

## Problems with filters can have the strangest causes

If you switch from „simple“ astrophotography to more difficult fields of activity and start working with different filters, correctors and systems, you will soon have a whole bunch of new error sources. Some distortions will become visible only after inserting a filter into the light path – but this filter is not necessarily the source of this problem.

The general rule is: The more lenses there are in an optical system, the harder it gets to handle. Although modern multi-coatings and manufacturing techniques make complex optics with many lenses possible, there will always be some surprises when you combine different optical components. Often the problems have got an origin at an unexpected place, sometimes even outside of the telescope.

### Horizontal lines and stripes

Some customers told us about bright horizontal lines or stripes which were seen in some combinations with CCD-cameras (mostly with Atik). They did not exist on the dark frames with lens-cap on the telescope, so that a problem with the camera seemed unlikely.

Rotating the filter did not change the image much, the lines were perfectly aligned with the edges of the sensor. This way, the problem could be identified in the end: Some CCD-chips have a highly reflective edge – that is on the place where the wires are connected. In combination with the Atik-filter-wheel, the Backfocus was so that

there was a forward-backward-reflection, when a filter was used. The result: bright lines on the sensor.

So, the filter made the reflections inside of the camera visible, but it did not cause them – an optical system is not designed to suppress scattered light from the camera.

After the cause was found, the solution was easy: The filter was mounted with an additional 5mm spacer ring, so that the maxima of the reflection were suppressed, and the system worked as intended.



*This image shows a horizontal line in the upper part – which was caused by the edge of the camera chip.*

## Halos around bright stars

Around bright stars there can be halos, especially if you use fast optics and interference filters. To find the cause of the halo, you should check several things and see if they cause the problem:

- Do you use a flattener or coma corrector – and is the halo still visible if you remove it?
- Can you turn the filter (with its cell or inside of it), so that the (more reflective) front side no longer faces the light source, but the sensor? Try this especially with unmounted filters. This way you can find out if there is back-scattering inside of the telescope. Optical elements which are close to each other may have a negative influence onto each other; an increased distance can improve the results notably.

Very large, overlapping halos are hints for reflections on remote surfaces, while internal reflections inside of the filter are rather small. If the halos closer to the edge of the image are eccentric to the star, they are probably caused by an arched surface like a lens, perhaps that of the flattener. Possible sources besides of the filter are e.g. the corrector lenses or the optical window of the CCD. It is possible that this window is not coated!

To find the source of the reflections, you should also try the setup at another telescope or with another camera – if the filter does not cause the halos or simply makes another source of reflections visible, then a replacement filter will not change anything.

Even mounted filters may tip a little bit. One indication for this is if the halos e.g. with combined RGB-photographs are not perfectly centered.

Interference filters, which use internal reflections for filtering, may be prone to show reflections, but these usually can be suppressed so much that they can't be noticed any more.

You can find a detailed text about the cause finding of filter halos at [https://web.archive.org/web/20140729003031/http://www.astrodon.com/articles\\_faq/articles\\_faq/press\\_release:391,355,49](https://web.archive.org/web/20140729003031/http://www.astrodon.com/articles_faq/articles_faq/press_release:391,355,49)



*This image shows large reflections caused by a coma corrector as well as halos around bright stars.*

## Halos – Image processing as a problem with H-Alpha, OIII and SII

Halos can also be the result of image processing. Most nebulae do not shine as bright in OIII- and SII-channels as they do in H-Alpha. The difference may be up to one to three orders of magnitude. If the histogram of OIII and SII is adjusted to similar values to achieve a well-balanced grey value distribution, pinpoint stars will be bloated, too.

Stars aren't simple points in the image data – instead, they appear rather as cones or bell-shaped curves. By stretching – that is, by adjusting the histogram – the flat bases of these stars will become more prominent, and it seems that these filters produce stronger halos than the H-Alpha-filter – although it is only a result of the image manipulation. The base of weaker stars is smaller and will be lost in the general background brightness.

Many people also tend to use filters with a broader half width to get a brighter image for these weaker channels. Unfortunately, this is not helpful because most emission lines of nebulae do not show the Zeeman effect or similar line broadenings. So, a narrow filter which fits perfectly to the center wavelength will show the nebula almost exactly as bright as a broader filter, the difference will be only a few percent. On the other hand, a broader filter will let much more light from the stars or the background pass through, so that the stars will be much more brighter in relation to the nebula. But exactly these stars are the problem: Their increased brightness will cause halos, blooming, colour aberrations and other effects caused by over-saturation.

On the other hand, a very narrowband filter may not work as expected at very fast optics because of the shifting of the center wavelength, because then the center wavelength will no longer pass completely through the filter. For these telescopes, broadband-filters work better, because they will not block any light coming from the nebula – neither because of fabrication tolerances nor because of the fast focal ratio.

Broader filters were a necessary compromise for older camera with a selfguiding chip behind the filter – today, we aim for long exposure times to show even faint nebular structures. A narrowband filter makes longer exposure times and „deeper“ images possible, because it dims the stars as well as the background.

### Haze caused by the atmosphere

Of course, also our atmosphere can cause beautiful halos. Light scattering at water drops in the air or at dirt on the lens has got the same effect as a softener in front of the lens. If a halo is very soft and without steps, it is very probably caused by this. Even faint cirrus clouds, which are hard to see for the naked eye at night, can have this effect. These halos will not appear in clear nights and with pristine optics – but they will cause confusion, if clouds are gathering in the night or the lens is moistened with dew.



*A halo which is caused by clouds in the atmosphere or dew on the optics.*

## Focus-problems with parfocal filters

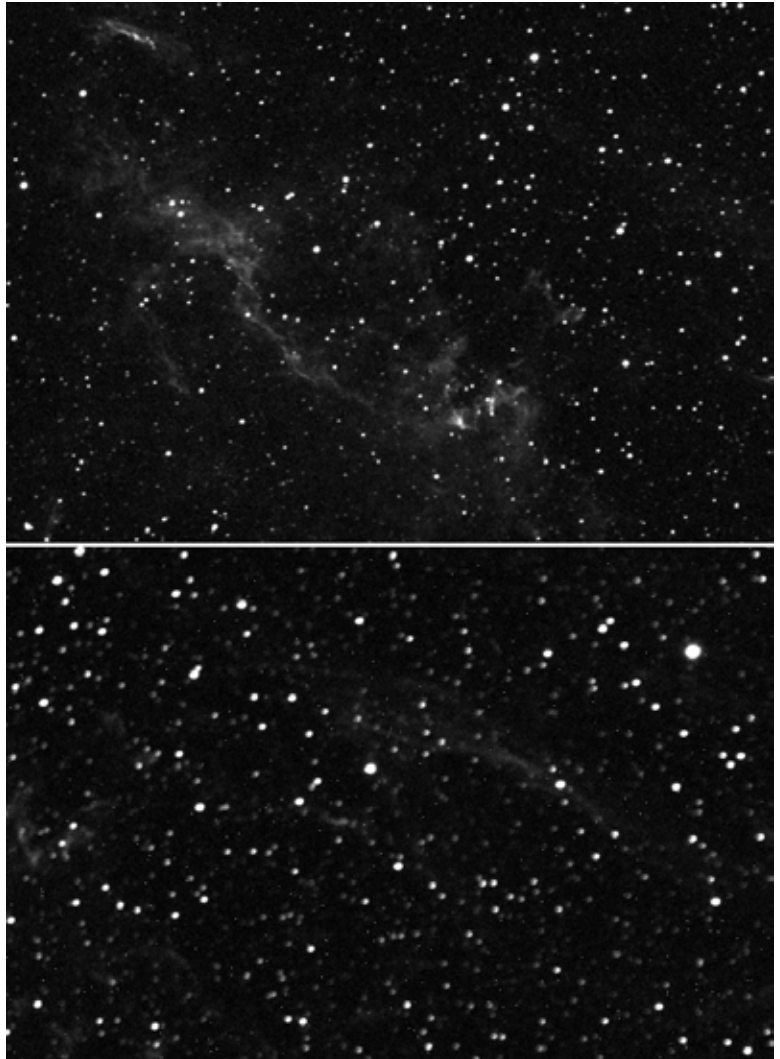
If you combine several images which were taken with different filters, there may be slight differences in focus and sharpness, even if they should be parfocal. Even the temperature differences during one night can make checking the focus necessary again and again, because the telescope tube slightly contracts, when it cools down.

Refractor telescopes without perfect colour correction will show a halo around bright stars especially in the blue channel. Refocussing may improve the image on these optics, too.

But even with parfocal filters, slightly different focus planes are possible – depending on the focal ratio for which they were designed. If not noted differently, most filters are designed for  $f/6$  till  $f/8$ , and they also work with slower optics. Small tolerances are not critical with these focal ratios.

The situation is completely different if you use optics with  $f/4$  or similar: Collimation of these instruments must be perfect, even small misalignments are obvious. We recommend that you check the focus of these instruments whenever you change a filter.

Please remember that normal interference filters will not work as desired with very fast optics. For real astrographs faster than  $f/4$ , we offer our  $f/2$  Highspeedfilters, which are optimized for  $f/2$ . They deliver much better results at optics between ca.  $f/1,8$  and  $f/3,5$  than standard filters.



*The focus-plane may change when you use different filters. This is valid especially for achromatic telescopes.*

## Some final words...

In all relentless pursuit of perfection: Each and every glass surface has an effect on the final image. That's why observers of the planets prefer eyepieces with only a few lenses. Even the most modern professional observatories know these problem, as this image by the VLT Survey Telescope of ESO (Press Release eso1705a) shows: There are halos around the bright stars caused by reflexions, which do not harm the fascination and the (also scientific) use of this image.



*To quote the ESO press release: This spectacular image from the VLT Survey Telescope shows the Cat's Paw Nebula (NGC 6334, upper right) and the Lobster Nebula (NGC 6357, lower left). [...] Note that the circular features in the image around bright stars are not real, they are due to reflections within the optics of the telescope and camera.*

*Credit: ESO. <http://www.eso.org/public/images/eso1705a/>*

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