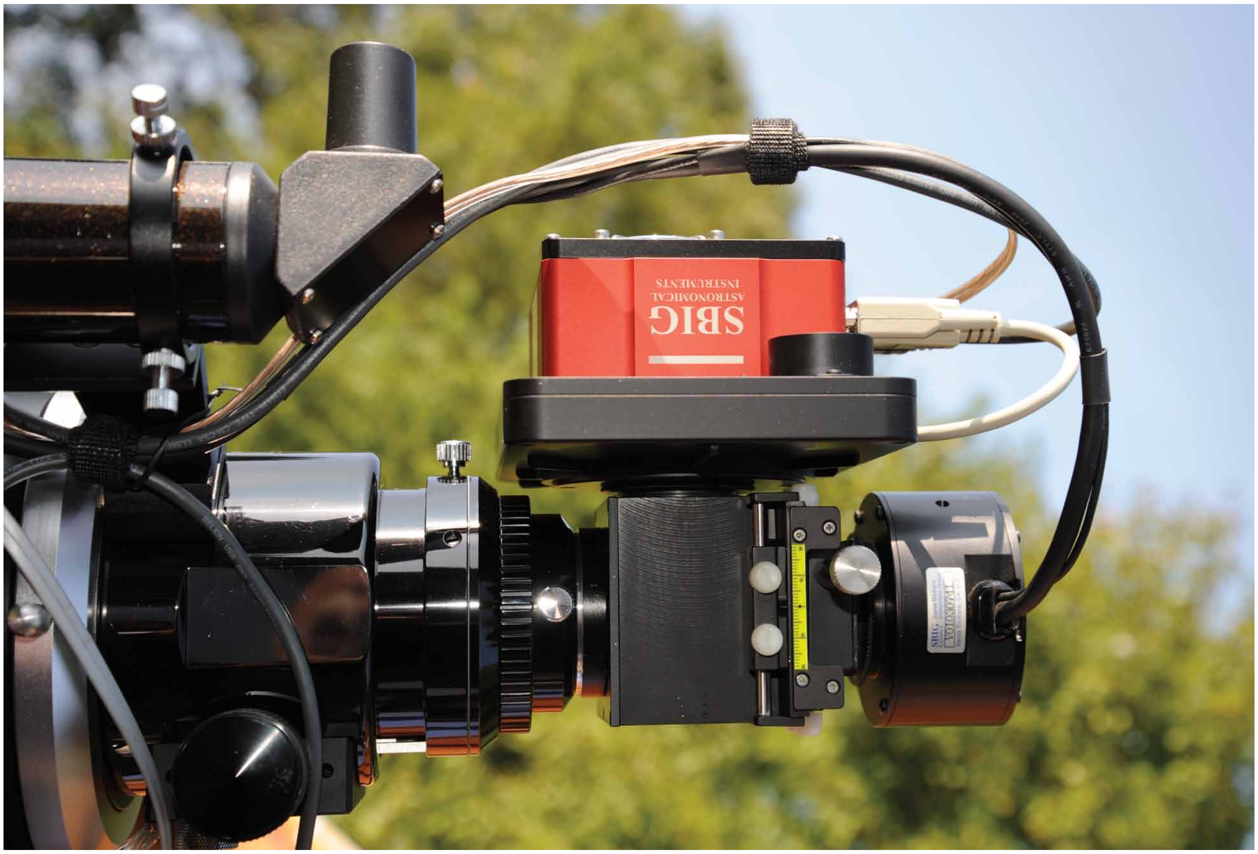
Dennis di Cicco

The ONAG from Innovations Foresight



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The ONAG looks like an exotic star diagonal and works by reflecting visual light to an imaging camera and transmitting infrared light to an autoguider. The author tested it with the Sky-Watcher 120-mm f/7 refractor reviewed in last June's issue, page 34.

The digital revolution (and the ONAG) gives us a new way to guide our astrophotos

Innovations Foresight's ONAG

U.S. price: $989
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OBSERVERS HAVE BEEN guiding their telescopes since the dawn of long-exposure astrophotography. It's a need that arises from a very long list of mechanical, optical, and atmospheric factors that makes it all but impossible for a simple telescope drive to precisely follow a celestial object for more than a minute or two as it moves across the sky.

The history of astrophotography is filled with ingenious ways people have devised to guide telescopes, and I thought about recapping some of them. But then I realized it would take way too much space to cover just the methods developed before the digital revolution began rewriting astrophotography's rules. Indeed, I've reviewed two products recently — the Telescope Drive Master (October 2011 issue, page 60) and the Paramount

MX (July 2012, page 64) — that use digital technology to transform the way we guide our telescopes. Now the ONAG (short for on-axis guider) from Innovations Foresight offers yet another fascinating method that is a byproduct of the digital age.

The Concept

One of the best ways to guide a telescope has always been to track a star at the edge of its field of view. Known as off-axis guiding (because the guide star is outside the field being photographed), the method eliminates many (but not all) of the mechanical, optical, and atmospheric problems mentioned above because the images of the celestial object being recorded and the guide star are formed by the same optical system. Off-axis guiding became mainstream with amateurs after the introduction of popular Schmidt-Cassegrain telescopes in the early 1970s, but it dates back to the earliest days of long-exposure photography at the turn of the 20th century. And it's the way the largest professional telescopes were guided when emulsion-based photography ruled the world of astronomy.

One downside to off-axis guiding, especially in the case of moving objects such as asteroids and comets, is that you can't guide on the same object you are imaging. Some people have tackled this problem by using a beam splitter to share a telescope's field of view with the imaging camera and guiding system, but this robs the camera of valuable light.

Enter the ONAG. Because digital detectors in today's autoguiders are sensitive to near-infrared (NIR) light beyond the visual spectrum, the ONAG works by sending a telescope's visible light to the imaging camera and the NIR to the guiding system. It does this with a beam splitter made from a so-called "cold mirror" that reflects visual wavelengths between 350 and 750 nanometers to one focal plane and transmits NIR beyond 750 nm to another. Ingenious! And it works because digital technology has given us the opportunity to easily use NIR light for guiding.

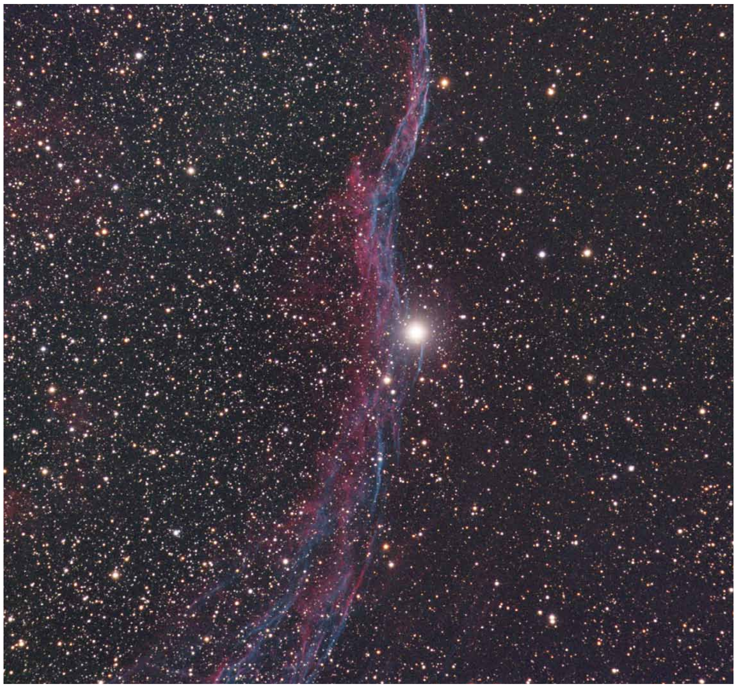
The ONAG

As clever as the concept behind the ONAG is, the devil is in the details, and that's where the ONAG really shines. The device, which from a distance looks a bit like an oversized star diagonal, is extremely well engineered and, more importantly, well made.

Even people new to long-exposure astrophotography have heard about the gremlin "differential flexure" that ruins photographs when there's shift between the imaging and guiding systems. This is a particularly common problem for people using separate telescopes for guiding and imaging. Despite conventional wisdom, differential flexure can also be a problem with off-axis (and on-axis) guiding if there isn't an absolutely rigid connection between the imaging and guiding detectors. The ONAG has a very rigid connection, and it's especially noteworthy

Left and below: **The ONAG's autoguider port accepts standard 1¼-inch equipment and comes with a fitting that has male T threads. The port is on an X-Y platform that travels on pairs of precision rails and locks in place with a total of eight nylon thumbscrews. The yellow scales on the X-Y axes can assist in positioning the port for guide stars selected in advance from star charts.**

Below: **Faint ghost images sometimes appeared near bright stars centered in the field of view, but it's unknown if they were due to the ONAG. Because the bright star 52 Cygni was slightly displaced from the center, it did not show a ghost in this view of the western Veil Nebula, NGC 6960.**



Guiding with the ONAG was so accurate that the author did not need to use stars to register the 90 minutes of exposures that were stacked for this view of the "Central America" region of the North America Nebula. Sean Walker did the final processing for all the astronomical images in this review.

because the device has an adjustable X-Y mounting for the guide camera, which helps in the search for suitable guide stars.

Using the ONAG involves getting your imaging camera and autoguider to reach focus simultaneously, and that means there are a lot of physical parameters to consider for your particular equipment. Fortunately, the Innovations Foresight website (**http://innovationsforesight.com**) gives very detailed mechanical specifications for the ONAG. So I'll just relate a few of the fundamental ones here. Because the ONAG's imaging port has a camera mount with male T threads, the system is best for detectors that span no more than 28 mm across their diagonal dimension. Although this includes the APS-size chips in popular DSLR cameras and Kodak's KAF-8300 CCD found in many high-end astronomical cameras, it is not large enough to completely illuminate the detectors in full-frame DSLRs or Kodak's KAF-11000 CCD.

The minimum back-focus distance between the female T threads on the ONAG's front mounting plate and the imaging port is 66 mm (2.6 inches), while the nominal back focus to the guiding port is 90 mm, with plus or minus 4½ mm available for focusing. Since most imaging cameras have more internal back focus (for filter wheels and the like) than autoguiders, the difference between the back focus on the ONAG's imaging and guiding ports is an advantage. As the accompanying pictures show, my setup with an early model SBIG ST-8300 camera and filter wheel and a now-vintage SBIG STV autoguider came to perfect focus without additional adapters. But for other setups that might need them, the ONAG comes with a set of 8-, 16-, and 24-mm extension tubes that work on both ports. The ONAG comes with a standard 2-inch nosepiece as well as a dedicated adapter that attaches directly onto the back of 8-inch Schmidt-Cassegrain telescopes.

The Guide Stars

The guider port accepts standard 1¼-inch equipment, and it comes with a drawtube with male T threads. As mentioned above, there's an X-Y stage on the guider port that allows the user to move the center of the autoguider's view 28 mm horizontally and 23 mm vertically, so you can essentially "explore" a 46-mm-diameter area of your telescope's focal plane to search for appropriate guide stars. This area is huge compared to what's available with most off-axis guiding systems. But there's another aspect of the ONAG that further improves the efficiency of finding a guide star.

As anyone who has done off-axis guiding knows, many telescopes produce crummy off-axis star images that are smeared by optical aberrations and dimmed by vignetting. Fainter off-axis stars can be so compromised that it becomes difficult for an autoguider to lock onto them for tracking. The guide stars available to the ONAG are closer to the telescope's optical axis and are thus of much better quality for guiding. That said, the ONAG's guide stars are not perfect, since they suffer from astigmatism introduced by the telescope's converging beam passing through the cold mirror's glass substrate tilted at a 45° angle to the optical axis. With careful focusing of the guide camera, the ONAG's guide stars were "tight" enough for my setup to easily guide on them. But Innovations Foresight offers an optional astigmatism corrector for those who want "imaging quality" stars available at the guiding port.

Although you can use virtually any camera that works as an autoguider with the ONAG, it has to be one without a built-in infrared-blocking filter. The only cameras that might have such a filter would be one-shot color cameras. Another aspect of the ONAG's guiding system worth noting is the apparent brightness of stars viewed at NIR wavelengths. What you "see" is not always what you get. Many stars that appear bright to our eyes can be relatively faint at NIR wavelength, and vice versa. This is of little consequence if you're hunting for guide stars by taking snapshots with your autoguider, since you'll just pick an appropriate star from the images. But it can complicate matters if you plan your imaging sessions beforehand with star charts.

As a case in point, consider the image of the open star cluster Collinder 399 (The Coathanger) on page 40. Although the westernmost star in the Coathanger's bar is visually the faintest, my autoguider on the ONAG saw it as nearly twice the brightness of any of the other stars in the bar. Typically, stars with later spectral types (those redder than the Sun) are relatively brighter at NIR wavelengths than earlier (bluish and white) stars. As such, planetarium programs that show stellar spectral types (such as Software Bisque's *TheSkyX)* can be helpful if you want to pinpoint potential guide stars in advance.

The only other aspect of the ONAG that I had to adapt to was the mirror-reversed "raw" views from my imaging camera. Although image-processing software can flip these images to make them right reading, I didn't always do this at the telescope. I was also handicapped by years of experience framing photos based on the merest hints of an object visible in a camera's viewfinder or in short test exposures, so more than once I mistakenly used a raw test exposure from the ONAG to nudge the telescope in the wrong direction before shooting a long exposure. All astrophotographers develop their own system of workflow at the telescope, so I can't recommend the best way to deal with the ONAG's mirror-reversed images other than to just call attention to them.

The Results

From the get-go I had excellent results with the ONAG. With autoguider exposures of 5 seconds or less, I could often find a suitable guide star without having to move the autoguider on the X-Y platform after I had my target framed in the field of the ST-8300 imaging camera. Those using imaging cameras with smaller detectors (which offer less flexibility framing targets), or with telescopes having a slower focal ratio than the f/7 system I was using (finding guide stars is a function of f/ratio, not aperture or focal length alone), may have to rely more on the X-Y adjustments to locate guide stars.

The guiding was remarkably accurate during all of my testing. The image of the asteroid 2 Pallas below is a good example. Although the picture shows that I could guide on the moving target *and* image it simultaneously, it's the result of stacking 18 five-minute exposures by registering the frames only to themselves (not to the asteroid or any stars). Had there been wobbly guiding or any differential flexure between the imaging camera and autoguider, Pallas would have showed a trailed image along with the stars. Although I generally use multiple stars as registration points when I stack my deep-sky frames, I could often dispense with this step when stacking images made with the ONAG. The cold mirror did not introduce any obvious color shift to my images.

After working with the ONAG for many nights last fall, I can certainly say that it's easier to use than any off-axis system I've tried (and that includes a few that I built myself). It also produced some of the most accurately guided image sequences I've ever obtained. It's yet one more way that digital technology has made the challenge of acquiring accurately guided images easier than ever before. ✦

What we liked:

- Uses guide stars in the same field being imaged
- Excellent engineering and mechanical construction
- Capable of extraordinary guiding accuracy

What we didn't like:

- Size of imaging field limited by T-thread fittings
- Selecting guide stars in advance based on visual magnitudes can be misleading

As explained in the accompanying text, the author could simultaneously image *and* guide on the asteroid Pallas in this 1½-hour exposure obtained during the early morning of last September 24th.

*Senior editor **Dennis di Cicco** doubts he can recall all the ways he's tried guiding telescopes during his nearly 50 years as an active astrophotographer.*