



PlaneWave's 12.5-inch CDK Astrograph

Born in the age of digital imaging, this astrograph leaves little to be desired.

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U.S. price: \$9,900

PlaneWave Instruments

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All photos by the author;
astronomical image processing by Sean Walker.

IT WAS A PLEASANT midsummer night testing equipment, memorable for everything going smoothly. The computer booted up, the CCD camera cooled down, the mount was tracking nicely, and even the mosquitoes seemed to be elsewhere. It was time to sit back and wait for a few Perseids. As the rhythmic beeping of the autoguider began harmonizing with the cricket's nighttime song, my thoughts began to wander.

What if, I wondered, some astronomical Rip Van Winkle dozed off at the guiding eyepiece 20 years ago (perhaps dreaming about SBIG's newfangled CCD autoguider/camera), only to awaken today? Can you imagine how dumbfounded he'd be by modern astrophotos? He'd be even more mind-boggled to learn that most of these spectacular images are made by amateurs. Surely he'd ask what caused this astrophotography revolution.

"Well, Rip," I'd reply, "as I see it the answer is three-fold." Foremost is computerized image processing — it runs circles around anything that you could do in the darkroom of yore. Next comes digital sensors, which are far more efficient and "linear" than film. Good signal-to-noise ratio (SNR) has always been at the heart of quality astrophotography, but digital sensors transformed the measurement and manipulation of SNR from a black art to a quantifiable and controllable process. And lastly, there's equipment. Better mounts and autoguiders are factors, but there's also a new generation of telescopes.

Rip would have nodded off when astrophotography was dominated by Schmidt-Cassegrain reflectors and



Pictured as tested in the author's suburban-Boston backyard observatory, the PlaneWave 12.5-inch f/8 CDK reflector was designed from the get-go as an astrograph for high-end CCD cameras. Little niceties such as 1/4-20 bolt holes in the tube's back plate and front ring make it easy to attach counterweights and other accessories used by astrophotographers.



The 12.5-inch CDK delivers pinpoint stars across the field of today's large-format CCD cameras as seen in this view of the globular star cluster M13 assembled from 10-minute exposures through red, green, and blue filters with an Apogee Alta U16M CCD camera.

modest-aperture refractors. But he would have awakened to a world of telescopes built for digital imaging — one example being the PlaneWave 12.5-inch f/8 CDK reflector towering at my side on this serene August evening.

The CDK Backstory

Short for corrected Dall-Kirkham, the CDK traces its roots to a 1990s telescope-making class at El Camino College in Torrance, California. Several participants, most of whom were Celestron employees at the time, decided to tackle a 42-inch transportable reflector. While mulling what to build, Dave Rowe, an amateur telescope maker with optical-design experience, joined the group. They settled on Rowe's variant of a Dall-Kirkham Cassegrain that incorporated a two-element correcting lens located near the focus (more about this in a moment).

Following the construction of a successful 18-inch prototype, in the mid-2000s the CDK design made a debut, albeit briefly, in the commercial arena when Celestron manufactured a 20-inch version. Through a series of

WHAT WE LIKE:

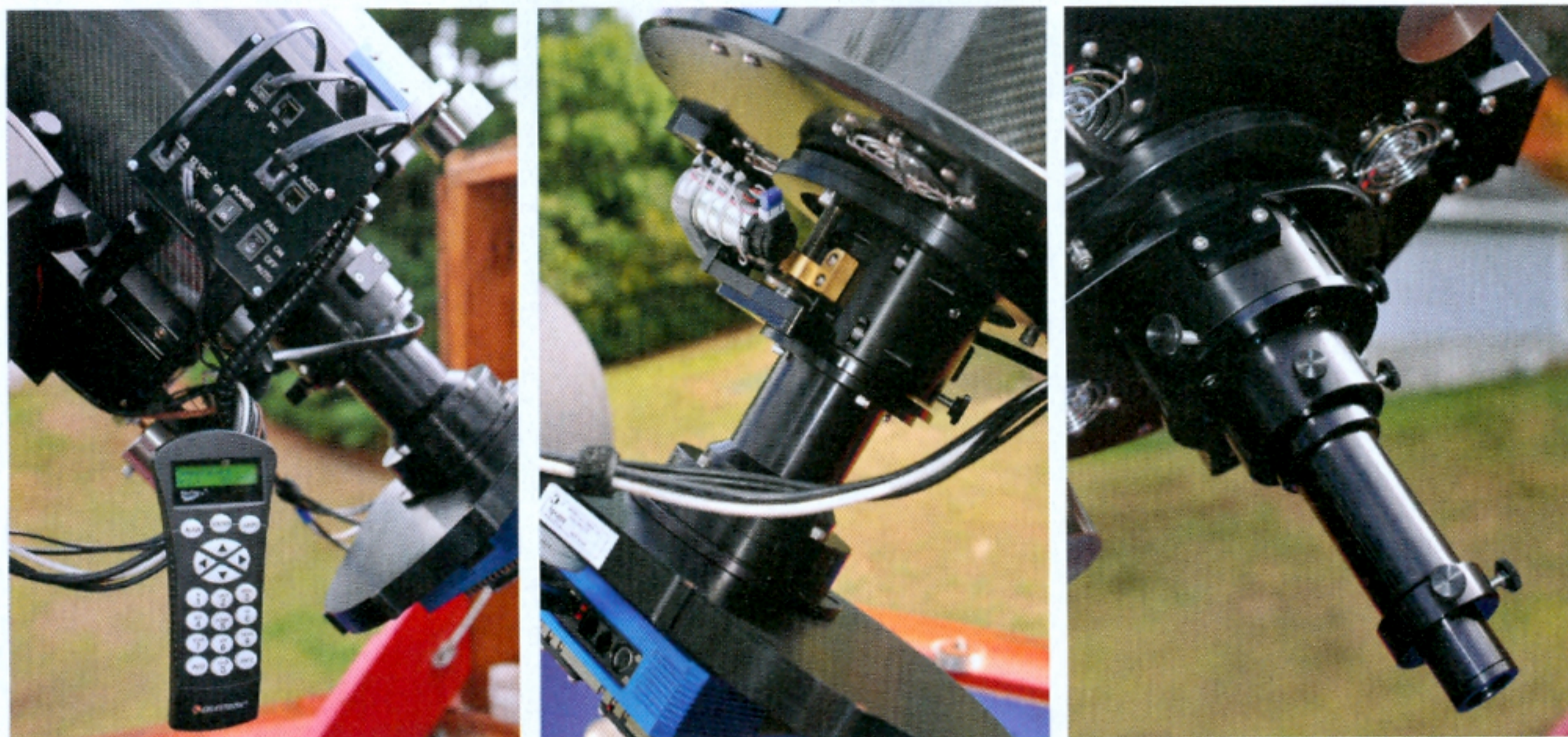
- Superb image quality across large-format CCDs
- Robust focuser and camera adapters
- Stable focus in changing temperatures

WHAT WE DON'T LIKE:

- Optimum camera adapters are often different for each camera

events after that scope was discontinued, and with the company's blessings, Rick Hedrick and Joe Haberman left Celestron to found PlaneWave Instruments and continue building the CDK.

PlaneWave stresses that the CDK is not just a "conventional" Dall-



Left: The optional Electronic Focusing Accessory adds motorized focusing with absolute-position readout (on a modified Celestron hand controller) and automation of the scope's built-in cooling fans for the primary mirror. **Middle:** The Hedrick Focuser and robust camera adapter pictured here are described in detail in the text. **Right:** Since the CDK's focus lies at a fixed point about $7\frac{1}{4}$ inches beyond the focuser, using the scope with eyepieces requires extension tubes. The one pictured here serves a dual purpose of placing a special Ronchi tester at the precise location needed to check the critical spacing between the scope's primary and secondary mirrors.

Kirkham with a corrector mounted inside the primary-mirror's baffle tube to eliminate off-axis coma and flatten the field. Instead, all of the CDK's optical surfaces have been optimized to work together as a system. The design still retains the Dall-Kirkham's ellipsoidal figure on the primary mirror, and the secondary remains spherical. As such, optical collimation is achieved with simple tip-tilt adjustments to the secondary, without the critical centering requirements of some Cassegrain systems.

Separation between the CDK's primary and secondary mirrors, however, should be held to a tolerance of 1 millimeter. The spacing, which is adjusted with a single screw on the 12.5-inch model I tested, is set at the factory. The scope comes with special tools and a clever optical method (using a star test) to check and adjust the spacing.

Designed for Astrophotography

Chances are, if you've visited a PlaneWave booth at any amateur gathering in the past year, you've seen the scope that we borrowed for this review. Apart from a few cosmetic bumps and scratches collected during its cross-country travels, the scope is a production model. With a base weight of about 50 pounds (23 kilograms), the 12.5-inch CDK is a nice match for the Celestron CGE Pro mount used for the review. The whole test setup, including a second dovetail mounting bar, CCD camera and filter wheel, and guide scope, totaled about 80 pounds.

The entire telescope, not just its optics, has been designed for astrophotography, and this results in differ-

ences from instruments made to also conveniently serve visual observers. Some of the differences are subtle, but others are not. For example, the CDK's carbon-fiber tube (to reduce focus shift in changing temperatures) and fixed primary mirror (to reduce image shift) are features that everyone will enjoy. But the rigidly fixed focal point located about $7\frac{1}{4}$ inches (18 centimeters) outside the focuser, and the focuser's limited travel (only $1\frac{1}{4}$ inches), make the scope challenging to use with eyepieces if you don't have a collection of extension tubes.

The fixed focal point also requires special consideration when you're attaching cameras to the telescope, since the camera adapter needs to be the proper length. There's nothing preventing the use of simple camera adapters that slip into the scope's $2\frac{3}{4}$ -inch focuser (or the focuser's standard 2-inch adapter) and tighten with thumbscrews. But PlaneWave makes its scopes with high-end CCD cameras in mind. Its adapters, while relatively expensive, are robust tubes and spacers that bolt together and then bolt to the camera *and* the focuser.

When I unpacked the \$800 worth of adapter parts supplied for the Apogee Alta U16M camera and filter wheel used for my tests, it took me a minute just to figure out how everything went together, and another 10 minutes to assemble everything. The end result, however, was one of the most flexure-free connections between a telescope and camera I've ever used. That says a lot considering that the camera equipment weighed about 9 pounds (4 kg).

The scope's Hedrick Focuser has a basic Crayford

arrangement with a drawtube riding on roller bearings, but it's driven by a lead screw rather than a friction shaft pressing on the drawtube. As such, there's nothing that can slip even when the heaviest cameras are attached.

Coupled with the scope's carbon-fiber tube, the CDK did an excellent job maintaining focus during the constantly dropping temperatures that are typical of my clear summer nights. But the focus stability was even more remarkable for its night-to-night performance. In New England's sweltering heat last summer, the daytime temperature inside my observatory often exceeded 110°F (43°C), but could be in the low 50s by morning. This constant cycling of temperature raises havoc with the focus setting on most of the telescopes I've used for astrophotography. But not the PlaneWave; it remained pretty much in perfect focus even after several days of inactivity. I'm impressed.

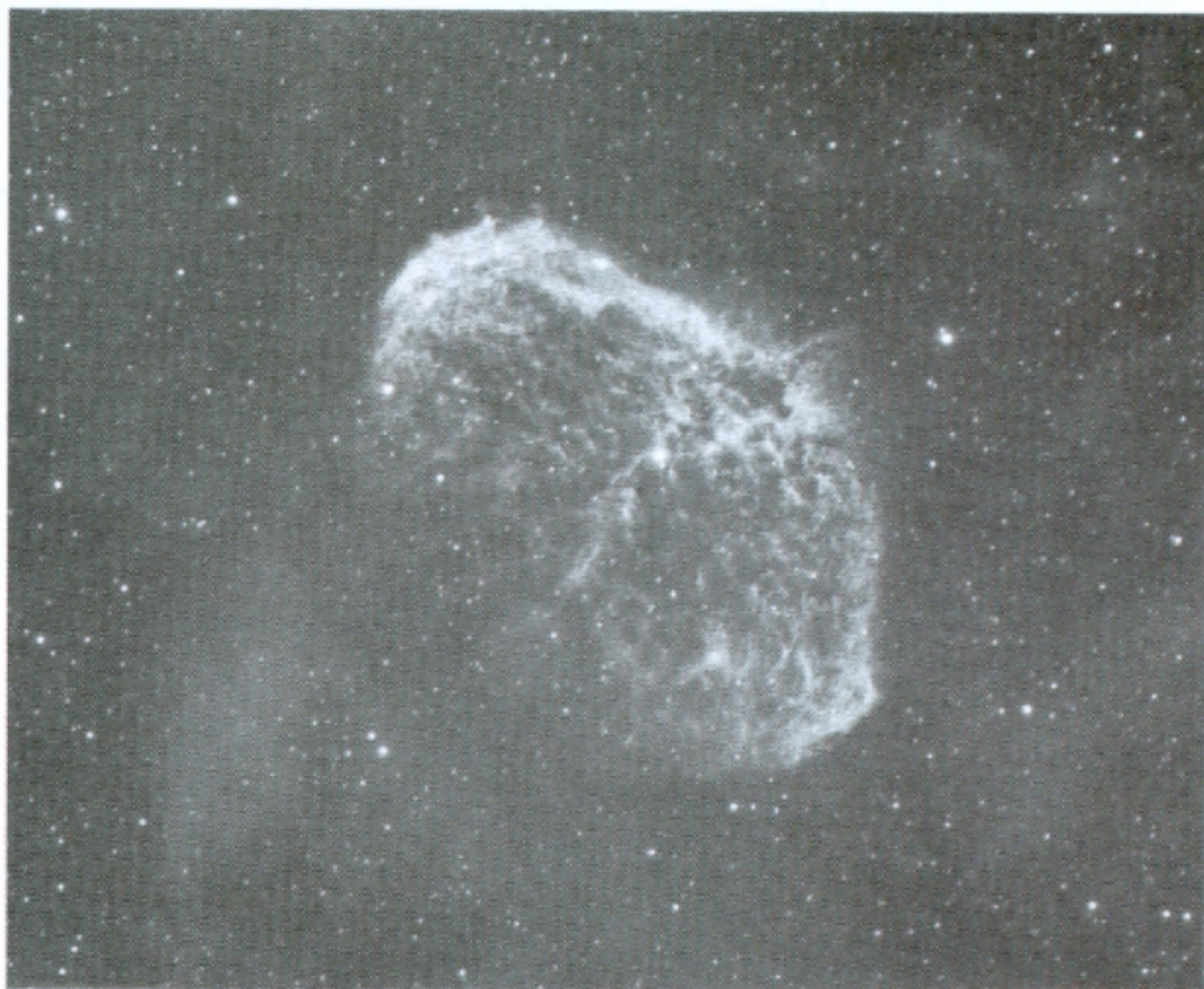
The scope's built-in fans were effective in cooling the primary mirror. I tested PlaneWave's optional \$800 Electronic Focus Accessory (EFA), which adds "smart" fan control as well as motorized focusing with digital readout. The EFA can cool the mirror to a set point (limited by ambient air temperature) or you can ask it to cool the mirror to a user-specified offset from ambient. I typically set the system to cool the primary until it was within 2°F of the ambient air temperature. Switching on the fans when I opened the roll-off-roof observatory around sunset (causing a drastic drop in the ambient air temperature around the scope) always had the mirror at the set point by the time I began imaging in late twilight. Furthermore, the fans did not cause any vibration that I could detect.

Given the scope's extensive travel history before reaching me, it didn't surprise me that the collimation needed to be adjusted. What did surprise me a little was how obvious the need for collimation was when I initially looked through an eyepiece. Off-axis stars clearly showed the effects of the system being out of adjustment.

The manual nicely explains the collimation process,



M27, the famous Dumbbell Nebula, was captured with 25-minute exposures through red, green, and blue filters.



The author was particularly impressed with the CDK's performance for narrow-band imaging. This 100-minute exposure of the Crescent Nebula, NGC 6888 in Cygnus, was through an Astrodon 3-nanometer hydrogen-alpha filter. The image resolution is 0.74 arcsecond per pixel, and the measured full-width, half-maximum diameter of star images across the chip is an impressively small 2.1 arcseconds.

which only involves turning thumbscrews on the secondary-mirror mount and examining stars in the eyepiece. But the manual emphasizes that it's a two-person process. That's true for most large telescopes, since ideally someone would be at both ends of the tube at the same time. I'm proof, however, that one person can do the job without becoming frustrated as long as you set aside enough time. But the really good news is that once I had the collimation set, it remained accurate throughout my testing.

The Envelope Please

Mechanically, the CDK was a pleasure to use as an astrograph. So the only remaining question is how did it perform optically? In a word, perfectly! Stars were tiny, round points from corner to corner across a Kodak KAF-16803 CCD (the largest chip in common use by astrophotographers). There was no difference in the size and appearance of stars across the field. The corners of the frame showed no vignetting, and I measured the smoothly illuminated field as having only about an 11% drop in brightness from the center to the edge. This is impressive performance. And while it should be expected for high-end instruments designed for demanding astro-imaging, it's nice that the CDK achieved it with no hidden caveats. The design delivers on its promises. It's a winner. ♦

According to his wife, if senior editor Dennis di Cicco dozed off for 20 years, he'd still be sleep deprived.