Vixen FL-55S/440mm Refractor

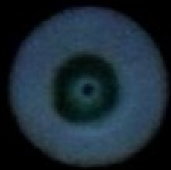
Vintage : ca. 1985
D=55mm,FL=440mm ,F/8
Doublet Fluorite APO

Collimation of focuser and lens cell

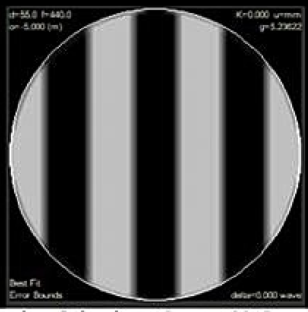
635nm laser collimator
(Howie Glatter Holographic)

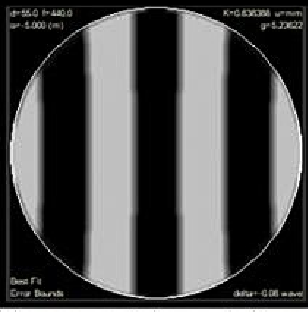
Chesire collimator
(Tectron Telescopes)

Flat1: <10 λ precision Van Keuren Co. mirror



Inside Focus	Focus (Null)	Outside Focus





Ronchi screen: 136 LPI ~5.235 LPmm
LED: 3mm green diffused
Flat: <10λ Van Keuren aluminized mirror

D (mm) FL (mm) LPmm = 136 LPI
55.0 440 5.23622
0.06 -7.620
P-V Wave Front Error Focal Offset

Slightly overcorrected sphere, matched by an induced error of 0.06λ P-V equivalent to 1/16λ.

As DPAC doubles the error, the true wave front error should then be half, i.e. 0.03λ P-V or **1/32λ**

A row of holidays and overcast weather, -- so I've taken the time to start a formal test of some of my small classic refractors.

Vixen FL55S/440mm #1

Here's the first result, for a small Vixen 55mm f/8 telescope; My preliminary (and inexperienced) attempt to quantify the result is ~1/30λ overcorrection.

Any help in interpreting the Ronchi-grams is of course most welcome.

Your lens has sphero-chromatism, so you only see the errors at one wavelength by testing in green. So, those errors are increased across all the other wavelengths. The result is that the total error in the wave front is worse than what you see only in green.

I don't know the design of the lens but for example a typical 60mm f/15 achromat made from BK7 and F4 glass -- when made perfect -- will have a total wavefront error of around 1/8 wave because a chromatic, and spherical aberration. That lens will be designed to have no spherical aberration in the green but will show spherical at other wavelengths. So, if it shows problems in the green then that error then adds to the spherical aberration it already has at other wavelengths.

So, you have to be careful in estimating the error in only one wavelength and assuming that this is total error in the wavefront. -- Dave

Here's some information on the lens design for the scope I tested:

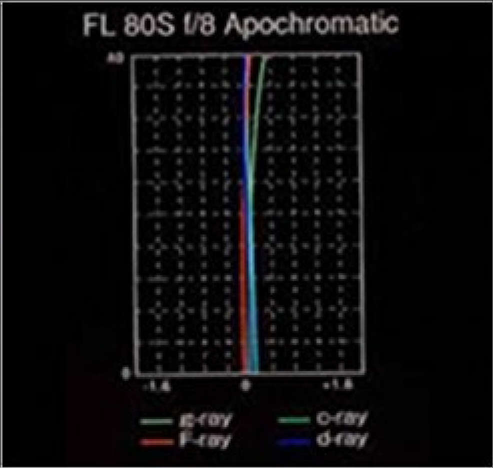
The lens design of the classic Vixen fluorite doublet objective is an **air spaced Steinheil** with:

- A positive (convex) uncoated fluorite **(CaF_2) crystal crown** at the back;
- A high-index lanthanum **(KzF_2) short flint** at the front.

Compared to a typical achromat with [BK7 | F4] glass, the Vixen FL-lens has **reduced CA** across the whole range of visual wavelengths, from the C - g Fraunhofer lines, and the **transmitted wavelength** from 0.125 to 10 microns is twice that of BK7 crown glass. The Vixen FL- lenses I have seen bench tested have also shown very **high Strehl**.

The FL-lenses (as all doublet APO's) do **show some SA**, though at f/8 it is not notable in visual use (but it may be so in astrophotography).

A question: how do I detect and quantify the amount of spherochromatism from a Ronchigram? - must I test the lens in other colors too; say C (red) and G (purple)?



To check the sphero-chromatism you have to test the lens in three known wavelengths that are fairly narrow in band width. So, using filters that have bandwidth of around 10 nm. You also have to check were those wavelengths come to focus in relationship to green and how that compares the theoretical data. As your lateral color plot shows green looks to be a perfectly vertical line so it shows if your lens was perfectly figured it should show a clean null. The other wavelengths are not straight lines so you would see spherical aberration. What causes the colors to come to focus are the radii on the surfaces, which are calculated for the glass types used. So, when you have the correct radii and of the correct surface figures (mostly spherical) everything works as theory shows the design to be, but if a surface or surface(s) are off, everything changes i.e., the color correction and spherical aberration.

DPAC testing is a great test but it doesn't tell the whole story with a lens, especially if the lens shows errors, because most of the time you're only testing in one wavelength. If the lens tests well in green though, that is strong indication that it was made correctly and everything else will fall in line. - Dave

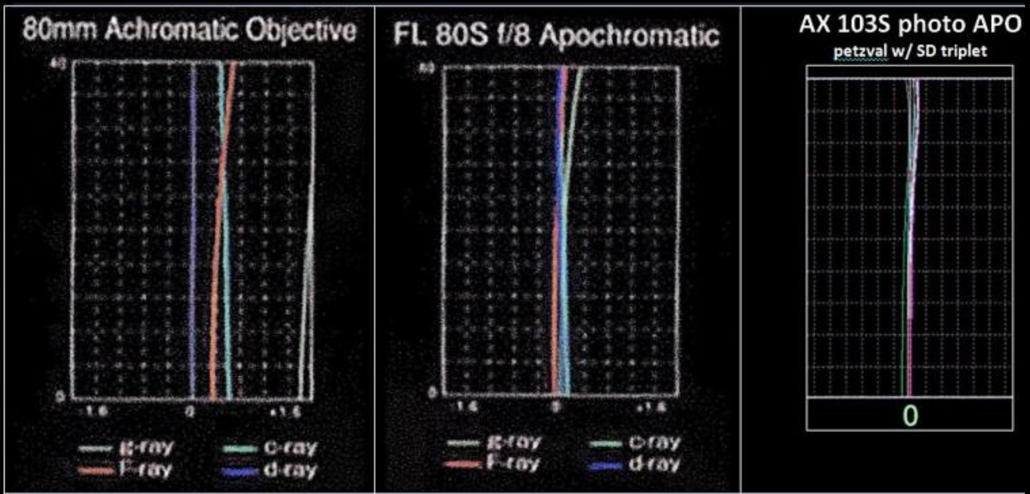
So, to sum up, a Ronchi-test in one color (usually green, for which wavelength the optics is typically optimized) can tell you if there are any gross errors such as a flipped lens assembly or elements, incorrect rotation or spacing of elements, incorrect collimation, tilt or figuring (TDE, coma, astig.).

It can also give you a rough estimate of the wave front error for the test color (again assuming green, which is supposedly the primary figuring and configuration target of the optical design), and a low wave front error in green is one major requirement for an excellent lens.

BUT the error for green cannot in itself be used as an overall quantifier for how excellent the lens is (I never said that, btw ;-), because every lens design shows both longitudinal and spherical chromatism, and these have to be estimated to get an overall figure of how the total wave front is corrected as a function of focal length. The problem here is, that it's hard to measure and quantify the combined effects of longitudinal and spherical chromatism in a Ronchi test.

We do know, however, that longitudinal chromatic aberration (the change in focal length with wavelength) is typically reduced in a doublet to a fraction of the FL as follows: BK7|F4 achromat 0.05%, ED APO 0.012%, Fluorite APO 0.006%. Sphero-chromatism (change in spherical aberration with wavelength) is typically minimized in green and the figure corrected in blue and red to counteract the residual longitudinal chromatism. We then end up with the chromatic error plots, which most of the high-end suppliers provide for their telescope optics.

Example from Vixen (20 micron / division):



My correction to the above (left) is that a Ronchi test used with double pass can shows very small errors, on the order of 1/20 wave or less. If you're testing a totally reflective system which is perfectly achromat, then you're seeing the total error in the system. With any system that has refractive elements you have to understand the total design and understand what the test is telling you, since you're most likely testing at only one wavelength. As I said before, if your lens tests well in green then the odds are very good that everything else is fine with it since all these corrections interact with each other.

Even when one does interferometry to determine the wave front error, it is done in only one wavelength at a time. So, it needs to be done in multiple wavelengths for a system that has chromatic aberration and all those wavefronts need to be analyzed to determine the true polychromatic wavefront of the system. Most of the time a report from interferometry for a commercial lens will show an excellent low wavefront error, but again it is done in only one wavefront so it can be misleading to the real quality of the lens. Another issue can be that most interferometry is done using a HeNe laser at 632nm while most lenses are designed to be best corrected at around 550nm in the green. Like I said before, I can test a singlet at one wavelength and get an excellent wave front error as well, but we all know that it would have a ton of chromatic aberration.

Like I have said many times, test your optics so you know what you have. If you know the quality of your optics and you're happy with the image, that is great! There have been many examples presented here that errors have been found like a flipped element that have gone uncorrected for years and the result has been taking a poor performing scope and turning it into a real winner.

One other thing I'll add is: be sure that you let your optics become temperature stabilized when you test them. Optical glass has a much higher Coeff. of thermal expansion than Pyrex or other materials used to make mirrors. So, they change shape much more as they are becoming stable.

Allan's lens a has CaF2 rear element which is temperature sensitive and one of the reasons why it is placed as the rear element. So, it is possible that the over correction he saw was from the lens not being stabilized.

Vixen FL-55S/440mm Refractor

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Collimation of focuser and lens cell

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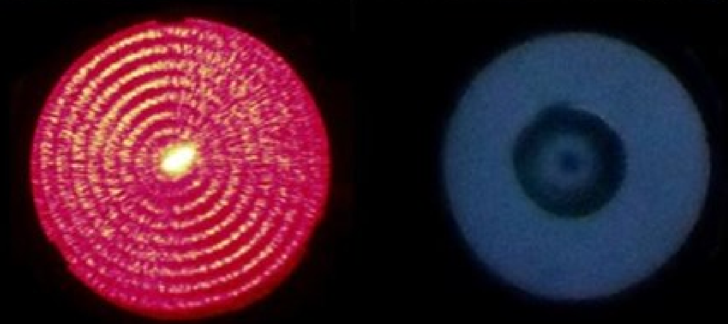
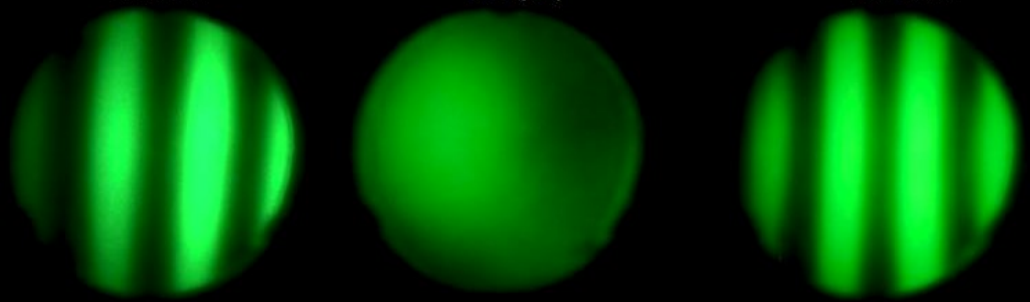


Flat: <10λ Van Keuron mirror

Inside focus | **Focus (Null)** | **Outside focus**



Ronchi screen: 136 LPI ~5.235 LPmm
LED: 3mm green diffused
Flat: <10λ Van Keuren aluminized mirror

Slightly overcorrected sphere, matched by an induced error of 0.06λ P-V equivalent to 1/16λ.

As DPAC doubles the error, the true wave front error should then be half, i.e. 0.03λ P-V or **1/32λ**

Vixen FL-55S/440 #2

Here's a test of my other FL55S (this one is normally mounted as a finder on my FL102S). The test result is close to that described above for the same type of scope. -- All pictures are of course straight from the camera (no processing).

Allan, -- I don't think your software is calculating the PV error in a wavefront that is produced by parallel light and an object at infinity but the PV error of the defocused image that is certain distance inside or outside of the focus for a mirror tested at the radius of curvature. Having used double pass for 35 years and compared its results to many other methods, the amount of bowing in your images looks to me to be closer to ¼ wave.

One example I show my students is 6" f/13 perfectly spherical mirror while being tested by double pass. One can just detect the bowing of the lines and its true wavefront error is about 1/15 of the wave. Your images easily show much more bowing than that, so I don't see how the error can be 1/32 of a wave.

I modeled a 55mm f/8 mirror with a conic of -0.6 which is what your images are showing, and that you are comparing the bowing of the bands too. OSLO shows that it has a PV wavefront of 1/7 wave. So, in double pass you would see 2x this amounts off errors and the lines would show a fair amount of bowing like I'm seeing in your images. Here is the screen shot of the data.

Double pass is also excellent at detecting astigmatism and I might be seeing it in these images. Place the grating inside of focus so there are three lines showing. Rotate the grating so the pattern is perfectly vertical. Now carefully move the grating to the outside of focus so again you have three lines showing. If the pattern rotates even by the smallest amount what your testing has some level astigmatism. – Dave

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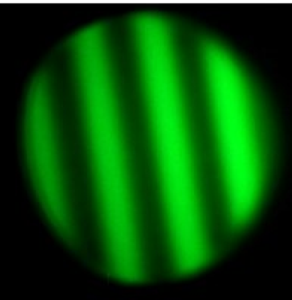
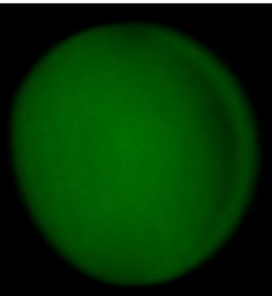
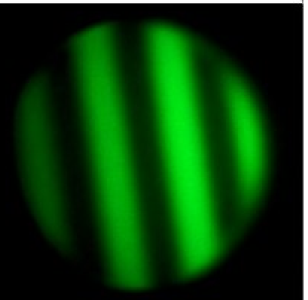
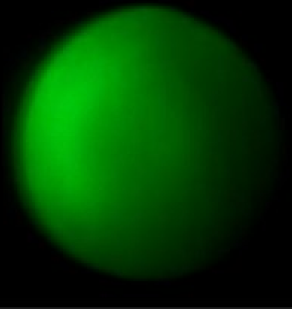
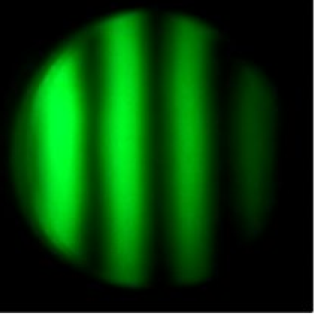
Dave, -- Thank you for the analysis of the Ronchi-grams, - this is the kind of feedback I had hoped to get! I'm still struggling with trying to model the result of my DPAC tests to get some quantitative approximation of the wavefront error for refractive systems.

You're quite right that the model I tried for the Vixen 55S is PV error for defocused images, and an error of 1/32 wave is clearly way off. It would be very helpful with a set of inside/focus/outside Ronchi-grams illustrating at least approximately how 3 lines defocus translates to typical wavefront errors of say; 1/2, 1/4, 1/8, 1/16 lambda. Your OSLO model of the 55S is no doubt reliable with respect to basic optic figure (we've discussed the inadequacy of single-color test to quantify chromatic error, scatter and other defects), but OSLO is quite an expensive piece of software as I understand it.

Here's the test I made today of a Zeiss Teleminor and a Telementor refractor;
It would be interesting to compare these with tests of say comparable Tak, AP and Nihon Seiko refractors. Anyone?

Ronchi screen: 136 LPI ~5.235 LPmm LED: 3mm green diffused Flat: <10λ Van Keuren aluminized mirror	Inside Focus	Focus (Null)	Outside Focus
Carl Zeiss Jena C50/540mm cemented achromat (camera a little off axis)			
Carl Zeiss Jena C63/840mm cemented achromat BK7|SF2 S2N=2.4			

Allan, -- Both Zeiss lenses are very good. The 63mm has slight aspheric correction vs a perfect spherical correction, but it is slight and only 1/2 has bad as shown since this a double pass test. I can see a slight outward bow of the lines one the inside of focus and inward bow on the outside of focus image which indicates a slight amount of the over correction.

It is difficult to use a double pass to qualify an exact wavefront.

- *A 1/4 wave or worse easily shows with the bowing of the lines. You can't miss it.*
  At the null positive the zones are very easy to see.
- *When you get to around 1/8 wave, there is a slight bowing but you still can see it without too much trouble.*
  At the null you can see the zones.
- *At a true 1/10 wave you have to start to look for the bowing and usually have to the rock the grating for one side to the other to see the lines slightly bowing, in and out. At the null the position you can detect any faint zones.*
- *At 1/15 wave or better you're fighting to see any departure from dead straight and*
  at the null position it looks like a uniform null. You have to fight to detect any zones.

I have been using double pass for many years, and I figure my optics until the Ronchi bands are dead straight and I can't detect any zones at the null position. What the exact wavefront is I don't know but they show a perfect star test. Double pass is why I have 10 optical awards at Stellafane *and is independent judge that the test works extremely well yet is easy to do. That is why I have been using DPAC for years in the classes I help teach.*

If you want to put an exact number on the wave front then you need to measure it with a well calibrated interferometer. What double pass gives you, is "poor", "good" and "great" range.

OSLO.EDU which is the educational version is free and as you said very powerful. It limits one to 11 surfaces but for 90% of the telescope design out there, that is more than enough. Some of the more exotic functions are turned off put for 90% of telescope designs one would want to check, you don't need them. I have been using it for years to design and analysis designs. Here is a link to the OSLO7.edu version https://www.lambdare...m/support/5900/

———————

When it comes to double pass, it comes down to understanding how a telescope works. It takes parallel light and brings it to focus. Stars and other astronomical bodies are so far away that the angle of the light coming from them is parallel. So, you want somehow to make parallel light in the shop. Understanding that if you place a light source at the focus of a telescope so it works backward, the light coming out of it is parallel. So now you have a source of parallel light.

To test a telescope, you need another telescope that is producing the parallel light that is as large or larger to fully illuminate the optics you're testing. So, in the case of the Clarks and the fact that they are making really big lenses, they would need another lens of that size or larger. Also, because big lenses have long focal lengths, you would need a long room to set them up back-to-back. So, it wouldn't take much thought to say " let's use a mirror instead ! That is a great idea ! " Now you only need 1/2 the space, you only need to figure the one surface to be flat instead of 4 surfaces in an additional lens and the flat mirror doesn't need to be super flat just optically smooth. Also, the errors in the flat don't directly add to the errors in the lens you're testing while the error in an additional lens does.

———————

Dave, -- Thank you very much for your rules of thumb for a qualitative assessment of optical quality, based on green color 3-bar Ronchi-grams! I'll go with that for now (while I have a closer look at the OSLO EDU tool).

CZJ C63/840mm Refractor "Telementor"

Vintage : ca. 1990
D=63mm,FL=840mm ,F/13.3
Cemented Doublet

Collimation of lens cell

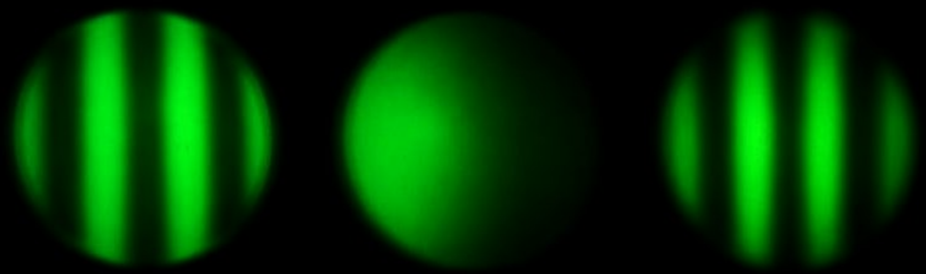
635nm laser collimator
(Howie Glatter Holographic)

Collimation of focuser

Chesire collimator
(Tectron Telescopes)

Flat: <10λ Van Keuren mirror

Inside focus | Focus (Null) | Outside focus



(185)

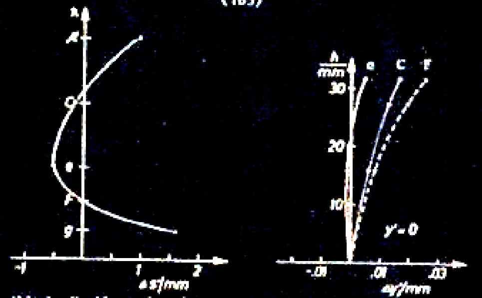


Abb.1 Farbkorrekturkurve; Schnittweitenänderung Δs' auf der opt.Achse (y'=0)

Abb.2 Zerstreuungskreisradius Δy' auf opt.Achse; optimal fokussiert für (e).

des Objektivs zu 0,05mm. Die sphärische Abweichung für (e), (C), (F) ist also ebenfalls sehr klein.

1.2.3. Zerstreuungsfiguren außerhalb der opt. Achse

Wieder ist die Auffangebene die beste Einstellebene für die Wellenlänge (e). Für das Kleinbildformat 24x36 mm erhalten wir Bildhöhen, also Abstände von der opt. Achse, von maximal y'=12mm und y'=18mm. Für diese geben die Abb.3 die Abweichung Δy' in mm in Abhängigkeit von der Einfallshöhe h in mm für (e), (C), (F) im sogenannten "Meridianschnitt" wieder. Dieser liegt in jener Ebene, die durch die Bildhöhenstrecke y' und die Objektivmitte aufgespannt wird. In ihm liegt das Bild neben der opt.Achse, weshalb die Einfallshöhen von h=-32mm bis h=+32mm, also von einem Ende des ebenfalls im Meridionalschnitt liegenden Objektivdurchmessers erstreckt werden müssen. Die Symmetrie der sich ergebenden Kurven zeigt, daß das System komafrei ist.
Wird die Ebene des Meridianschnitts um 90° um die opt. Achse gedreht, entsteht die Ebene des sogenannten "Sagittalschnitts". In ihr ergeben sich Abweichungen Δx'

(186)

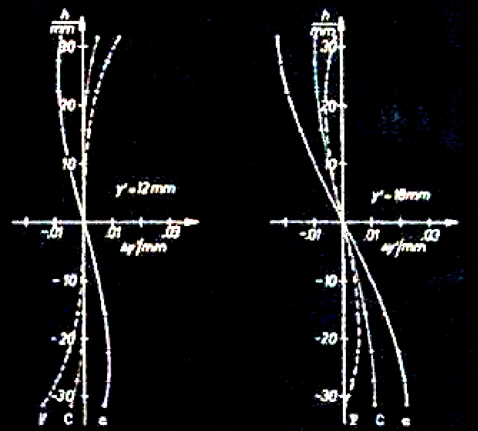


Abb.3 Abweichungen Δy' neben der opt.Achse, Meridianschnitt, für y'=12 u. 18mm, optimal fokussiert für (e).

und von dem Bild der Bildhöhe y' bleibt nur der Punkt auf der optischen Achse; infolgedessen besteht mit Bezug auf diese Symmetrie. Es genügt daher, wie in Abb. 2 die Einfallshöhen h von der Objektivmitte bis zum Rand, also von 0mm bis 32mm, wachsen zu lassen. Analog zum Meridianschnitt gelten die Abb.4 für den Sagittalschnitt.
Betrachten wir Δx' und Δy' für gleiche Einfallshöhen h, so stellen wir Unterschiede fest – es besteht ein kleiner Astigmatismus Δx'-Δy'. Es ergeben sich für den Objektivrand und y'=18mm elliptische Bilder von Außer-

Here's my test result for another Carl Zeiss Jena C63/840mm "Telementor" refractor, along with the Zeiss spec for the color correction of the lens. I can see a slight inward bowing for the inside focus, and straight lines for the outside focus (or at least I'm struggling to see any deformation here). The null looks clean as can be. Now that should place it between 1/8 and 1/10 wave overcorrection, right?

PS: Here's a link to Ronchi tests of some high-end refractors: http:/www.rohr.aiax.de/refractors.pdf Unfortunately, they use 5 bars (instead of 3) and they are seemingly in white light to estimate chromatic aberration (?), but I assume they are double pass, so they are still interesting for comparison.

Allan, -- This second Telementor looks to me to be at least a true 1/10 wave in green. If you're seeing straight lines on one side and slight bowing on the other, that might be a slight misalignment to the flat./objective. The null looks very good without any evidence of zones. So, a really excellent lens. My own Telementor tests this way.

Are you sure that the data is for lens design used in the Telementor ? The reason is that the plot for focused image show that the e line is not straight. This would mean that one would see spherical aberration when testing in green

I have seen the Japanese site before. Testing with 5 lines showing reduces the sensitivity so I always recommend to go down to three and also look at the null position as well. Testing in white light gives ones a feel for how well the lens is color corrected. The better the color correction the less color fringing you''ll see on the edge of the Ronchi bands. Since the chromatic aberration is doubled in double pass autocollimation the color correction or lack of it stands out. Testing in white light softens the contrast of the edge of the bands so it becomes harder to determine how straight the bands are and also soften the zones at the null position because ones have all the different over lapping images from the different colors coming to focus at slightly different positions. By the way, don't use a white LED but an incandescent bulb so you have a continuous spectrum. - Dave

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Dave, -- Yes, I think you're probably right that there's a slight misalignment to the flat. The flat I used was a small 3" mirror, and the alignment was just a fast "eyeballing".

I got this Telementor OTA with another buy and planned to sell it, -- but the star test and visual performance were so good, that I've had a hard time letting it go... Now I understand why ...

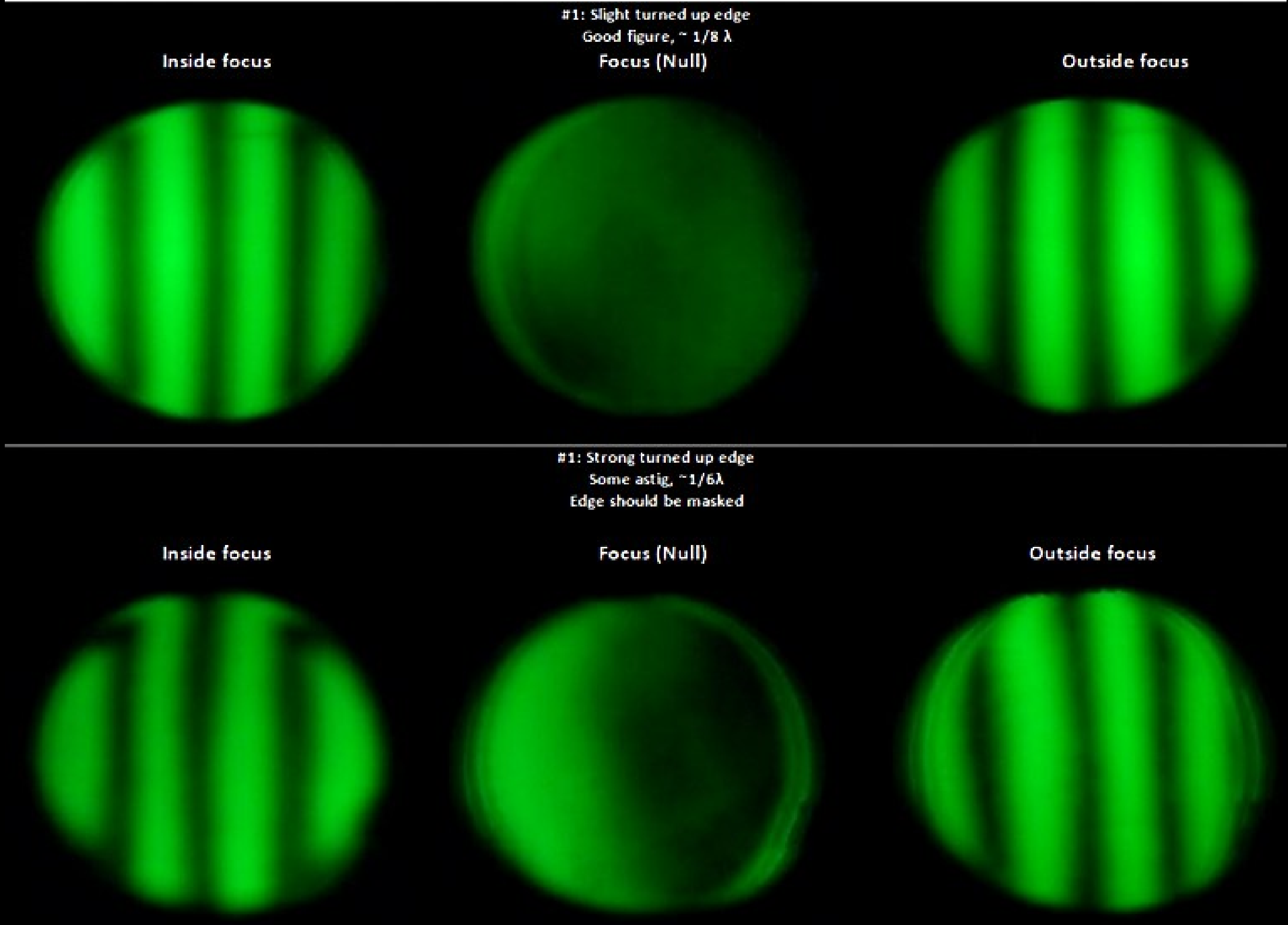
The figures showing the color correction for the Telementor objective are from: *Österreichische Astronomische Monatsschrift, Der Sternbote, "Ein empfehlenswertes Fernrohr für Amateure: Telementor/Telemator", ISSN 0039-1271 / 26. Jahrgang, 326 / 1983-10.*

Fig.1 shows the color correction of the Telementor Fraunhofer C63/840 lens on the optical axis, i.e. where the colors come to focus: the secondary spectrum from C-F is ~0.55mm;

Fig 2 shows the spherical aberration from the center optical axis to the rim of the objective: it is optimized for the e line (which is not quite straight, but close), and the max aberration is 0.05mm for F. I haven't checked these data with other sources.

Here's my latest test of two Nihon Seiko 60mm/900mm (F/15) Fraunhofer air spaced doublet refractors. The first is mine, the second that of a friend). Mine is good (~1/8 λ?) with a slight turned up edge, my friend's shows a more pronounced TUE and I think some astigmatism, but could be ~1/6 λ ? with a proper aperture diaphragm.(And btw, my lens is an earlier version than that of my friend.)

Nihon Seiko 60/900mm Refractor; D=60mm,FL=900mm ,F/15 Fraunhofer air spaced doublet
Ronchi screen: 136 LPI ~5.235 LPmm; LED: 3mm green diffused; Flat: 3" <10λ Van Keuren aluminized mirror



Hi Allan, -- You might try using a real knife edge to view and image the null position. It will give you a cleaner image. You're getting a shadow at both the left and right side, that might be a real zone or more likely it is part of one Ronchi band and part of another.

Your friend's lens has some real problems. A turned edge really hurts the wavefront and with the astigmatism your most likely worse than 1/4 in green and that would make the polychromatic wave front even worse. Before you call that lens bad though, I would try loosening the retainer ring to be sure it is not being stressed in its cell. Also be sure that the spacers are at 120° centers. - Dave

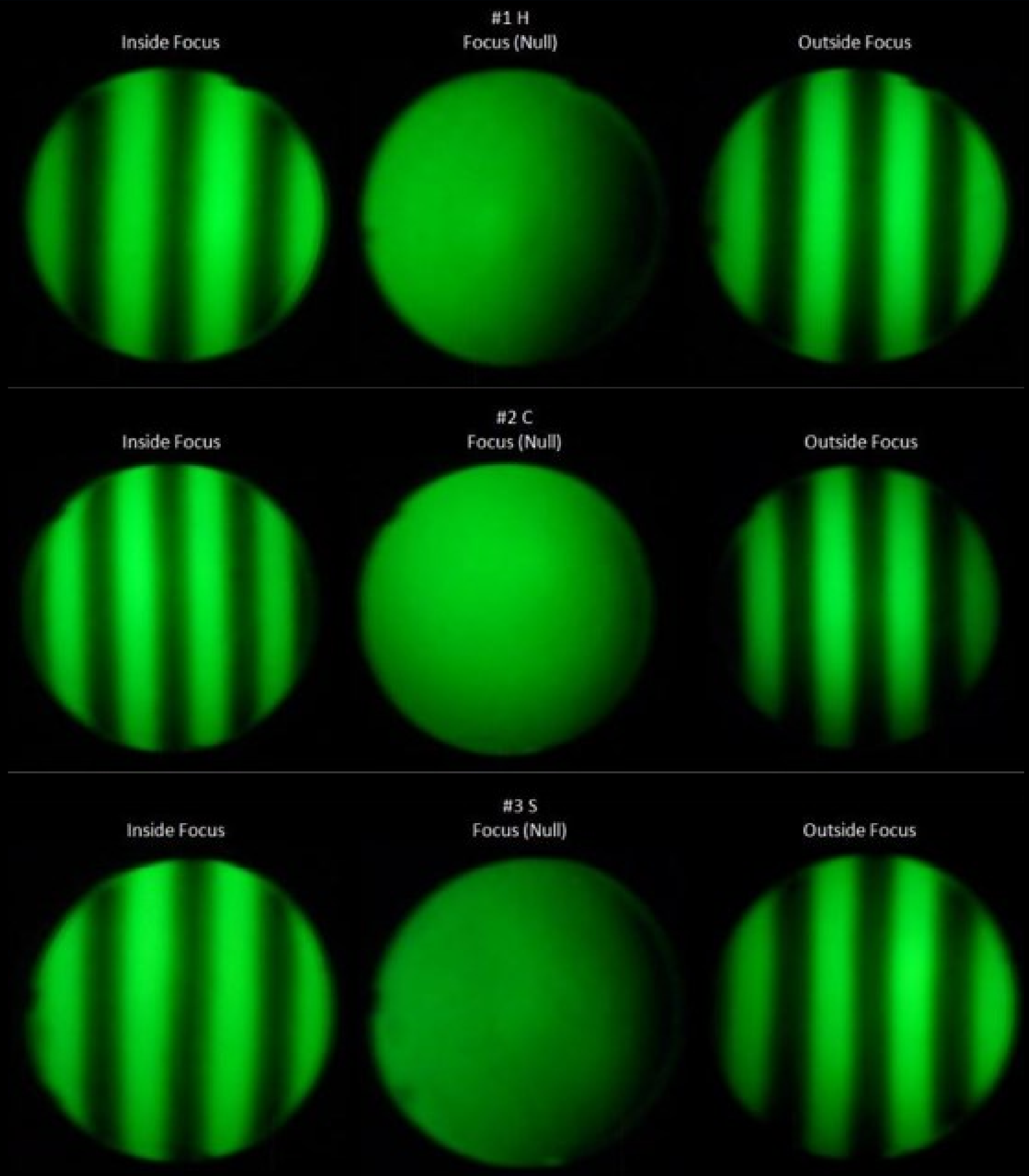
The shape of the Ronchi lines is analogous to contour lines on an elevation map. Instead of showing changes in elevation the Ronchi bands are showing where the light is coming to focus. If the lines are dead straight it means that light from every part of the optical system is coming to focus at the same position.

What is also critical is where the light source is located. A telescope is designed to take parallel light and bring it to perfect focus. So, to have it show straight Ronchi bands with perfect optics, the light source needs to produce a wavefront that is the same as one that object at infinity would produce. If not, you will see spherical aberration and to determine if your optics have errors you need to calculate the amount of spherical aberration and then measure it to see how they compare.

In the classic Foucault test the light source is not at infinity but placed at the radius of curvature of the mirror i.e., 2x the focal length. A spherical mirror with an object at this distance will perfectly focus light and show straight Ronchi line and a clean null i.e., grey all over with a knife edge test. The problem is that a spherical mirror when used with an object at infinity will not bring all the light to a common focus, -- we need a parabola or an additional optical surface. If we test a parabolic mirror with the light source at the radius of curvature it will not focus all the light to perfect focus, but it will show some level of over corrected spherical aberration. We calculate that amount and then measure it to see how it compares to what theory shows it should be. We continue figuring until in theory they match. The problem with any test method that requires that you make measurements is that there are errors associated with those measurements, so you need to know what those errors are; If not what you believe you have and what you really have may be very different.

A better test is a null test which requires no measurement. You can just look and see if there is problem i.e., if the Ronchi bands aren't straight. To have a null test requires a wavefront that has the characteristics of an object that is located at infinity. In Double Pass autocollimation we use the telescope to do that, first working backwards to make that wavefront since in theory a perfect set of optics will produce a perfectly parallel light just like an object at infinity. If the optics aren't perfect the wavefront coming from the telescope will have errors. The angle of the light won't be perfectly parallel. Now this light is reflected off an optical flat mirror and back into the telescope, where the optics again add errors to the light, hence double the errors. So now we a have simple to setup test, that requires no measurements and twice the sensitivity of most other optical test. The result is that one can easily test their optics and quickly determine if they have problems with making any measurements.

The bottom line is that double pass autocollimation is a very sensitive test with very few sources of error. In combination with Ronchi screen it is easy for beginner to understand what is going on. DPAC is the real "magic" in why Clark lens where better than the rest; They had a much better test method which allowed them to better figure their optics. -- Dave



Here are 3 lenses I'd like your comments on -- they all seem pretty good to me, maybe with some very minor issues. I find it difficult to rate these 3 lenses.

Allan, -- All three are good lenses.

- *Number 2 is the best a with clean null,*
- *#1 is second with tiny hill in the middle and*
- *#3 has a bit more roughness at the null.*

I would say #2 is true 1/10 wave in green maybe better. The other two are at least 1/8 wave in green and maybe better. As I have said before, you have to analysis the total polychromatic wave front to get the true quality of the lens. You can have a f/4 achromat made from BK7 and F2 that tests perfect in green yet the total polychromatic wavefront will be much worse then 1/2 wave because of the residue chromatic aberration that is just inherent in the design. Typical binoculars have a large amount of chromatic aberration from the lenses being in the F/3 to F/4 range but they use fixed low magnification in the 6x to 20x range so the chromatic aberration is not objectionable.

As for your friend's lens that tested with problems, respacing it won't fix those problems only a pitch lap and polishing will. - Dave

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Thank you again, Dave! -- your evaluation is in perfect alignment with my own assessment here! Judging the lens quality from Ronchi-grams is a learning curve, but the more tests I make and the more feedback you offer, the more I feel confident in my own assessments.

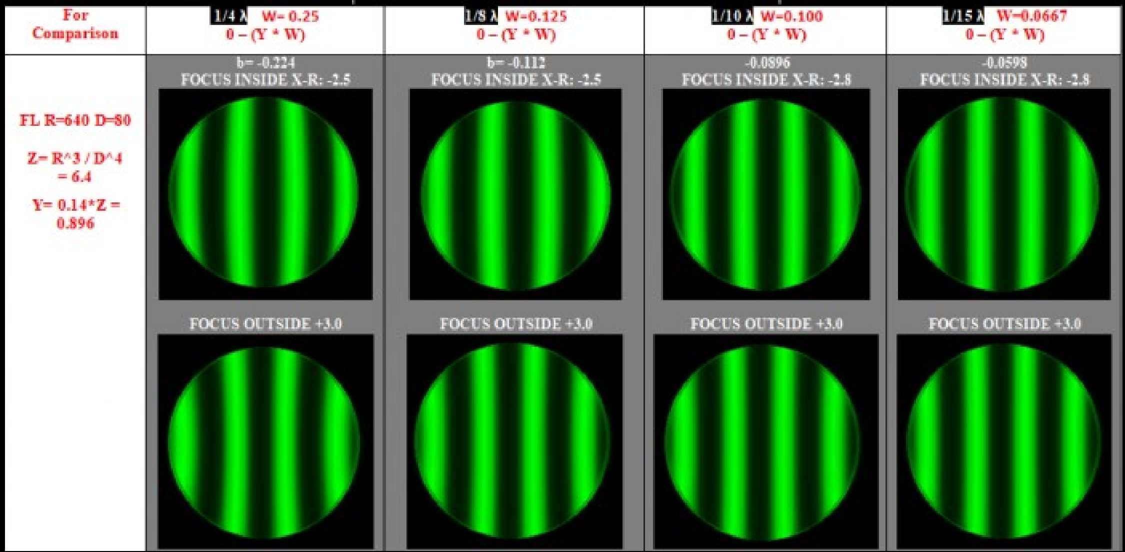
Like you I find #3 to be lagging a tiny bit behind; #1 and #2 were more difficult for me to rank, but I can follow your description, and I do agree with your evaluation.

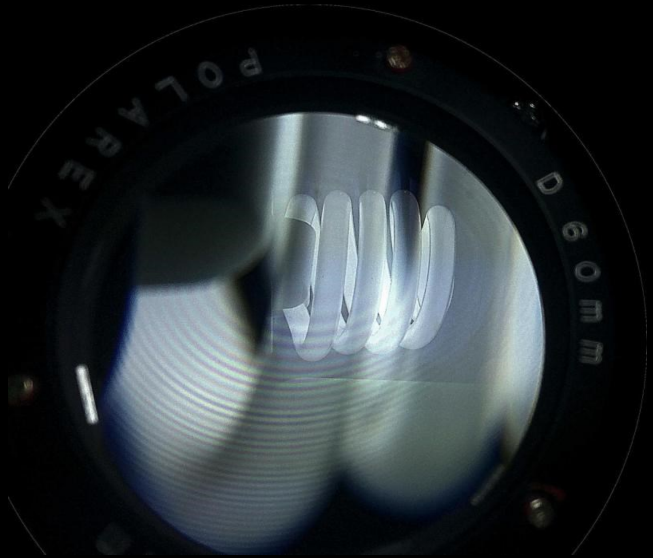
PS: The objectives here are apochromatic with excellent color correction, so I'm not too concerned about the polychromatic wave front. – Allan

A never-ending row of overcast days up here in Scandinavia, so today I decided to do a fast Ronchi test of my most used Vixen FL-80S/640mm refractor, and compare the result with a wave optics diffraction simulation program in order to get a rough quantification of the quality of the objective.

I already know (from comprehensive observations) that this doublet APO is an excellent performer, but just how well would the DPAC images stack up against those generated from optics theory for different levels of wave-front errors ("deformation coefficient", aka Schwarzschild constant)?

Here's the result; You can judge for yourself:





I did a quick DPAC of the NS 60mm lens after the spacing adjustment, -- and it still looks good;
Below snaps are with handheld camera, so not as pretty or aligned (tilt) as they could have been, but...

Air spaced doublet interference test.

I tried the spacing test of air-spaced doublets as described by DAVIDG recently in a thread nearby you; As Dave advised, I used a simple standard 23W twist CFL bulb, and it worked fine.

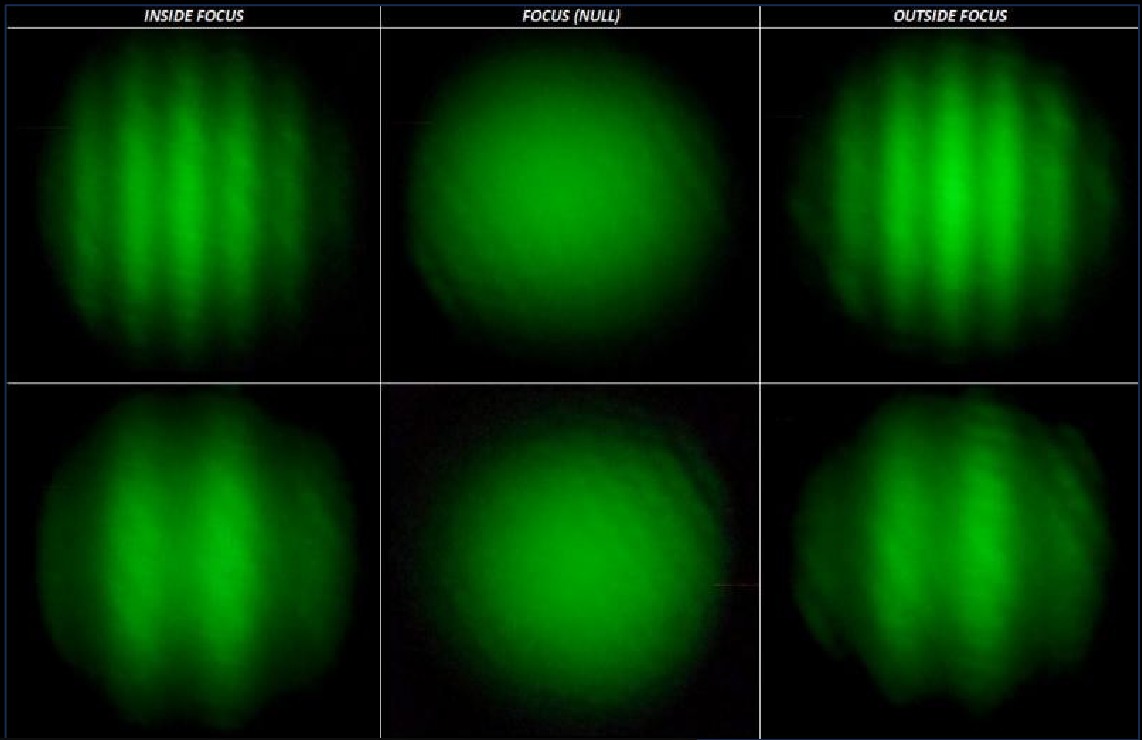
I tested the spacing on my 60mm NS Polarex air-spaced doublet, and yes, the interference pattern was quite a bit de-centered. In the end it took only small (sub-mm) twists of the three screws to center the rings, and then I had to fix one of the screws with *Loctite* to keep it in place. (I'm thinking NS may have fixed the screws from the factory for exactly this reason).

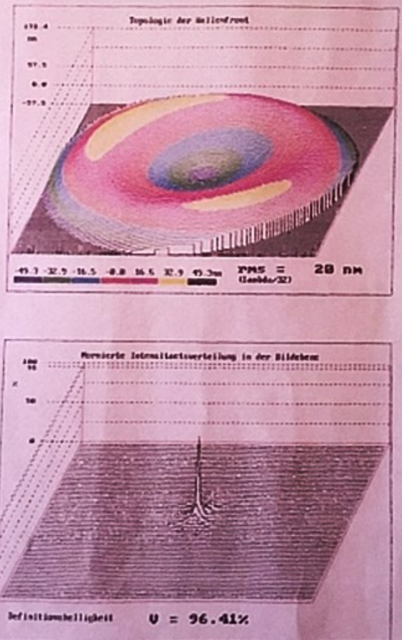
Here's a snap of the lens adjustment showing the interference rings nearing the centering point (not so easy to photograph, but you get the idea...).

What happens when the air gap isn't uniform is you get lateral color. Star and planets turn into short rainbows when it is really bad. Depending on how bad it is, at low to middle power you won't see it, but even a small amount shows up at high power and smears out planetary detail and you might think it is seeing. So, by simply adjusting the air gap so it is uniform you'll get a sharper planetary image.

As I keep trying to show it isn't difficult to test optics and it doesn't take expensive equipment. You are using one of Nature's very best rulers, which is light ! As I have said before, people in this forum spend many hours of painstaking mechanical and cosmetic restoration but very little on what actually makes a telescope work, which are the optics. -- Dave

Test of a 100mm APO triplet objective -- close to perfection.



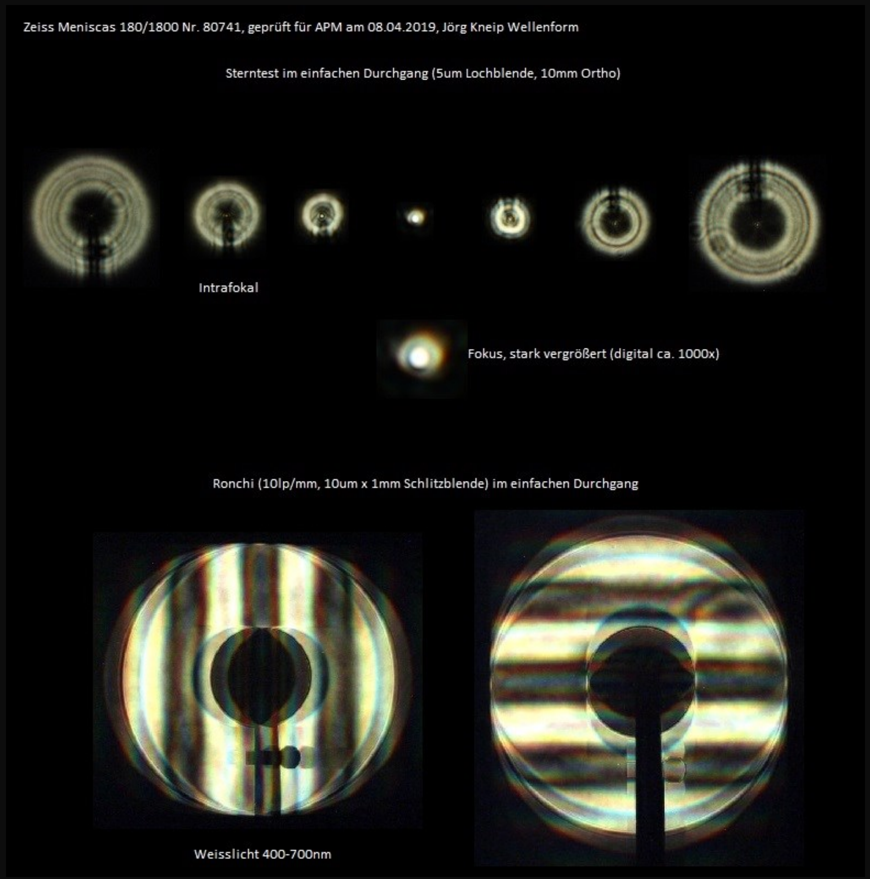


Wellenfront
Fläche konstanter Phase in einem Wellenfeld
Die Wellenfront steht senkrecht zu den Strahlen. Aus der Messung der Wellenfront, die ein optisches System durchlaufen hat, können die Abbildungseigenschaften errechnet werden.

Wellenfrontanalyse
Auswertung der gemessenen Wellenfront
Sie liefert Lichtwegdifferenzen zwischen der realen Wellenfront, die ein optisches System überträgt, und der idealen Referenzwellenfront.

rms
root mean square
Mittlere quadratische Abweichung der Wellenfront von der Sollwellenfront.

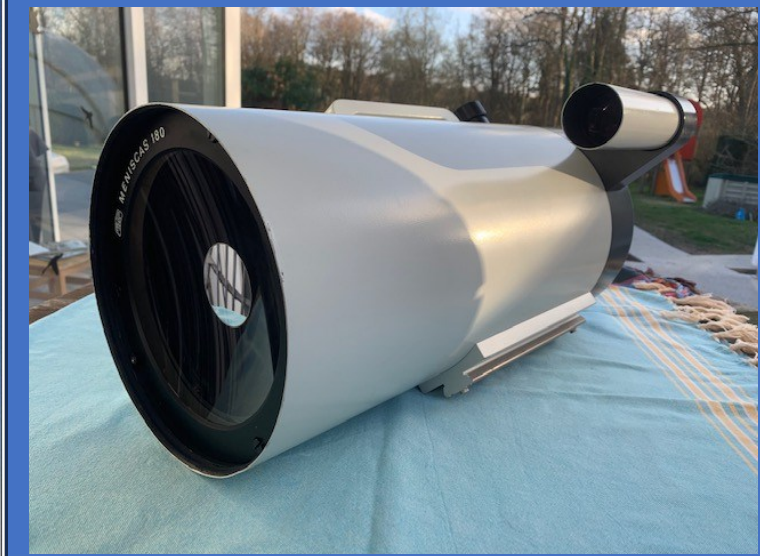
Definitionshelligkeit
Normierte Intensität im Bildpunkt
Die Definitionshelligkeit errechnet sich aus dem rms-Wert und erreicht bei einem idealen optischen System den Wert 100%.



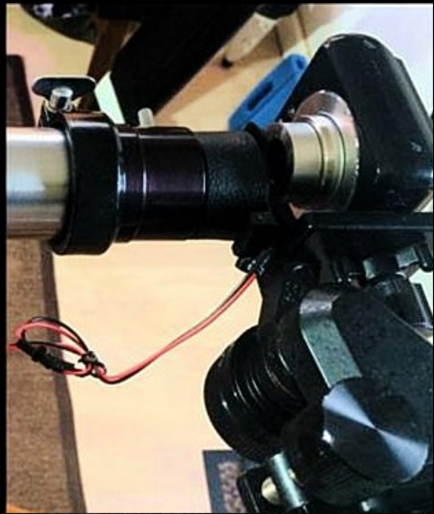
Because this is the best I had from many in a long time, I asked *Wellenform* to service it and make a report, see attached. As you see an excellent sample of Meniscas 180. This sample has for sure a Way better Strehl than 90%, as you see the Ronchi-test looks almost perfect. The Meniskas 180 is rated to be similar to a Zeiss APQ.

The Meniskas has 40 mm diffraction limited FOV, larger than any APQ. It has a very wide focus range, zero image shift and better color-correction than an f/10 APQ. A Mak like that shows details above 1 arcsec better than a 6" APO, but for details below 1 arc the 6" Apo will show more; Also, the Mak is less affected by the atmospheric dispersion than a APO. The Meniskas is a mechanical masterpiece of engineering. Once you have one in your hand you understand the hype of the Mak 180.

Viele grüsse, best regards, Markus Ludes / APM Telescopes, Service & Logistik Center
Quierschieder Weg 38, 66280 Sulzbach, GERMANY







Here's my DPAC test setup

Flat on a table stand on the left;
Battery box with On / Off & Dimmer center;
Ronchi eyepiece and camera on the right




Close-up of battery box & Ronchi Eyepiece
The lid with the LED can be flipped up and the Ronchi screen changed to another LPI.
Also ,the top of the EP can be changed to a lid with another color LED.
The barrel of the EP is an old 1.25" plastic film canister.