The William Optics Star 71 Refractor

By James R. Dire, Ph.D.

William Optics has done it again! Just when I thought they had developed the perfect optical design for astronomical imaging with their Gran Turismo (GTF) 81-mm and 102-mm refractors, they have developed a new telescope design even more impressive than the last. The GTF 81 refractor is a five-element apochromatic refractor (Apo) with a f/5.9 focal ratio, essentially a triplet objective with a built-in two-element field flattener (see *ATT* July/Aug 2013), while the GTF100 uses the same optical design operating at f/6.9 (see *ATT* Sept/Oct 2013). What more could an astronomical imager want? How about a five-element, flat-field Apo operating at f/4.9! That's exactly what you'll get with the new William Optics Star 71 refractor.

The WO Star 71 is, as the number in the model implies, a 71-mm objective apochromatic refractor. The new patented optical design uses five elements of FPL-53 fluorite glass in three groups to produce color-free, pin-point images across a flat field. The telescope is powder coated white with gold accents (**Image 1**). The bare optical tube assembly (OTA) weighs a mere 4.5 pounds!

The Star 71 comes with a nice gold 15-cm long Vixen-style dovetail plate (**Image 2**) and a pair of tube rings. I was

Image 1 - The beautifully crafted William Optics Star 71 five-element apochromatic refractor. Note the temperature gauge built into the focus knob.

quite impressed by the engineering detail in the OTA, and even more impressed that the engineering detail was also very apparent in the tube rings. These rings were incredibly lightweight, but strong and were tapped on the top and bottom. The OTA comes with a small dovetail base plate for a finderscope that can be mounted with two screws on either the top left or top right side of the OTA! My Orion 9x50 correct-image finderscope/bracket fit perfectly into this base plate. The telescope comes with a 2.5-inch rack-and-pinion focuser with a normal and a 10:1 slow-speed knob on the right side and a normal speed knob on the left side containing the unique William Optics English and metric temperature gauge. A locking screw on the bottom of the focuser keeps the focuser from shifting under load during long-exposure astrophotography.

Image 3 shows the telescope with the drawtube completely cranked out. The graduated drawtube indicates the

Image 2 - This view of the Star 71 highlights the retractable dew shield, two-speed focuser with locking screw, and the gold dovetail plate.

Image 3 - The William Optics Star 71 has a graduated drawtube with 35 mm of travel and includes a finderscope mounting base which can be positioned on either side of the tube.

focuser has 35 millimeters of travel. The drawtube terminates in male M48 threads to which a Canon EOS T-ring adapter can be attached. Many CCD cameras also attach using M48 threads, so I had no difficulty mating the WO Star 71 to both of my SBIG CCD cameras (**Image 4**).

Since the Star 71 was designed with digital imaging in mind, the telescope does not come with a diagonal. The scope will not accept a 2-inch diagonal since there is insufficient back focus with this unique optical design for that much additional optical path. William Optics does have an optional 1.25-inch diagonal that attached to the M48 threads on the drawtube (Image 3). The diagonal can rotate 360 degrees and has a locking screw to hold it in place. At first, I was concerned that I could not use my longer focal length 2-inch eyepieces with this telescope. But then I realized that because its focal length is a mere 348 millimeters, I probably would predominantly use my Tele Vue 15-mm Plössl (23×), 12-mm Nagler (29×) and 5-mm Nagler (70×) eyepieces, all which have 1.25-inch barrels. Each provided exceptional views with this telescope. In addition, I borrowed a friend's (thanks Tom) 6-mm (58×) and 3.7-mm (94×) Tele Vue Ethos eyepieces, a step up from my short focal length Naglers. The latter provided very respectable magnification for this small telescope.

The Star 71 arrived the morning of a full Moon; not the best evening approaching to test the instrument. However, I just happened to have a solar filter that fit the optical tube perfectly. So I decided to do a little solar observing and imaging. With the current solar maximum, there was a plethora of sunspots to explore.

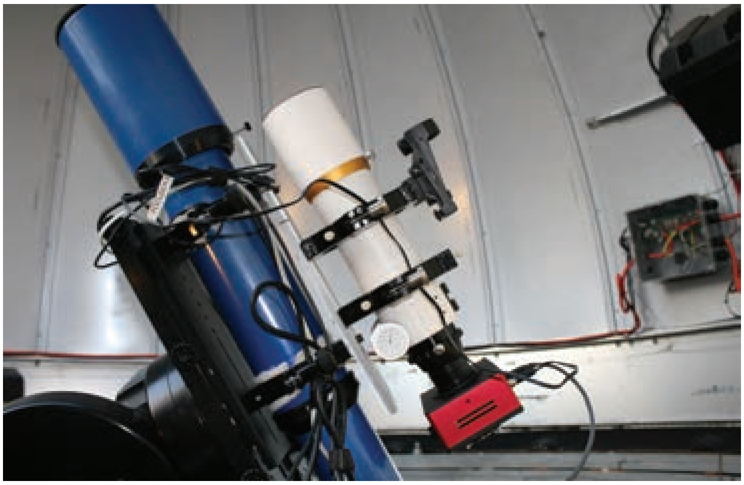

Image 4 - The WO Star 71 with a CCD camera mounted in the author's observatory.

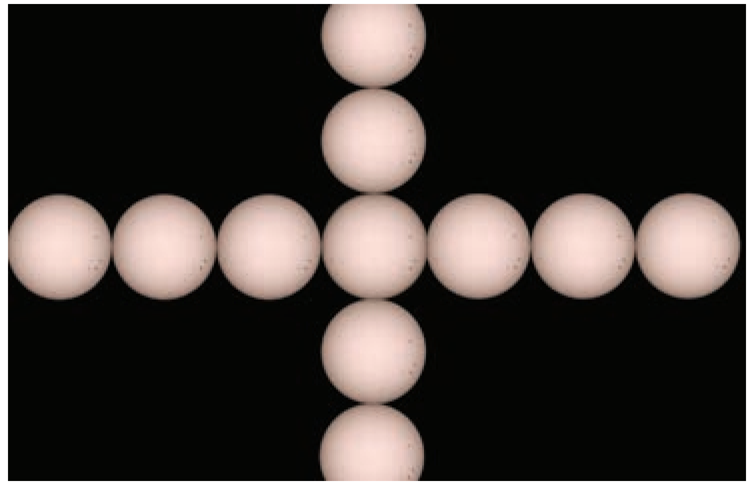

Image 5 - The Sun captured with the WO Star 71 using a Canon EOS T3i DSLR camera. The author cloned the Sun's image to demonstrate the field of view with this camera-telescope combination.

Finding the Sun was easy, even without a finder on the telescope. Watching the shadow of the OTA on the ground assisted in pointing it towards the Sun. When the shadow of the OTA showed the smallest image of the scope's diameter, I knew it was pointed at the Sun. My best eyepieces were at my observatory 26 miles away, but I always keep backup eyepieces stashed in my myriad telescope cases. A 32-mm Plössl eyepiece provided a 4.6-degree field of view (FOV) at 11×, allowing me to center the Sun and then switch to a 9-mm Plössl, yielding 39× with a 1.4-degree FOV. The views of the sunspots were excellent, and I could easily make out sunspot umbras and penumbras.

Next I removed the diagonal and attached a Canon T3i DSLR camera to the telescope, using the Canon adapter that came with it. Although the focuser on the Star-71 has 35 mm of travel, I only had to move the focuser 1-2 mm from the focus position with the diagonal and eyepiece to achieve focus with the camera. This demonstrated another engineering feat in the design of this instrument for use with Canon EOS DSLR cameras and the optional WO diagonal! **Image 5** shows a 1/1000 s exposure of the Sun and the sunspot detail obtained. I cloned the Sun's image and populated it along both axes to show the FOV with the Canon camera. Since the Sun is approximately 0.5 degrees across, the field spans 3.5 degrees from left to right.

A week later, during the third-quarter Moon, I took the telescope out to a dark observing site and mounted it side-by-side with my Stellarvue 70-mm f/6 ED doublet refractor (see *ATT* Nov/Dec 2011) on the mount pictured in Image 1. Although the 70-mm scope has a longer focal length, it was close enough to the Star-71 for a good side-by-side comparison. I moved two 1.25-inch eyepieces back and forth between the two scopes to compare them visually: a Tele Vue 15-mm Plössl, and a Tele Vue 5-mm Nagler. Physically, the Star 71 should demonstrate better color correction and a flatter field than the ED doublet. That is exactly what I observed.

Image 6 - The Lagoon Nebula, M8, captured by the author with a 90-minute exposure using a single-shot color CCD camera.

Image 7 - Emission nebula IC4592 and the star Nu Scorpii captured with a 150-minute exposure using a single-shot color CCD camera.

Both telescopes performed well on Saturn with the 5-mm Nagler. The color and clarity were notably better with the five-element William Optics telescope. In the Star 71, this eyepiece provided 69× magnification; plenty to see the rings in their splendor, the Cassini Division, and lots of dark space between the rings and the planet. I could even make out Saturn's darker polar hood. In addition, Titan and three smaller Saturnian moons were easy to spy. If I had brought my 2x Barlow, I could have pushed the telescope to its maximum usable magnification (using the thumb rule that the maximum usable magnification of a telescope is 2 × d, where d is the objective diameter in mm). I'll have to try that next time.

Using the 5-mm Nagler, I viewed many Messier objects with the Star 71 including globular clusters M4, M13, M22, and M28; planetary nebulas M27 and M57; and bright nebulas such as M8 and M20. Theoretically, all Messier objects should be visible in a 71-mm refractor as this is about the same size telescope Charles Messier used, albeit with much better optics. The most impressive object I observed was Omega Centauri, the largest globular cluster in our skies. Countless stars were resolved with the 5-mm eyepiece, and the cluster filled the entire field of view.

The 15-mm eyepiece delivered less magnification with a FOV slighter greater than two degrees. This combination made most of the Messier objects appear like tailless comets. No wonder

Messier wanted to catalog all objects that might interfere with his search for comets! Perhaps the most joy I obtained with this telescope occurred with the 15-mm eyepiece when I panned across the myriad Sagittarius star fields. From my dark-sky site, the contrast between bright Milky Way regions and large dark nebular complexes was stunning.

This telescope was designed for digital imaging, so that is what I tested next. I mounted the telescope in my observatory piggyback atop my 4-inch f/7.9 Apo on a Paramount ME German equatorial (Image 4). I guided with one CCD camera attached to the 4-inch Apo and another attached to the WO Star 71. With its fast optics and wide FOV, the Star 71 is the perfect instrument to image large nebulas like the Rosette Nebula, Elephant Trunk Nebula, and the Heart and Soul Nebulae, or large galaxies like M31 and M33. These are not well positioned in the mid-summer for imaging, so I targeted several nebular complexes along the southern summer Milky Way.

My first target was M8, the Lagoon Nebula (**Image 6**) in the constellation Sagittarius. This 90-minute exposure certainly captured the detail I was expecting. Unfortunately, I did not have a good sharp focus. I discovered my normal focusing procedure failed because I wasn't used to imaging with such a short focal length telescope. With short exposures since the stars were so small, neither my eye nor the software readily detected changes when I adjusted the focus. Prior to the next image run, I took myriad multi-minute exposures to ensure I had the optimum focus.

I keep my observatory air conditioner thermostat set to 80°F. During the subsequent image runs, I noted the ambient temperature dropped 10° from the end of twilight until I packed it in. The telescope maintained its focus over this temperature range with no corrections required!

Image 8 - This three-hour exposure of the Rho Ophiuchi Nebula captures a stunning field of view most refractors are unable to match.

My next test object was IC4592 (**Image 7**) in the constellation Scorpius, a bright nebula surrounding the binary star Nu Scorpii (also known as Jannah). The FOV with the SBIG ST-2000XCM CCD camera on the Star 71 is approximately 2.0 × 1.5 degrees, so this nebula quite nicely fits onto the CCD chip. The exposure was 150 minutes. Note the pin-point-sharp stars I captured with the proper focus compared to the previous image. This is the only nebula I have ever imaged with blue, yellow and brown colors in it; perfectly captured by the WO Star 71.

My last test image was that of the Rho Ophiuchi Nebula (**Image 8**). The prominent "triple" star in this image is Rho Ophiuchi, although the primary is actually a double not resolved in the image. So it is really a quadruple star! The blue nebula surrounding Rho extends throughout the Star 71's field of view and beyond. This nebula was captured with a 180-minute exposure.

I believe these images demonstrate the wonderful potential of this outstanding instrument. Truly the Star 71 is the best optical design offered by William Optics and definitely the best in its size available anywhere. Its small size makes it a great travel telescope, its unique high-quality optics make it a great imaging instrument, and its short focal length and fast optics allow imaging of large objects unable to be captured in longer focal length telescopes. William Optics has another winner with the Star 71! ATT