PART 3 OF AN INTRODUCTION TO ASTRONOMICAL FILTERS Deep-Sky Filters

By Jim Thompson

Figure 1. A Selection of Deep-Sky Filters: To sate my curiosity, I purchased deep-sky filters across the available range from broad-band to narrow.

Part 1 of this series described the basic functions and characteristics of astronomical filters, while Part 2 introduced planetary filters. At last we get to deep-sky filters, a surprisingly complicated high-tech accessory that relatively few people know much about.

Deep-sky filters are potentially more useful than the colour filters discussed in Part 2 of this series; that is at least if you plan to observe anything other than the Moon and planets. This is doubly true if you observe primarily in an urban setting. Deep-sky filters are all subtly different from each other, use non-standardized naming conventions, and are, as a rule, considerably more expensive than colour filters, making trial and error a costly way to find a filter that works for you.

Deep-sky filters function in a way similar to planetary filters: They block undesirable wavelengths of light so that the desirable wavelengths are easier to see. The difference is in the level of complexity of the coatings used to produce the filter. Deep-sky filters are interference type; they operate using the principle of destructive light wave interference. Filter manufacturers achieve this by applying thin alternating layers of two different materials to a clear glass blank, each material having a different index of refraction – one high, one low. When there is a change in the index of refraction along a beam of light's path, such as at the boundary between layers, some light is reflected and some is transmitted. A good example of this is the surface of a lake on a sunny day; there is a bright reflection of some sunlight, while the rest passes through.

The thickness of each layer applied to the filter determines what wavelengths can pass through and those that are cancelled out. This combination of number, type, and thickness of layers results in the ability to make a filter with pretty much any spectral response you want. Many optics manufacturers exist today with the capability to fabricate interference filters as the technology has wide-ranging applications outside of amateur astronomy. As a result, there are many different deep-sky filters available on the market.

The only way to really understand the strengths and weaknesses of a particular deep-sky filter is to look at its spectral

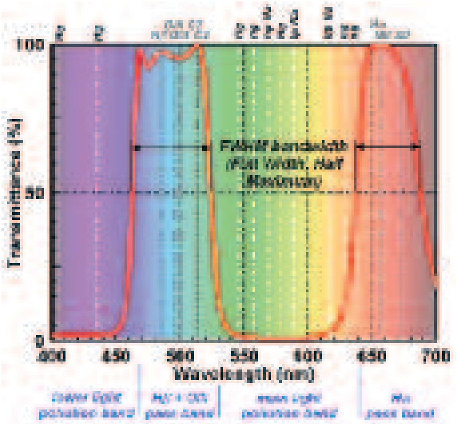

Figure 2. Example Spectral Transmissivity Plot: Deep-sky filters tend to have similar appearance as they are trying to achieve the same goal: Pass the desirable Hβ+OIII and Hα passbands, and cut the undesirable light pollution bands. Note that "bandwidth" is normally defined at half the maximum transmittance value of the filter, known as FWHM.

transmissivity curve. Opposite to what I found for colour filters, pretty much every deep-sky filter maker publishes a spectral response curve of some sort. Most people do not find these curves all that useful since they do not know how the spectral response relates to visual performance. Also, the big thing (for me anyway) is that there is no easy way to compare response curves from one filter to another.

My own desire to make an informed purchase drove me to compile spectral transmissivity data from as many filters as I could find. The manufacturer-supplied curves have been painstakingly converted into spreadsheet data, allowing them to now be plotted and compared to each other as well as allowing for the calculation of luminous transmissivity (%LT). I was surprised at how many different types of deep-sky filters I was able to find: 19 different manufacturers, and 65 different filters. I know for a fact that there are other filters out there, but I was not able to find spectral response data for them. For example, I was able to locate a spectral transmissivity plot for Antares' broad-band filter, but not for its narrow-band or OIII filters.

With such a large number of filters, it made sense to have a set of criteria for sorting them into groups. I chose to divide the 65 filters into nine categories based on their spectral transmissivity curves: Oxygen III Groups A and B, Hydrogen β Groups A and B, Narrow-Band, Medium-Band, Wide-Band, Extra Wide-Band, and Multi-Band. Each filter category also happens to roughly correspond to a different application. OIII and Hβ filters are best suited to heavy light-pollution conditions and are most effective on emission nebulae, planetary nebulae, and supernova remnants. Narrow-band and medium-band filters are best suited for moderate-to-no light pollution, again targeting only emission-type objects. Wide-band filters work well under mild-to-no light pollution on emitting type nebulae, but can also be used to some extent on other deep-sky objects like clusters and galaxies; the benefit being more apparent when imaging these types of objects. Extra-wide and multi-band filters are well suited for mild-to-no light pollution, for viewing and imaging of all types of deep-

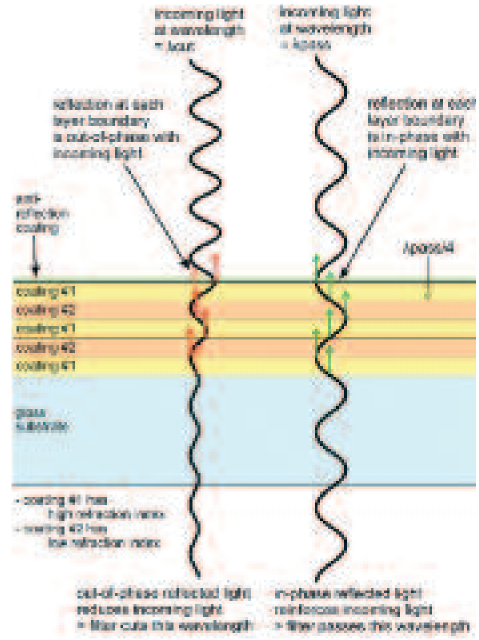

Figure 3. How Interference Filters Work: At each interface between filter layers, some light is reflected. The reflected light interacts with the incoming light, attenuating some wavelengths and amplifying others as defined by the layer thicknesses.

sky object.

Note that the benefit realized by using a deep-sky filter on targets like reflection nebulae, clusters, and galaxies is much less than for emitting type nebulae. The reason is that objects like clusters and galaxies are broad-spectrum (i.e. white light) emitters, and some of their emission is cut by the filter along with the light pollution. Emitting-type nebulae have emissions only in the desirable wavelengths that deep-sky filters are designed to pass, so all or most of their emission gets to your eye.

To decide what filter to buy, you need to ask yourself the same four questions I asked myself: What do I want to look at, what telescope will I use, where will I observe from, and how much am I willing to pay? The most common application of deep-sky filters is emission-type objects, but some astronomers, including myself, have had a small amount of success using them for reflection nebulae, clusters, and galaxies. Knowing what objects you wish to observe will go a long way to helping

Figure 4. Effect of Deep-Sky Filters On M42: These images illustrate the impact of a range of different categories of deep-sky filter on the emission nebula M42. As the width of the band pass becomes narrower and narrower, more light pollution is filtered out, and the contrast between background and nebula is increased. In addition, star brightness is reduced, further increasing contrast in the nebula.

you down-select to at least a filter category. Lists of deep-sky objects and what filter is best to use can be found online at many websites, including my own Abbey Road Observatory website (karmalimbo.com/aro/).

The type of telescope you have affects what filter you should choose, with the parameter of concern being aperture. Deep-sky filters attenuate a large percentage of the light coming through your telescope, making some limited to use only on larger-aperture telescopes.

Filter performance is also affected to a lesser extent by telescope focal ratio. This is due to the filter's spectral response shifting in wavelength depending on the angle of the light rays passing through it. Light passing through the filter on an angle has the same effect as increasing the thickness of the filter layers. Thus, a fast focal-ratio telescope would have poorer light-pollution rejection on the outer edges of the view when compared to the middle. This effect becomes important when using filters with narrow pass bands such as Hβ or OIII. Coincidentally, the phenomenon

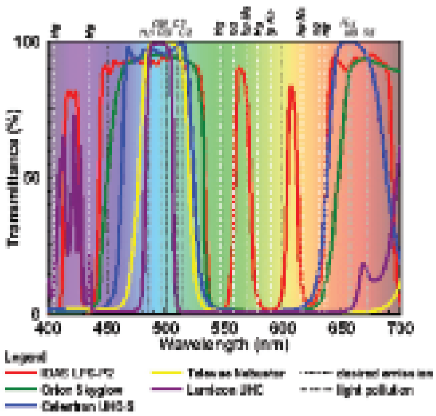

Figure 5. Example of Data Available from Manufacturers: Most manufacturers of deep-sky filters provide spectral transmissivity data for their products, however, the buyer needs more information to make a properly informed purchase.

is used constructively in tunable Hα filters for solar observation.

Deep-sky filters are designed to eliminate light pollution. Therefore, if you are lucky enough to observe from dark skies, you may not need a deep-sky filter at all. If you live in the suburbs of a large city, maybe you only need a multi-band or wide-band filter. Likewise, you should consider that deep-sky filters can also improve your dark-sky view of faint nebulae by reducing the brightness of other neighboring objects, such as stars.

The final question to answer is: How much are you willing to pay? The old adage, "you get what you pay for," seems to apply to deep-sky filters. The most expensive filters do tend to also be the best performers and have the highest quality.

Category	Prerequisite	Application	%SLT	Min. Aperture
O-III Group A	Allow both doubly ionized Oxygen wavelengths to pass	View emission/planetary nebulae & supernova remnants under heavy light pollution	12-27	5.5" (140mm)
O-III Group B	Allow only one doubly ionized Oxygen wavelength to pass	Image emission/planetary nebulae & supernova remnants	5-11	10" (254mm)
H-beta Group A	Pass H-beta wavelength with >90% transmission	View faint emission nebulae, with or without light pollution	10-13	8" (203mm)
H-beta Group B	Pass H-beta wavelength with <90% transmission	Image faint emission nebulae	4-7	11.5" (292mm)
Narrow Band	H-beta + O-III pass band is <35nm wide	View & image emission/planetary nebulae & supernova remnants under moderate-to-no light pollution	22-33	4.5" (114mm)
Medium Band	H-beta + O-III pass band is >35 but <50nm wide	View & image emission/planetary nebulae & supernova remnants under moderate-to-no light pollution	33-43	3.5" (89mm)
Wide Band	H-beta + O-III pass band is >50 but <70nm wide	View emission/planetary nebulae & supernova remnants under mild-to-no light pollution; image all deep-sky objects	50-61	2.5" (64mm)
Extra Wide Band	H-beta + O-III pass band is >70nm wide	View or image all objects under mild-to-no light pollution	59-73	no limit
Multi Band	More than two major pass bands in the visible range	View or image all objects under mild-to-no light pollution	51-74	no limit

Table 1. Deep-Sky Filter Categories: Deep-sky filters can be organized into nine categories based on their spectral transmissivity curves. Each filter category has an application for which it is best suited, as well as a minimum recommended telescope aperture.

That does not mean, however, that less expensive filters won't fill your needs. As with any piece of hardware, be sure to ask around your local astronomy group or online forums before you buy.

Additional information, including spectral transmissivity data for all filters and application to deep-sky objects, is available by contacting me at: karmalimbo@yahoo.ca. ATT

Manufacturer	Full Name	Category	% Luminous Transmissivity	
			Photopic	Scotopic
1000 Oaks	LP-1 Broadband	wide band	16.8	50.6
	LP-2 Narrowband	narrow band	9.3	26.5
	LP-3 O-III	O-III A	4.5	11.8
	LP-4 H-beta	H-beta A	4.2	10.8
Andover Corporation	O-III	O-III A	4.4	14.2
	3 Channel Narrowband Nebula	narrow band	12.5	32.9
Antares	Anti-Light Pollution, Broadband	wide band	26.0	59.6
Astro Hutech	IDAS O-III	O-III A	7.3	16.2
	IDAS H-beta	H-beta A	2.6	10.2
	IDAS Light Pollution Suppression p1	multi band	46.3	73.5
	IDAS Light Pollution Suppression p2	multi band	44.9	72.7
	IDAS LPS v3, Narrow-Band Nebular	wide band	22.5	54.3
	IDAS LPS v4, Narrow-Band Nebular	wide band	20.6	54.1
Astronomik	O-III	O-III A	6.6	20.5
	O-III CCD	O-III A	6.2	20.9
	H-beta	H-beta A	2.5	12.6
	H-beta CCD	H-beta A	2.8	11.8
	Ultra High Contrast	medium band	11.8	33.6
	Ultra High Contrast - Economy	medium band	23.9	42.5
	"Clear Sky"	extra wide band	31.1	67.5
	"Clear Sky" CCD	extra wide band	24.3	65.8
Baader Planetarium	O-III Visual Nebula	O-III B	2.0	6.5
	H-beta Narrowband CCD	H-beta B	1.1	5.4
	UHC-S Nebula	wide band	22.5	54.7
Burgess Optical	Broadband Nebula - Light Pollution Reduction	wide band	26.9	47.7
Custom Scientific	Narrowband O-III	O-III B	1.5	4.8
	Narrowband H-beta	H-beta B	0.8	4.3
	Multiband H-beta / O-III / H-alpha	narrow band	5.5	21.5
DGM	High Performance O-III	O-III B	10.4	10.7
	Narrow Pass Band Nebula	narrow band	12.3	22.6
	Very High Throughput Nebula	medium band	14.1	33.3
	Galaxy Contrast Enhancement	extra wide band	33.4	67.7
Denkmeier Optical	Hi Def O-III	O-III B	2.0	7.8
	Hi Def Ultra High Contrast	medium band	10.7	38.8
	Hi Def Planetary	special A	52.8	54.3
FLI	O-III 8nm	O-III B	1.9	6.1
Lumicon	O-III	O-III A	3.8	12.6
	H-beta	H-beta A	2.4	10.1
	Ultra High Contrast	narrow band	7.0	24.8
	Deepsky	wide band	23.8	60.6
Meade	O-III	O-III A	6.7	16.7
	Narrowband Nebular	narrow band	8.9	28.1
	Wideband Nebular	medium band	10.2	37.8
Omega Optical	OIII Narrow CCD	O-III B	1.7	5.6
	Hb Narrow	H-beta B	4.1	6.8
	Hb&OIII Nebula II	wide band	20.2	49.4
	Hb&OIII Nebula	medium band	12.0	34.3
	Hg&Na Skylight Reject	extra wide band	52.5	72.8
	Colour Enhancing LPF	multi band	50.4	50.9
Optec Inc.	O-III	O-III B	3.2	9.7
	Deepsky	extra wide band	33.6	59.4
Orion	O-III	O-III A	4.2	13.8
	H-beta	H-beta A	1.8	9.5
	Ultrablock	narrow band	8.7	26.5
	Skyglow Broadband	extra wide band	26.5	64.8
	Skyglow Imaging	multi band	61.9	68.5
Sirius Optics	Nebula	medium band	17.7	41.1
TS Optics	O-III	O-III B	3.0	9.9
	Ultra High Contrast	narrow band	5.9	22.2
Televue Optics	Bandmate O-III	O-III A	9.7	27.3
	Bandmate Nebustar	medium band	14.9	42.5

Table 2. Deep-Sky Filter Manufacturers: There is a long list of deep-sky filter manufacturers, each with a filter that is subtly different from those of its competitors. Those listed here are ones that I could find published spectral transmissivity data.