

Chapter 2

Grab ‘n’ Go Refractors

Small refractors—those telescopes that use lenses instead of mirrors—have long been favored as the ideal accompaniment for astronomy or nature studies on the move. Small, lightweight and capable of delivering both low and high power views more or less out of the box, it is no small wonder that a rich array of instruments can now be had, with price tags that range from bargain basement to outrageously expensive.

Refractors come in two distinct flavors: achromatic and apochromatic. Achromatic telescopes use tried and trusted crown and flint glass to bring two colors of light to a sharp focus. These are perfectly adequate for most applications—either terrestrial or astronomical—and are less expensive than their apochromatic cousins, which employ special, low dispersion (ED) glass to focus three wavelengths of light. Apochromats give brighter images and throw up less secondary spectrum (violet fringing round bright objects than their achromatic counterparts. Because of their modern glass prescriptions, apochromats command a heftier price tag.

Good achromatic optics are *much* closer in performance to apochromats than is commonly believed. Indeed, it was with achromatic optics that all the splendors of the heavens were unveiled to the observers of yesteryear. Moreover, achromatic images are qualitatively different to apochromats; the image is dimmer at a given magnification than the apochromatic counterpart and may suit some observers more than others. Indeed, this author has vociferously expressed a preference for achromatic optics and helped raise awareness about the rich astronomical culture they once commanded.

Up until fairly recently, there was only a limited range of spotter-type ‘scopes available for consideration. These were rather fastidious in their design, often

displaying fixed magnification ranges—frequently only ranging from low to medium powers—and built with an eye to sating the needs of birders and other wildlife enthusiasts. And although these telescopes can certainly be used to good effect in astronomical projects, they are not ideally suited to the task. Over the last decade, many small refractors have been brought to market that can be used with interchangeable diagonals and eyepieces and can thus be employed for a broader range of applications that transcend the usual limitations of both spotting 'scopes and dedicated astronomical telescopes.

Another great advantage of using these so-called 'crossover' telescopes is that they can be purchased as so-called optical tube assemblies, and so you can carefully choose the accessories tailored to your needs. This makes them far more versatile than dedicated spotting 'scopes. One can choose either a 1.25-in. diagonal or a 2-in. diagonal, depending on the eyepiece you want to use.

Most birders make do with spotting 'scopes that use relatively lightweight 1.25-in. eyepieces. The 2-in. eyepieces deliver greater fields of view, which is fine for astronomy but normally overkill if you're trying to concentrate on the variegated feathers of a nesting Robin. By purchasing an optical tube assembly, *you* get to choose the kind of viewing you want to experience. Having observed through traditional spotting 'scopes for many years, with their dedicated, non-interchangeable zoom eyepieces, you might find this new-found freedom a great liberation.

Small refractors manufactured primarily for amateur astronomy do not yield correct orientation views but a number of companies, including William Optics, produce both 1.25- and 2-in. prismatic diagonals angled for 45° viewing. They were designed to give very good images over typical daylight magnifications for their small ED 'scopes, like the Zenithstar 66, but the image quality seems to rapidly degrade if powers above 60× or so are employed.

There is a near perfect panacea for this, thankfully, and it is embodied in the form of a high-quality mirror diagonal. In general, its excellent optical flatness and high reflectivity allows you to use much higher magnifications—if your project calls for it—than the 45° prismatic diagonals. The best mirror diagonals have dielectric coatings that boast 99 % reflectivity.

The term 'near perfect palliative' is given for a purpose; the only caveat with mirror diagonals is that, although they yield upright images, the view is reversed left to right. What's more, traditional astronomical mirror diagonals are designed for looking high in the sky and thus are designed with 90° angles. One notable exception is the 1.25-in. Tele Vue 60° Everbrite diagonal. Designed by Al Nagler, this diagonal offers all the comfortable terrestrial viewing of a 45° prismatic diagonal does but delivers noticeably better images, especially during high-power applications. As you might expect, it doesn't come cheap (\$210) either. One birder known to this author uses one with his inexpensive \$100 spotter!

Another issue for spotting 'scope users is minimum focus distance, or *back focus*. That's the closest distance to an object that your spotting 'scope will focus on. If you like using your 'scope as a long-distance microscope, you'll need to be able to focus at close range, often within a few meters. If the 'scope you purchase



Fig. 2.1 The Tele Vue 60° Everbrite diagonal (Image © Venturescope. Used with permission)

doesn't come with this information, you'll need to try before you buy. Most commercial spotters can achieve sharp focus at distances ranging from 3 to 6 m. In general the larger the 'scope, the greater the minimum focus distance achieved.

Dedicated spotting 'scopes with non-interchangeable eyepieces tend to be significantly lighter than an equivalent aperture crossover 'scope. Many of the more expensive models are made from ultra-light metal alloys that can be over 50 % lighter than a similar aperture crossover 'scope. The extra weight is not much of an issue when it comes to astronomical applications, when the 'scope is not hauled about as much. Most spotting 'scopes also need to be adequately mounted if a nice steady view is to be enjoyed. We'll be discussing mounting options for these and other 'scopes later in the book. Buying a decent 'scope can be a significant investment. Selecting the right model for your needs and your budget is vitally important. Fortunately, the increased demand for quality optics has led manufacturers to keep their prices down while producing a dazzling assortment of 'scopes from which to choose.

We'll now take a look at one highly regarded traditional spotting 'scope: the Leica Apo-Televid 82. This 3.2-in. (82-mm) aperture spotter is available in a choice of either straight or 45° angled body, but optically these are identical. The focuser can be rotated a full 360° around the mounting collar. On the straight body, this rotation facilitates orienting an attached camera to compose an image as desired. The straight body is a good choice when operating around flat marshy areas devoid



Fig. 2.2 Spotter king: the Leica APO Televid 82 (Image © Ace Cameras. Used with permission)

of trees or high ground. For some people it's easier to sight through the straight body telescope onto a distant target, too.

For quicker sighting when using the camera adapter, or for observing from a car window mount, you should use the straight through view body, too. That said, a straight body will place the eyepiece and spotting telescope at the same height, so a taller tripod or stand will be required compared to that needed for the angled body.

The angled body is the better choice for most users, since this provides more comfortable eye position, particularly when observing objects higher than the observer—a bird perched high in the tree canopy or a craggy cliff edge, or indeed a celestial object. A noteworthy advantage of the angled body, since it too can rotate in the collar, is that the eyepiece can be positioned up, down or to the side to allow people of differing heights to view. When target shooting, the telescope barrel can be rotated so that the eyepiece can be seen from a prone position. For surveillance viewing, the observer can remain hidden around a corner or below a ridge while you are still able to look through the eyepiece. And the view is correct left to right and right side up regardless of the eyepiece position!

The Leica Televid has a special five-element objective (in four groups) containing fluorite for top notch color correction. It has a focal length of 440 mm (so it's about F/5), and the supplied zoom eyepiece delivers magnifications from 25 to 50 $\times$. The lenses are coated with an innovative anti-reflection coating called AquaDura that prevents water droplets from adhering, and the surface is also resistant to the formation of fog. Looking forward, we should see similar stuff applied to the objectives of mainstream astronomical refractors. Furthermore, the entire 'scope is nitrogen-filled and water resistant to a depth of 5 m. The 'scope body is made from die-cast magnesium, making the whole package extremely light—just 3.6 pounds (1.5 kg)—for a scope of its size. Being less than a foot (30 cm) long, the Leica Televid 82 is superbly designed for the outdoors in temperatures ranging from 25 to +55 °C.

So, in the cold light of day, is this telescope worth the astronomically high price tag Leica commands for it?

That's a difficult question to answer. It's stylish, rugged, ultra-light and has excellent optics. But it has limited latitude in terms of the range of magnifications

it can be used with. Sure, Leica also supplies two very nice additional eyepieces for the Televid 82—a 32× wide-angle and a higher power 20× to 60× zoom—but that’s it. Even if it could be charged with higher magnifications, the tiny amounts of color visible at 50× as seen in daylight from a store window would throw up considerably more color under typical astronomical use. Seen in this light the Leica APO Televid 82 is very much a specialist ‘scope. After having spent a small fortune for one, a small, premium ‘scope really ought to be able to do everything superbly! It should be lightweight and compact, have superb, color-free optics and be able to use interchangeable eyepieces. In short it should perform equally well by day and by night. To that end, in the last few years, an amazing array of small, ultra-portable cross-over ‘scopes have made their debut, and they have sold by the thousands across Europe and North America. We’ll now take a look at some of these models.

The William Optics Mini-Scopes

The year 2005 provided a bumper crop for small refractor lovers. That’s the year William Optics launched not one, not two, but *three* sensational little refractors all at the same time. No doubt it was a bit of an experiment on the part of the company to see which one would win out with the consumer, and at first it was hard to know the winner.

The first to appear was a 66-mm f/6 four-element Petzval, billed as semi-apo. Then came the Zenithstar 66 ED f7 triplet apo, followed fast on its heels by a 66-mm f/6 SD doublet. All came in a beautifully anodized tube complete with rotating Crayford focuser and logoed soft case. All three came with a retractable dew shield and all weigh in at about 5 pounds. As if that weren’t enough, all three came with a 1/4–20 L mounting bracket that could be used with nearly any photo-tripod.

The 66 ED Petzval had a nice flat field—a real bonus if you’re into photography—but it displayed quite a bit of color in daylight tests at moderate powers (> 30×). The single FPL-51 sub-aperture element and Petzval design frankly didn’t subdue false color as much as hoped. The triplet Zenithstar 66 was much better in this regard. Daylight and nighttime testing showed only the merest trace of false color, even when pushed to high magnification or bouts of atmospheric thermal instability. The Zenithstar 66 SD then arrived, with an impressive level of color correction. The full aperture FPL-51 element did a superb job at wringing out any chromatic aberration from all but the most stringent testing of objects.

Within a few months of the launch of the Zenithstar 66 f/5.9 SD doublet (\$395), the Petzval and triplet models were discontinued. That was probably a wise move on the part of William Optics, as both are more complex and thus harder to manufacture than the SD doublet. Since 2005, the Zenithstar 66 SD has gone on to become one of the best-selling small telescopes in the world. This little telescope offers excellent optics for its modest price tag (\$329 for the optical tube, 1.25-in. diagonal and hard case). Although the latest models sold have black and white



Fig. 2.3 The William Optics Zenithstar 66 SD doublet (Image © Ian King Imaging. Used with permission)

anodized tubes, William Optics cashed in on the incredible popularity of these ‘scopes as ‘luxury’ finders mounted atop larger ‘scopes. To this end, they produced both ‘Celestron’ orange and ‘Meade’ blue tubes to delight an army of Schmidt Cassegrain fans.

Weighing in at just over 2 kg with a 1.25-in. diagonal and eyepiece inserted, this little ‘scope serves up sharp, high contrast and color-free views at low and moderate powers. Even high powers ($>100\times$) reveal only a trace of color fringing around high contrast objects.

Star testing a few of these telescopes showed pretty good results with only minor spherical aberration and a trace of astigmatism detected when pushed to $120\times$ or so. As discussed later, William Optics Zenithstar 66 SD showed a bit of red excess when viewing bright stars at high power, but after reading about Canadian amateur, Clive Gibbons’ experiments with short focal ratio ED doublets, the author tried an inexpensive prism diagonal that removed the red excess at the expense of introducing a slight bluish fringe around bright stars and planets at high power.

William Optics also supplies an adaptor that allows the 66 SD to be mated to 2-in. diagonals (in fact it is deliberately designed to take popular SCT accessories) to obtain the widest possible views for a telescope with these specifications. Think about it—a 31-mm Nagler eyepiece would yield a field of view nearly 6.6° wide. That’s 13 full Moon diameters!

Nonetheless, despite its appeal as an ultra-rich field ‘scope, its aperture (and limiting magnitude of +10.8) restricts its performance as a serious deep sky instrument. Because the 66 SD is so light, it can be easily mounted on a conventional photo-tripod for terrestrial viewing. The dual speed Crayford focuser, fitted as standard on these ‘scopes, is a great benefit when homing in on wildlife constantly on the move. The 66-mm doesn’t sound like much aperture, but it’s enough for most daylight applications using moderate magnifications. The only scenario in which the Zenithstar 66 SD would probably prove lacking is in low light conditions. That said, if you’re after an ultra-portable travel ‘scope that won’t break the bank but nonetheless offers very good, color-free optics, then there is little to go wrong with the William Optics SD doublet.

Since the launch of the Zenithstar 66 back in 2005, the ‘scope has been a huge success for William Optics. In the autumn of 2009, the company announced it was ceasing production of this popular model—no doubt a reflection of the global economic recession that preceded it. However, a number of other companies have marketed their own clones of this ‘scope, most notably Astronomy Technologies (ASTRO-TECH). Produced in a wide variety of colored anodized tubes, the AT66 (\$359) has essentially identical optics to the William Optics mini-scope. The only significant difference between the two lies with their focusers. The AT66 has a 1.25-in. focuser while the William Optics ‘scope has a 2-in. focuser, making it more useful for adding photographic adapters. If you want the widest fields of view with big 2-in. eyepieces the Zenithstar 66 is the better choice. Other than that, choose the model (or color) that’s right for you. Alternatively, Sky Watcher and Kunming United Optics also produce competitively priced clones of the ASTRO-TECH ‘scope.

William Optics and ASTRO-TECH also market two other ED doublets, slightly larger instruments built around the success of the 66 SD. William Optics produce the Zenithstar 70 (f/6.3) and the Megrez 72 FD (f/6). ASTRO-TECH also market an almost identical 72-mm f/6 ED (\$379). Although the images these ‘scopes serve up are quite comparable to the Zenithstar 66, the Megrez 72 FD and ASTRO-TECH 72 deliver slightly brighter views. Both ‘scopes when kitted out with a 1.25 in. diagonal and eyepiece still weigh in at or just over 4.4 pounds (2 kg), making them easy to use and transport in the field.



Fig. 2.4 The ASTRO-TECH 72 ED doublet (Image © Altair Astro. Used with permission)

As commented on before, the FD labeling on the 72-mm model is a little annoying, especially since it's an ED doublet (most probably FPL-51). A quick daylight look through one of these 'scopes shows that although color correction is very good, it is not as color free as its smaller sibling, the Zenithstar 66 SD. For the record Stellarvue (California, USA) also offers a 70-mm f6 ED 'scope. Called the SV70ED, it comes with all the features of the William Optics Zenithstar 70 but includes a threaded dust cap with the Stellarvue logo, a Vixen-style mini rail and a very nice hard case all for \$399.

The Borg Mini-Scopes

When it comes to having fun with a small portable refractor, no company seems to understand the market better than Hutech Corporation and their series of tiny, high quality ED refractors in the range of 1.8–3-in. apertures (45–76-mm). These Mini-Borgs offer a range of finely made 'scopes with Japanese optics. They are modular in design and so can be used with other Borg accessories for visual use, wide field imaging or just for guiding larger 'scopes during long exposure astrophotography.

Perhaps the most remarkable of all is the MiniBorg 45ED, the world's smallest apo refractor. Sporting a high-quality ED doublet objective, this little 'scope has a focal length of 300 mm (f/6.6) and can be used as a faster one (f/5.6) when used in conjunction with a dedicated focal reducer/field flattener. Only 6.6 in. in length with the focuser racked in and weighing less than a pound, this 'scope would get lost in a woman's handbag! Its well-designed helical focuser has very generous back focus (up to 6.5 in.), so it'll work well visually or with a CCD or digital camera.



Fig. 2.5 The world's smallest apo, the Borg 45 ED (Image © Steve Asbury. Used with permission)

Despite its \$349 price tag, it's hard not to have a soft spot for this 'scope. Images are crisp and color free, and it's a super little instrument for looking at the Moon at a moment's notice. It'll take magnification well but won't break the laws of physics. Hutech Borg also offers a similarly designed 60-mm f/5.8 ED model for significantly greater resolution and light grasp.

More recently California-based Stellarvue have launched their own mini ED 'scope, which sports a 50-mm doublet objective and a focal length of 330-mm (f/6.6) and can accommodate 1.25-in. accessories for visual or imaging applications. Weighing in at just 2.5 pounds, it comes with a clamshell, dovetail plate and soft carry case. The downside is that you need to spend quite a lot of money to acquire this limited aperture 'scope (\$499).

Choice 60-mm Telescopes

The William Optics, ASTRO-TECH and Borg mini-scopes are a good dollar value. They are the Ford KA of small, ultra-portable 'scopes. But some aspire to owning a Mercedes A Class, and in the telescope world there are several candidates: the Takahashi FS-60C and two from Tele Vue (their 60 and 76 models). All are ED doublets of excellent optical and mechanical quality.

Takahashi affectionately calls the FS-60C the 'itinerant' telescope par excellence. This tiny 2.4-in. (60-mm) refractor weighs virtually nothing (OK, 2.9 pounds for the optical tube assembly) and is less than 12 in. long when used in visual mode. Optically, it's a fast f/5.9 doublet with a fluorite front element mated to a low dispersion flint. The little Takahashi excels mechanically as well. Its oversized 2-in. rack-and-pinion focuser is thoughtfully designed for astrophotography and CCD imaging. A thumb screw maintains the focuser in position whatever the direction of pointing is.

You'd expect such a fast doublet to show a bit of color, but some careful testing by day and night shows that views are almost entirely devoid of chromatic aberration. It's one sharp optic. It will handle 150× on a good night before the image begins to go a bit soft. Moreover, by using an adapter called the Extender Q (exclusively designed by Takahashi) the focal length of the native 'scope can be extended from 355 mm to 566 mm (a 1.6× focal length boost), and it'll be easier to achieve high power for lunar and planetary viewing. However, the expensive Extender Q (\$268) is probably overkill if you only wish to use it on this tiny 60-mm 'scope. Better to spend your hard-earned money on a high quality eyepiece that'll do the trick. A 2–4-mm Nagler zoom (discussed later) fits the bill perfectly!

Al Nagler, founder of Tele Vue Optics, New York, has enjoyed an almost guru-like status among small refractor lovers, especially in the United States. But it's not just the amateur astronomy community who venerate him. Unlike the other high-end refractor makers, Nagler has vigorously marketed his prestigious mini 'scopes to the birding community. And it's paid off. Tele Vue's two smallest refractors are now as likely to be used by day as they are by night. The smaller of the two, the



Fig. 2.6 The Takahashi FS-60C (Image © Geoffrey Smith. Used with permission)



Fig. 2.7 The beautiful, tapered tube design of the Tele Vue 60 apo (Image © Venturescope. Used with permission)

Tele Vue 60, is arguably the most beautiful mini-telescope in the world! Optically, it's got a very similar specification to the Takahashi FS-60C, but its mechanical design couldn't be more different. This is a telescope designed for the discerning visual observer who wants to extract the very finest images from an ultra-light portable setup. Its focuser is a 1.25-in. format, so you can't use 2-in. eyepieces with it like you can on the mini-Takahashi, but the Tele Vue 60 can still deliver a maximum true field of 4.3° and a 24-mm Panoptic.

Neither is its focuser a rack and pinion, as you find with the Takashashi FS-60C. Instead, Nagler reverted to the wondrously smooth helical focuser design once used on the now discontinued 70-mm Tele Vue Ranger. Coarse focusing is done by loosening the knob at the top of the tube and sliding the draw tube in and out. When an approximate focus is achieved, the knob is locked and the helical focuser takes over to do the fine tuning. It sounds a bit clumsy—and more than a few folk have expressed dissatisfaction with it—but it's fairly intuitive to use and gets there in the end. After 5 min in the field, you'll have memorized the approximate distance the draw tube needs to be extended for quick results.

Weighing in at just less than four pounds with a diagonal and eyepiece in place and measuring just 10 in. long with its dew cap retracted, it's no wonder Nagler calls it his 'briefcase' 'scope.

More Complex Alternatives

More recently, a number of telescope outlets have introduced 60-mm triplet apochromats. These use not two but three lenses to bring light to a sharp focus. One interesting example, introduced by Altair Astro in the UK is the Lightwave EDT 60-mm f/7 triplet apochromat. Promising excellent color correction—a notch above the aforementioned doublets—this little telescope weighs in at only 2 kg. For £499 you'll get dedicated tube rings, a ten dual speed microfocuser and even a nice aluminum case to pack it all away. The only caveat for long-term use is the relative complexity of the triplet objective, which is more sensitive to misalignment and consequently more difficult to re-center. In addition, some user reports indicated that on high power targets a traditional 60-mm classic refractor delivered more satisfying views, even though the former costs many times less than the latter.

The Altair 60-mm ED triplet has a number of competitors with four elements specifically designed with the astro-imager in mind. Take, for example, the Astrotech AT65EDQ, a 65-mm optical system consisting of four elements in two groups. The first group is made up of a triplet. One of these elements is made from exotic FPL-53 glass with special dispersion properties, which is a key factor for eliminating chromatic aberration. The fourth element is a dedicated field flattener made of ED glass.

As you can imagine, the AT65EDQ (\$599), with its four optical elements, is not lightweight. Weighing in at about 2.8 kg (and substantially more when you mate a CCD camera and other accessories onto it), you'll need a fairly beefy mount to get the most out of this for imaging purposes.

These small refractors have an Achilles' heel. All these 60-mm 'scopes, despite being optically perfect, are only 60-mm, and while they handle most daylight projects very well, there are significant advantages to looking for a 'scope with a little more aperture.



Fig. 2.8 The little Altair EDT 60-mm triplet apochromat (Image © Altair Astro. Used with permission)



Fig. 2.9 The AstroTech AT65EDQ four-element refractor/astrograph (Image © Astronomics. Used with permission)

A Budget Travelscope

No matter which way you slice it, cheap, ‘department store’ telescopes greatly outsell so-called serious telescopes by a very wide margin. Most people with a casual interest in nature studies or astronomy are not willing to shell out what they see as ‘exorbitant’ sums of money for a premium telescope and are quite content with a budget model. So when Celestron launched their Travelscope 70 package, this author was keen to see what category this instrument would fall into.

After ordering a presumably random sample from the Internet, the package arrived the very next day. The black carry case containing the telescope and accessories was snugly wrapped inside a double boxed package. The telescope, a 70-mm refractor with a focal length of 400 mm, came with a flyweight photographic tripod, a correct orientation prism diagonal and a couple of eyepieces—20 and 10 mm—delivering magnifications of 20 $\times$ and 40 $\times$, respectively.

Thanks to an exceptionally well written instruction manual, the ‘scope was set up in just a few minutes. The total weight of the instrument and mount is less than 2 kg.

The telescope itself is well made and certainly does not create the impression of being toy-like. It has a solid, 1.25-in. metal focuser, which moves smoothly along a simple rack and pinion mode, similar if not identical to that seen on the well regarded short-tube 80 achromat. The telescope is adequately baffled and painted matte black inside to minimize stray light. The finder scope was of very poor quality (possessing a singlet objective) and was not used in subsequent field tests.

After affixing the telescope to the tripod, it was charged with the 20-mm eyepiece, which delivered pleasantly sharp, wide field views. Although it was certainly better than nothing, the tripod proved to be the weakest link. It was just too spindly



Fig. 2.10 The Celestron Travelscope 70 package (Image by the author)



Fig. 2.11 The coated objective of the Celestron Travelscope 70 (Image by the author)

to enjoy prolonged daylight views, where moving the telescope from object to object was a necessity. During a few brief excursions outside at night, this author found maneuvering the flimsy tripod accompanying this telescope to be an exercise in frustration. While it's true that some limited low power sweeps (20 $\times$) of the night sky are possible with the supplied tripod, the telescope benefitted greatly by mounting it on something sturdier. In this capacity, the remainder of the field tests were conducted on this telescope my mounting it on a Vixen Porta II alt-azimuth mount and/or a robust table top photo-tripod.

To be honest, great things were not expected from a package costing so little. The objective lens is magnesium fluoride coated. Star testing the instrument using the available eyepieces revealed some astigmatism and field curvature. There was also some obvious spherical aberration apparent as revealed by the asymmetry of the intra- and extra-focal images. Chromatic aberration was obvious using the supplied 40 $\times$ ocular.

This is not a telescope for high power use—but neither did the instruction manual lay claim to such activities. Making an objective lens well at $f/5.7$ is not easy! That said, high powers could be coaxed out of the instrument by replacing the stock diagonal with a high quality 1.25-in. dielectric model and adopting higher quality orthoscopic eyepieces. Used with these improved accessories, the magnification could be increased to about 70 $\times$ before the image began to deteriorate. Stopping down the aperture to 60 mm allowed this author to increase the magnification to 90 $\times$ or so.

So, just how much fun can you get out of a telescope like this? Quite a bit, as it turned out! The Travelscope 70 makes for a very decent spotting 'scope, so long as magnification is not pushed too high. With a closest focusing distance of 5.8 m (with the supplied 20-mm eyepiece), it doubles up as a nice long distance 'microscope.' In addition, the telescope serves up some decent, low resolution images of



Fig. 2.12 The nicely made rack and pinion focuser of the Celestron Travelscope 70 (Image by the author)

the solar disk using a white light filter; the larger, more prominent spots on the solar photosphere could be resolved with this telescope.

Lunar images through the Travelscope 70 were clean and sharp within the magnification range previously established for it. Our natural satellite presents a wealth of detail that can be studied as its phases change from thin crescent, through first quarter, and on to full Moon. Jupiter's two main belts were cleanly resolved, as well as the large Galilean moons, which change their aspect with the passing of the hours and days.

Very pleasing deep sky views were delivered with an inexpensive 30-mm Plossl eyepiece, delivering a power of 13 $\times$ and a true field of just under 4°. Sweeping the telescope through the Cassiopeia Milky Way and its rich star fields, one can enjoy nice high contrast views that are only possible with the unobstructed optics of a refractor.

The elliptical shape of the Ring Nebula (M57) in Lyra could be clearly discerned, as well as the famous globular cluster, M13, in the keystone of Hercules, which presented as a small, amorphous blob that was distinctly non stellar at 44 $\times$. Using a favorite 8-mm ocular, yielding 50 $\times$, this author tracked down a few of the showpiece doubles of the late spring sky, including, Albireo, Mizar and Alcor, Cor Caroli and the lovely orange suns represented by 61 Cygni A and B.

In summary, the Celestron Travelscope 70 was found to be a decent performer within the remit of its very modest price. The light weight of the optical tube would also make it an attractive option as finder 'scope astride a larger instrument. As with any other tool, a telescope is only as versatile as the person using it. And while the instrument would not be recommended as a serious telescope, it is most definitely not a 'toy.' Upgrading some of the accessories will also improve its performance. If you are only casually interested in star gazing and limited to a very tight budget, then this might be a good option for you.

More from Tele Vue

Long-established New York telescope maker, Tele Vue Optics, have offered two very nice doublet refractors for the busy astronomer who demands the highest quality optics in a portable package. These are the Tele Vue 76 (\$1,995) and Tele Vue 85 (\$2,425).

Introduced in 2002, the Tele Vue (TV) 76 was the replacement for their older ED 'scopes—the Ranger and Pronto—both of which were splendid 70-mm f/7 doublets with good but not apo-quality color correction. The TV 76 (f/6.3) has a slightly larger aperture but the same focal length as the older 'scopes. Like the Tele Vue Pronto, it has a beautiful rack and pinion focuser in a 2-in. format. Bought new, the package includes a custom made soft case, a screw-on lens cover and sliding dew shield, a 20-mm Tele Vue Plossl eyepiece and 2-in. Everbrite diagonal, a 1¼" adapter (all with clamp ring fittings) and a manual signed by Uncle Al himself. When outfitted with an eyepiece and a diagonal, it tips the scale at just over 6 pounds. That's significantly heavier than some top-of-the-range spotting 'scopes but not enough really to present problems in the field. Any loss of portability, though, is made up for by the TV 76's amazing versatility. A 3-in. aperture is just about large enough to make high resolution visual observing worthwhile, and its short focal length (480 mm), coupled to a big, wide-angled eyepiece, means that you get majestic 5.5° views of the night sky.

The optics on these telescopes are first rate. In comparison to several lower cost ED doublets of similar specification, it is clear that the TV 76 bests them all.



Fig. 2.13 The TV 76 goes anywhere at a moment's notice (Image by the author)

Star testing this ‘scope at 120× shows how superbly crafted the optics are. Vega displays a hard white Airy disc surrounded by a single diffraction ring. No significant color error was noted. The diffraction patterns both inside and outside focus were nearer to perfection than in any other telescope. They’re cleaner and easier to see compared to the slightly fuzzier patterns usually observed with cheaper ED doublets. Like other two-element apos, it does display a small amount of color on the rim of the diffraction pattern both inside (magenta) and outside (green) focus, but that’s normal behavior for an instrument with an ED doublet objective.

It’s easy to test good optics, and you don’t need an optical test bench to do it. A well-figured lens ought to be able to take very high magnifications before noticeable image breakdown occurs. Daylight and nighttime tests with high-quality eyepieces and image amplifiers show that the TV 76 can take amazingly high powers, and this little ‘scope can hold 100× per inch of aperture under ideal conditions. It has very low spherical aberration and is devoid of astigmatism and coma. This is extraordinary for an ED doublet with such a fast focal ratio (f/6.3). And it’s no accident either. It’s down to the excellent figure of the lens and the employment of a large air gap between the objective elements.



Fig. 2.14 The TV 76 atop a lightweight Tele Vue panoramic mount (Image by the author)



Fig. 2.15 The butter-smooth rack and pinion focuser on the Tele Vue 76 (Image by the author)

The TV 76 really rocks when it comes to resolving the prettier double stars, despite its fairly short focal length. However, like all other short focal ratio ‘scopes, maintaining sharp focus can be a bit fiddly, especially during high-power applications under less than perfect seeing conditions. The instrument’s excellent color correction makes seeking out variegated doubles a joyous adventure. Albireo, 61 Cygni and Almaak unveil their austere beauty at moderate and high powers. Forget Polaris and Rigel too. These high-contrast companions usually cited as tests for a 3-in. refractor are too easy for this refractor.

More challenging (and more fun) is the lovely triple system of Iota Cassiopeiae, and close binaries such as Delta Cygni and, both of which the TV 76 managed to resolve. And though it’s not the hardest binary system to discern with a good 3-in. refractor, Epsilon Bootes (Izar) is arguably one of the most compelling sights to see in a small telescope in all the heavens. Steady skies and high magnifications are required to elucidate its lovely secret—a magnitude +4.6 blue-green companion separated from its primary by just 2.9 arc seconds of sky. Now this little telescope can resolve pairs as close as 1.5 arc seconds *provided* they are of fairly equal brightness. But the near sevenfold difference in brilliance between Izar and its main sequence companion renders the secondary hard to see, overwhelmed as it is by the light of its primary. Optics plays a role with this system, too. The 4-in. instruments consistently struggle with this system, but a high-quality 60-mm refractor should just do the job under good conditions. And one of the finest views of Izar (Epsilon Bootis) can be seen with this 3-in. refractor. During a vacation to a tiny coastal resort on the North West coast of Scotland, this author chanced upon some fair weather. Tucked away in a shallow inlet, the early evening winds subsided gradually

to a dead calm after midnight, allowing me to take advantage of exceptional observing conditions with dark magnitude +6.5 skies. On two successive nights, I was able to rack up the power on my 'scope to 200 $\times$ to get a razor-sharp separation of the system. Like a budding yeast cell seen under a microscope, the pale blue ball of the secondary sat on an otherwise perfect first diffraction ring of a golden orange primary. It's at moments like this that one can more fully appreciate why the famous double star observer Otto Struve christened it *Pulcherimma*!

Its bigger brother, the Tele Vue 85 is everything the 76 is, only larger. It has acquired a rather cult-like following among refractor aficionados. But with its significantly higher price tag, it ought to!

Budget 80-mm Doublets

If you are in the market for a small telescope that could be used at the drop of a hat, then you should consider an 80-mm refractor. This aperture is about the minimum that can engage a serious observer on most objects. Thankfully, there are many varieties available, and here we shall discuss some of the more popular models used by amateur astronomers.

Some of the best bargains on the market today are the 80-mm f/11 achromats, made by Vixen, as well as a huge number of older used models available. Their long focal length, good color correction and quick cool down time have endeared them to lots of people. Excellent for high resolution work like double stars, the planets and the Moon, they can take surprisingly high magnifications and are an excellent alternative to the shorter focal length 80-mm refractors with low dispersion glass.



Fig. 2.16 An 80-mm refractor, an f/11 achromat with a nicely made objective from Nihon Seiko (Image by the author)



Fig. 2.17 A Vixen 80-mm f/7.5 ED refractor fitted with an 8–24-mm zoom eyepiece (Image by the author)



Fig. 2.18 The Sky-Watcher Equinox 80 ED doublet (Image © Sky-Watcher. Used with permission)

Perhaps the most popular grab 'n' go refractor of all is the ED 80. Introduced more or less simultaneously by Sky-Watcher, Celestron and Vixen, these telescopes sold like hotcakes when they first hit the market in 2004. Sporting an ED doublet objective for improved color correction and a focal length of 600 mm (f/7.5), it is relatively short and lightweight, lending itself easy to transport and use on a fairly lightweight mount. Optically, these telescopes score high, with their sharp, color free images and their ability to be pushed to high powers when called for. Their modest price (\$599) makes them a very attractive package for the savvy grab 'n' go astronomer.

Since then, a number of similarly designed 80-mm ED 'scopes have appeared under Chinese rebranded names such as Altair, Barska, Ikharus and Sharpstar.

The 80-mm Triplet Apos

As well as offering their smaller refractors in the 66- and 72-mm aperture classes, William Optics also market two slightly larger but still very portable ED triplet refractors. The first offering is the GTF 81 (\$1,219 for the tube assembly only). Sporting a focal length of 478 mm (f/5.9), it comes with a sturdy, 2.5-in., fully rotatable focuser. The larger aperture model—the FLT 98—offers slightly better performance, owing to its larger aperture, but it comes at a very steep price (\$2,495)—fully twice that of the smaller GTF81.

Other companies offer very similar products. Take, for example, the Meade Series 6000 triplet apochromats. The 80-mm utilizes the high-grade fluorite-based FPL53 glass in its lens construction, which is not present in its larger models. In a very attractive package deal, the telescope comes with a 2" Series 5000 Enhanced 99 % Reflectivity Slip-fit diagonal, aluminum cradle rings with mounting dovetail and hard case. All this for \$999.



Fig. 2.19 The William Optics GTF81 triplet apo (Image © OPT. Used with permission)



Fig. 2.20 The 80-mm Meade Series 6000 triplet apochromat (Image © OPT. Used with permission)



Fig. 2.21 The Explore Scientific 80-mm triplet apo (Image © OPT. Used with permission)

If you think Meade is offering a good deal on its 80-mm Series 6000 triplet refractor, take a closer look at the Explore Scientific equivalent, which offers much the same package for \$799. Unlike the Meade model, the Explore Scientific 80 mm does not come with a carry case but offers the same optics in a lighter weight carbon fiber tube for an extra \$200.

With optical tube weights averaging about 7.5 pounds, these telescopes are very easy to transport in the field. Their triplet optics ought to deliver excellent images but are more sensitive to misalignment and temperature fluctuations than their doublet counterparts.

Older Models to Look Out For

Although the market is flooded with new models promising the Earth, it is reassuring to know that some excellent 3-in. grab 'n' go telescopes can still be had on the used market. Arguably one of the best is the Takahashi FS 76 doublet apochromat. Now discontinued, this small refractor offers up razor-sharp, sharp and color-free images a notch up from the more ubiquitous ED 80 refractors.



Fig. 2.22 The superlative Takahashi FC76 (Image by the author)

In the achromatic genre, keep a look out for a used Stellarvue 80/9D. Build quality is excellent in an all-metal tube, 2-in. focuser (rack and pinion) and a retractable dew shield with a screw on metal dew cap. Star testing on Vega showed that the optics were undiminished, that is to say, excellent. An 80-mm f/11 achromat, mounted side by side with the SV80/9D, provided a good test. After checking on a few stars; the best available of which included Altair and Deneb, it was pretty clear the latter had a distinct edge optically; the star test marginally better and in-focus star fields displaying slightly greater contrast. Two fine 'scopes, one just a wee bit better than the other! The SV80/9D is one of the sweetest 80-mm achromats available. It was well worth any additional cost of cleaning it up. Kudos again to Vic Maris of Stellarvue. Indeed, as you'll later discover, this modest telescope was used to divine many of the showpiece objects in the sky, described later.



Fig. 2.23 The Tele Vue Gibraltar mount is beautifully matched to the SV80/9D (Image by the author)



Fig. 2.24 The Takahashi FSQ-85ED "Baby Q" (Image © Astronomics. Used by permission)

Takahashi, in Japan, has also introduced its own version of the ultra-portable imaging ‘scope in the corpus of the FSQ-85ED. Dubbed the “Baby Q,” this 85-mm four-element apochromatic refractor sports top notch optics but at a price that will take your breath away (\$3,650). Are these four-element designs for you? Perhaps, especially if you have imaging in mind. But for purely visual pursuits, simpler designs are more reliable and will serve up equivalent or better images at a significantly lower cost.

A Very Special 90-mm Achromat

Excellent grab ‘n’ go refractors needn’t cost a fortune. Take the SkyWatcher Evostar 90-mm f/10.1 achromat, which can be bought used for much less than the original cost.

The telescope has a lovely, lightweight tube, and is thus eminently portable. The dew shield is plastic, which is not a problem in itself. The dust cap (also plastic) is neat looking with a 60-mm aperture mask, enabling it to operate as a 60-mm f/15. Cool!



Fig. 2.25 The SkyWatcher Evostar 90-mm f/10.1 achromat (Image by the author)



Fig. 2.26 All good grab 'n' go 'scopes need a lens cap (Image by the author)

Removing the dew shield reveals a pristine 90-mm air spaced doublet objective with very nice multi-coatings applied to all surfaces. The instrument cannot be collimated, however. Checking collimation with a Cheshire eyepiece under a bright blue sky revealed good but not perfectly aligned optics, but neither is it enough to worry about in the slightest. Unlike some earlier budget achromats examined, the paintwork on the inside of the tube was immaculately applied and the baffling is more than adequate.

The focuser is the regular 1.25-in. Synta rack and pinion. Nothing to write home about, but more than adequate for the task; remember, it's $f/10.1$! It handles heavy 1.25-in. eyepieces very well. Pity it doesn't come with a 2-in. focuser for use with modern wide angle eyepieces.

This 'scope can be used with a regular 90° diagonal for astronomical use or a 60° , correct orientation diagonal for terrestrial applications, like this one.

Daytime assessment of the optics revealed nothing out of the ordinary. Indeed low power views of the birds seeking refuge in the trees nearby were sumptuous—tack sharp and rich in detail, free of any secondary spectrum.

Inserting a medium-power eyepiece (and filter, of course), you will be delighted with the sharp, high resolution detail you can see on the solar photosphere.



Fig. 2.27 The fully multi-coated objective of the SkyWatcher Evostar 90 (Image by the author)



Fig. 2.28 The SkyWatcher Evostar 90 is nicely baffled and blackened internally (Image by the author)

Contrary to what you may have heard before, it only takes one good night to assess a telescope's optics. Only on imperfect nights does one need to pass it through multiple star tests. Centering the bright star Vega in the field of view of an eyepiece generating 150 $\times$, the Evostar produced a clean, white, sharply focused



Fig. 2.29 The simple rack and pinion focuser on the SkyWatcher Evostar 90 (Image by the author)



Fig. 2.30 The SkyWatcher Evostar can be fitted with a 60° diagonal for terrestrial viewing (Image by the author)

Airy disk with a nicely formed first diffraction ring. The star is surrounded by a beautiful halo of purple; absolutely normal for this type of telescope and perfectly acceptable for visual use. Defocusing ever so slightly revealed no signs of astigmatism. Examining the Fraunhofer diffraction pattern both intra- and extra-focally using a green filter demonstrated smooth, well corrected optics with only slight under correction. All in all, a very good result for a telescope that costs so little!

Epsilon 1 and 2 Lyrae can be perfectly resolved into four stars. The greenish companion to Epsilon Bootis—now sinking lower into the western sky—was nicely separated from its orange primary at 150 $\times$. The same was true of Delta Cygni. Pi Aquilae, while certainly not resolved, was plainly shown to be strongly elongated. Its deep sky prowess was decent, too. During the darkest period of twilight, this author could see the beautiful incandescent annulus that is the Ring Nebula, M57, sharply defined at 101 $\times$. Moving into Hercules, one can track down the globular cluster M13 and be rewarded with a bright, highly condensed image. With a concentrated gaze, the attentive observer can make out quite a few individual stars on its periphery. The telescope does not disappoint on open clusters like M52 either, its modest aperture revealing several dozen stars in a kidney-shaped arrangement, the eye being drawn to a striking eighth magnitude orange sun on its flank. The lack of field curvature of this ‘slow’ object glass makes examining these bright clusters a particular joy.

In summary, the SkyWatcher Evostar 90-mm achromat is arguably one of the best buys in the small refractor market. Usually touted as a beginner’s telescope, it is much more than that. The Evostar 90-mm would embarrass instruments costing ten times its modest cost new. It is super light, super portable and delivers fine views at low and high power. If you’re in the market for a no-nonsense 90-mm telescope, this would be the one to go for. Because of its low cost and excellent durability, it would be especially useful to astronomy clubs undergoing public outreach. It would also serve as an excellent telescope for the instruction of undergraduates in astronomy/astrophysics.

The 4-In. Refractors

What is the most versatile refractor for grab ‘n’ go purposes? Well, such an instrument ought to be large enough to gather a decent amount of light to enable the observer to engage with both the deep sky as well as Solar System objects, including high resolution images of Luna and the bright planets. There is arguably one instrument that can fit that niche supremely well; enter the 4-in. refractor.

Like the smaller refractors, there is a huge range to select from, both achromatic and apochromatic. The biggest recent buzz has come from the Celestron 102 GT, which was being offered by several telescope outlets for significantly less than \$100.

These are 4-in. (102-mm) achromatic doublets with a focal length of 1,000 mm. At f/10, the color correction is quite acceptable, allowing you to push magnifications to 200 $\times$ and more. These Chinese-made instruments are perhaps the best testimony yet to the great virtues of traditional achromatic optics. They will deliver razor-sharp views of the Moon and planets, double stars and the brighter deep sky objects. A great many people bought them out of sheer curiosity. How can you get something so good for so little? The answer lies in the relative ease with which modern production methods can churn these objectives out both cheaply and well.



Fig. 2.31 The Celestron 102 GT (Image © Celestron. Used with permission)

Of course, you still have to outfit the Celestron 102 GT with a star diagonal and tube rings and mount it decently, but it still ranks as one of the best deals this author has witnessed in decades.

If you're in the market for the classic looks of a long refractor that is still very portable and quick to cool down, then look no further than the Astrotelescopes 102-mm f/11 achromat. Manufactured by the Kunming Optical Company in China, the author contacted the sole UK importer of these instruments, Lyra Optical, Rochester, and requested a sample for review. Supplied as an optical tube assembly, the only accessory included in the package was a pair of well-made tube rings.

Tipping the scales at just over 10 pounds, the nicely finished white CNC tube is fitted with a fully retractable dew shield. Fully extended, the tube measures 47 in. long but, impressively, is 8 in. shorter when collapsed away for storage. That makes it shorter than a 4-in. f/10 achromat!

After pointing the telescope skywards, it was discovered that the dew shield was held too loosely, and it fell back down the tube with a loud 'thwack.' The problem can be remedied by affixing some blu-tack to the sleeve. This could have been easily avoided by padding it with more felt.

The telescope comes with a solidly made, fully rotatable, two-speed Crayford focuser that can accept 1.25- as well as 2-in. accessories. In practice, the focuser seems to be a little fiddly. Specifically, it had a bit too much tension and made fine focusing slightly more difficult to achieve in comparison to other units.



Fig. 2.32 Despite its longer focal length, the 4-in. $f/11$ (*lower*) collapses to a shorter tube than its $f/10$ counterpart (*upper*). The tape measure is set at 110 cm for scale (Image by the author)

The objective is a fully multi-coated, air-spaced crown-flint achromat. The coatings look smooth and very evenly applied. The inside of the tube is painted matt black, and three baffles keep stray light at bay. A telescope this size is easily mounted equatorially or on a simpler alt-azimuth mount. Both systems were used to evaluate the performance of the telescope in the field.

This telescope generated high expectations in terms of optics. With its high F-ratio, it ought to have a number of desirable features for the visual observer. For example, it ought to enjoy greater areas of the field of view that are diffraction limited. Its deep light cone should also allow inexpensive eyepieces to work better, especially in regard to their ability to reduce astigmatism. The gently curving $f/11$ optics ought to be easier to make in comparison to its shorter F-ratio counterparts. What is more, high F-ratio ‘scopes are easier to collimate and less sensitive to misalignment. In addition, the greater depth of focus of high F-ratio telescopes renders them much easier to focus accurately. That’s why, by necessity, short F-ratio (fast)



Fig. 2.33 The two-speed Crayford focuser is basic but adequate. It would have been preferable to have a simpler rack and pinion with this instrument, though (Image by the author)



Fig. 2.34 The multi-coated objective of the 4-in. $f/11$. Note the three light baffles inside the tube (Image by the author)

'scopes require micro-focusers. Furthermore, the ordinary crown and flint glass changes its shape less severely than a typical ED 'scope of the same aperture (an important attribute as temperatures continue to fall during an observing run), allowing you to get diffraction-limited images faster than the latter.

So how did this 4-in. f/11 live up to these considerations? As it happens, very well indeed! Mounted on both a Gibraltar Alt-Az as well as a sturdy equatorial mount, the 'scope was subject to field tests over several weeks of extremely cold weather. Star testing at 167 $\times$ showed very well corrected optics. In focus, bright stars such as Vega and Capella focused to nice round Airy disks. There was no sign of coma or astigmatism. The stars were surrounded by an unfocused violet halo, a natural consequence of the telescope's achromatic nature. Racking the 'scope inside focus revealed textbook perfect diffraction rings devoid of rough zones. In that scenario, the focuser was ever so slightly cutting off a bit of the light cone and impacting the edges of the unfocused stellar image.

Extra-focally, the rings were just a tad softer, a classic sign of slight under correction. Inserting a 40-mm wide angle Erfle delivering a wide 2.4° field of view, a small amount of distortion in the outermost 10 % of the field could be detected, while the same eyepiece showed up a perfectly corrected field in a 4-in. f/15 instrument set up alongside it. All in all, this optic rates very high, certainly a notch up on the very capable 4-in. Russian f/10 achromat but not quite in the same league as the 'sensibly perfect' f/15 achromat.

With the testing over, it was time to relax and enjoy using the 'scope. The first target was a post opposition Jupiter. During good seeing conditions the 4-in. f/11 delivered very sharp, high contrast images of the giant planet, with several bands evident and hints of ovals and swirls set among them. The slight violet halo was actually quite pleasing to the eye. Certainly, it did not detract from the fine views this 'scope delivered. The first quarter Moon was a sight to behold at all magnifications from 28 $\times$ to 200 $\times$. The 'scope's mettle in subzero temperatures was tested on a suite of difficult multiple star systems, including Delta and Mu Cygni (triple system), Theta Aurigae and Eta Orionis. It passed them all with flying colors. The generous 2.4° field offered with a 2-in. eyepiece presented the glories of M35, the Double Cluster (C14), the Alpha Persei Association and the Orion Nebula (M42), in rich, high-contrast detail.

Minor mechanical issues aside, this telescope appears to be a viable alternative to a 4-in. ED 'scope (and at less than half the price). It shows more color than an ED 'scope, no question, but an experienced observer should be able to divine everything the ED 'scope can. So, it's not just a very good 'scope for the money, it's simply a very good 'scope. While other examples of this 'scope may or may not prove to be as high quality, this Chinese 4-in. f/11 achromat was certainly true to the promises of its design. Isn't it nice when optics and experience sing from the same hymn sheet!

A Russian Favorite: The Tal 100RS

Introduced in the late 1990s by the Novosibirsk Instrument-making plant in Russia, the Tal 100R enjoyed a lot of success, especially in Europe, owing to its razor-sharp images with minimal false color and little in the way of other aberrations that can



Fig. 2.35 The Tal 100RS refractor astride a lightweight Vixen Porta mount (Image by the author)

ruin an image. Over the last decade, they've had consistently good optics. But the original Tal 100R had its problems. For one thing, the mount accompanying the instrument, despite its good-looking appearance, was insufficiently robust to do justice to a fairly long, 4-in. refractor. The telescope itself had a 1.25-in. focuser with very limited focus travel. Some eyepieces couldn't come to focus with it; and as for using a Barlow lens—forget it! In addition, while the supplied 1.25-in. diagonal is of high quality, its peculiar design means that it cannot be interchanged with other 1.25-in. diagonals from other manufacturers. Finally, a number of users had issues with the inadequate internal baffling of these 'scopes. But once these issues were sorted out, the instrument performed excellently.

This author compared the Tal 100R achromat with a Tele Vue f/5 Genesis fluorite refractor and found that the Russian achromat had the edge on planets and double stars. Over the years since its introduction, the Tal 100R has undergone some significant changes. For one thing, the 1.25-in. focuser was replaced with a solid 2-in. focuser (which looked very 'Synta esque'). But it had a great deal more focus travel and so could now be used for almost any visual or photographic application. The reassuringly solid aluminum tube finished in white was totally redesigned with a vastly superior baffling system. The new model was renamed the Tal 100RS.

More Expensive 4-Inchers

There are many other 102-mm (4-in.) refractors to choose from on the market. The only real reason to acquire these instruments is for their improved color correction, but the differences between a good f/10 achromat and the former are subtle at best. That said, some very nice instruments in this aperture class need mentioning. First up is the Tele Vue 102. This venerable 4-in. refractor is considered by many to be the ideal grab 'n' go instrument. It's large enough to collect enough light to keep a serious observer busy for years, and can serve up views of the Moon, planets and double stars rivaling those seen through much larger reflectors.

This author's first serious foray into the world of high-end 4-inchers came when he acquired a 'classical' Tele Vue Genesis refractor (non-SDF). It was a beautiful 'scope, built like a tank and capable of producing wondrous, sharp images with a very flat field. Low power views more than 5° wide were awe-inspiring. It was also a solid performer on Luna and bright planets, taking magnification well and only showing a little bit of false color on high-contrast objects when pushed above 150× or so. It was close to a 'perfect' telescope, but a few things niggled me about it. For one thing, because it was such a fast refractor, finding the sweet spot of fine focus was often a challenge, especially when used at high powers. When you have an f/5 refractor, there's no room for ambiguity; you're either in focus or you're not. In addition, it had a very short focal length—504 mm—and so was difficult to get ultra high power views. Thus, added to a four-element objective, one has to resort to adding a two-element Barlow lens and a five-element Plossl eyepiece to get those savored 200×+ views that are achievable on the steadiest nights. That's a lot of glass to put between you and the heavenly realm, so much so that I wondered whether it would really take the edge off many high resolution images of the Moon and planets. After briefly looking at a variety of double stars, Mars and Saturn through the economical Orion 100ED (a f/9 FPL-53 ED doublet), it was immediately convincing that the Genesis was indeed failing to deliver the best high power views.

The Tele Vue 102 (now discontinued) is a doublet ED refractor with a aperture of 102 mm (4 in.) and focal length of 880 mm (f/8.6). As you might expect, the instrument comes with an excellent rack and pinion focuser and retractable dew shield. The tube is beautifully made of high strength aluminum, finished in a textured ivory powder coat. Optically, it leaves little to be desired, throwing up excellent high contrast images of the Moon, planets and brighter deep sky objects. Star testing a unit revealed excellent spherical correction with no signs of astigmatism or coma that plagued a refractor image. The 102 is an excellent double star telescope being capable of resolving pairs down to its theoretical limit.

More recently, Synta introduced the ED 100, a very similar performing instrument to the Tele Vue 102 but at a significantly lower cost. Optically, there is not much to choose between them but the heirloom quality of the Tele Vue mechanicals



Fig. 2.36 The lovely Tele Vue102 atop a wooden Gibraltar Alt-Az mount (Image by the author)



Fig. 2.37 The original Tele Vue f/5 Genesis on a Gibraltar mount (Image by the author)



Fig. 2.38 The Explore Scientific carbon fiber 102-mm triplet apochromat (Image © OPT. Used with permission)

leave the basic ED 100 model in the dark. That said, many ED 100 users have elected to upgrade the basic focusers that accompany these instruments, and an army of loyal fans use them each and every clear night.

Those on the lookout for the most compact, ultra Portable 4-inchers would do well to look at the current suite of triplets and four-element Petzvals. Because of their greater complexity, they invariably command a greater price than the simpler models outlined above. Also, in the long run, their optical components will have a tendency to go out of mutual alignment, hence requiring readjustment.

Chinese-made models, such as the Explore Scientific 102 mm f6.7 ED triplet refractor (\$1,349), feature a nicely designed objective using Hoya low dispersion glass, a state of the art dual-speed 2-in. focuser, tube rings, mounting plate and a built-in carry handle. Other variations on this theme are marketed by Meade Instruments.

Like the smaller Explore Scientific triplets, these telescopes come with everything you need to get started—a 2-in. dielectric diagonal, tube rings, a dovetail plate and an ergonomic hard case.

Triplet apochromats, like any other type of instrument, come in various tiers of quality. Here, we'll showcase just one 'high-end' model in this aperture class, the APM 107/700 F6.5 Super ED.

With a lens designed by Russian optics giant LZOS, the objective has a fully multi-coated FPL53 ED element ensuring excellent color correction. This model comes with a very robust 3-in. fully rotatable dual speed focuser to allow heavy accessories like large eyepieces and CCD cameras to be attached. The 3-in. focuser



Fig. 2.39 The APM 107/700 F6.5 Super ED triplet apo (Image © Altair Astro. Used with permission)

bumps up the mass of this unit to 5.7 kg. With a retractable dew shield, the instrument collapses to a very Comfortable 580 mm and when fully extended 655 mm. A hard carry case is included in the price tag.

The Last Word: Why Not Consider a Rich Field Refractor?

Thus far, we have only considered achromats and apochromats that offer excellent color correction. But there are also a number of large aperture rich field telescopes available at very reasonable prices. These are usually simple achromatic doublets with short focal lengths, optimized for deep sky viewing at low and moderate powers. Because they display fairly prominent chromatic aberration on bright objects, they are not the best instruments for lunar and planetary study but can be used for casual observing. Here, we will discuss a couple of models that have piqued the attention of the amateur community.

First up is the Explore Scientific AR 102 package. The telescope has a 4-in. (102 mm) aperture and is fully multi-coated, possessing a focal length of 650 mm. The AR 102 has a robust 2-in. dual speed focuser to accommodate the sturdiest of (often) heavy wide angle oculars, a 8×50 finder tube and rings with carry handle dovetail plate. The package also included a high quality 2-in. dielectric diagonal.



Fig. 2.40 The Explore Scientific AR 102 (Image credit and © OPT)

A similar 4-in. $f/6.5$ doublet achromat was put through its paces. Its performance was surprisingly good on all celestial targets. Magnifications could be pushed to about $160\times$ for lunar and planetary observations and indeed can be extended to nearer $200\times$ with an appropriate minus violet filter. This author has enjoyed many hours with one of these instruments and after experimenting with filters that suppress chromatic aberration, found that they were decent instruments on tough targets like Jupiter, Mars and the Moon. Where a telescope like this really shines is in the deep sky work, where its relatively large aperture pulls in some of the fainter galaxies, globular clusters, open clusters and bright emission nebulae.

If you want a telescope complete with a computerized go-to mount then you might want to give the Celestron Nexstar 102 SLT a closer look. Featuring optics with very similar specifications to the AR102, the telescope comes with a light, but fairly sturdy, computerized mount. With the touch of a few buttons, you can slew it off to any of 4,000 objects, where the telescope will center the object of interest and allow you to automatically track it for half an hour or more. Two eyepieces delivering $26\times$ and $73\times$ allow you to make a decent start, but the experienced user will almost certainly upgrade these budget oculars to higher quality examples to get the very most out of the very decent optics delivered by this telescope. All in, such a complete package will set you back a mere \$430 plus shipping.

This brings to an end our brief survey of the grab 'n' go refractor market. As you've seen, there is an enormous range of instruments to suit everyone's needs and budgets. Choose the model that best suits your schedule. Of course, if you wish to



Fig. 2.41 The Celestron Nexstar 102 SLT (Image © OPT. Used with permission)

learn more about refractors specifically, then check out *Choosing & Using a Refracting Telescope* by this same author for more details. In the next chapter, we'll take a look at the world of the Newtonian reflector, a long time favorite of the grab 'n' go astronomer.

<http://www.springer.com/978-1-4939-0825-7>

Grab 'n' Go Astronomy

English, N.

2014, XI, 245 p. 144 illus., 127 illus. in color., Softcover

ISBN: 978-1-4939-0825-7