SKY & TELESCOPE

TEST REPORT

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Apogee Instruments was the first company to release astronomical cameras with Kodak's new CCDs, in part because the company already had a time-tested body designed for 37-millimeter-square chips.

WHAT WE LIKE:

- **High-performance Kodak CCD designed for scientific applications**
- **Time-tested camera design (especially the cooling system)**
- ***MaxIm DL/CCD* camera-control and image-processing software included**

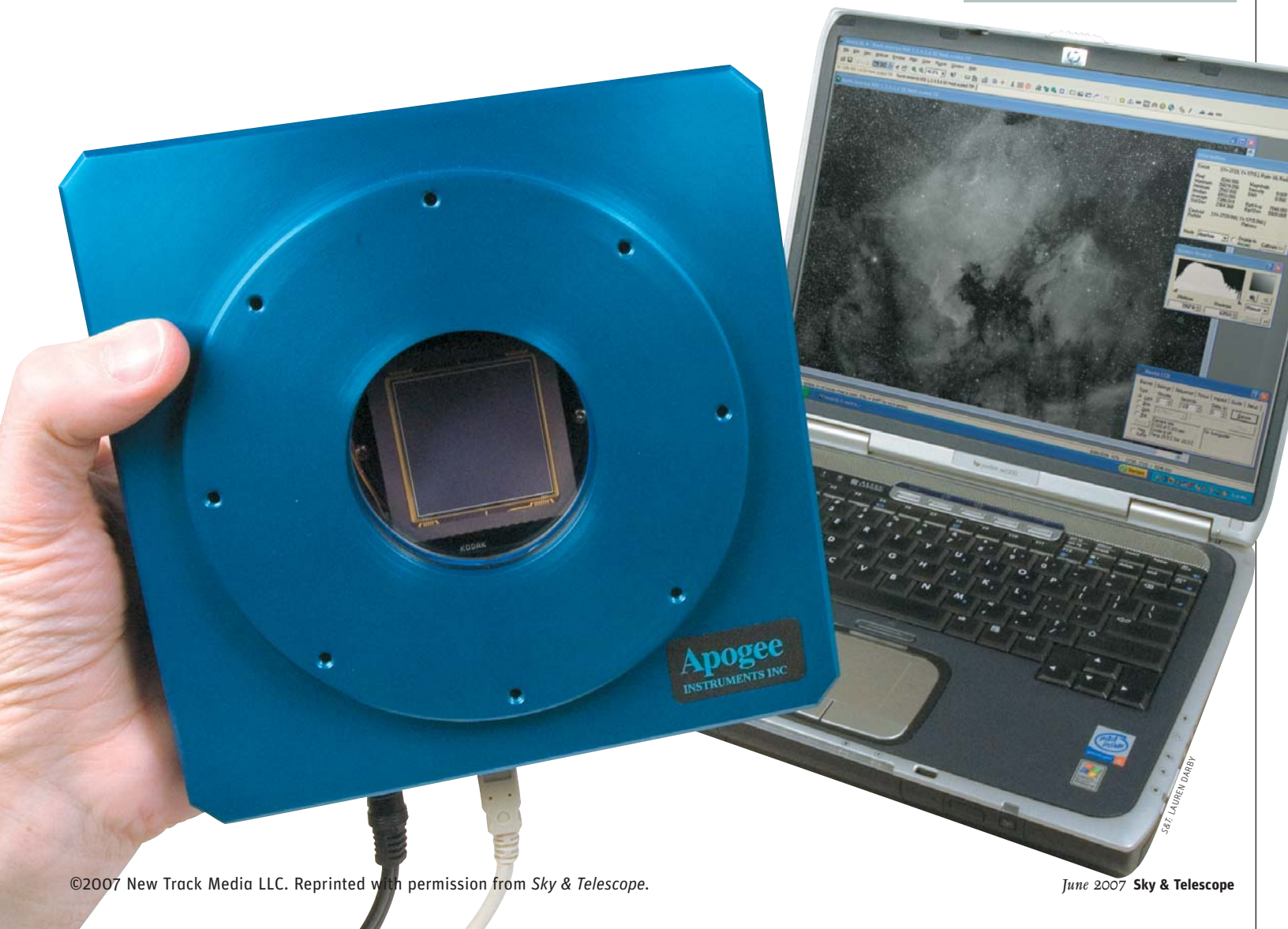
WHAT WE DON'T LIKE:

- **Limited selection of available telescope adapters**

Apogee's Alta U9000 CCD Camera

The first astronomical camera with Kodak's next generation of large-format CCDs shows that there's more to be excited about than just size.

By Dennis di Cicco



S&T: LAUREN DARBY

I've never been one to chant the mantra "if big is good, then bigger is better," but you wouldn't know it based on my enthusiasm for Apogee's Alta U9000 camera. Fitted with a CCD larger than a frame of 35-millimeter film, the camera offers the largest imaging format currently marketed to astrophotographers. So if not chip size, what is it that I find so attractive about the U9000? The list is long, and it involves three heavy hitters in the world of CCD imaging: Eastman Kodak, Apogee Instruments, and Diffraction Limited.

When Kodak announced two new megapixel CCDs with an imaging area almost 37 millimeters square last year, they impressed this magazine's editors enough to be selected as Hot Products for 2007 (January issue, page 100). Initially it was their price that caught our attention, since the new chips were about one-third the cost of Kodak's earlier giant CCDs. This price reduction suggested that future cameras might be priced at merely the high end — rather than the stratospheric end — of the amateur market. But a closer look showed us that there was a lot more to be excited about than just the chips' lower cost.

Apogee Alta U9000 CCD Camera

System includes camera, power supply, cables, and a full version of Diffraction Limited's *MaxIm DL/CCD* software for camera control, image acquisition, and image processing.

US price: $9,995

Apogee Instruments
1020 Sundown Way, Ste. 150
Roseville, CA 95661
916-218-7450

The new Kodak CCDs were developed for scientific applications, especially next-generation digital radiography, and they offer significant performance improvements over their predecessors. They are very-low-noise, full-frame (instead of interline) chips with microlens technology to boost sensitivity and antiblooming protection to eliminate streaky image artifacts on bright objects. They also have 50% quantum efficiency at the astronomically important wavelength of hydrogen-alpha light (656.3 nanometers), which makes them twice as sensitive to this red light as the Kodak KAI-11000M CCDs found in the previous generation of king-size cameras. This all translates into great news for astrophotographers who want to capture stunning pictures of the deep sky.

The new KAF-09000 chip (in the Apogee Alta U9000 camera tested here) has a 3,056-by-3,056 array of 12-micron-square pixels, while the KAF-16803 (available in the Alta U16M camera) has a 4,096-by-4,096 array of 9-micron pixels. You can

S&T: DENNIS DI CICCO & SEAN WALKER

The Alta U9000's high sensitivity and broad spectral response make it an excellent performer for photographers assembling tricolor images from separate exposures made through red, green, and blue filters. This $2^1/_2°$-wide view of the Rosette Nebula in Monoceros was created from 2 hours of exposure through each filter using a Tele Vue-NP127is (5-inch f/5.2) refractor, one of the few off-the-shelf telescopes that can cover the camera's full field with high-quality star images.

download Kodak's extensive documentation about these chips from Apogee's website, www.ccd.com.

Hardware

Last July Apogee was the first company out of the gate with a camera incorporating the new Kodak CCDs, since its D7 camera body introduced in late 2003 was already designed for this format. While the camera is relatively large and heavy, its power and computer connections are elegantly simple. The 5.1-pound (2.3-kilogram) body is 7 inches (18 centimeters) square and 3 inches thick. All the power it needs comes from a 12-volt DC, 5-ampere "brick" supply with a universal AC input, physically very similar to the power supplies that come with most of today's laptop computers.

A single USB 2.0 cable connects the camera to any suitable Windows-based PC running the supplied camera-control software. Although computer requirements for camera control and image acquisition are modest, if not meager, by today's standards, processing the Alta U9000's 18-megabyte files can give even the most powerful systems a workout. And for archiving purposes, a DVD burner is desirable, since it's not unusual for a night's worth of images and calibration frames to exceed the 700-megabyte capacity of a CD-ROM.

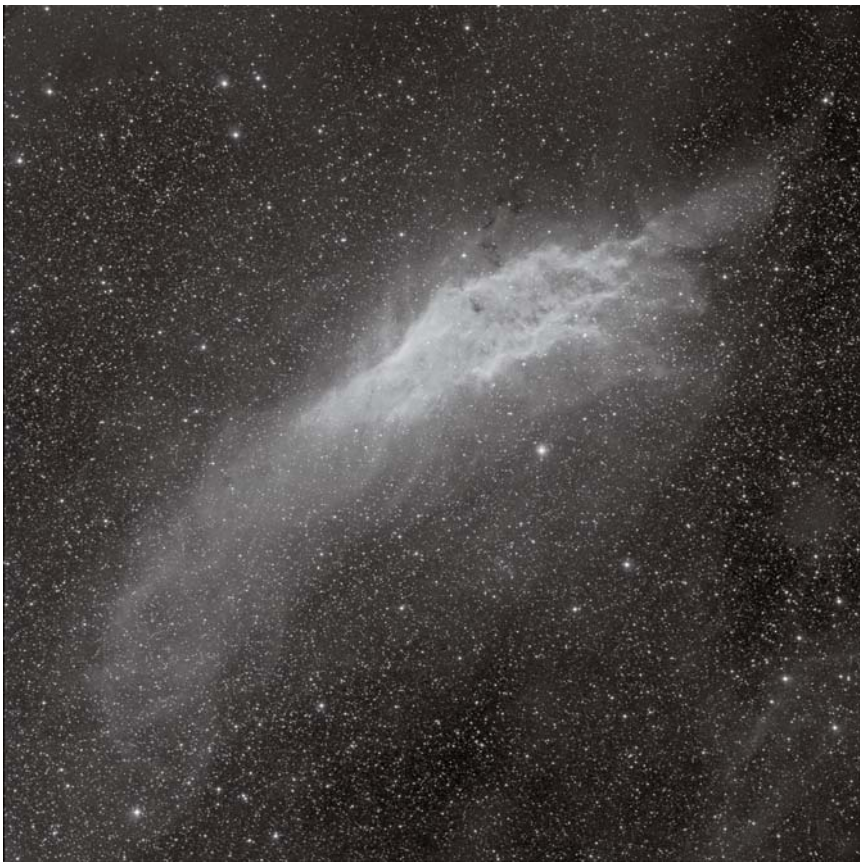
I'm particularly impressed with the Alta's robust, two-stage thermoelectric cooling system. It could easily maintain the camera's CCD at the specified 40°C below ambient air temperature, often doing so at less than 90% of the cooler's capacity. Nevertheless, I rarely worked the system that hard. At –20°C, the KAF-09000 chip adds dark current to each pixel at a rate of only about 0.4 electron per second. This means that the total dark current in a 20-minute exposure amounts to only ½% of a pixel's full-well capacity. This is outstanding performance for a deep-sky camera. Furthermore, by always setting the cooler at –20°C, I was able to build a permanent library of dark frames for calibrating images. And this way I didn't have to waste valuable observing time acquiring them each time I observed.

The cooler is very well regulated, typically holding the CCD's temperature fixed to within 0.1°C, but on camera startup it cools the chip rather slowly. After turning the camera on, if the cooler had to drop the temperature more than about 20°C from ambient, I typically gave it an hour to stabilize before shooting images. I could, however, safely turn the camera off at the end of an observing session without having to first slowly warm the CCD back to ambient temperature. The camera can also run for extended periods with the cooler on, and Apogee's Gary McAnally told me that at least one customer has been operating an Alta camera 24/7 for nearly a year without any problems.

Software

I loathe installing computer software and hardware, but even with this Luddite mindset, I considered getting the Alta U9000 to cooperate with my Windows XP laptop a breeze. Installing (in my case, upgrading) Diffraction Limited's *MaxIm DL* version 4.56 software took only minutes. It took a similar amount of time to install the proper drivers and establish a working link with the camera. The installation process went so smoothly that in less than an hour I had figured out lots of the camera's functions and even made a rudimentary tricolor image in my basement workshop. My previous experience with *MaxIM DL* as an image-processing program certainly helped, but even a first-timer should have a smooth ride getting started.

In the world of amateur astro imaging, it's safe to say that *MaxIm DL* has become the gold standard for image processing and camera control. There isn't room here for me to even begin listing all its advanced features, so I'll simply leave it by saying that I can't think of a better package to be included with the Apogee camera. After more than five months of testing and hundreds of saved exposures, many obtained in the wee hours and mind-numbing cold of New England's winter nights, I never lost a single image due to software problems. It doesn't get any better than that.



S&T: DENNIS DI CICCO & SEAN WALKER

This is not your father's California Nebula! The brightest portions of this glowing hydrogen cloud in Perseus resemble the state of California, but if early photographers had been shooting with the Alta U9000 camera, the object might be known as the Scimitar Nebula. This 2-hour exposure with an f/4 Pentax 100 SDUF astrograph and hydrogen-alpha filter is 5° wide with north up.

I find it especially commendable that *MaxIm DL* comes with a superb printed manual. It's nice to have online help available in the dark to answer a question, but even nicer to have a manual to page through on cloudy nights in search of operating tips and subtle features buried in the program.

The Alta U9000's full-frame, full-resolution, 16-bit images download to the computer in 10 seconds. But where this download speed really shines is during focusing. By opting to display just a small portion of the frame containing a suitable star, my focusing updates happened in the blink of an eye. Furthermore, *MaxIm DL* includes excellent tools for assessing focus on the fly. Together these made obtaining sharp focus a simple and pleasant task.

One counterintuitive aspect of the camera-control software is worth mentioning. *MaxIm DL* allows downloaded images to be displayed in a variety of orientations, but the software does not keep track of these settings, which can cause problems when you are later calibrating images.

Here's an example. I began shooting one evening with my telescope on the west side of a German equatorial mount. Because of my setup, I displayed the downloaded images rotated 90° *clockwise* to conveniently show the field with north up. When I later switched the scope to the east side of the mount, I had to rotate the images 90° *counterclockwise* to achieve the same north-up view. I also used this rotation for my dark and flat-field frames. Images from the second half of the night calibrated fine, but the earlier ones were a mess. After some handwringing, my colleague Sean Walker and I figured out that the orientation of the calibration frames was the culprit.

After that, I left *MaxIm DL*'s image download in the default orientation and just twisted my head if I wanted to see a fresh-from-the-camera image with north up. Of course, once images are calibrated you can turn them any which way you want.

Good News: There's No Bad News

With all the foregoing good things I've said about the Alta U9000, there must be something bad, right? But the truth is, I really have nothing negative to say about the camera. There are, however, several caveats that go with using any large-format CCD, and one in particular involving this camera.

As of mid-March, there are no telescope adapters I know of specifically made for the Alta U9000. McAnally told me the company is working on adapters and two filter wheels that should be introduced by the time you're reading this.

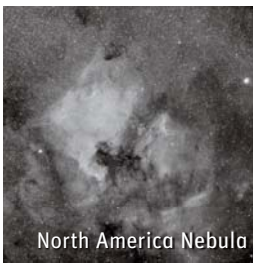
When the camera we borrowed from Apogee for this review arrived last September, I simply disappeared into my workshop for a few evenings to make adapters and filter holders for several telescopes and medium-format camera lenses (it's one of the advantages of owning a lathe and a milling machine). Mechanical drawings and specifications for the camera are available on Apogee's website, and if you don't own a lathe you can always turn to companies such as PreciseParts in Florida (www.preciseparts.com) to make custom adapters for just about any setup.

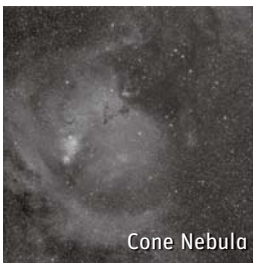
Filling the Alta U9000's CCD with pinpoint stars to the corners of the frame requires an optical system with an optimized imaging circle at least 52 mm in diameter. Typical amateur telescopes won't cover a field this large. And even ones that can with photographic film may not work as well with CCDs, since the chips' high sensitivity and broad spectral coverage make them less forgiving of minor optical aberrations. For example, I tested the Alta U9000 with an array of Zeiss-made Hasselblad camera lenses designed to cover image circles almost 80 mm across. Most were fine, but one that worked nicely with color film gave disappointing results with the CCD.

While in the past the expense of a large-format CCD might have seemed squandered if the chip's entire area wasn't used to advantage, the outstanding astronomical performance of these new Kodak CCDs make them attractive even if your telescope doesn't illuminate the full frame or you crop the field to remove less-than-perfect star images near the edges.

Large chips and their corresponding large fields of view offer calibration and image-processing challenges sometimes absent with smaller chips. My long-term method of making flat-field frames (as much black art as science) needed some major tweaking to work well with the Alta U9000. And more often than not, I had to rely on Sean's image-processing talent to remove large and complex brightness gradients in my frames caused by local sky conditions.

I'm extremely impressed with the Alta U9000 camera, in part because the companies behind the CCD, camera, and software have well-established and well-deserved reputations in the imaging community. Much of my time testing the Alta U9000 was loosely related to a long-term fascination I have with mapping the Milky Way's hydrogen-alpha nebulosity. Despite my backyard location in the Boston suburbs, the camera's extremely low noise and high red sensitivity allowed me to record swaths of nebulosity that I never knew existed. And the images here show some of the spectacular results I achieved with the ones we all know about. The quality exceeds anything I've been able to do in the past with film or other CCD cameras. In my opinion, the Alta U9000 launches a new era in astronomical performance for high-end amateur cameras. ✶


North America Nebula


Cone Nebula


Rosette Nebula


IC 1848 and IC 1805


Simeis 147

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Senior editor and lifelong New Englander Dennis di Cicco *says that with each passing year it takes more inspiration for him to observe in winter — yet the Alta U9000 lured him outside on every one of the coldest nights this past season served up.*