Cleaning Fraunhofer aplanats

by Carlos Nogueira *click to email author*

At the very outset, I would like to set expectations about the subject. Anyone who reads this doc must be aware that:

1) Although I'm a somewhat experienced amateur astronomer, I'm not an optician, so this paper isn't a textbook excerpt.

2) The procedure presented in this document is the one I use when cleaning my scope's objective (an AR5 with the "old" non-collimatable cell). It's a procedure that can be easly generalized for any similar achromat (any Fraunhofer doublet mounted in a non-collimatable cell) in the market (many of the cheap achromats fall in this category).

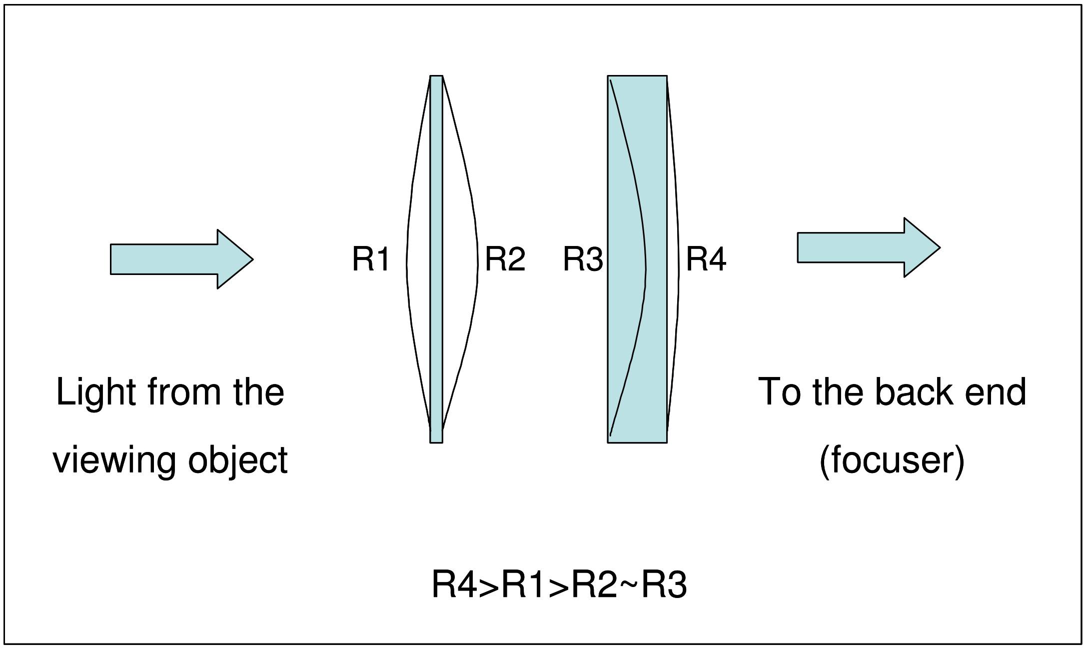
3) The procedure is simple and demystifies much of the issues that keep many amateurs frightened and at bay whenever they need to disassemble achromat objectives. Nevertheless, the reader must keep it in perspective, since such simplification is possible only because we are talking about a mass produced classical Fraunhofer doublet. When cleaning more sophisticated achromats or EDs, the assembling/disassembling procedures will require far more attention and care to precise alignment between the lens elements than I depict here. What about cleaning APO triplets (many of them oil-spaced) or Petzval quadruplets? Well, it's time to get really frightened, so just send them to the manufacturer or to an experienced and well equipped optician.

4) By the way, I have no interest in any of the companies which brands eventually show up in the pictures, or are mentioned in the text.

I) Introduction:

Before starting the procedures, let's discuss some concepts involving the objective design. As I mentioned above, the AR5's lens is a classical Fraunhofer doublet. It means that the front lens element (the farthest from the focuser), also called "Crown" element (because it's made of crown glass substrate), is a biconvex lens, having its external surface (the one that points to the viewing object) less curved than its internal side (the one that faces the second, internal lens element). When I say less curved I mean a longer curvature radius. Therefore, if we call R1 the radius of the external surface and R2 the radius of the internal surface, we have R1>R2. The difference is big enough to be easily identified by simply looking at the edge of the lens element. It helps a lot when disassembling and assembling the objective, since you can relax during cleaning, and just check out the correct position before reassembling, so you will be sure that you didn't flip the element when reassembling.

The second or back element (the closest to the focuser) is a concave lens, which is clearly thicker than the front biconvex element. It's also called "Flint" element (also because of the glass substrate). The front and the back lens elements are kept apart by 3 small spacers (typically 2mmx3mm aluminum foil rectangles 120 degrees apart from each other). That's why the Fraunhofer is called an "air spaced doublet design" (there are others). The front surface of this negative lens (the one that has the 3 spacers attached to it and faces the front Crown element) has a curvature equal (or nearly equal) to the corresponding side of the front element. Therefore, if we call its curvature radius R3, we have R3~R2. The back side of this element is slightly convex (looks almost flat), having the longest curvature ratio of all surfaces. If we call it R4, we have R4>R1. The following diagram (displaying the Crown element at left of the Flint one) summarizes the relative positions and curvatures of all surfaces involved (curvatures are somewhat exaggerated).



The scheme above is all that you must keep in mind when reassembling the lens in the AR5's cell in order to avoid any element misplacing or flipping.

II) Removing the lens cell from the scope's tube:

After removing the dew shield, you will see 3 Philips screws that hold the cell on the tube. Mark one of them as shown on the picture below.

This is an important step because it will allow you reassembling the cell back on the tube without rotating it, assuring that you'll preserve the collimation set by the manufacturer.

Now you can relax about collimation, and then remove the screws and carefully slip the cell out of the tube.

III) Disassembling the lens cell and removing the doublet:

After laying down the cell on a table, upon its back end, unscrew the lens retention ring, handling it with only one hand, as shown below. The ring is made of plastic (as the whole cell body), so if you try to use both hands or grab the whole ring's perimeter with one hand as if you were unscrewing a lid, you will probably induce some elliptical deformation, making the unscrewing procedure stiffer and harder to carry on.

Once you've removed the retention ring, it's time to take the lenses out of the cell. My preferred household tool to ease this task is a common paper towel roll, placed on the table in an upright position. All you have to do is to slip (gently, please) down the cell along the roll, so the lens doublet will be left sitting atop the roll. Here in Brazil paper towel rolls have a core tube made of soft cardboard, which is completely harmless to the lens. If it's not the case of paper towel rolls in your local market (some have stiff cardboard or even plastic tube cores), please make sure to cover it with a cotton pad in order to avoid scratching the lens. Anyway, two stacked toilet paper rolls can also do the job.

Ok, now it’s time to put some marks on the edges of the lens elements, as shown below.

These marks can help you in three ways. First, and most important, it will allow you to control how tight you will be screwing the retention ring when reassembling the lens cell. Second, it serves as an additional remind on which side of the front element faces the concave back lens, so in the future you won’t need to recall the diagram shown at the beginning of this document. Third, and least important, it will allow pundits to reassembling the lenses while assuring minimum rotation of the front lens element relatively to the back one. I personally don’t care at all about this relative rotation, for reasons I will present in the conclusion section of this document.

IV) Cleaning time:

Take the elements, once at a time and put it over a clean soft cloth. Use a blower brush to remove all dust specks from both sides. Pay special attention when cleaning the concave side of the back element, for it has the small spacers attached to it. Avoid touch or blow the spacers. If one of then get blown off, please return it to its proper place (it usually lefts its position “ghost-marked” on the lens surface).

If you need to remove fingerprints, just drop a tiny amount of lens cleaner fluid on the spot and wipe (gently) it out using soft cloth (microfiber is great). Be sure to blow out dust specks before applying the tissue on the lens surface. This way you will avoid scratching the coatings. If you apply lens cleaner to the inner (most curved) surface of the front element or to the concave surface of the back lens (the surfaces that face each other), please allow at least 5 minutes before reassembling in order to assure that it will dry out.

V) Reassembling the lens cell:

Time has come to pack everything back. Take the empty cell out of the paper towel and clean it, specially the lens bed ring, by using the blower brush. Slip the cell back down the roll. Place the lenses on top of the roll using the marks and/or the diagram to remember their correct relative positions (Crown element atop the Flint one, with its more curved side pointing down, while the Flint element goes with its concave side pointing up to the Crown lens). Rotate the front lens element (after lifting it a bit) so the mark you made on its edge lags about 35mm (1.4 inch) behind (counterclockwise) its corresponding mark on the second element. Slip the cell up along the roll until the lenses get into it and settle down on its bed rim (be careful to avoid having a tip of paper towel bitten between the lens and the bed ring (it may cause severe misalignment). Be sure that the lenses are leveled and loose in the cell, and then screw the retention ring back carefully. When tightening, look at the marks trough the lens glass. When you start tightening, you'll see the mark on the front "Crown" element rotating clockwise, approaching its counterpart on the second "Flint" element. When they align to each other you must stop tightening, otherwise you may pinch the objective lenses.

VI) Putting the cell back on the tube:

Now that you have the cell reassembled, check the back side of the lens for dust specks (or paper fibers from the towel roll) that may have accumulated during the reassembling process. Remove whatever you find using the blower brush and then reattach the cell to the tube, by performing the inverse sequence presented in topic II above (pay attention to align the marks you made on the cell and the tube).

VII) Conclusion:

Ok. You are done and it was almost painless. The whole thing may have taken about 20 minutes of your time, not a big deal if you take into account that it's something you won't do again for a long time. But what about those frightening issues, such as after-cleaning collimation & centering and how to avoid the relative rotation of the crown-flint pair? OK. Let's call the exorcist.

VII.1) About the need of after-cleaning collimation/centering:

It's not an issue at all. Supposing that the objective was previously collimated, the procedures presented above - if carefully followed - will keep it this way.
There are only three ways to introduce misalignment during cleaning. The first is to disregard the markings on the tube and the cell, so you rotate the cell relatively to the tube when reattaching them. The second is to lose one or two of the aluminum foil spacers that go between the lenses. The third is to reassembling the lenses in the cell in a sloppy way, by not allowing them to settle down evenly and loosely upon their bed rim, or by leaving some huge dust speck or paper tip between the lens and the bed ring.

To get you relaxed even further about any misalignment, it's important to have in mind that classical achromatic doublets, mainly of the Fraunhofer type, are quite tolerant to misalignment (*). In fact, collimatable cells are an overkill, not to say an unnecessary annoyance, in Fraunhofer achromats.

On the centering issue: The AR5 lens cell has no significant gap between it and the lens edges. Anyway, the retention ring, when adequately tightened, will assure proper objective centering, thanks to its turned edge, where it touches the lens.

VII.1) About the internal relative rotation of the doublet (or "exorcising the wedge demon"):

Many amateurs agonize about this issue. They are afraid of rotating the crown element relatively to the flint one, because it could create a wedge in the doublet. It's really an issue that must be properly addressed when we are disassembling and reassembling manually figured high-end achromats or APOs. Such lenses sometimes have an edge thickness that varies a bit (less than 0,01mm) around their perimeter, the so called lens wedge (**). Therefore, when assembling the doublet, the optician carefully matches the thinnest side of the crown lens with the thickest part of the flint one, so minimizing wedge, which could impart color correction.

But now let's go back to our commercial AR5 scope. It's a mass produced model, so the lenses are almost surely polished by machines. The bad news are that machine polished lenses may show some surface roughness or even circular zones, something absent in high-end, manually produced units. On the other hand, a machine polished lens enjoys good circular symmetry, meaning that its features are very well reproduced if you turn it halfway around. Therefore, the risk of producing wedge by rotating the lenses (of a mass produced doublet) relatively to each other is pretty negligible. Moreover, even if the lenses have some variation in edge thickness, I really don't believe that they are carefully matched during assembling in the factory. It's a too time-consuming task to be performed in the assembly line of mass produced scopes.

In order to probe the arguments above, I run a test in my AR5, by rotating the crown lens full 180 degrees relatively to the flint element. I compared the images – before and after the procedure – of Jupiter, Saturn and bright Sirius. Bottom line: I couldn't detect any gain or loss in image quality. Subtle Jovian and Saturnian belts and zones were unchanged in sharpness and contrast. Color fringes around Sirius remained untouched. The bright star image showed no signs of any "lateral spectrum", the symptom of wedging, a kind of asymmetrical color fringe that rotates when you turn the OTA along the tube axis. Concluding, the wedge demon isn't an issue for AR5 owners.

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(*) Suiter – Star Testing Astronomical Telescopes – Section 6.5.2
(**) Suiter – Star Testing Astronomical Telescopes – Section 12.6.1