- Home
- Products
- Dealers
- Articles & FAQ
- Gallery
- Ask Astrodon
- Contact

Astrodon Narrowband FAQ

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What is a narrowband filter?

A narrowband filter is designed for a specific astronomical emission line, such as hydrogen-alpha (H-a).   It only passes a few wavelengths of light along with the emission line, rejecting all other light. As a result, the contrast improves dramatically, showing a great deal of structure.   Think of it as a red laser compared to a red light bulb.
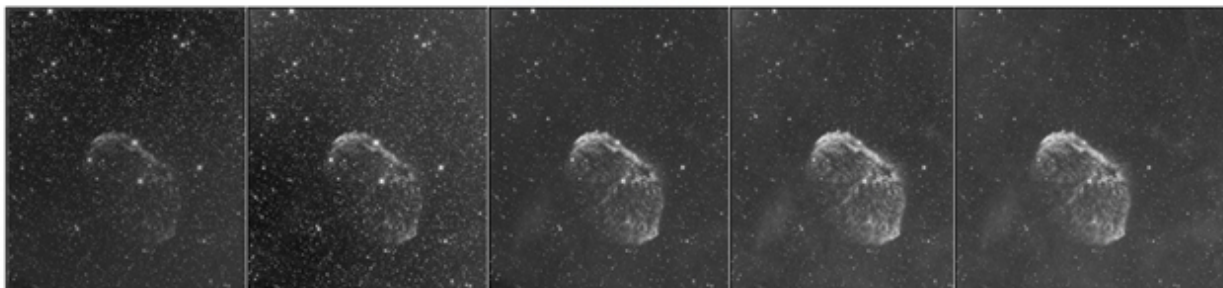

Why are they useful?

There are three major reasons. First, they bring out fine structure much better that RGB filters. Second, they allow you to image when the moon is up, thereby extending the time that you can use your equipment. Third, they allow you to image from light-polluted locations, where RGB imaging may be problematic.

Crescent Nebula

You can see the enhancement of detail as the filter becomes spectrally narrower, from red filters to narrowband filters. You can even see more detail as the narrowband filter becomes narrower from 9 to 4 nm, not only in the bright object, but also in the background nebulosity.

What is the most popular narrowband filter?

H-a (hydrogen-alpha) at 656 nm (nanometers) is deep red in color and the most popular narrowband filter. Hydrogen is ubiquitous in the cosmos and is present in emission nebula (North American, Pelican), planetary nebula (Dumbbell, Ring), Wolf-Rayet objects (Crescent, Thor's Helmet) and supernova remnants (Veil).   Many imagers like to present just a black-and-white H-a image of an object. It is has a beauty all by itself, like an Ansel Adams photo. However, most imagers blend their H-a data into their red RGB data to enhance structural detail while maintaining a "natural" look. Therefore, the H-a filter should be your first narrowband addition to your LRGB filters. The basic imaging set of 5 filters becomes LRGBH-a.
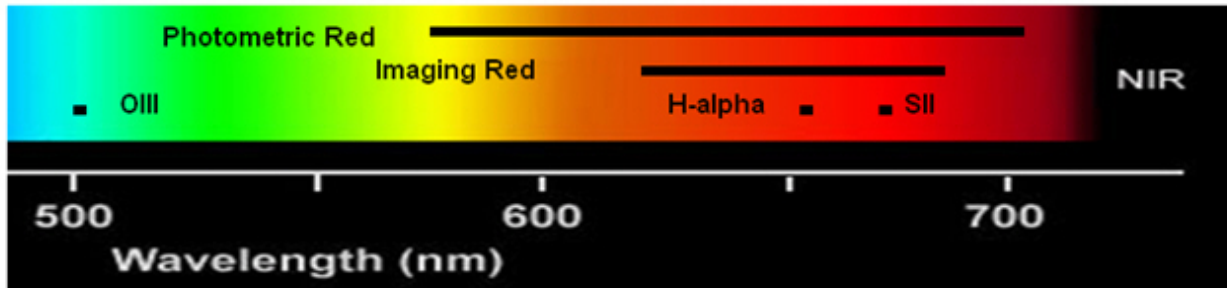
What about other popular narrowband filters?

The next filter to complement your LRGBH-a set is an oxygen filter. OIII ("oh-three") emits light near 500 nm and is a blue-green- or teal-colored filter. Many of my images of planetary nebula and supernova remnants are taken only with H-a and OIII filters. They show great structural detail, but have natural colors, looking like an RGB image.

If you want the look of Hubble Space Telescope (HST) images, such as the famous "Pillars of Creation" (the Eagle Nebula, Messier 16), then the next filter to consider adding to your collection after H-a and OIII is the SII (es-two) or sulfur filter. The SII filter, like H-a, is a deep red filter near 672 nm. H-a, OIII and SII filters provide that Hubble look for many emission nebula. Again, tri-color narrowband imaging with these three filters can be done with the moon up, so your equipment is not sitting dormant for several weeks.
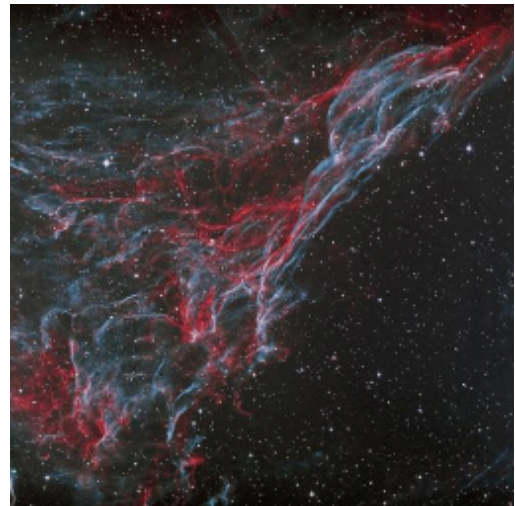
What about H-beta or other narrowband filters?

H-beta is of interest for scientific research, but is not useful for narrowband imaging. It is a blue filter at 486 nm. It has the same information as the H-a filter, but its signal is one-quarter to one-third as intense. Thus, it does not really add new information and provides a weaker signal. Helium (He) and Nitrogen (NII – "en-two") filters can show different structures in certain objects like planetary nebula, but are more restricted in their use. Astrodon does offer a NII narrowband filter for those wishing to explore these differences (see section below).

What is Mapped Color?

It is obvious when you combine your RGB data into a colored image how the colors are assigned. Narrowbands are different, since OIII is a mixture of green and blue, and H-a and SII are both red. So, we need to decide on what "color palette", or color mapping protocol to use. The Hubble palette assigns (maps) red to SII, green to H-a and blue to OIII (in order of wavelength). This generally results in those familiar central blue backgrounds surrounded by golden yellow shock fronts in HST images. This image of the Pelican Nebula that I took is mapped this way. The golden color results from mixing green H-a and red SII that are enriched in the shock fronts. However there are many other ways to map colors. So, it is up to the imager to decide how best to portray his/her object. Regardless of what color palette is used, the goal is to use color to emphasize structure in an aesthetically pleasing manner. Our hobby is very technical, but the end result is art – technical art.

What is the Peak Transmission of the Filter?

H-a Filter Transmission Plot
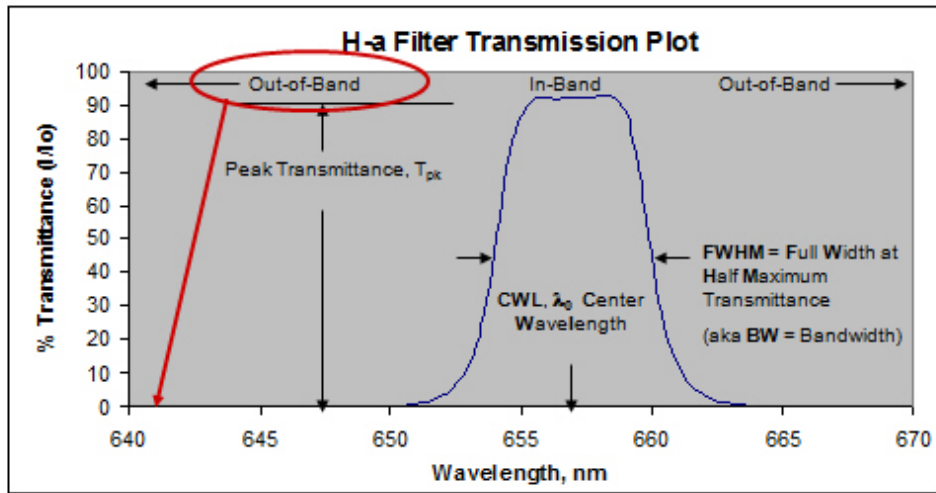
This peak transmission of the filter is a very important parameter. It represents how much light passes through the filter. This is expressed in percent, such as 95%T (T=transmittance or transmission). This means at that wavelength, the filter passes 95 out of every 100 photons to the detector. Commercial (non-astronomy) filters typically transmit only 50-60%. Astronomy is much more demanding, and nowadays, narrowband astronomy filters transmit in excess of 80%. The transmission of the filter improves the signal in the signal-to-noise (S/N) of your image. So, you want this value as high as possible. Astrodon 5 nm narrowband filters typically have 95%T, the highest value available, for this reason. Even our ultra-narrow 3 nm filters are guaranteed to be >90%T.

What is the Bandwidth, Width, FWHM of a Narrowband Filter?

This is also a very important parameter that we use to describe narrowband filters. Let's envision the transmission of a narrowband filter as a bell-shaped curve. Refer to the above chart. There are two wavelengths at 50% of the peak (maximum) transmittance; one at a higher and the other at a lower wavelength than the central or peak wavelength. The wavelength difference of these 50% points is referred to as the full-width-at-half-maximum transmittance (FWHM). It is also referred to as the bandwidth or width of the narrowband filter. When you hear about a 5 nm narrowband filter, the 5 refers to the bandwidth or FWHM in nm (nanometers). Narrowband filters are considered to have widths of 10 nm or less, with most ranging from 4.5 to 7 nm. Astrodon also offers an ultra-narrowband with a 3 nm width. Narrower filters enhance contrast by reducing the broadband light which decreases the noise (N) in S/N. The background signal decreases linearly as the bandwidth decreases. Narrower filters make it easier to image with the moon out (broadband light) and from light-polluted locations.

What's the Catch?

The goal is to maximize S/N. Therefore you want the highest peak transmission with the smallest bandwidth. However, it is more difficult to make narrower filters without losing peak transmission. If you buy a narrower filter with lower peak transmission, then S decreases as N decreases and you will likely not see any improvement in S/N. Astrodon has solved this problem and provides 5 and 3 nm narrowband filters guaranteed with peak transmissions > 90%T. In fact, they are typically closer to 95%T. Thus you can be assured of maximum S and lower N than other filters.

How do I Select the Right FWHM for Me?

Our 5 nm narrowband filters will be appropriate for most people. Reflected moonlight peaks near the OIII wavelength. OIII will pick up more moonlight and show more gradients than H-a or SII filters. Since we tend to use narrowband filters when the moon is up, a 3 nm OII filter may be a better choice to reduce the effects of moonlight, especially if there is a blanket of reflective snow on the ground. It is OK to mix narrowband filters of different bandwidths. If you live in a light polluted location, all 3 nm filters may be a better choice. I personally prefer all 3 nm filters for highest contrast and detail.

What About Using Narrowband Filters with Faster Optics?

You may have heard that a narrowband filter shifts its bandwidth to shorter wavelengths with faster optics. As this shift occurs the transmission at the emission wavelength may decrease, making the filter less efficient. This is not significant with our 5 nm narrowband filters for most scopes slower than about f/3. The 3 nm filters may lose perhaps 20%T at f/3, but still useable. Below is a comparison of 10 min exposures of our 5 and 3 nm H-a filters taken on a Takahashi f/3 Epsilon-180 telescope with an SBIG STL11000 camera from suburban Sacramento, CA. Good signal is still achieved with the narrow 3 nm H-a filter at f/3 even with a 15% loss of signal due to the spectral shift because the lower background signal helps to compensate this.
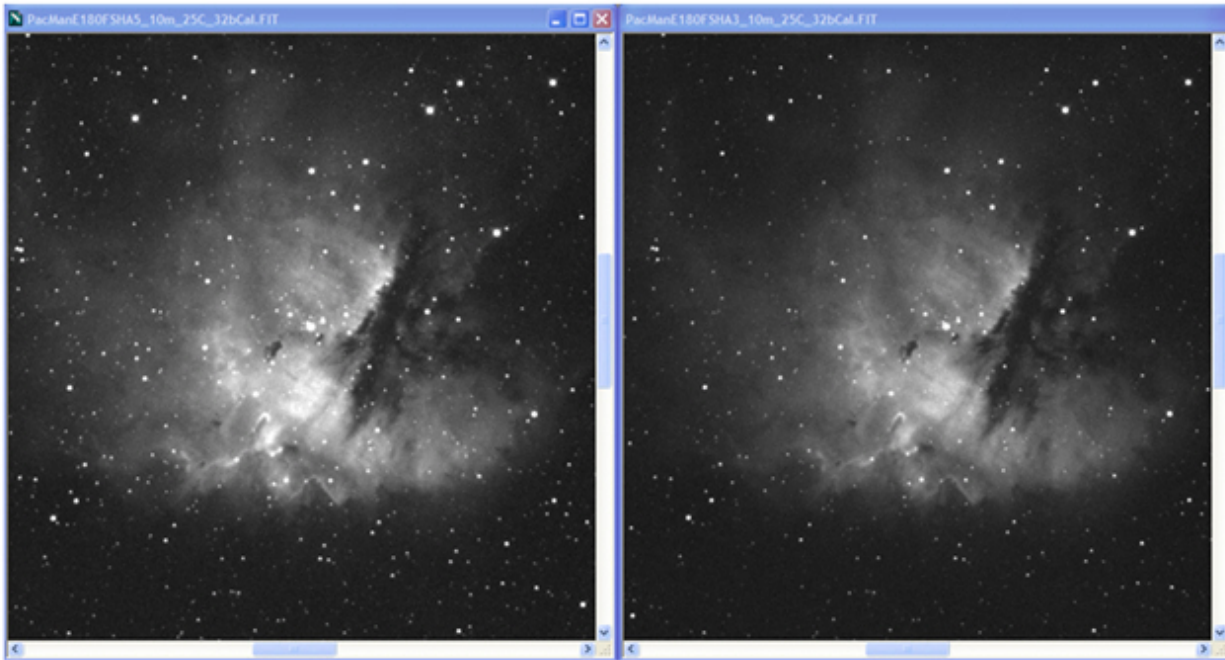

## What are the Negatives for Narrowband Imaging?

Narrowband filters are more expensive than LRGB filters. Stars are much dimmer, making guiding behind narrowband filters more difficult. As a result, you may need to consider off-axis guiding, such as with an Astrodon MonsterMOAG, or a separate guide scope, where in both cases, the guide camera sees unfiltered light. Also, narrowband signals are inherently weak, requiring long exposures of 20 – 40 minutes. This requires a mount that is stable over these times with acceptable periodic error.

What about NII and H-a?
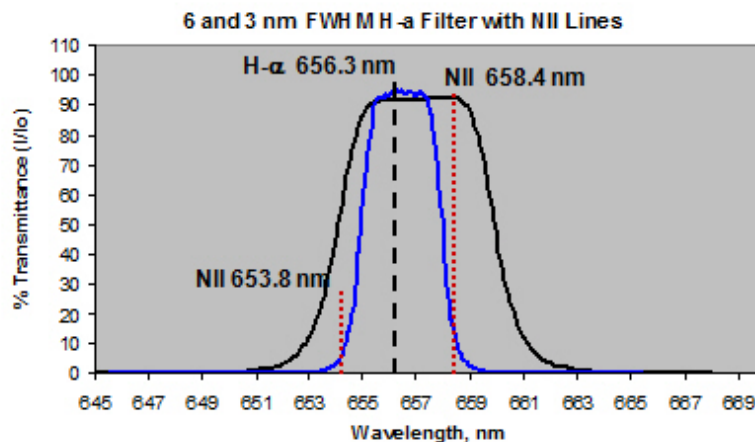
This is a bit complicated. It is not well known that most H-a filters pass both H-a and NII. H-a emits at 656.3 nm and NII emits most strongly at 658.4 nm (and weakly at 653.8 nm). These are very close together spectrally. Thus, most H-a filters are wide enough (e. g. 4.5 nm bandwidth and wider) to pass both emission lines as shown for the older Astrodon 6 nm filter above. Our 3 nm H-a begins to separate both emission lines and reduces the NII contribution significantly, also shown above (blue curve). In this example the 3 nm filter only transmits 15% at the NII 658.4 nm wavelength, whereas the H-a remains unchanged. As mentioned earlier, some objects are enriched in NII, such as planetary nebula and Wolf-Rayet bubbles. The Dumbbell Nebula, M27, is a good example, as shown below, taken with 3 nm narrowband filters. The wispy clouds in the core of M27 are dominantly NII. A tricolor narrowband image is also shown below, mapping OIII to blue, H-a to green and NII to red to produce a beautiful color image. This information

provides you with a choice based upon your light pollution, desire for more detail, or simply wanting all the photons you can get out of your H-a filter.
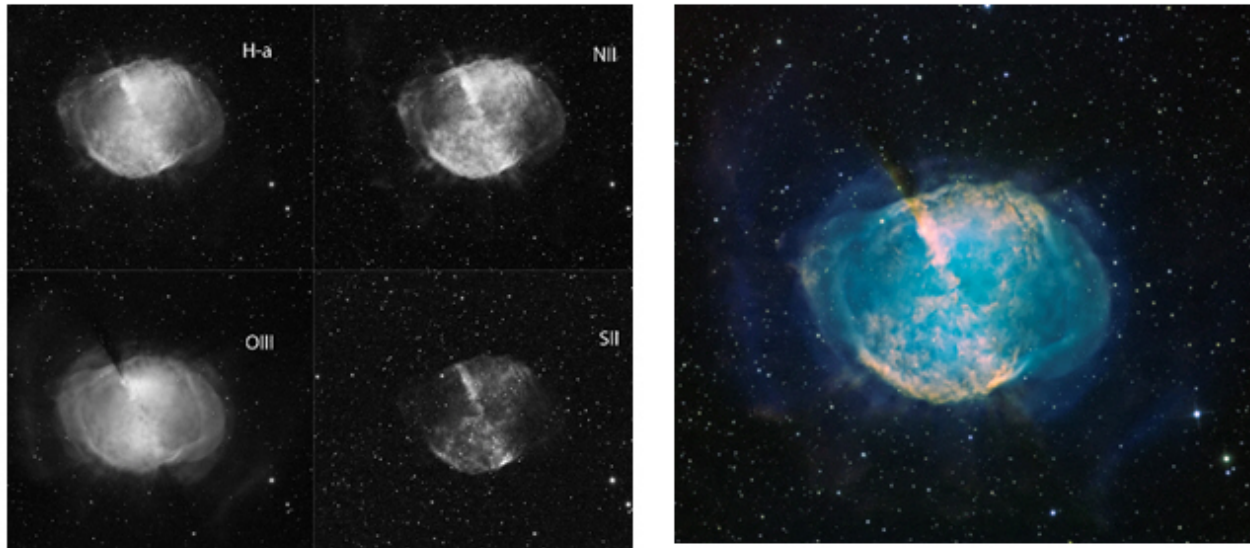

Can I mix narrowband filters of different FWHM?

Yes. Stars will be smaller with narrower filters, but the effects can be dealt with in processing. Processing will be required even if your bandwidths are the same. This arises because OIII and SII are much weaker signals than H-a.   OIII and SII data must therefore be stretched during processing to match the intensity of the strong H-a. Stretching makes those stars larger, often even larger than the H-a stars. You may have seen magenta halos around bright stars in tricolor narrowband images. This is how they arise, since we often map OIII to blue and SII to red. Blue + Red = Magenta.   Software methods such as deconvolution prior to color combining can offset some of these effects. Selective color correction that desaturate magenta is another means to reduce the problem.

OK, I Bought Your Narrowband Filters - Where's the Data?

If you are used to the strong signals that you get from your LRGB filters, you may be disappointed or even concerned with the relatively weak narrowband signals, especially from OIII and SII. They may only be 500 - 1000 ADU (counts - analog to digital units) as displayed on your computer screen. But, in most cases, these signals are there. Your first look at your object is from your data acquisition program just after a frame is downloaded. This is a raw frame, that is, it has not been calibrated with darks, biases or flat frames, and has hot pixels. The image is scaled by these hot pixels pushing the weak narrowband data into the background. So, it looks like there is almost nothing present. One trick that I use in MaximDL is to perform a Kernel/Median filter on the displayed image. The image below shows a 30 min. raw frame from an Astrodon 3nm H-a exposure of IC1795 (left) and after the application of the filter in Maxim (right). Notice how the H-a signal, especially in the fainter background regions, pops out after the filter is applied. This filter only operates on the displayed data. The file is not changed unless you ciick Save, so do not click on Save.
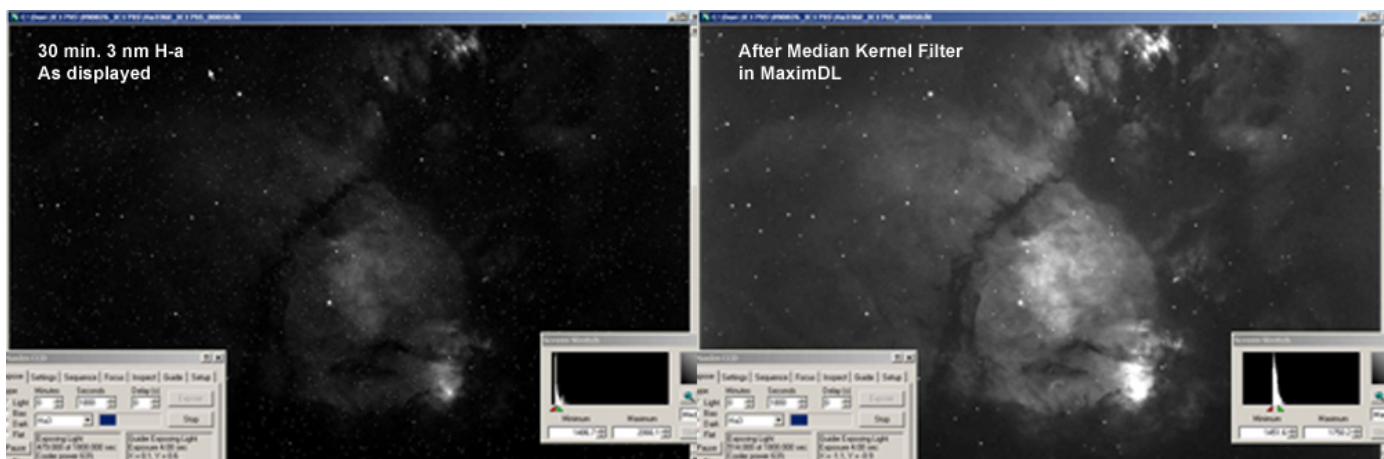
Lastly, please realize that the OIII and SII data can be relatively weak and that you will have to "stretch" the data during processing to achieve a better match with the typically strong H-a data. These processing methods include, digital development (DDP) in programs such as MaximDL and CCDStack, and curves, shadows/highlights and others in Adobe Photoshop.

Happy Narrowband Imaging!
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