Filters

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Important High-Level Concepts

Don't use Narrow Band Filters on Color Cameras

Because color cameras have a built in Bayer Filter (which basically eliminates the need to use LRGB filters) it makes no sense to use many of the narrow band filters (such as H-Alpha, S-II, etc…) because the two filters will conflict with each other.

I made this beginner mistake when I started out and you can see the results in the OIII section where the image turned out all green.

Wide band filters (like the Lumicon L-Pro) can be used with a color camera because, contrary to a narrow band filters, they let through most of the light and only block certain narrow bands – such as those from city lights.

Narrow band filters are for use on monochrome cameras ONLY. Because the pixels on a monochrome camera do not have a Bayer filter, they can accept any frequency of light, and therefore will work with all filters.

Focusing with Filters

Any time you alter the telescope light path – typically by adding or removing a piece of glass, be it a lens or a filter – you change the image focus slightly. So, for example, if you focus your telescope with no filter in the light path, and then add a filter, the image will no longer be in perfect focus.

Parfocal Issues

Parfocal is a characteristic that refers to whether two filters will focus the light to the same point in the light path. If both filters are 'parfocal' then the focus will not be affected by switching out one filter for the other.

Ideally you want all of your filters to be parfocal so that your focus is not affected on filter changes. The best way to ensure this is to purchase all of the filters from the same manufacturer and make sure they are parfocal. You may be able to get parfocal filters from different vendors, but it is much more difficult to ensure that they are parfocal.

Clear Focus Filter

Because the camera focal algorithms rely on the ability to see a broad range of stars, it can be quite difficult to focus with a narrow band filter in the light path. For this reason, vendors offer clear focus filters – which are basically just a clear piece of glass that is parfocal with the vendor's other filters.

By using a parfocal clear focus filter during focusing, you can ensure that the focus will not change when the other narrow band filters are later switched in.

If you have limited space in your filter wheel (ex: ZWO 2" 7 position wheel) you can generally use your 'L' (luminance) filter in place of a clear focus filter.

Mounted vs Un-Mounted Filters

Mounted filters are easier to handle because they are already fixed inside a metal screw-in body. However, mounted filters don't perform so well at the edge region where the filter meets the body, and may produce image distortions in this region. So, if your camera sensor extends into or near the edge of the mounted filter, then you would be better off using un-mounted filters. Another alternative would be to simple crop these areas, but that may not be practical in all cases.

Prefer "Low" Height Filters

Many applications require filters to fit into tight spots. Always prefer low profile 7mm (or less) filters to avoid problems – especially in filter wheels and drawers.

LRGB vs RGB process

From various internet threads (ex: Cloudy Nights) it appears that RGB is 'technically' the best way to get a perfect picture – but it takes a lot more time. If you are a perfectionist with unlimited time and money, this will probably be your choice.

For the rest of the world, LRGB appears to offer an 'almost' as good picture, but with substantial time savings.

Filter Band "Tolerance" and "Price" tradeoffs

In addition to the overall quality of the optics produced by the filter manufacturer, it is important to note that filters are also qualified by how "tight" they limit the passed photons around the target band wavelength.

Less expensive filters might allow tolerances up to 7.0nm or more, whereas more expensive filters might limit tolerances down to 2.5nm.

For example, you can see this effect in different Antlia 2" OIII filters (see following page for actual performance charts):

- Antlia Ultra Imaging 2.5nm $590
- Antlia Pro Imaging 3.0nm $395
- Antlia Edge Imaging 4.5nm $290

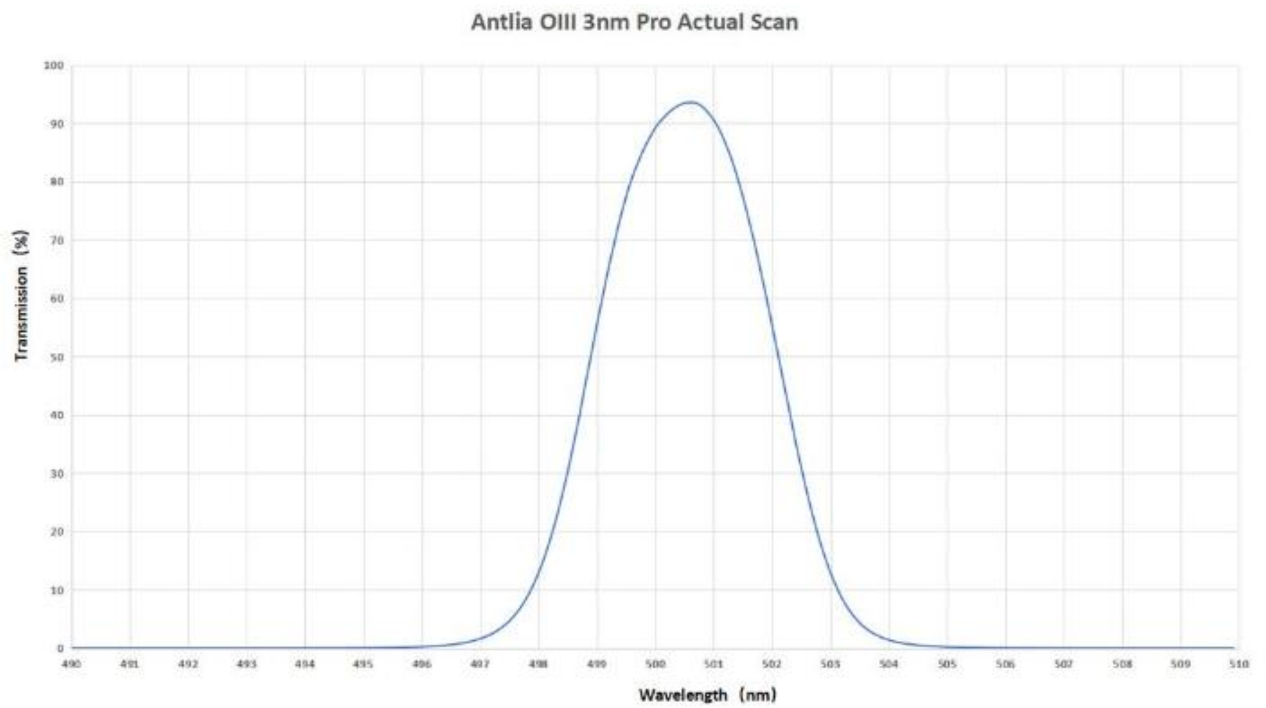
Compare this to the lower cost Optolong and Celestron 2" OIII filters

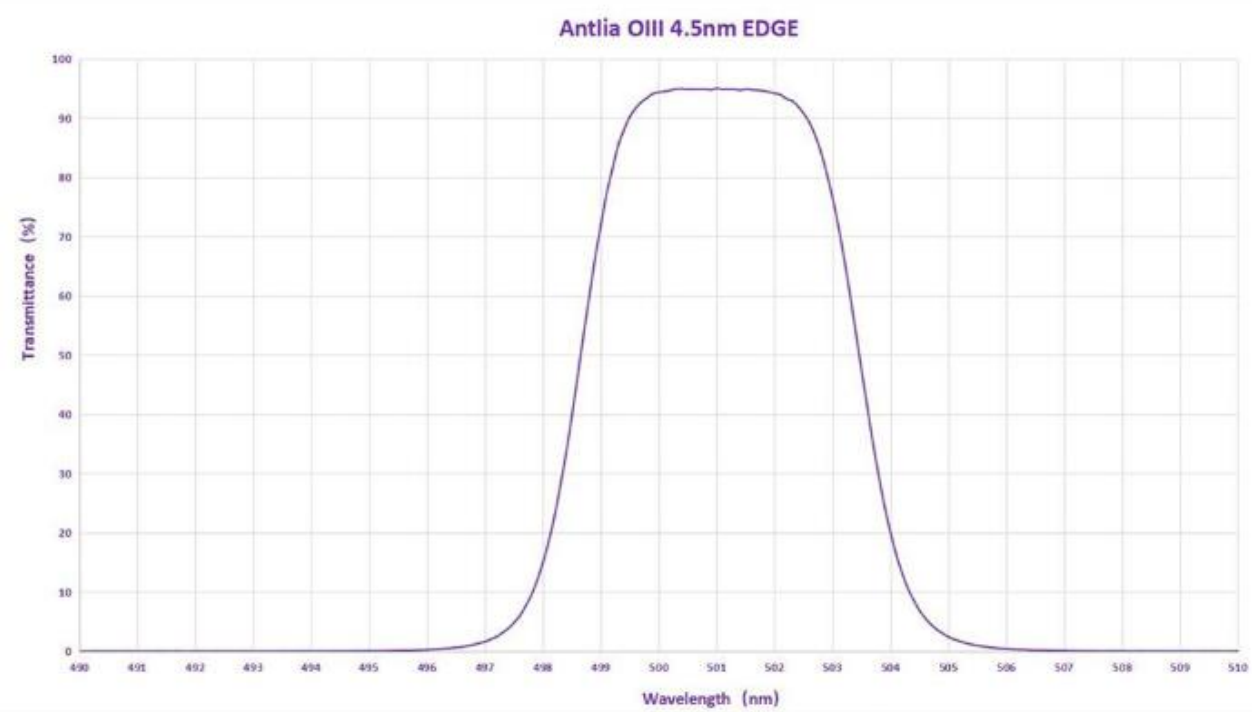
- Optolong 6.5nm $229
- Celestron ?.?nm (not rated) $119.95

On the other extreme are high quality filters made by Chroma. The Antlia filters are middle of the road and (especially the OIII) are sometimes subject to halos in the image. Chroma is top notch with zero defects, but you are going to pay a lot more.

- Chroma 3nm $1,300

Here you can see the difference between the Antlia 3nm & 4.5nm filters – this difference costs $105 so you should be sure it is worth it to you in your applications before shelling out the extra money.





Filter Speed

In astronomy, filter speed refers to the focal ratio (f/ratio) of a telescope, which affects how light enters the filter. The f/ratio affects the angle of light incidence, which can impact the filter's transmission curve. In other words, using a good filter in an incorrect telescope can alter the filter's performance.

Here is a good article describing this highly technical issue: Altair Web page

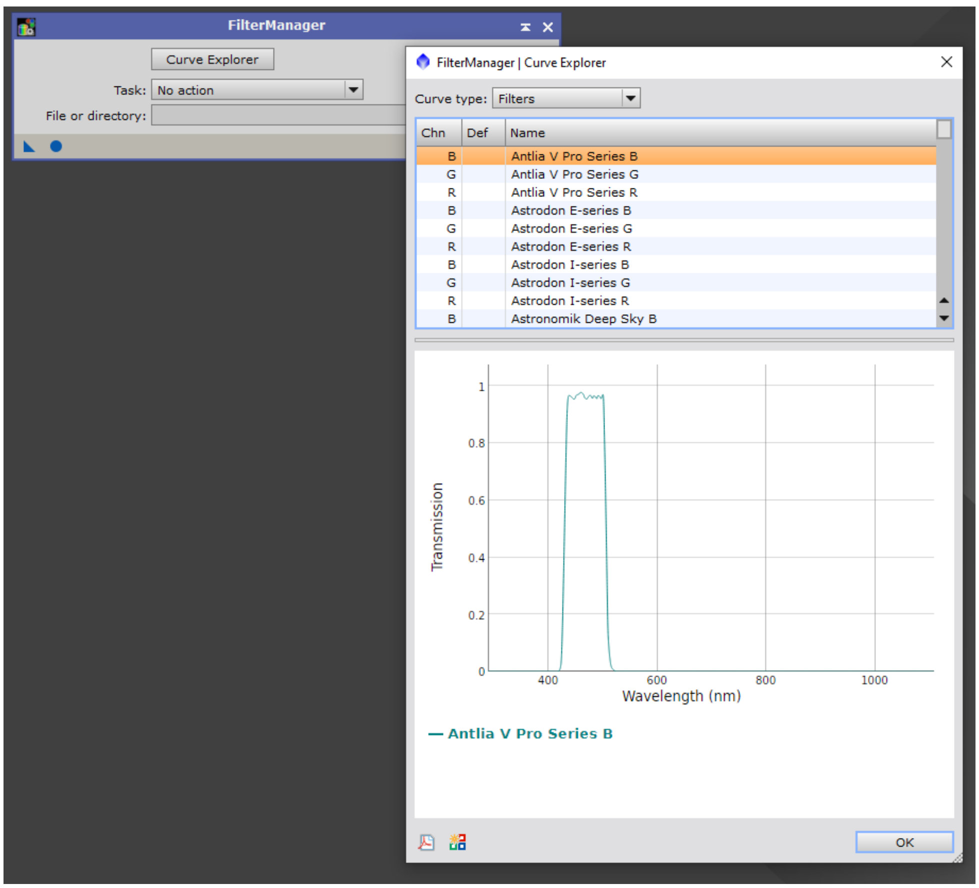
Due to issues like this, it appears to me that you are better off getting started with a relatively inexpensive set of filters and not having expectations that are too high. As you learn more and want to get more precise you may find that you need different sets of filters for each of your telescopes (assuming they have different 'f' ratios.)

Post Processing Support

Many post processing software packages require you to specify the filters used for certain operations. If the filter you buy is not currently supported, you will either have to custom configure it or be out of luck. For example, PixInsight supports the following RGB filters out of the box:

1. Antila V Pro
2. Astrodon E & I Series
3. Astronomik Deep Sky & Type 2C
4. Baader
5. Several Sony filter types
6. ZWO

To view and update filters supported in PixInsight go to Process-All-Filter Manager and click on "Curve Explorer" as shown below.



Overview

Here are two excellent articles that cover pretty much everything you need to know about using filters:

Useful filters for viewing deep sky objects
Filter performance comparisons for some common nebulae

You should read these to get a good understanding of how filters work. The information that follows below are my personal observations on using filters.

Due to the many complex issues with filters, it appears to me that you are better off getting started with a relatively inexpensive set of filters and not having expectations that are too high. As you learn more and want to get more precise you may find that you need different sets of filters for each of your telescopes (assuming they have different 'f' ratios.)

Camera Built-In Filters & UV/IR Cut Filters

Your camera typically has a piece of protective glass above the sensor element. This is either an IR-CUT or AR window. An AR window is coated to limit reflections but passes IR light pretty well whereas an IR-CUT window will cut off the IR part of the spectrum and limit what the camera sees to visible light only.

If you are imaging with a reflector (which can focus IR to the same point as visible light) then you should be OK with just an AR window, but if you are imaging with a refractor (which will usually focus IR to a different spot than visible light) then you'll want to add an IR-cut (or UV/IR cut) filter to avoid getting a smeared image from the IR.

It's not that one is better than the other... if your camera has an IR cut window then you don't need to bother with a separate filter, but you lose the ability to image in IR with a suitable scope.

UHC (Ultra High Contrast) Filter

UHC filters block out typical orange/yellow wavelengths of light, reducing the effect of light pollution to allow for more contrast between the 'black' night sky and the objects you want to capture. Suitable for telescopes of nearly all apertures. CCD camera users should pair their UHC filter with an IR blocking filter. Standard and modified DSLR cameras will gain from the contrast-enhancing abilities of a UHC filter, but these filters are not suitable for use with planetary webcams.

Narrow Band Filters

Narrowband filters are more discriminating, typically letting through light in the 20nm to 30nm range. The wavelength band coincides with the emission lines of hydrogen beta at 486.1nm and doubly ionized oxygen at 495.9nm and 500.7nm. These filters cut out most light-pollution lines as well as most of the continuous spectrum from stars and galaxies. So, they provide a nice dark background sky but prove of little use on objects other than emission and planetary nebulae. On those latter objects, however, narrowband filters boost the visual appearance dramatically.

General Notes about Nebulae (from link)

The emission nebula we can see emit light in 3 prominent spectral lines we can see at night:

- H-ß at 486.1nm
- O-III at 495.9nm
- O-III at 500.7nm.

Many nebulae emit light at all 3 lines. Some only emit light at H-ß, and some at only O-III. If you don't want to research the spectrum of each nebula, here is a basic guide:

- Large H-III region nebulae like M8, M20, M17, M16, M42--all 3 lines
- Most Planetary nebulae--O-III lines
- Most Wolf-Rayet excitation nebulae like NGC2359, NGC6888---O-III lines
- Supernova remnants--O-III (the Veil) or all 3 (Crab)
- Large ultra faint H nebulae normally seen in photos only--H-ß line.

What filter does them all? The narrowband filter that passes all 3 lines. Examples:

- TeleVue BandMate II Nebustar
- DGM NPB
- Astronomik UHC Visual
- Lumicon UHC
- Orion Ultrablock.

Later on, if you are looking for another, second, filter to give a trace more contrast on selected objects, try an O-III filter. Examples:

- Astronomik O-III
- Lumicon O-III
- TeleVue BandMate II O-III

Filters are used at low power (under 10x/inch of aperture usually), which means if you use high powers to look at planetary nebulae, you'd do so without a filter. The higher the power, the less effective the filter is.

H-Beta Filter

An 8-inch rich-field telescope can use the H-Beta to show larger objects like the Gamma Cygni nebular complex (IC 1318) or segments of Barnard's Loop and the California Nebula. There are other fainter targets which the H-Beta can be used on, although some require moderate to large aperture:

USEFUL TARGETS FOR THE H-BETA FILTER

While the H-Beta is probably one of the less-used nebula filters, the commonly expressed idea that it works only on a handful of objects is not necessarily true. Here is a list of some of the more prominent objects that the H-Beta may be at least somewhat useful on. Some may require larger apertures (and some may be slightly better in other filters), but a few have been seen from a dark sky site by just holding the filter up to the unaided eye and looking at the sky. Some of these will also be helped by a narrow-band filter like the Lumicon UHC.

1. IC 434 (HORSEHEAD NEBULA)
2. NGC 1499 (CALIFORNIA NEBULA, naked eye and RFT)
3. M43 (part of the Great Orion Nebula)
4. IC 5146 (COCOON NEBULA in Cygnus)
5. M20 (TRIFID NEBULA, main section)
6. NGC 2327 (diffuse nebula in Monoceros)
7. IC 405 (the FLAMING STAR NEBULA in Auriga)
8. IC 417 (diffuse Nebula in Auriga)
9. IC 1283 (diffuse Nebula in Sagittarius)
10. IC 1318 GAMMA CYGNI NEBULA (diffuse nebula in Cygnus)
11. IC 2177: SEAGULL NEBULA (Diffuse Nebula, Monoceros)
12. IC 5076 (diffuse nebula, Cygnus)
13. PK64+5.1 "CAMPBELL'S HYDROGEN STAR" Cygnus (PNG 64.7+5.0)
14. Sh2-157a (small round nebula inside larger Sh2-157, Cassiopeia)
15. Sh2-235 (diffuse nebula in Auriga).
16. Sh2-276 "BARNARD'S LOOP" (diffuse nebula in Orion, naked eye)
17. IC 2162 (diffuse nebula in northern Orion)
18. Sh2-254 (diffuse nebula in northern Orion near IC 2162)
19. Sh2-256-7 (diffuse nebula in northern Orion near IC 2162)
20. vdB93 (Gum-1) (diffuse nebula in Monoceros near IC 2177)
21. Lambda Orionis nebular complex (very large, naked-eye)
22. Sh2-273 "Cone" Nebula portion south of nebulous cluster NGC 2264

In addition, a number of the brighter nebulae like NGC 7000 or M42 will respond to H-Beta use for revealing certain specific detail, although other filters may provide a somewhat better view overall.

Many articles say that it is only useful with apertures of 8" and larger. However, several of the targets on the list were visible in an 6" f/5 and 4" f/7, so the filter has a use. But to see the Horsehead in an 8"?

That requires a VERY dark sky. I tried for 11 years with an 8" and filter and never saw it, but it was suddenly easy in the 12.5".

I have seen the Horsehead in a good pair of 6" f/5 binoculars (with filters), so I am not certain 8" is too small an aperture to see it. But I do believe you need skies of around magnitude 6.8-7 to really see it. Don't expect something small. It's almost as big as M11! And it doesn't really look like the picture--it's like a large "bite" out of IC434. If you can't see IC434, you'll never see B33, the Horsehead.

But don't fail to look at other objects in the list. NGC1499 (California Nebula) becomes EASY with the filter, even in a 6". And I've caught it with my 4" refractor as well.

OIII (Oxygen III) Filter

The most extreme narrowband filters, sometimes referred to as line filters, let through light from only one or two emission lines. The OIII filter (or Oxygen III, which stands for doubly ionized oxygen) ranks in a class by itself. It effectively doubles the size of your telescope when it comes to observing emission and planetary nebulae. Bright nebulae look stunning even from the city, and the views under a rural sky are beyond compare. An OIII filter will make faint planetaries pop into view. The filter has only one drawback: It darkens stars so much — by two to three magnitudes — that it can be difficult to find the correct field at medium and high magnification.

Neutral Density Filters

Neutral density filters are used to reduce the amount of light reaching the camera sensor when viewing very bright objects (ex: moon, sun, etc.) You may be able to get away without using this on a small aperture scope, but as the aperture gets larger the amount of light reaching the sensor overwhelms the sensor electron wells and creates a washed-out image – see below for full moon shot taken with Redcat 71.

Here is the chart showing how much light is let through an ND filter. The markings on the filters themselves are confusing because some manufacturers display "density", whereas others display "light transmittance", and others display both "ND Number" and "density."

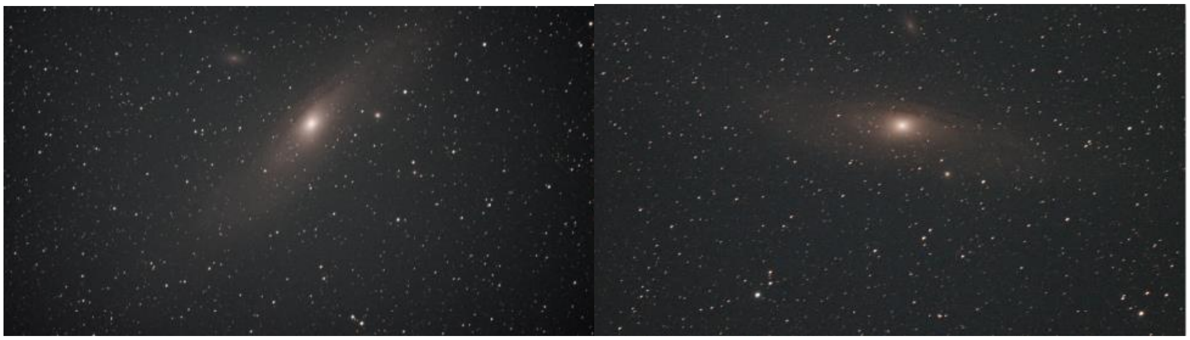
ND Number	Density	Stop	Light Transmittance
ND2	0.3	1	50%
ND4	0.6	2	25%
ND8	0.9	3	12.50%
ND16	1.2	4	6.25%
ND32	1.5	5	3.10%
ND64	1.8	6	1.50%
ND100	2.0	7	0.50%
ND200	2.5	8	0.25%
ND500	2.7	9	0.20%
ND1000	3.0	10	0.10%

12.5% transmittance is good for the moon on larger scopes, 25% may work fine on smaller scopes.

Filter Examples

UHC and UV/IR CUT Filters

I did a test comparing images of the Andromeda galaxy with no filters compared to using SVBONY UHC and Optolong UV/IR Cut filters. The results are below – the image on the left is the "no" filter image, and the right has both filters.



As you can see, there is no "dramatic" difference in my case. Even when you zoom in 5x to the bottom left corner, it appears as though the NON-filtered image has a darker background (which is the revers of what is expected.)

Nonetheless, from a human eyeball test of the full-size images, it does appear that there is a "very slight" darkening of certain regions of the image background in the image using the filters.

I ran other tests using each individual filter and found that the UV/IR Cut filter had no visible effect, and that the UHC filter was responsible for all of the "very slight" darkening effect. I suspect that UV/IR Cut filter had no effect because my camera sensor is small and does not reach to the edge of the focal area. I suspect that the UHC only had a limited effect because of my location on the edge of the desert high above the city lights.

OIII Filters

Below is a comparison of shots I took of the Orion Giant Nebula using a SVBONY UHC filter (on the left 30s exposure 252 gain) and an SVBONY OIII filter (on the right 120s exposure 450 gain.)

Note how a longer exposure and higher gain is needed with the SVBONY OIII filter due to the fact it lets less light pass through to the sensor. Note also how more subtle detail is available with the OIII filter view even though the color has been lost.

You can see the full-size images by following these links:

- Orion Giant Nebula.jpg (3840×2160) (alphaengineeringlabs.com)
- Orion Giant Nebula - OIII Filter.jpg (3840×2160) (alphaengineeringlabs.com)

Filter Wheels

Pay Attention to Balance

Another user installed these 4 filters in the ZWO 7-position filter wheel in slots 1-4. Due to the low friction between the filter wheel's motor and the wheel's rubber belt, they had gravity move the filter wheel off of the filter in slot 4 on a few images. The solution is to space them out for better balance or fill the other 3 slots with filters.

Filter Height Limitation

Filters come in different heights. I got a set from Celestron that were 11mm thick and would not fit into a standard ZWO filter wheel – I'm guessing these were meant for visual use to attach to your eyepiece. If you are planning on using these in a filter wheel for photography, make sure you get the lower profile 7mm versions.