by Timm Bottoni *03/29/06* | Email Author

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William Optics 80mm APOGRADE Fluorite Doublet Upgrading the Megrez II SD 80mm refractor to an APO

by Timm Bottoni | March 21, 2006

For those who don?t want any background or don?t like to read

Feel free to skip ahead (since this review is rather long), look at the comparison pictures, draw your own conclusions, and read whatever parts interest you, I won?t mind.

What are the goals of this review and article?

I will try to accomplish three things. ***First***, I will describe the installation of the APOGRADE. ***Second***, I will offer a direct comparison between the original optics of the Megrez II SD Semi-Apo scope and the optics of the WO APO Fluorite Doublet upgrade. ***Third***, I will document the tests I used so that others can try the same thing if they want to, and I hope to present things in ?layman?s terms?, describing only my own equipment.

What is an APOGRADE and who is William Optics?

An APOGRADE is an APO (Apochromatic) upgrade lens replacement from WO (William Optics ? http://www.william-optics.com) that was co-designed by optics designer Thomas M Back of TMB Optical (http://www.tmboptical.com). At the time of this writing, the APOGRADE was in stock in the USA, and was being offered by WO and its dealers as an upgrade for a number of 80mm refractors. Check the WO website or with your dealer for current pricing and availability.

The original lens is on the left, and the APOGRADE is on the right. From this view, the only difference that can be seen is the obvious difference in the reflection of the flash from the camera.

WO is headquartered in Taiwan, led by William Yang, with WO USA in California, providing sales and

support to its US customers and dealers. WO celebrated their 10th year in business in 2005 with a special anniversary model telescope. The Red ZenithStar Fluorite Doublet APO, 80mm Anniversary model refractor sold out quickly in its first production run after good reviews and a great deal of customer excitement over a new APO Fluorite Doublet, and additional units were produced to meet demand.

WO announced that this scope would be a limited production model, but apparently produced significant additional quantities of the lens assembly, and has been selling the same lens in the Megrez Fluorite Doublet APO, and is now selling the same lens as the APOGRADE upgrade for their non-APO 80mm Megrez and ZenithStar models. WO is also offering to sell the APOGRADE to customers who have 80mm scopes from other manufacturers, whose design has the same thread size on the tube, which allows for a user installable upgrade. I recommend that interested customers contact WO directly (check the WO web site to start) to determine if their 80mm refractor is a model that will work with this upgrade.

Who decides whether it?s an Achro, a Semi-Apo, or an APO refractor?

I have links to articles in the reference section on this to read if you like. I think that the market for small refractors has become an increasingly confusing place. I?ve read various marketing claims made by manufacturers regarding the quality of their scopes and optics, and there appears to me to be a great deal of confusion over terms like APO, Semi-APO, well corrected, low false color, performs like an APO, etc. It would be nice if there were a way to get past the marketing claims, and have a single trusted testing source that could accurately compare various models of telescopes using a standard testing methodology, but there is not. Instead we rely on others to write reviews, and in the end we make our own call on what to believe and buy. That is why I created this review, to let people decide for themselves based on my experiences.

My Background:

I am a volunteer moderator of the William Optics Yahoo group, and I read and participate in a variety of groups on Yahoo Groups, Astromart Forums, and CloudyNights Forums. I live in the Chicago area, so I have lots of light pollution, varied weather, and very few nights of really excellent seeing, but I get outside to observe on from my deck as often as I can. I enjoy doing research, writing reviews, taking digital photos and reading others? reviews. I bought a WO Megrez II SD Semi-Apo 80mm refractor in 2005 and have been very happy with it for astronomical, photographic and spotting scope use. I have also been very happy with the customer service that I have received from William Optics. In this review I have done my best to describe the upgrade process, and to provide accurate details regarding how I tested both the original SD Semi-APO optics and new Fluorite Doublet APO optics (i.e. APOGRADE).

So what?s the big deal about an APO refractor anyway?

An APO refractor is considered by some to be the highest contrast, and best image quality of all telescope designs because it eliminates the false color associated with achromatic refractors by using more expensive glass and designs, and provides an obstruction free view. Chromatic Aberration (CA), or false color, often seen as a bright purple fringes, is more bothersome to some than others, and is visible in achromatic refractors around very high contrast items (like bright stars, planets, the moon and many daytime objects).

Can you really turn any APOGRADE compatible 80mm achromatic refractor into an APO just by unscrewing the lens and putting a new one in?

Yes, the lens in the refractor is the primary factor that determines what the scope is capable of.

Will it cut off some of the light (vignette) going from to a 555mm focal length because the baffles in the scope were designed for a shorter focal length?

I tested mine and did calculations, and it doesn?t on my Megrez II, but you should contact WO directly if you are concerned about this.

Is it worth it to upgrade to an APO scope using the APOGRADE?

It depends! It depends on how much money you are willing to spend; it depends on how sensitive your eye and/or photo gear is to false color and how bad you want an APO in 80mm. Anyone can sell their existing refractor and buy an APO refractor, but upgrading does have one advantage that I personally find very appealing. I can keep everything I have now, and not have to hassle with selling my scope on the used market. I know lots of people like to buy and sell used astronomy equipment, but I?m not one of them. I simply don?t want the hassle or the risk of buying anything used unless I have to.

How can I test these and make an accurate comparison?

The testing techniques I used are really only going to work well if you can compare two scopes (or lenses) side by side under the exact same conditions like I did. It?s just too hard to compare scopes unless you can do this. In the end, my hope is that the reader will have enough information to make an educated decision on their own, regarding the WO APOGRADE. The testing results and methodology I used will show you how to examine your own optics in a way that may provide insight about its quality. If you are happy with your optics, and don?t want to take any chances on catching an expensive disease commonly referred to by some as ?APO FEVER? you might want to stop reading now.

First Impressions and Installation of the APOGRADE

IMPORTANT NOTE ? BEFORE YOU BEGIN: Since the original Megrez II OTA (Optical Tube Assembly) was built with a 500mm focal length lens and this is a 555mm focal length replacement lens, **it will not reach focus without the addition of a 2? diameter extension**. I used the WO 2? extender at all times, along with the WO 2? Photo adapter for all of the prime focus pictures in this review, and I used a WO 2? Dielectric Diagonal for all of the visual comparisons.

First Impressions:

The lens comes nicely packaged in high quality WO packaging, with high density foam, in a sturdy and attractive box. Upon taking out the lens assembly, I immediately noticed that the lens almost seems to disappear when you look through it. I had read reviews about the new STM coatings, but this was the first time I had seen them in person. I don?t know what makes these coatings do what they do, but comparing the two lenses side by side it was easy to see that the APOGRADE was noticeably clearer, less reflective, and was brighter to look through.

Installation of the APOGRADE optical lens assembly

In my opinion, the installation of the APOGRADE is very easy in the 80mm Megrez II scope design, all done without tools in minutes.

Step 1: Remove the sliding dew shield.

The Megrez II design has a small silver spring clip on the inside of the sliding dew shield that is easily popped out, which allows the dew shield to slide backwards, allowing the lens cell assembly to be unscrewed.

Step 2: Remove the lens assembly.

This is done by unscrewing the lens assembly counter-clockwise. The original lens cell is an air spaced semi-apochromatic doublet, which uses three adjustment screws to collimate the lenses in the machined aluminum cell. I was able to tweak just a bit better collimation out of mine, and the optics of my semi-apo lens looked good to my eyes, showing only a slight astigmatism and a reasonable amount of false color. I will not attempt to teach anyone how to collimate their refractor, and I appreciated a lens that is user adjustable, for those of us who are capable of adjusting it if needed to avoid the cost of having to send it back.

This picture shows the scope with the spring clip off, the dew shield slid back, and both lenses out. The replacement lens moves the glass forward about 10.5mm.

Step 3: Install the new lens assembly.

This is done by simply screwing on the new lens assembly clockwise. Slide the dew shield forward and replace the spring clip, and you are all done.

From the picture it might also be clear that it has a longer metal assembly that makes the scope longer than it originally was, moving the center of the glass elements 10.5mm in front of the original design. It makes the entire telescope longer, so **if you have a case that was custom made for your existing model, you will have to modify it to fit the new longer scope**. In order to fit the scope back into my WO backpack carry case, I had to cut a bit of the foam from the front section of the pocket that holds the OTA.

The replacement lens assembly is also an air spaced doublet which can be collimated. I didn?t adjust the lens assembly at all; I wanted to see how it looked out of the box. I later verified that it came perfectly collimated from WO with a nice star test. In fact, all through the testing process, I was able to simply switch lenses back and forth without adjusting the collimation of either lens assembly, and both remained collimated. Again, I can only make this statement for my scope, since I have no idea if other companies make their tubes and focusers to same level of precision.

Testing the two lenses

While the installation was simple, the testing part was challenging, but fun. While researching ideas for how to test scopes and write this review, I did a lot of reading on the internet from a variety of expert and trusted sources about Chromatic Aberrations and found that this problem is quite old, and is being addressed by optics designers in a variety of ways for refractors and camera lenses. Since this lens was co-designed by Thomas M Back, I searched for and found articles written by him and other top optical experts (see the reference section at the end).

I decided to use testing techniques from the photography world because there are some pretty good tests that users can do themselves on their camera lenses. A refractor, attached directly (prime focus) to an SLR/DSLR acts just like a big fixed length, fixed aperture lens as far as the camera is concerned. In my case it?s a 555mm (about 11X) lens but because of the cropping factor yields about an 18X lens (approx 888mm). I decided that I could easily view and photograph a high contrast subject outside during daylight. I chose a dark chimney vent, and did comparisons to determine whether CA (chromatic aberration) was visible or not. I also decided that I could setup a very high resolution lens testing chart in my basement, under very controlled conditions for both visual and photographic results. And I also used some familiar nighttime viewing targets to compare the two lenses

Testing Basics

For daytime outdoor tests, I was able to use a sturdy tripod, setup on my deck, pointed at the neighbor?s roof chimney vent. It provided a way to keep most of the variables under control. To compensate for the differences in magnification due to different focal lengths, I was able to move closer and further away on my deck, with only a minor change in size and perspective.

For the indoor testing, I used a chart that seems to match a standard ISO 12233 lens test chart that is available as a downloadable PDF file that I found online (see references listed at the end of this review). I printed it myself on 8.5?x11? Kodak Glossy Photo paper using the highest quality printing resolution (1200x1200 dpi) available on my HP Photosmart 7960 printer. It?s also possible to purchase a chart, or have one printed by a photo developer. If you can?t see white space between all of the lines on the chart (using a magnifying glass) it?s not a high enough resolution print and probably not going to work well for testing.

The Tests with Comparison Pictures and Analysis

Visual Testing Results and Analysis

Since my existing optics seemed quite good to me, I wasn?t sure how much of a difference I would be able to see in the daytime or at night, so I decided to try a variety of tests. In both scopes I tried a variety of daytime views. I tried all my eyepieces, and included a variety of low contrast and high contrast objects at varying distances, alternating at times between the two lens assemblies. The more I compared the two lenses, the more I became aware of the false color in the SD lens at the higher magnifications (above 80X) on bright subjects, while there was no visible false color that I could see in the APO lens at any magnification I tried. It takes some time to look deeply at some objects to really see the details, but the findings were very conclusive, the APOGRADE significantly out performed the Semi-Apo SD lens. I also used the WO VR1 filter, which is a violet reduction filter. It eliminates a great deal of the purple fringing, but at a cost of reduced light and a color shift that makes everything look greenish to yellowish. Its not really usable for daytime viewing but at night for planets and the moon the color shift is very fine on those objects that when viewed at high power are blurred to my eyes by the purple edges. I noticed that even with the VR-1 filter, and the purple color mostly gone, fine details were not nearly as clear or sharp in the Semi-AP lens vs. the APO lens

Views of Saturn and the Cassini division were noticeably better in the APO scope. The moon showed identical improvements, and the edge of the moon showed no false color on axis, and while in focus using the APO lens. At all magnifications I tried, the APO lens was sharper, had better contrast, and had no false color resulting in images that snapped into focus extremely well. To me the differences visually were not only better, they were stunning. I wasn?t expecting it to be this noticeable visually because I really think the SD Semi-Apo is quite good for the money.

It?s hard to quantify the differences visually, but once you see the same objects both in daylight and at night in both lenses, my opinion is that the APO lens is sharper, has higher contrast, no false color and is significantly better.

Outdoor Daylight Test Shots

All of these pictures were taken on the same day, at the same time, on my deck which faces West, in the mid afternoon, of the same chimney on the same house, but the distance was adjusted to try to get the image size to be the same, and the elevation was slightly different which is why the view changes slightly. Everything was allowed to reach ambient temperature before I began, and collimation was verified to be excellent for both lenses later that night using a star test.

SD Semi-APO Doublet lens Shots	APO Fluorite Doublet lens Shots

Original shot ? standard exposure

Original shot ? standard exposure

Cropped to 100% - standard exposure

Cropped to 100% - standard exposure

Cropped to 100% - 1 stop overexposed

Cropped to 100% - 1 stop overexposed

Cropped to 100% - 2 stops overexposed

Cropped to 100% - 2 stops overexposed

I found that the camera was much better at ?seeing? the chromatic aberration and other optical aberrations than my eye was, especially when I increased exposure. I increased exposure by up to two stops and found that CA show up more vividly in the Semi-Apo scope, however there was almost none

in the APOGRADE. All of these shots are in focus. The differences you see in these shots are due to the differences in the optics, and the level of exposure.

For comparison I also shot some pictures with the VR-1 filter

Original shot ? standard exposure ? White Balance set to automatic

Original shot ? standard exposure ? White Balance set to sunlight

Cropped to 100% + WO VR1 Filter ? White Balance set to automatic

Cropped to 100% + WO VR1 Filter ? White Balance set to sunlight

Cropped to 100% + WO VR1 Filter ? White Balance set to automatic ? 1 stop overexposed

Cropped to 100% + WO VR1 Filter ? White Balance set to automatic ? 2 stop overexposed

I wanted to see how using the VR1 filter compared to the APOGRADE. Since my VR1 filter is a 1.25? filter, I had to use the 1.25? camera adapter which is why there is some vignetting (darkening near the outside edges) in these images that is not in the ones taken with the 2? photo adapter. Also, I took most of the pictures with the White Balance set to automatic, but took one with it set to sunlight, which gives the picture this greenish yellowish hue to them. This is how it looks to your eye as well, which makes the VR1 filter not suitable for daylight visual use, but it works well at night and with the camera set to auto white balance.

You will also be able to notice that even though the VR1 does an excellent job of removing the purple, and make the picture appear to be in better focus, it still doesn?t compare to the sharpness and contrast of the APOGRADE pictures.

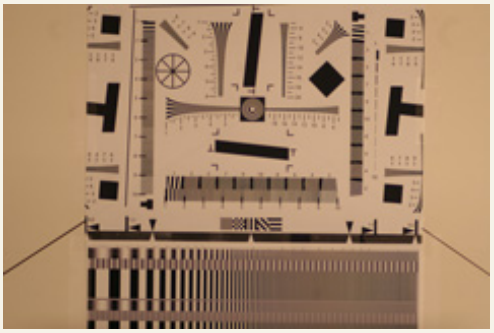
Indoor Visual Tests

The indoor testing, under high controlled conditions, made the task of comparing the two lenses much easier than the outdoor testing. My perception of the two lenses was that the contrast and sharpness was vastly superior on the APOGRADE lens. If I had never looked through the APOGRADE, I would have concluded that the Semi-APO lens was very good quality, but once the two were compared, one after the other, by easily switching them back and forth, the difference on the black and white test chart left little doubt in my mind, just how much better the APOGRADE was over the original Semi-APO lens.

Indoor Test Shots

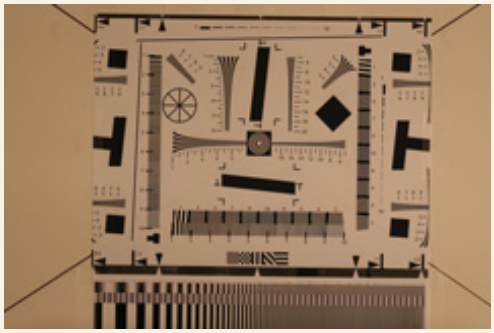
These pictures were shot in my basement at an approximate distance of 32ft for the Semi-Apo and 35ft for the APO, which is about the closest distance I could focus.

SD Semi-APO Doublet lens Shots

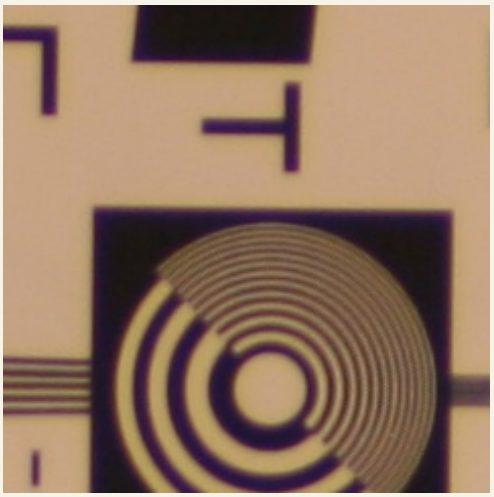
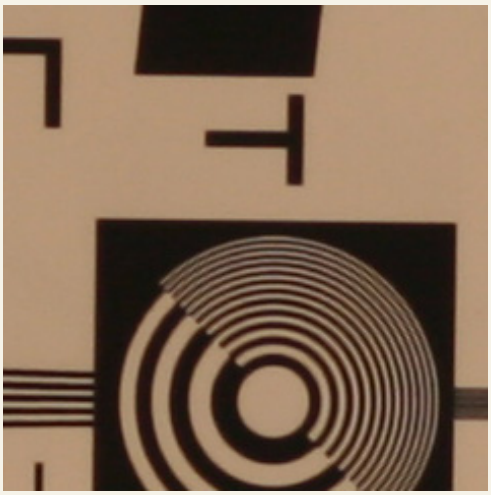
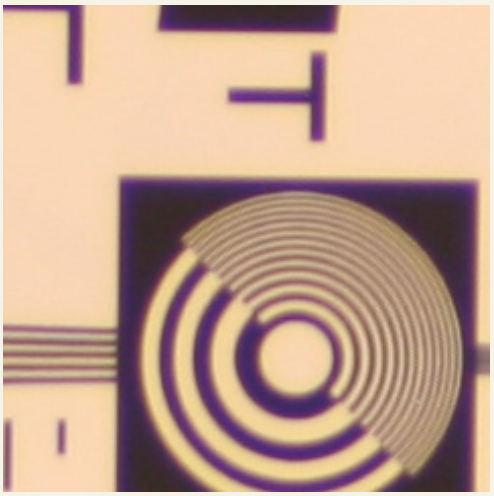
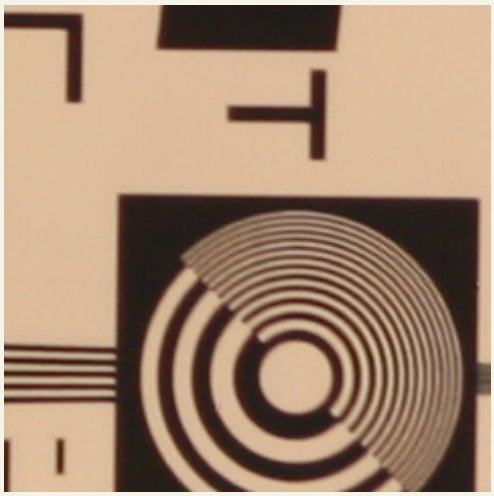
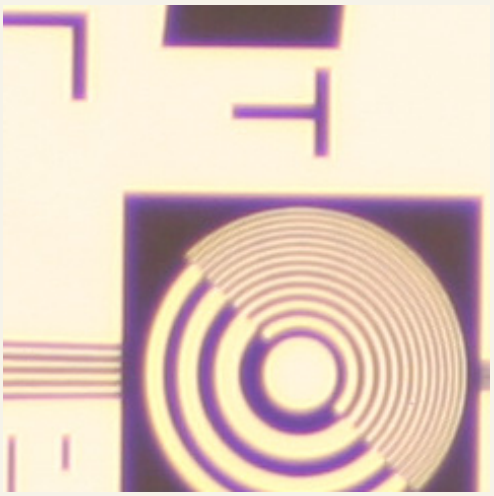


Original shot ? downsized to fit the page

APO Fluorite Doublet lens Shots



Original shot ? downsized to fit the page

Camera settings as taken: 1/50 sec	**Camera settings as taken: 1/50 sec**
 **Cropped to 100% - 1/50 sec**	 **Cropped to 100% - 1/50 sec**
 **Cropped to 100% - 1/25 sec**	 **Cropped to 100% - 1/25 sec**
 **Cropped to 100% - 1/13 sec**	 **Cropped to 100% - 1/13 sec**

Conclusion:

They say that pictures are worth 1000 words, and it seems that the pictures speak for themselves. Overall, I would say it?s a great product, with the only reservations being that you will need a 2? extension, and will need to modify the foam in your case.

References:

Lens test charts and ideas

http://www.graphics.cornell.edu/~westin/misc/res-chart.html

http://www.imatest.com/docs/lens_testing.html

http://www.imatest.com/docs/sfr_chromatic.html

Articles on testing telescopes and lenses

http://www.dpreview.com/learn/?/key=chromatic+aberration
http://www.dcviews.com/tutors/tt55813.htm
http://www.vanwalree.com/optics/chromatic.html

http://reviews.cnet.com/4520-6603_7-1014358-1.html
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http://www.backyardastronomy.com/appendix/startesting.pdf
http://www.cloudynights.com/item.php?item_id=1354&pr=3x75
http://astro.geekjoy.com/calcs/rescalc.html

Articles on Refractors

A Survey of Refractive Systems for Astronomical Telescopes by Roger Ceragioli http://alice.as.arizona.edu/~rogerc/
Defining Apochromatism by Thomas M Back - http://www.tmboptical.com/catsTree.asp?cat_id=25
A Star Test Primer by Thomas M Back - http://www.tmboptical.com/itemsGrid.asp?cat_id=31
An Introduction To Chromatic Aberration In Refractors by Jay Reynolds Freeman http://www.maa.mhn.de/Scholar/chromatic_aberration.html
Color Correction in Refractors by Roland Christen http://geogdata.csun.edu/~voltaire/roland/color.html
Other Essays from Roland Christen available http://geogdata.csun.edu/~voltaire/roland/index.html
Small Refractor Shootout by Tom Trusak? http://www.cloudynights.com/documents/80mm.pdf
Stellarvue Nighthawk by Tom Trusak http://www.cloudynights.com/documents/nighthawk.pdf
William Optics Zenithstar 80 by Tom Trusak http://www.cloudynights.com/documents/zenithstar.pdf
Two Tiny APOs from William Optics by Tom Trusak http://www.cloudynights.com/documents/66woapo.pdf
The Megrez II ED 80mm Triplet Apochromat by tom Trusak http://www.cloudynights.com/documents/wotrip.pdf

Other useful sites that I found good articles and advice on
http://home.att.net/~jak.stargate/wsb/html/view.cgi-home.html-.html
http://www.lcas-astronomy.org/
http://www.cloudynights.com/item.php?item_id=1128
http://www.cloudynights.com/item.php?item_id=547
http://www.cloudynights.com/item.php?item_id=597

Additional Testing Notes:

For all photos I used; a sturdy photo tripod, or a self-modified Celestron Nexstar 114GT mount. I used a variety of settings, and used the Canon 20D?s Mirror Lock-up feature along with a shutter release cable to prevent camera shake. The pixel resolution of the 8.2MP image is 3504x2336, which results in about a 3MByte file. Because of the large sizes, the pictures have been sized and cropped accordingly to allow for them to easily fit in this review. Shots shown at 100% are cropped to the exact pixels shown.

I took a lot of pictures but only kept the best focused shot from each series that I shot.

All pictures were shot at the highest quality JPG setting, and were NOT altered in any way other than cropping and downsizing. This is extremely important, since the proliferation of digital photo retouching tools allows easy changes which would result in inaccurate comparisons.

I have the following accessories that I used while testing.

Plossl Eyepieces ? Televue 15mm, 11mm, and 8mm, Meade 4000 25mm, Orion Highlight 6.3mm

Wide angle Eyepieces - WO SWAN 33mm

Celestron Ultima Barlow which tests out at about 2.2X magnification on average

WO 2? Dielectric Diagonal, WO 2? extension, and WO 2? Photo Adapter

Orion 1.25? Variable Adapter which can be used as a T-Adapter or as a variable Eyepiece projection tube and adapter

WO 1.25? VR1 ? Violet Reduction Filter

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