Finger Lakes Instrumentation's Atlas Focuser

An Aptly-Named, High-Payload, Ultra-Precise Imaging Focuser Astronomy

By Dr. Barry Megdal

Long image trains are no problem for the Atlas Focuser

The ever-increasing size of the latest CCD chips used for amateur astrophotography has resulted in cameras that are much larger and heavier. Then we may add a large filter wheel with slots for 50- mm square filters, a field flattener, and perhaps an off-axis guider. The result in the case of my imaging rig is a weight of around 15 pounds and a long moment arm, placing a large torque on the telescope focuser.

Although the factory rack and pinion focuser on my refractor is excellent (and can be motorized using one of several aftermarket solutions), I have always preferred accessory electronic focusers that are in-line with the image train. A good focuser of this type eliminates any possibility of slippage or other inaccuracy while focusing.

The Atlas by FLI is the next step in their line of electronic focusers, and has been improved from their very successful PDF focuser in several ways. Most obvious is in the precision with which it focuses – though the total focusing range is a relatively small (but more than adequate) 0.35 inches, the Atlas manages to make an incredible 105,000 precise steps over that range – resulting in each step being only 3.33 millionths of an inch, or 0.085 microns. Though this seems like serious overkill, it is actually just what astrophotographers need to get the best results, as I will explain.

Highly accurate focusing is critical to obtaining the best possible images. In a recent article I coauthored [Don Goldman, Barry Megdal. "Get Focused!" Sky &Telescope Aug. 2010], we demonstrated that the traditional definition of "Critical Focus Zone" (the range of focus within which there is no change to the image quality) was not nearly strict enough. If there is to be no significant degradation of image quality, the focus must be off by no more than 0.8 * f2 * λ from the point of perfect focus (where f is the focal ratio of the telescope, and λ is the wavelength of the light being focused). To consider a real example, assume the light is being imaged through a blue filter (λ=0.45 microns), and the telescope is a fast astrograph (f=3.3). This results in a one-sided critical focus zone of 3.9 microns – a very small distance indeed (and since such a comparison seems obligatory, less than 1/5 the diameter of the smallest of human hairs). Even with a more typical f/5.6 scope the focus must still be within 11.3 microns. This is nearly impossible to achieve by hand, and barely within the capabilities of even the best add-on electronic focusers available before the Atlas. And it is unlikely the telescope will maintain this accuracy of focus as the ambient temperature changes. Now it is clear why the 0.085-micron steps of the Atlas focuser are so useful.

But it is not only the accuracy with which focusing must be done that makes a good electronic focuser so important. Astrophotography is usually done using a set of filters to select the desired range of wavelengths of light for each image. Although many sets of filters are advertised as "parfocal" (meaning the light will come to focus at the same point, no matter which filter is used), in reality this is not the case. The cause can be the filters themselves, or with a refracting telescope, the fact that the optics may focus each color of light to a slightly different point. Either way, the most common result is that the system must be refocused after every filter switch and also after any significant temperature change.

This means you must not only have a good focuser, but an equally good methodology for focusing. Simply turning the focuser knob on your scope until the image looks sharp on the computer screen is just not good enough. Fortunately, there are now hardware and software aids to make focusing so easy that it can (and should) be done for each filter you use, and repeated often as the temperature changes during the night.

The Atlas focuser is a valuable accessory, and was the finishing touch on my imaging system. I am lucky to be the owner of a rare refracting telescope. All of the telescopes made by master optician Roland Christen of Astro-Physics are extraordinary performers, and he made only about twenty or less 206EDF (206mm or 8-inch aperture, f-ratio of 7.7) refractors in the early 1990s; they may well be the ultimate Astro-Physics telescopes. The glass to make lenses of this size has become very expensive and hard to get, but he had one or two blanks left over. About three years ago, Roland custom-made one additional 206EDF for a famous astrophotographer, and I was recently able to acquire that scope. It is a joy to use both visually and photographically and was my motivation to put together the best imaging system I could, with the 206EDF at the core.

Integrating the components of this imaging system required careful attention to a number of areas, including mechanics, optics, electronics and software.

No matter how good the telescope, it can perform no better than its mount, so the Astro-Physics 1200 was an easy choice, as it handles large loads, but is still portable enough to allow me to escape from the lights of Los Angeles when possible. The AP1200 sits on a Particle Wave TechnologiesMonolith pier, which has excellent load capacity and rigidity, but folds nicely when needed.

I chose the FLI PL16803 camera for its large chip size, excellent cooling and low noise. It has reasonably high quantum efficiency, which is especially important since I am often doing narrowband imaging from the middle of a large city. Such imaging is only possible by using narrow emission-line filters, and I have chosen the 3-nm narrowband filters from Astrodon. Theses 50-mm square filters (along with and LRGB set) are mounted in the FLI 5-7 filter wheel that is designed to mate with the PL16803 camera.

In order to get pinpoint stars all the way to the corners of the 52-mm diagonal 16803 CCD chip, I use the Astro- Physics field flattener that is matched to the 206EDF scope. There is a very tight spec (±1 mm) for the distance from the rear of the field flattener to the surface of the CCD, and properly calculating this distance requires taking into account the optical thicknesses of the filters and the CCD cover slip. Clearly custom adapters had to be made, and unless you are an expert machinist, there is no better source for such adapters than Precise Parts (www.preciseparts. com). Even with the help of their excellent website, deciding on the details of such adapters can be confusing, and I had to deal with an additional complication – off-axis guiding.

I had previously spent quite a bit of time imaging with a smaller and shorter focal-length refractor. With that scope, accurate guiding was easily accomplished using a small 60-mm guide scope mounted above the main telescope and a low-cost CCD guide camera. The separate guide scope had the advantage of gathering light independently of whatever filter was in use on the main camera, which is especially important when using narrowband filters that seriously dim most stars. When I switched to the 206EDF scope, it soon became clear that the external guide scope was no longer adequate, and the culprit was something called "differential flexure." When pointed to some parts of the sky, the long and heavy 206EDF, even though on a very capable AP1200 mount, would bend just enough to cause the star images to be slightly elongated on fairly long (e.g. 30-minute) exposures. It didn't take too many frustrating nights to realize that I needed to change over to off-axis guiding, where the guide camera sees light that passed through the main telescope and has been picked off by a small prism, and importantly this light is sampled before it passes through the narrowband filters, so there are plenty of guide stars to choose from. This method avoids all differential flexure issues and produces perfectly round stars even with very long exposures.

Essentially all telescopes have limited back focus (i.e. the maximum distance the focuser can be extended), and this is an especially important issue for refractors. I knew I wanted to leave enough space in my imaging train for the Atlas focuser, but fitting the filter wheel, offaxis guider and field flattener in the light path, while still leaving room for the focuser, required some creativity. My solution was to use theMega-MOAG off-axis guider (OAG) from Astrodon (www.astrodon. com), because it had a large 4- inch opening that allowed me to have adapters made such that the OAG was placed after the field flattener, with the rear element of the field flattener extending partially inside the OAG. Once these adapters had been designed and fabricated, there was just enough room for the Atlas focuser in front of the field flattener (mounted with its own pair of custom adapters). The Starlight Xpress Lodestar guide camera (which fits directly into the eyepiece adapter on the MegaMOAG) was chosen for its small size, light weight and high sensitivity. The final "tweak" was a correcting lens (purchased from Astrodon) that was added to the OAG, in front of the guide camera, to position the Lodestar at a convenient distance from the OAG body.

Rigidity of such an imaging train is critical to good results, and the Atlas focuser was designed with this in mind. The Atlas is a change from FLI's previous focusers in that, rather than having two plates that are moved together and apart, all motion in the Atlas is internal, as is the focusing motor itself. This makes for a very compact and aesthetically pleasing design. The Atlas is rated to carry a 25- pound payload, and has had no trouble with the approximately 15 pounds it is carrying on my rig.

Another very useful feature of the Atlas is FLI's proprietary Zero Tilt Adapter. This evolution of the traditional dovetail mechanism uses a circular steel rod to apply even pressure around the connection when the set screws are tightened, making for a very precise and secure connection, and without the marks typically made by the setscrews on the dovetail.

As mentioned, my imaging setup (see Image 3) is based on a camera that uses the 36-mm square 16803 CCD chip. For more than a year I had been using the PDF focuser from FLI. While an excellent product, the weight of the imaging train proved too much for reliable operation of the PDF. I was excited to try the Atlas when it became available, and have not been disappointed.

With the optics and mechanics taken care of, attention had to be paid to the electronics necessary to run this system. I wanted the option to run from either 110 VAC or a 12-volt battery, and decided to mount all of the electronics onto one board, so that setup time was minimized in the field. The result was the electronics board which includes a 110-volt uninterruptible power supply, so that even if I trip over the power cord I have a few minutes to plug back in before my imaging session is ruined. . The Alinco DC switching supply can provide ample current for all of these items. The RIGrunner products are the perfect way to distribute DC power using proven Powerpole connectors – they are much better than cigarette lighter plugs, which were never designed for reliability, so I have changed all of my cords to Powerpoles. A USB hub provides for control of most of the electronics, except for the mount, which requires the USB to RS232 converter.

The final part of the system to discuss is software. I have chosen Maxim DL for camera control, the Sky X for telescope control, PinPoint for plate solving, and CCDAutopilot for automation of unattended operation. The details of integrating these software packages, along with the underlying ASCOM and device drivers, is best left for another article. However, since the focus (sorry) of this article is on the Atlas, it is important to mention that there are a number of software solutions that can take most of the pain out of the important task of precise focusing. Imaging software such as Maxim DL or CCDSoft include algorithms to automate focusing. And what I believe to be the best performing focusing software available is free – FocusMax by Larry Weber and Steve Brady, available at http://users.bsdwebsolutions. com/~larryweber/ .

Underlying all of this elegant software must be an accurate, "absolute positioning" electronic focuser. An absolute focuser is one that can, on command, return to the exact same position time after time. The Atlas (and its supplied software driver) is fully ASCOM compliant and should work with any focusing application.

In over two dozen nights of intensive imaging the Atlas has operated smoothly and precisely. It does make a bit of noise while focusing, and the 105,000 steps make moving through full focus travel take a minute or two, but even at its $2295 list price the results are more than worth it. I recommend the Atlas very highly.

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