Planetary Filters

Image 1 - Available Spectrum of Colour Astronomy Filters:
The standard set of planetary filters available today originates from Wratten colour filters made for film photography.

Part 2 of an Introduction to Astronomical Filters

By Jim Thompson

Probably the least explained but most common accessories to be found in telescope cases are planetary filters. Known also simply as colour filters, they have been in use for many years by astronomers for improving the contrast of features when viewing planets and to a lesser extent the Moon. The question I ask is why? Why does one filter work better than another? Do I need three shades of red? Why are there no pinks? What's the difference between violet and indigo? I went on a search for the answers to these questions and many others, the result of which I am sharing with you all in this second part of a multi-part article on astronomical filters.

Colour filters used in astronomy find their origin in film photography. Colored gels and later colored glass filters have been used for colour separation or correction in film photography since colour photography began in the late 1800s. Very soon after the invention of colour photography, a British inventor named Frederick Wratten developed a standard system for defining and producing colour

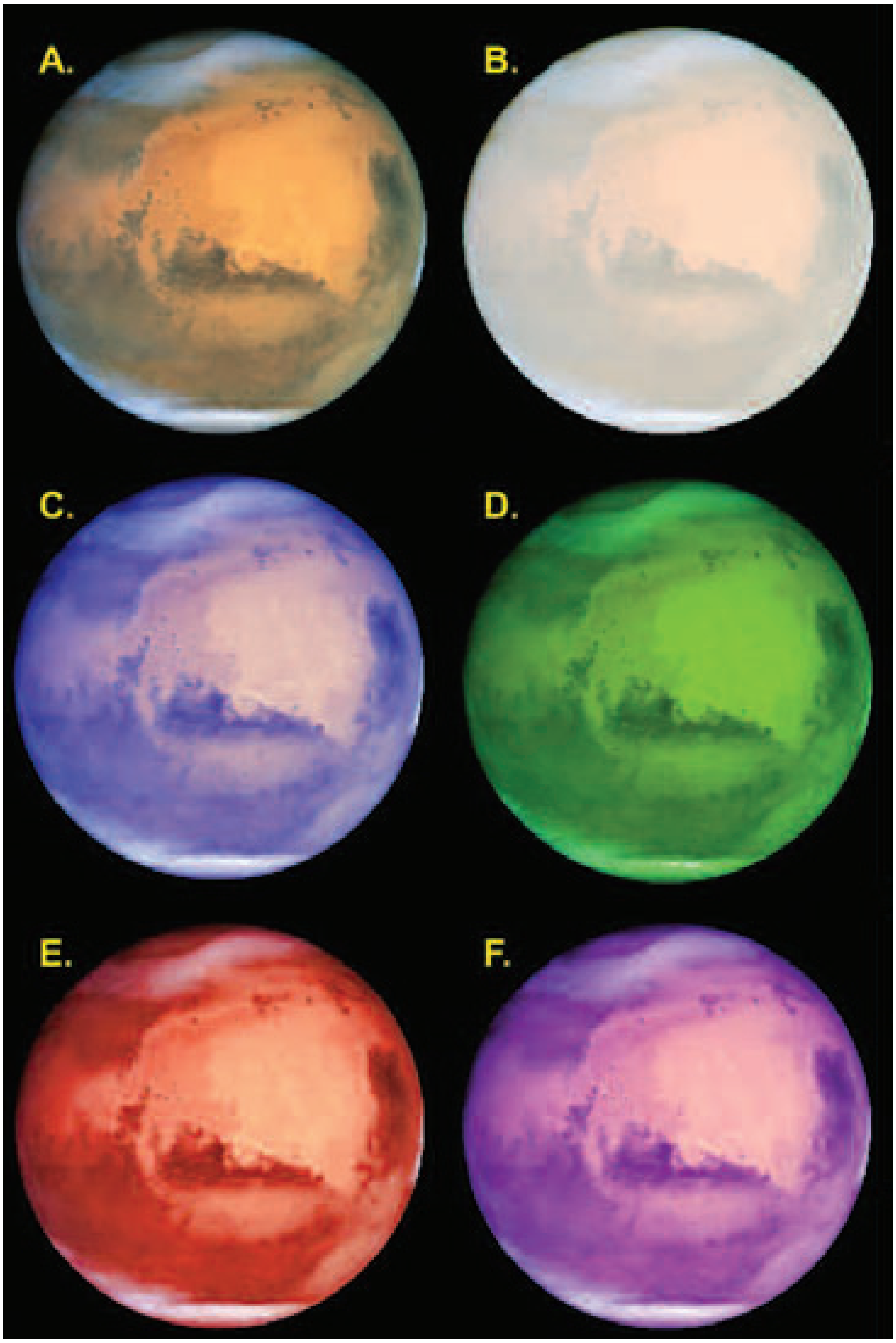

Figure 2. How Filter Colours Affect a Planet's Appearance: In this computer simulation, the effect of colour filters on the appearance of Mars is shown. Image A is the natural appearance of the planet as observed from space; Image B is how the planet generally looks through an amateur telescope; Image C is with a blue filter applied, highlighting clouds and polar caps as well as improving contrast; Image D is with a green filter, doing little to improve the view; Image E is with a red filter, greatly increasing contrast, but cutting out clouds and polar caps; and Image F is with a magenta filter, combining the benefits of both a blue and red filter. Original Mars image from HST.

filters. In 1912 Wratten and his partner sold their business to Eastman Kodak, a company that produces "Wratten" filters to this very day. The numbers often used to identify colour astronomy filters refer directly to the Wratten filter colour standard.

Today there is a pretty much standard set of inexpensive filters available for astronomical use. They can be subdivided into three groups based on the general shape of their spectral transmissivity curve; i.e., how they respond to different wavelengths of light. Blue filters (Wratten Numbers 82, 80, 38, 47), are broad bandpass filters with their peak response somewhere around 450nm. Greens (Wratten Numbers 56, 11, 58) are also broad bandpass filters, except their peak response is around 525nm. Yellow (Numbers 8, 12, 15), orange (Number 21), and red (Bumbers 23, 25, 29) filters all have the same basic response shape, a high-pass filter with the cut-off wavelength defining the colour from light yellow (490nm) to dark red (620nm).

There are also a number of miscellaneous astronomy filter colours available which can be useful: Number 1A skylight (a UV filter), Number 30 magenta, and Number 47H light violet (from Hirsch Optics). I personally have also tried some additional filters available only for photography and had good results: CC30M magenta, Number 81 light brown, and Number 85 light orange.

Finally, there are neutral density filters that cut the amount of light getting through the filter uniformly at all wavelengths, making them grey in colour. A variable polarizing filter is a practical alternative to neutral density filters since the user can adjust the amount of light getting through just by rotating the two parts of the filter relative to each other.

All of these filters do the same basic thing: They remove some or all of a particular range of colours in order to highlight the remaining colours. All basic Wratten-type colour filters are absorption

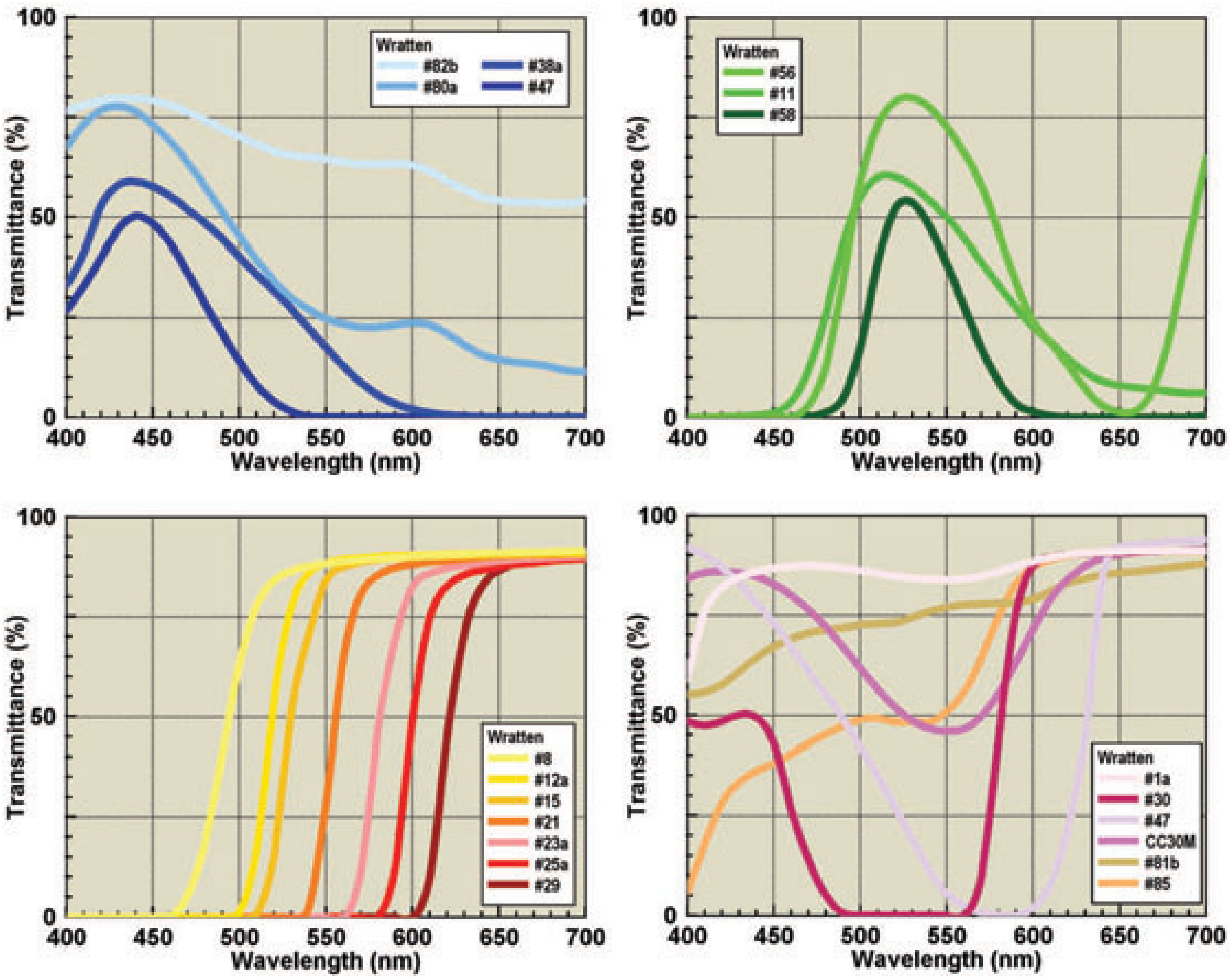

Figure 3. Spectral Transmissivity of Planetary Filters: Colour filters for astronomy can be grouped based on their general spectral response shape: blues, greens, and yellow-reds. Some additional Wratten filters are worth trying if available such as the violet-magentas and orange-browns.

type. They have a layer of some substance dissolved in gelatin or other carrier that is sandwiched between layers of clear glass. Some colour filters dissolve the absorbing substance in the actual glass itself. Either way, the filter works by absorbing only certain wavelengths of light and passing the rest. For example a Number 25 Red filter absorbs essentially all the wavelengths of light from blue up to green, making those colours in an image appear black but passing the reds unaffected.

In Part 1 of this series, I suggested that a good way to compare the performance of filters is by looking at their spectral transmissivity. Manufacturers of planetary filters do not typically have this data available. Luckily the data is available if we look back to the original Wratten filter standard. The standard includes tables of spectral transmissivity data, as well as Photopic Luminous Transmissivity (percent PLT), a number that filter manufacturers do quote.

While digging into colour filters I became curious about how well the filters made for astronomy matched the original Wratten standard. I devised my own make-shift spectrum analyzer using commercially-available laser pointers in six different wavelengths: 405nm (purple), 473nm (blue), 532nm (green), 589nm (yellow), 635nm (red), and 650nm (dark red). I used a relatively inexpensive digital light meter to measure the lux from each laser with and without a filter in between. Dividing the with-filter measurement by the without-filter measurement (x100) gave me the percentage of transmittance

Colour	Wratten #	Specification %LT		My Measured %LT			Notes
		Photopic	Scotopic	Photopic	Scotopic	Manuf. Of Tested Filter	
lt pink	1a	86.0	85.7	88.4	90.6	Celestron	different
lt pink	1a	86.0	85.7	87.1	85.9	Kakon	match
dk violet	47	2.9	17.6	17.0	39.5	Hirsch	actually lt. violet
dk violet	47	2.9	17.6	0.1	1.9	Meade	different
lt magenta	cc20m	67.5	70.7	68.5	67.8	Tiffen	match
lt magenta	cc30m	58.6	62.7	59.3	62.2	Tiffen	match
magenta	cc40m	50.6	55.3	50.4	54.8	Tiffen	match
lt blue	82a	72.5	76.6	71.8	76.6	Vivitar	match
lt blue	82b	64.3	70.6	61.7	81.1	Hirsch	actually cyan
blue	80a	27.8	46.0	24.6	54.4	Hirsch	different
dk blue	38a	16.4	37.8	1.9	14.9	Meade	different
green	56	52.1	45.4	40.4	35.6	Meade	different
yellow-green	11	39.6	38.8	67.8	62.0	Hirsch	actually lt. green
yellow-green	11	39.6	38.8	42.3	39.4	Kodak	match
dk green	58	23.3	22.4	22.1	19.4	Hirsch	different
lt yellow	8	83.7	52.9	91.7	85.6	Meade	different
yellow	12a	75.3	31.1	86.3	65.2	Hirsch	different
dk yellow	15	67.6	22.1	75.7	15.9	Lumicon	match
lt yellow	cc20y	89.4	79.9	88.2	78.9	Tiffen	match
lt brown	81a	82.2	78.5	81.4	76.8	Hoya	match
lt brown	81b	77.1	72.2	82.5	73.3	Vivitar	match
lt orange	85	63.5	47.3	73.6	53.0	Vivitar	different
orange	21	47.5	7.7	34.5	9.2	Hirsch	different
lt red	23a	27.3	1.8	33.7	3.0	Hirsch	match
red	25a	15.8	0.4	14.4	0.4	Hirsch	match
dk red	29	7.1	0.1	7.2	0.1	Lumicon	match
lt red	cc30r	56.7	50.7	56.7	45.5	Vivitar	match
Orion Mars		29.2	52.6	-	-	-	dk. magenta
Denkmeier Optical HD Planetary		52.8	54.3	-	-	-	brown
Baader Planetarium Moon & Sky Glow		55.3	72.3	-	-	-	lt. violet
Sirius Optics PC1		40.7	35.9	-	-	-	dk. brown

Table 1. Colour Filter Test Results: All the filters listed here were tested using a low-tech laser pointer-based six-band spectrum analyzer. The measured data was used to generate corrected spectral transmissivity curves that were in turn used to calculate percentage LT values.

at that wavelength.

A collection of both astronomical and photographic filters were tested. Of all the astronomical colour filters tested, only the onw brand seemed to be consistent with the Wratten specification. All others made specifically for astronomy were largely different from the standard. The photography filters on the other hand were all a very good match to the standard. A useful outcome from my testing was a value for the photopic (light adapted) and scotopic (dark adapted) percent LT (percent PLT and percent SLT respectively) for each filter, calculated from the measured spectral transmissivities.

In the end, much of the benefit from planetary filters perceived by the observer is subjective. One observer may like the added contrast from using a colour filter, while another may dislike the unnatural hue that accompanies using the filter. A complete list of what colour to use with each planetary feature is too lengthy to include here, but there are numerous lists available online or in astronomy books that can provide guidance to the amateur astronomer.

From my own experience, observers need to do their own experimentation to determine what they like best. If you ask around your local astronomy club, you are sure to find someone willing to lend you some colour filters to try. I have found it useful to have at least one of each basic type of colour filter handy (blue, green, red), plus a yellow for cutting achromatic fringing, a magenta for Mars, and a variable polarizer for very bright targets like the Moon or Venus.

I have also had very good success with the Baader Planetarium Moon & Skyglow filter on all planets. I encourage you to try your telescope with any of the colour filters mentioned here, however it is important to note that all filters reduce the total amount of light getting to the eye. This means that a filter with a small percentage SLT is likely not going to provide a very good view through a small aperture telescope. A good rule of thumb is to use the following relation: Minimum Aperture (in mm) = 0.02*(%SLT - 100)2.

For example, planetary filters will provide the best results with an 80-mm refractor for percent-SLT values greater than 37 percent. Since absorption type filters are not sensitive to the angle of light through them, typical colour filters can be used at any focal ratio.

Finally, there are a few planetary filter outsiders that bear mentioning. They are a cross between colour filters and the specially engineered interference-type filters that will be discussed in Part 3 of this series. Sold by companies like Televue, Baader Planetarium, and Orion, they can provide superior views of planets when compared to simple colour filters, but again the results are subjective. They are more expensive than simple colour filters, so make sure you ask around or test them out before you buy.

More detailed results from my observations and tests, as well as complete lists of colour filter applications are available by contacting me at: karmalimbo@yahoo.ca.

Object	Recommend You Try...
Moon	variable polarizer (glare), yellow (daytime contrast)
Venus	variable polarizer
Mars	violets, magentas, oranges, browns
Jupiter	violets, magentas, oranges, browns
Saturn	violets, yellows, browns
all	Baader Moon&Sky

Table 2. My Filter Suggestions: I haven't had an opportunity to try every filter-object combo, but filter colours that have worked for me in the past are listed above.