Review: Atik 16IC

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Last year, Atik Instruments (http://www.atik-instruments.com) announced the latest addition to their popular 16-series cameras, the Atik 16IC. The line, based on the Artemis cameras, already had the Atik-16 (based on the Sony ICX429) and the Atik-16HR (based on the Sony ICX285) cameras. Both were available in both monochrome and one-shot color variants. Both existing cameras also sport larger chips than the 16IC, which may make the introduction of the 16IC seem a bit puzzling at the outset. Why in these days of bigger and bigger chips does one release something smaller?

I've now spent several months with a monochrome version of the 16IC and believe I know the answer. It's just a great little camera that is incredibly versatile. Just getting started and want something affordable, yet clean and reliable? Need a great guide camera? Want to compliment your DSLR or other one-shot color camera with a monochrome camera for some line filter work? Need something cooled that can run in the heat of the summer without noise? Need something free of interlacing artifacts and other errors that could make astrometry, photometery, or spectroscopy a problem? The 16IC hits on all counts. For $645 you get an exceptionally clean, solid camera whose only real fault is that the chip size prevents you from getting those nice wide field shots at high resolution.

Features and Layout

The camera is round (4.25" diameter, 1.25" thick) with female T-threads on the front and USB port, a ST-4 style autoguide output port, a fan, and a 12V DC jack. In addition, a T-1.25" adapter is provided to allow you to attach the camera to a standard 1.25" focuser. Thus, from an outward appearance it is very similar to the Orion StarShoot Deep Space Color Imager (with the addition of the fan and autoguide port). The onboard ST-4 output enables the camera to be used as an autoguider for mounts that use an "autoguide" input port to directly drive the motors (rather than send commands over a USB or serial port). The USB port is USB1.1 which does slow the full-frame download rate a bit (3.9 s) during framing and composing your shots. During normal downloads, cameras are typically read at rates slow enough to keep USB1.1 from being the limiting factor (this is done to reduce noise). But USB2 does allow other cameras to have a fast readout mode that trades higher noise for faster refreshes. Given that the camera supports region of interest (ROI) downloads, fine-focus on a star can still be done quickly as even with USB1.1 downloading a small region is quick.

Manufacturer Specs
CCD: Sony ICX424AL
Resolution: 659 x 494
Pixel size: 7.4 x 7.4 µ
Sensor area: 4.9 x 3.6 mm
ADC: 16 bit
Read noise: 7 e-
Power: 12V DC at 0.55A
Exposures: 0.001 s - Unlimited
Weight: 350g (0.8 lbs)
Interfaces: USB1.1 and ST-4
Price: $645 US

Software

The Atik 16IC comes with Artemis Capture, a basic application for image capture. Camera controls are well laid out and it is easy to use. It is, however, fairly limited as it is only designed for image capture. That it does well and offers some very nice features for use in the field. I particularly liked the "Quick" menu and keyboard shortcuts that let you direct the

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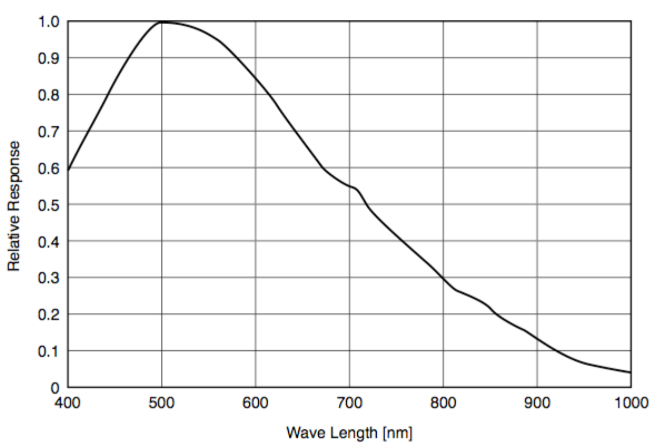
camera to quickly grab an exposure at several handy durations (e.g., 0.1s 1x1 bin, 1s 1x1 bin, 5s 2x2 bin, etc.). But, once you have the images, you're entirely on your own. There is no provision for any kind of pre-processing (e.g. dark subtraction) or stacking much less stretching. There is also no provision for guiding.

Atik does provide drivers for AstroArt and for Maxim DL. In addition, the camera is supported in Nebulosity and PHD Guiding from Stark Labs and K3CCDTools (Disclaimer: I am the author of Nebulosity and PHD Guiding). Both of these are far less expensive than AstroArt or Maxim DL and both offer camera control, image processing, and guiding tools.

Technical Notes and Tests

The sensor used in the monochrome version of the camera is a Sony ICX424AL and an ICX424AQ in the one-shot color version. These are progressive-scan CCDs with square pixels that employ Sony's HAD technology (for reduced dark current) and microlenses over the CCD wells. They are not SuperHAD (revised lens shape) or ExViewHAD (extended infrared response) CCDs but do offer very clean images. Sony does not publish absolute quantum efficiency (QE) specs, nor does Atik attempt to do so. However, Sony does publish the relative response, shown here.

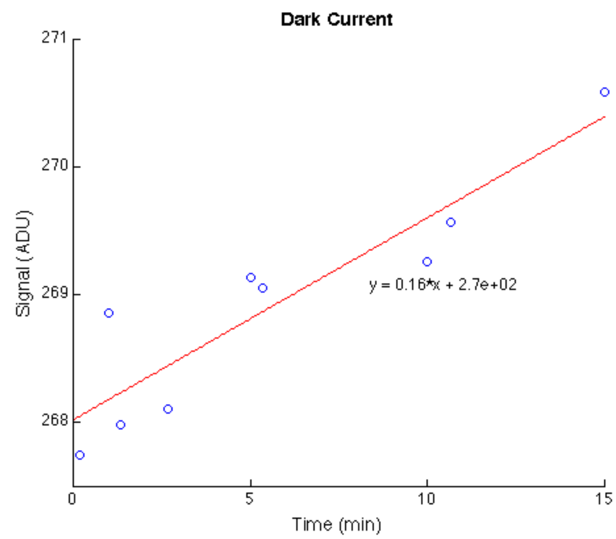


Thus, while we do not know the absolute QE, we do know that the sensor is down to about 65% of the max QE at the main emission line of hydrogen-alpha, etc.

Cooling

The 16IC uses a single-stage Thermoelectric Cooler (TEC) to chill the CCD and combat thermal noise. The system is very effective and really eliminates the need for dark frames. While dark frames can be effective at removing hot pixels and other aspects of noise injected into an image by the dark current (build-up of charge in the CCD wells based not on photons of visible light from our target by based on thermal energy), dark frame subtraction does have its problems. Large numbers of dark frames are needed for an accurate estimate of the true dark current to subtract from each pixel so that dark subtraction does not inject noise into the light frame. These should be either at the same exact same temperature as the light frame or, if fairly close in temperature, scaled to match the light frame.

A second problem, and a far greater one, is the fact that noise is proportional to the signal (scaling with the square-root of the signal). Thus, the greater the dark current, the greater the noise. CCD pixels don't care whether the energy comes from dark current or light pollution. Signal is signal and variance (noise) is proportional to the amount of signal. Your images will be noisier if you take them under light polluted skies or if taken with a lot of dark current, regardless of dark sub-



traction. A perfect dark frame will remove the constant current built up in the pixel, but the additional noise superimposed on this value (the random noise) cannot be pulled out. Thus, the less "bad" signal you have (dark current, light pollution, etc.) the cleaner your images will be.

The Atik 16IC has a very effective single-stage cooling system. I measured the dark current in the camera at an ambient temperature of ~78F (~25C) by taking a series of nine dark frames ranging from at 10 seconds to 15 minutes and cropping out a 150x200 portion in the middle of each frame. A linear regression calculated the dark current to be 0.16 ADU/minute. A 10-minute exposure would induce (on average), less than 2 counts out of 65,535 worth of dark current.

Noise

The Atik 16IC uses a progressive-scan Sony sensor. I have always found the progressive scan chips (which read the image off from top to bottom in one pass) to at

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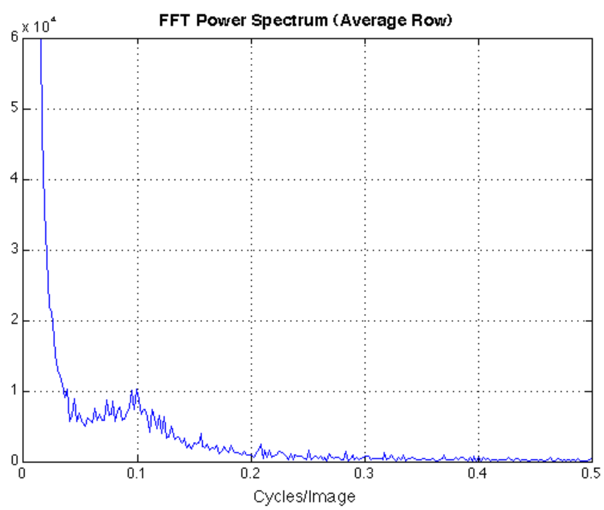
least visually appear cleaner than the interlaced chips (which read the odd and even lines separately and then re-assemble the image). The Atik 16IC is no exception here as it provides a very clean looking bias image with both very low noise levels and almost no apparent structure to the noise.

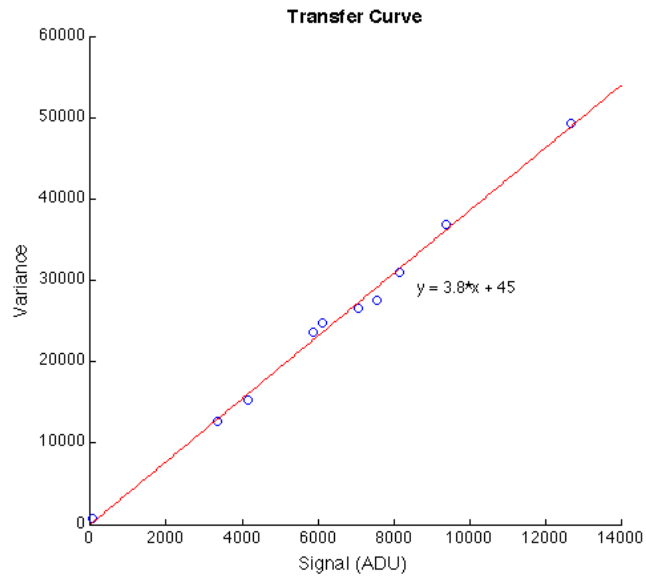
The noise was quantified by using pair-wise comparisons between several bias frames. By taking the standard deviation of the difference between bias frames (done on the same 150x200 portion in the middle, free of obvious hot pixels) and correcting by 1.414 for the additional noise induced by the subtraction, I arrived at an average read noise of 24.5 ADU. Each frame averaged 25.3 ADU. Further, measuring the read noise of sample bias frames versus a median stack of 20 bias frames also yielded an average read noise of 25.6 ADU. Thus, we can be confident in the read noise being approximately 25 ADU. Note, this is purely in Analog / Digital Units (i.e., counts or raw intensity) and not in electrons.



I further examined the bias images by performing Fast Fourier Transforms (FFT) on the median bias stack, looking at individual rows, the average row, and the average column. Quite often, cameras suffer from periodic noise across the image as things like USB read delays affect the timing of the readout from the CCD. The FFT of the vertical component (average column) showed a perfectly clean response. The FFTs of individual rows and average rows showed only a small deviation from a perfect response at a frequency of ~0.1, corresponding to ~65 pixels. This structure can be seen in the bias image but it is almost imperceptible. I have seen far worse bias frames and few even as good as produced by the Atik 16IC.

Transfer Curve: e-/ADU

So far, the results have been presented in ADU (Analog/Digital Units), not in electrons. High-end cameras typically list the number of electrons per ADU, so that other measures can be in electrons (recall that CCDs convert some percentage of the photons that strike their wells into electrons). This rate, the number of electrons per ADU (e-/ADU) is a measure of the system gain and can be calculated by plotting the variance versus intensity across a number of image intensities. Following the methods of Nikos Drakos and Tim Abbot (1995), pairs of flats were taken at the same exposure duration with different light intensities. The median bias stack was used to correct each image and, for each pair, the median value of one image and the half the variance of the difference was calculated. The slope of the linear regression to these points was 3.8 indicating the e-/ADU was 0.26 (inverse of the slope). Using a somewhat simpler method described by Apogee, the e-/ADU was measured at 0.24.



If we assume the e-/ADU is 0.25, we can calculate the average dark current to be 0.00067 e-/ADU and the average read noise to be 6.25 e-. While the dark current is not specified on the Atik website, the read noise is specified at 7e- and the current tests show the camera is meeting that spec.

Linearity

The linearity of the CCD's response is of interest to users who wish to perform photometry. Unfortunately, without very controlled light sources, I must use the camera's onboard exposure timer to vary the amount of light striking the CCD. Any deviation in timing accuracy will be reflected in the linearity curve. To attempt to account for this, the linearity tests were performed three times under three different lighting conditions (and therefore exposure durations).

What I observed was that while the response was overall linear, there were portions of the response that

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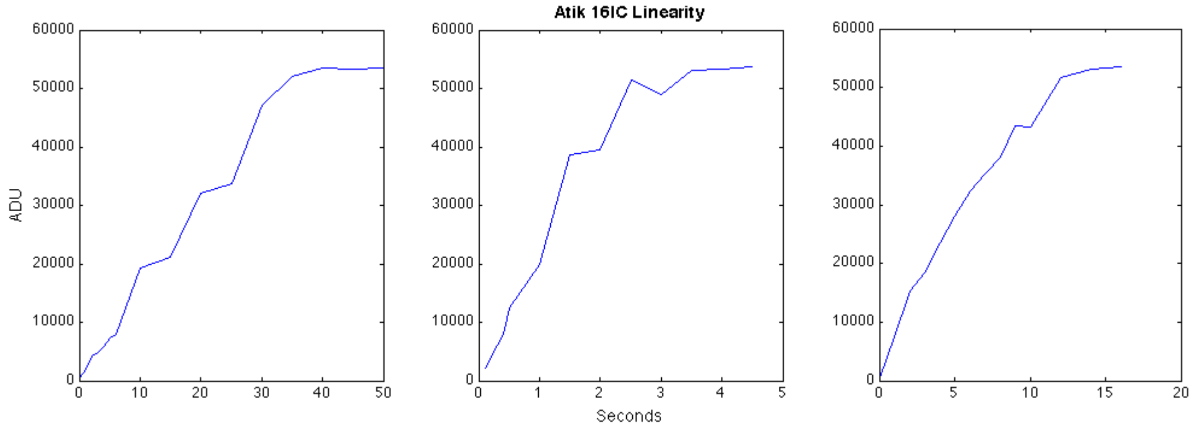
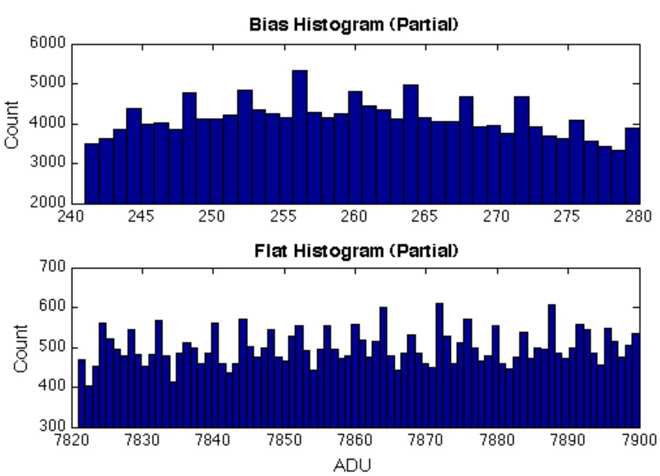


deviated from linearity. For example, on the leftmost graph, we see deviations around 10 s and 20s. Similar errors are seen below 10 s. Both of these are mimicked in the middle and rightmost graph and in all cases the deviations from linearity are consistent with exposure duration and not with the actual intensity (e.g., in the rightmost graph, the region from 20,000 - 40,000 ADU is nicely linear). From this we can conclude that a large portion, if not all, of the deviations from linearity are the result of inaccuracies in the exposure duration and not from anything inherent in the CCD and its readout. This is quite good as exposure duration variability would not affect photometric analysis.

From these graphs, we can also get a handle on the linear range of the camera. We can see that the camera begins to enter saturation and become non-linear around 50,000 ADU with complete saturation near 53,000 ADU. Given 0.25 e-/ADU, this would put the full-well capacity at just over 13,000 e-. Note that neither Sony nor Atik publish full-well capacities.

This full-well capacity is lower than I anticipated, having seen tests on similar Sony CCDs. This measurement does rely on an accurate e-/ADU rate. I measured this several times and arrived at very similar numbers each time. Further, a detailed examination of the histogram showed peaks every 4 ADU. This is consistent with an overall system gain of approximately 0.25 e-/ADU (as real signals from photons are discrete with one photon being approximately 4 ADU).



In Use, Under the Stars

Tests are tests and they can tell a lot about a camera, but how does it actually do in the field? The camera does quite well, I'm glad to report. I have used a large number of "entry level" cameras for both imaging and guiding purposes. The Atik does more than hold its own in the field. One night I did a head-to-head comparison to see what 1 minute exposures would do on M51 on a selection of of cameras using the larger and more sensitive ICX429AL chip (all else held constant). While the Atik 16IC gave up a little bit in sensitivity, signal-to-noise is the name of the game and the Atik's very low noise let it hang with even the far more expensive, cooled, more sensitive cameras.

When people are considering cameras, they may consider the relatively small chip and limited pixel count as very limiting factors. To address these concerns, I took two shots to show here. The shot of M57 was a test shot taken on a 6" Intes Mk66 at it's prime focus of

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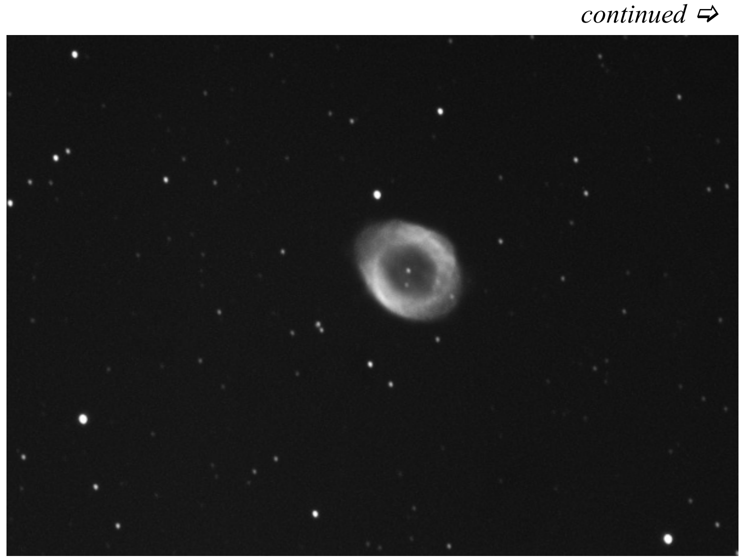

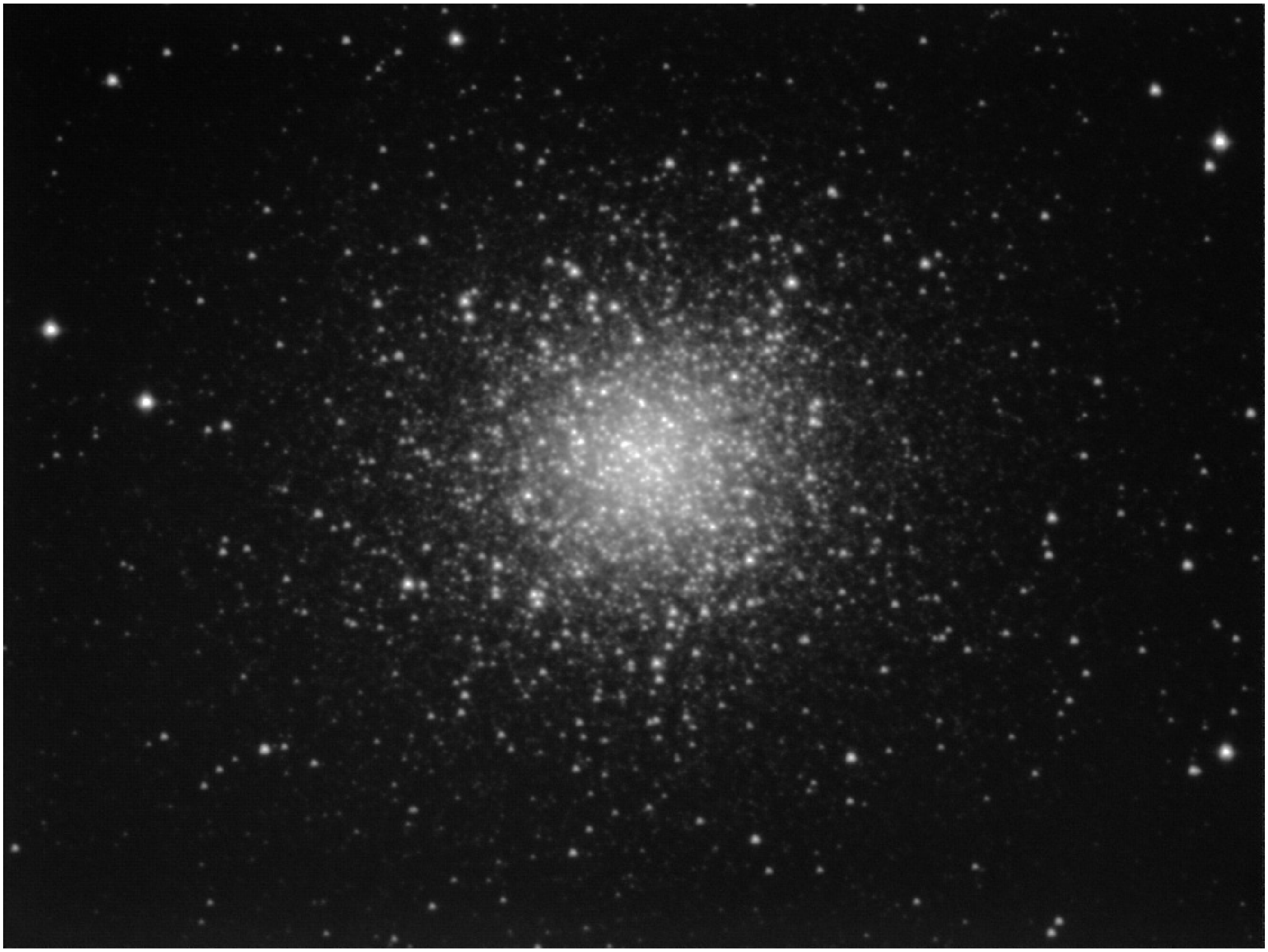

f/12. The objective from an 8x50 finderscope was used as a guide scope. A total of 50 1-minute frames were stacked (capture and stacking in Nebulosity, guiding in PHD Guiding). The shot of M13 was taken on an 8" Vixen R200SS (f/4) with 118 40-second frames stacked using Drizzle to recover lost resolution (capture and stacking in Nebulosity, guiding in PHD Guiding). I certainly wouldn't suggest a 6" f/12 is ideal for this camera given the pixel size, but despite urban skies and running at a long focal length and high f-ratio, the camera delivered a nice image with minimal effort. Something more like the 8" f/4 with it's 1.9"/pixel from the 800 mm focal length is more appropriate for the camera, covering a respectable 21' x 16' (that could double with a short focal length refractor). Here again, a nice image was generated with little effort. With both scopes, the camera performed quite well delivering very clean images without an ounce of hassle or complaint. All in all, there are a lot of targets that can be covered with the right scope on this sized chip and the wonderfully low noise from the Atik 16IC helps you pull those faint fuzzies out cleanly.♦

By day, Craig Stark, Ph.D. is a professor whose research involves trying to pull faint signals out of noisy, moving images of people's brains. By night, he is an amateur astrophotographer and operates Stark Labs (http://www.stark-labs.com). Stark Labs provides software to help users pull faint signals out of noisy, moving images of the heaven