of

continued ⇨

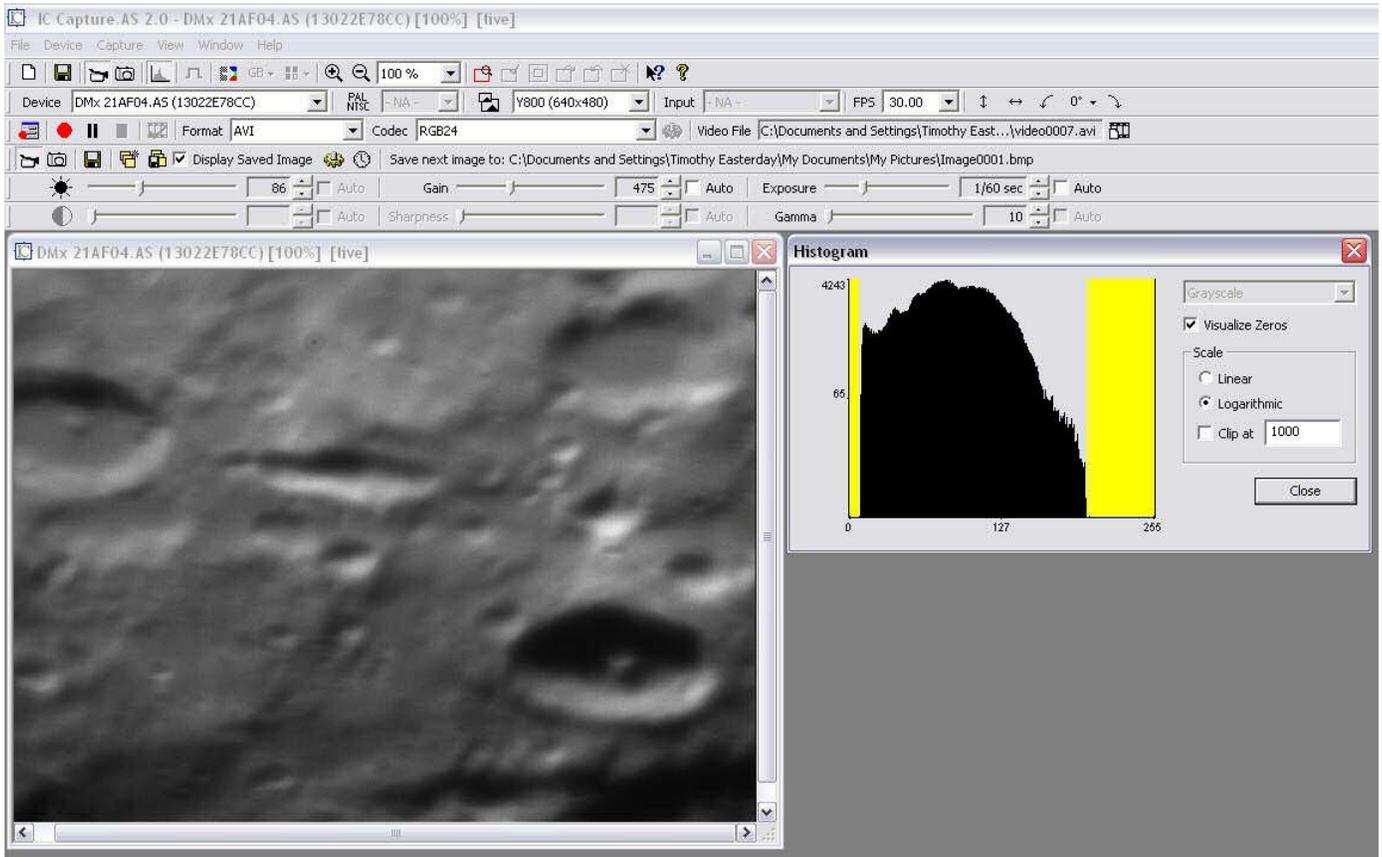


Figure 3 — IC Capture screen shot with the DMK 21AF04.AS

the lunar surface. I have also found the histogram useful for attaining the best focus. As you move the focuser, the histogram will maximize on the X-axis when proper focus is reached.

The Philips SPC900NC is another story when it comes to bundled software. The included VLounge software only records in MPEG compressed format, making it useless for planetary imaging. Fortunately there's good software out there to record AVI files with this camera and the best part is that most of them are free. I've tried QCfocus, AMCap, and K3CCD Tools 3. The first two are free but K3CCD Tools will cost you \$49.99 for the full version. K3's software does a whole lot more than just video capture and is well worth the price (and it also works well with the TIS FireWire cameras). But for just recording a few video files I prefer QCfocus. Actually I use a combination of QCfocus and another program called WcCtrl. This is because QCfocus only allows the camera's standard adjustment sliders for gain, brightness, gamma, etc. These sliders do not have any numerical reference and there's no way to save a preset for future use. WcCtrl has adjustment sliders with numbers and allows settings to be saved to a preset file. And you can run both programs at the same time. I use WcCtrl to fine-tune my

exposure while viewing the live image in QCfocus.

Recording files in QCfocus is very simple and the program allows automatic filename incrementing similar to IC Capture. Here again you must make a choice for the recording format. There are three formats possible: I420, IYUV, and YUY2. The first two are the same format according to FourCC.org but YUY2 is a higher bit-depth format and takes up more file space. Beyond the format there is not much else to set in QCfocus if

continued ⇨



Figure 4 — QCfocus and WcCtrl screen shot with the Philips SPC900NC

you are using WcCtrl too. The only setting to change is to turn off auto exposure in QCfocus first before trying to adjust the exposure in WcCtrl. Otherwise you will not be able to turn off auto exposure in WcCtrl.

Stacking up the Results

This summer was pretty poor for imaging of any kind, but I managed to get a couple of good nights with clear skies (but poor seeing) to test out both cameras. Saturn was at a low but acceptable altitude late in the spring and became my first choice for a target. At that time I did not have a filter wheel yet which limited me to strictly monochrome imaging with the DMK camera. This was not a problem – I didn't need any extra complications during my first attempt at planetary imaging. I was instantly impressed with the results from the DMK 21AF04. The AVI files taken with IC Capture looked awful for the most part due to the turbulence in the atmosphere, but the DMK was able to capture those microsecond-long moments of good seeing. Divisions in Saturn's rings became visible as did some banding on the planet's surface. The Philips SPC900NC was then popped in for some color imaging. Compared to the DMK the image was not quite as sharp and detailed, and showed some sort of noise pattern of bands going across the entire frame. I still don't know what is causing the occasional noise pattern but I suspect it is due to either overexposing the video capture or pushing the levels of the final image a bit too much. As an experiment, I combined the DMK image as a luminance layer over the SPC900NC color image. Overall not too bad for my first try.

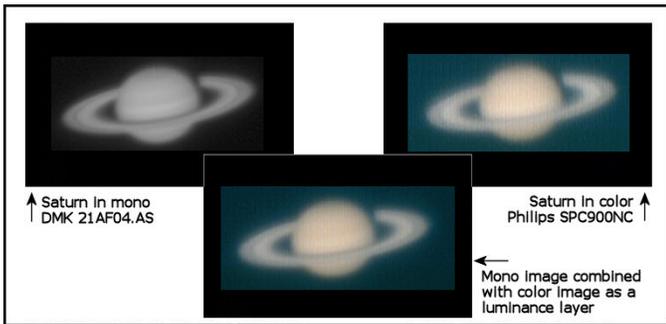


Figure 5 — A comparison of Saturn images

Later in the summer it was on an even more challenging target – Jupiter. The fast rotation of this gas giant means you have to be pretty quick. Making it even more challenging was the fact that I was using a manual filter wheel with LRGB filters on my DMK camera for the first time. On the SPC900NC I just used a Baader UV/IR blocking filter. I recorded 300 frames with the DMK for each of the LRG filters and 200 frames for the blue filter. Each time I adjusted the gain and exposure to get the histogram looking right. Each separate video file was

stacked and processed in Registax and then saved as a TIF file. The images were then processed just a little again in Photoshop with the final LRGB combine performed in Images Plus. Overall it was a LOT of work to get a color image. Using the SPC900NC I recorded 300 frames, stacked & processed in Registax, then performed some final adjustments in Photoshop. This took me just a fraction of the time as the LRGB processing. I'm sure the final results could be better (I am just beginning to learn Registax and image processing) but I was pleased with my first try at Jupiter and happy to catch Jupiter's moon Io transiting the planet. The Philips SPC900NC actually produced a pretty good image – not quite as good as the DMK but a lot less work. The colors and banding details seemed sharper on the DMK image. Also, Io disappeared on the SPC900NC final image but mostly remained on the DMK image, albeit with a bit of color shift due to my slowness with the filters.

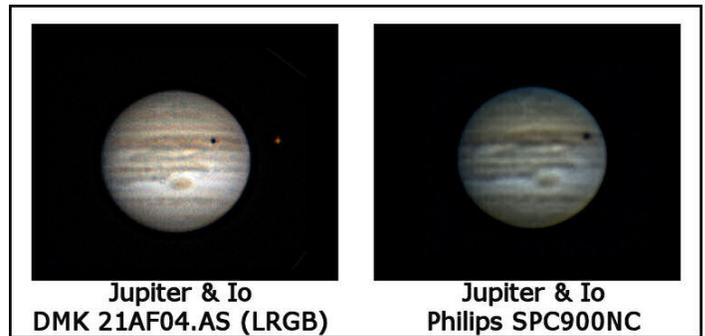


Figure 6 — A comparison of Jupiter images

Finally, I chose a bright 18-day old Moon for another comparison. For both cameras I just used a UV/IR blocking filter. It was not ideal conditions with poor to average seeing, although the skies were crisp and clear due to a cold front passing through the day before. I picked a couple of interesting features to try out each camera. The live image at 1/30th of a second exposure rate was a boiling mess most of the time but there were some very brief moments of stable images. I recorded about one thousand frames for each camera on each feature. I eliminated nearly half of the frames in Registax and processed all the video files in a similar manner with minimal post-processing. Different capture programs were used as mentioned earlier, so exposure settings were not exactly the same, but pretty close. I was surprised to see such a good result from the Philips SPC900NC. I have done quite a bit of lunar imaging previously with the DMK, but never with the Philips webcam. On this night the SPC900NC performed very well in poor imaging conditions with final images just as good, if not a little better than the DMK. My past imaging efforts with the DMK were much, much better, so it may just be a case of poor seeing leveling the playing field.

continued ⇨

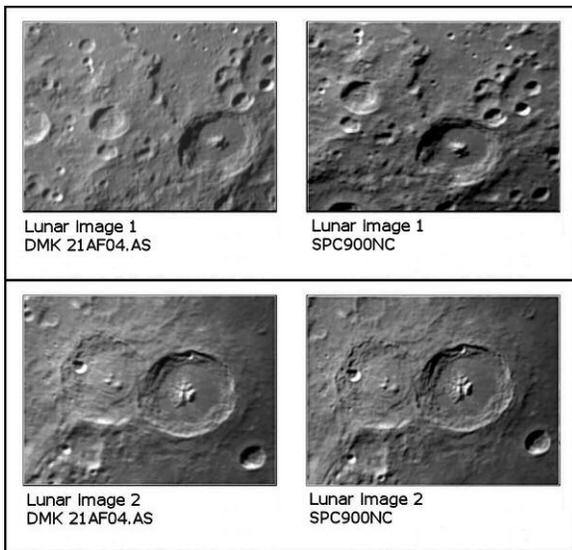


Figure 7 — A comparison of lunar images

Summing it all up

For anyone getting started in planetary imaging, the Philips SPC900NC is an ideal entry point at a very affordable cost. The convenience of a one-shot color webcam saves time in post processing and requires very little investment in additional equipment to get good color images. Basic software to support this camera is free and easy to use. More advanced software like K3CCDTools v3 will get you many more additional features for not much more money. Regarding its use as a guide camera (the original reason why I bought it) I have found that the SPC900NC probably won't meet my needs because guide star selection becomes difficult with the lower sensitivity and lack of a long exposure mode. However, there are instructions posted on the Internet for a long-exposure mod and it does not look too difficult. Some online shops sell these cameras already modded. If not for the (unplanned) purchase of a Meade DSI Pro, I probably would have performed the long-exposure mod myself by now. I'll still keep this camera around for when I just want some quick color shots without all the extra fuss of filters.

For anyone who wants to take the next step up, the DMK series from The Imaging Source with their monochrome CCD sensors offer more sensitivity, better throughput performance, and awesome bundled software. Color imaging will require an investment more than the camera itself to get good results, but it's worth it if you want the best images possible in this price range. Larger apertures will benefit even more from these cameras as the increased sensitivity should help pick out more detail

when the seeing is good. My DMK is a keeper that will remain an important part of my imaging setup for a long time.

I mentioned earlier that the SPC900NC had already been replaced by multi-megapixel CMOS imagers. This seems to be the trend as CMOS performance gets better and better, while the sensors get bigger and bigger. Eventually I'll get my hands on some of these newer CMOS webcams and see how they stack up. With these sensors being mass produced much more than CCD's, the choices for astrophotographers should get more interesting & hopefully cheaper. I welcome that change, and hope it helps us all enjoy this wonderful hobby even more. ♦

Tim is a 1992 graduate of Purdue University with a B.S. in Electrical Engineering Technology. He is currently a senior project manager for the Intelligent Switchgear Organization, LLC. He has enjoyed observational astronomy and reading astro-related books most of his life, but caught the astrophotography bug in 2006. Tim lives in Buford, GA with his wife and many, many pets.

Affordable CCD Imaging



An exciting new range of deep sky, cooled, long exposure CCD cameras featuring sealed sensors & electronics, 16-bit RAW data, fast USB 2.0, CNC machined metal body & 1.25" nosepiece. Include PSU, cables & software for camera control & imaging. Computer requirements: Windows 2000/XP/Vista, USB 2.0.

<div style="border: 1px solid blue; border-radius: 15px; padding: 5px; display: inline-block; color: blue; font-weight: bold;">Opticstar DS-145M ICE</div> <ul style="list-style-type: none"> • Sony ICX285AL CCD • 2/3" 1.4 Megapixel CCD • 16-bit monochrome • High sensitivity sensor • CCD: 1434 x 1050 pixels • Binning support • Pixel size 6.45 x 6.45 µm • Cooled 30°C below ambient • Low dark current • Excellent anti-blooming • Max. exposure: 60 minutes+ • Preview - 1434x1050: 3.5fps • Raw 16-bit image transfer @ 1434x1050: 0.5 second <p style="color: gold; font-weight: bold; font-size: 1.2em;">\$ 1799.95</p>	<div style="border: 1px solid blue; border-radius: 15px; padding: 5px; display: inline-block; color: blue; font-weight: bold;">Opticstar DS-335C ICE</div> <ul style="list-style-type: none"> • Sony ICX262AQ CCD • 1/1.8" 3.3 Megapixel CCD • 24-bit colour (16-bit mono) • CCD: 2140 x 1560 pixels • Binning: 1x1, 2x1, 2x2 • Pixel size 3.45 x 3.45 µm • Cooled 30°C below ambient • 48-bit RAW colour images • Max. exposure: 24 minutes • Preview - 2048x1536: 2-3 fps • Raw 16-bit image transfer @ 2048x1536: ~1 second <p style="color: gold; font-weight: bold; font-size: 1.2em;">\$ 999.95</p>
<div style="border: 1px solid blue; border-radius: 15px; padding: 5px; display: inline-block; color: blue; font-weight: bold;">Opticstar DS-335C</div> <p>Non-cooled version.</p> <p style="color: gold; font-weight: bold; font-size: 1.2em;">\$ 699.95</p>	
<div style="border: 1px solid blue; border-radius: 15px; padding: 5px; display: inline-block; color: blue; font-weight: bold; font-size: 1.5em;">OPTICSTAR</div> <p>www.opticstar-ccd.com info@opticstar.com</p>	