The Evolution of Intelligent Design

A History of Starizona's HyperStar

By Scott Tucker

Any device that claims to inexpensively convert a mass-produced Schmidt-Cassegrain telescope into a high-speed, wide-field imaging system with excellent optical performance, sounds too good to be true. Telescopes for imaging are supposed to be expensive and astrophotography is supposed to be hard. At least, that used to be the way everyone thought.

But times have changed and technology has made astrophotography accessible to almost any amateur astronomer. Computerized telescopes and inexpensive CCD cameras have put equipment within the reach of the average stargazer. Now Starizona's HyperStar system makes deep-sky imaging not only affordable, but also extremely easy.

In 1997, Celestron released the Fastar 8 telescope. The scope featured a removable secondary mirror, allowing a Fastar lens to be installed, converting the scope from f/10 to f/1.95. This resulted in a 25-fold increase in speed, shortening exposure times dramatically and providing a much wider field of view. At the time, only relatively small CCD sensors were available to most amateur astronomers. The short focal length of the telescope in Fastar configuration was ideal for these smaller cameras. In particular, the Fastar was designed to work with the Pixcel-255 camera, an SBIG system sold through Celestron. An upgrade of the camera to the Pixcel-237 model (later sold directly through SBIG as the ST-237 and then ST-237A), provided a larger chip, but was still small compared to most of today's cameras.

People seemed slow to catch on to the Fastar idea. Ten years ago most astrophotographers still used film, and a common lament regarding CCDs was that the field of view was too small, due to the small size of the sensors compared to film. Also, there may have been a belief that astrophotography was just supposed to be difficult. After all, the great historical astrophotographers like E. E. Barnard spent hours taking single exposures. There was a sense of pride in a kinship with the masters, spending hours standing behind a scope, manually guiding through a crosshair eyepiece, wondering what in the world that noise was in the bushes. There was a certain machismo in being an astrophotographer, and the rewards for one's efforts were perceived to be greater because of the difficulty involved in obtaining them. Fortunately that mindset began to change, but it has been a slow revolution.

The Fastar 8 was never a big seller, but Celestron began to include the Fastar option on their popular computerized telescope, the Ultima 2000. The start of the computerized telescope age helped to popularize Fastar, but still relatively few astronomers were using the system. After spending some time with the Fastar system, Starizona realized the potential for high-

Rosette Nebula – Image by Steve Loughran, HyperStar C8, QHYCCD QHY8 CCD Camera

speed CCD imaging. But there were still shortcomings, primarily in the limited size of the CCD cameras available. Still, as a means of getting successful results right away for a new astrophotographer, Fastar was a great system.

Celestron also released a Fastar lens for their 14-inch SCT, converting it from f/11 to f/2.1. However, like the 8-inch Fastar, the lens was designed to match the Pixcel cameras. As the digital photography revolution advanced, it became apparent that there would come a day when astrophotographers would outgrow Fastar. Once bigger CCDs became available to more astronomers, Fastar reached its limits.

Dean Koenig, owner of Starizona recalls his first experience with Fastar. “I was always an ‘oh, wow’ kind of observer; I loved visual observation. But the very first night I used a Fastar telescope, I was hooked on imaging. I was amazed that in a single 30-second exposure, I could see more than at the eyepiece of my 20-inch Dobsonian. I was sold.”

Koenig also realized the limitations of the system. So he posed a question to a friend and experienced optical designer. Was it possible to improve on the Fastar system? The answer came back “yes,” and HyperStar was born.

Fans of Celestron’s Ultima 2000 telescope had long been waiting for the day when the company introduced an 11-inch go-to SCT. That day finally arrived with the release of the NexStar 11 GPS. In addition to providing lots of aperture with computerized functionality, the telescope featured the removable secondary mirror associated with the Fastar system. Many users of the NexStar 11 began eagerly awaiting the Fastar lens itself. However, production never began on the 11-inch Fastar lens. Conveniently, at the same time, the HyperStar lens from Starizona was finally coming together.

In 2002, Starizona released the first HyperStar lens, designed for the 11-inch Celestron. It improved on the Fastar lens in three regards: speed, performance, and compatibility. The first HyperStar converted the telescope to f/1.8, a 30-fold increase in speed over the standard f/10 configuration. The optical performance was improved over the original Fastar lens. And, perhaps best of all, the lens was compatible with a wider range of cameras. The Fastar lens was optimized for use with the 6-mm sensor in the Pixcel-237 camera, while the new HyperStar lens accommodated sensors up to 11 mm.

With the introduction of HyperStar, high-speed CCD imaging started to become more popular, but again, the idea was slow to catch on. Larger CCDs and digital cameras began to bring about the death of film photography. Astrophotographers were starting to embrace the age of digital imaging. But the long-exposure mindset still existed. Plus, there was an ingrained opinion that mass-produced SCTs simply were not cut out for high-quality as-

M8 – Image by Gil Esquerdo, HyperStar C11, Starlight Xpress SXVF-H16 Camera, telescope in alt-azimuth mode

trophotography. Premium apochromatic refractors remained the telescope of choice for wide-field imaging.

Starizona followed up the 11-inch HyperStar lens with a model for the Celestron 14-inch SCT. The larger aperture of the C14 allowed for a larger CCD sensor to be used; in the first HyperStar C14 lens, up to a 15-mm sensor could be handled. At f/1.9, the HyperStar C14 was nearly 25 percent faster than the original Fastar.

I recall the first night out with Dean Koenig and the HyperStar C14. We tested the lens on David Levy's 14-inch SCT at Levy's observatory south of Tucson. We used the SBIG ST-10 camera for which the HyperStar had been optimized. Our first target was the Trifid Nebula. We aimed the telescope and took a 60-second exposure, assuming this would be sufficient to at least see the object. We were using the first-generation ST-10, which used a parallel port connection. There was a 3-minute download period, which I think only added to the suspense of seeing the first image through the new HyperStar. When the image finally displayed on the computer screen we were amazed to see that not only was the Trifid there, it was completely overexposed! We shortened the exposure first to 30 seconds, then to 10 seconds, before getting an image that looked right. I remember laughing the entire time, thinking of all the time I had spent guiding 2-hour astrophotos with film – and here was a deep-sky object in 10 seconds!

A HyperStar lens for the 8-inch Celestron soon followed, making high-speed imaging available to users of the most pop-

M31 – Image by Fred Lehman, HyperStar M14, Starlight Xpress SXVF-M25C Camera

ular-sized telescope. It was then discovered that Meade was shipping certain telescopes with removable secondary mirror assemblies. There were no comparable Fastar-type lenses from Meade, it just happened that the way in which the secondary mirror assemblies were mounted, they were easily removable. A HyperStar lens for the 10-inch Meade was the next in the HyperStar family.

The first major step toward the current line of HyperStars came with the design of the HyperStar lens for the Meade 14-inch SCT. Starizona went back and re-evaluated the design of the HyperStar to see what the ultimate limits of the design were. At the same time, the popularity of using digital SLR cameras for astrophotography was growing. The HyperStar M14 was thus designed to be compatible with not only CCD cameras, but also DSLRs. HyperStar could now cover sensors up to 27 mm in size.

The HyperStar C14 was redesigned to take advantage of the improved performance. As larger cameras became less expensive and available to more imagers, the demand for larger-format HyperStar lenses for the smaller telescopes grew. In early 2008, Starizona released the HyperStar 3 lens for the 8-inch Celestron, followed a few months later by the HyperStar 3 for the Celestron 11-inch. Both the 8-inch and 11-inch systems had been through two previous generations, improving optical performance and mechanical design, but remained limited to 11-mm sensors, hence the new models being designated HyperStar 3. 27-mm sensors were now compatible with most of the HyperStar lenses, and DSLRs in particular could be used with the 11- and 14-inch models.

Eventually, Celestron discontinued outfitting their telescopes with removable secondary mirrors. Also, the increasing popularity of the system made for a demand for older telescopes or new models without removable mirrors to be used with HyperStar. Starizona began manufacturing conversion kits to retrofit non-compatible telescopes to allow use of HyperStar lenses.

The HyperStar takes advantage of the fact that the primary mirror of an SCT operates at f/2. Thus the HyperStar is a field corrector rather than a focal reducer. Normally, the secondary mirror provides a 5x magnification factor, yielding an f/10 system with focus at the back of the telescope. By removing the secondary mirror, focus is moved to the front of the telescope, and the focal ratio goes to f/2. However, removing the secondary mirror induces aberrations that the secondary normally corrects, primarily spherical aberration. The HyperStar lens corrects not only for this aberration, but also coma, astigmatism, chromatic aberration and field curvature. The result is excellent optical performance across a very large field of view.

The telescope in HyperStar configuration outperforms the native f/10 system. In fact, stars are up to 12 times smaller at f/2 than at f/10, over the same size sensor. Performance rivals that of the best apochromatic refractors. Measurements of star sizes in images taken through a 4-inch apo refractor and a HyperStar C14 with the same camera are identical. Plus, the HyperStar system has an extra 10 inches of aperture and a focal ratio 8 times faster!

To arrive at this level of performance, a new mechanical feature had to be introduced into the HyperStar lens: the ability to collimate. It was discovered that performance, especially with the larger-format versions of the lenses, was not always equal across the full field. This is due to the fact that the primary mirror of the telescope is not always perfectly orthogonal to the optical axis. This can normally be compensated for by collimating the secondary mirror, but with HyperStar there is no secondary mirror. By making the HyperStar lenses collimatible, Starizona allowed the system to reach its full potential. Collimation is easily achieved with three sets of thumbscrews. To compliment the collimation system, the HyperStar lenses also feature independent camera rotation, allowing the camera to be oriented as desired while retaining the collimation of the system.

All components of the HyperStar lenses are manufactured in the USA and are hand assembled at Starizona. A HyperStar lens includes a counterweight (except for use with German equatorially mounted telescopes, where it is unnecessary), a holder to protect the secondary mirror while out of the telescope, and a custom-fit hard carrying case.

An adapter for one camera is included with the HyperStar lens, while others are available optionally. Each camera requires a separate adapter in order for the distance from the HyperStar lens to the camera's focal plane to be set correctly. This distance is very critical at f/2 and is crucial to getting the ideal performance out of the lens.

Switching from the standard f/10 configuration to the f/2 HyperStar mode takes just a couple minutes. Replacing the secondary mirror to go back to f/10 is equally quick. Collimation is retained thanks to an indexing pin and notch on the secondary mirror assembly, so no adjustment is necessary after using the HyperStar. Starizona's website features a short video showing how simple it is to install a HyperStar.

The high-speed imaging revolution is finally sweeping through the astrophotography community. Now compatible with a wide variety of cameras, the HyperStar system has become extremely popular. Once thought of as a useful gadget for new astronomers just getting their feet wet in astrophotography, HyperStar has become a mature imaging system, providing ease of use for beginners and high performance for advanced imagers.

I'm convinced the future of astronomy is imaging. The number of amateur astronomers engaged in astrophotography is growing rapidly. As light-pollution becomes ubiquitous, imaging becomes ever more essential to seeing the wonders of the night sky. HyperStar can be used like an extension of visual observing. The images come down to the computer with very little delay, and with typical exposures of 30 seconds, there is hardly any wait whatsoever. In fact, with a high-sensitivity video system, such as the Mallincam or Stellacam, it is possible to do deep-sky imaging in real time, making HyperStar the perfect teaching tool for schools, planetariums, and star parties.

Now that amateur astronomers have realized it's not necessary to wait and suffer to take astrophotos, the future of astronomy is here now. ATT