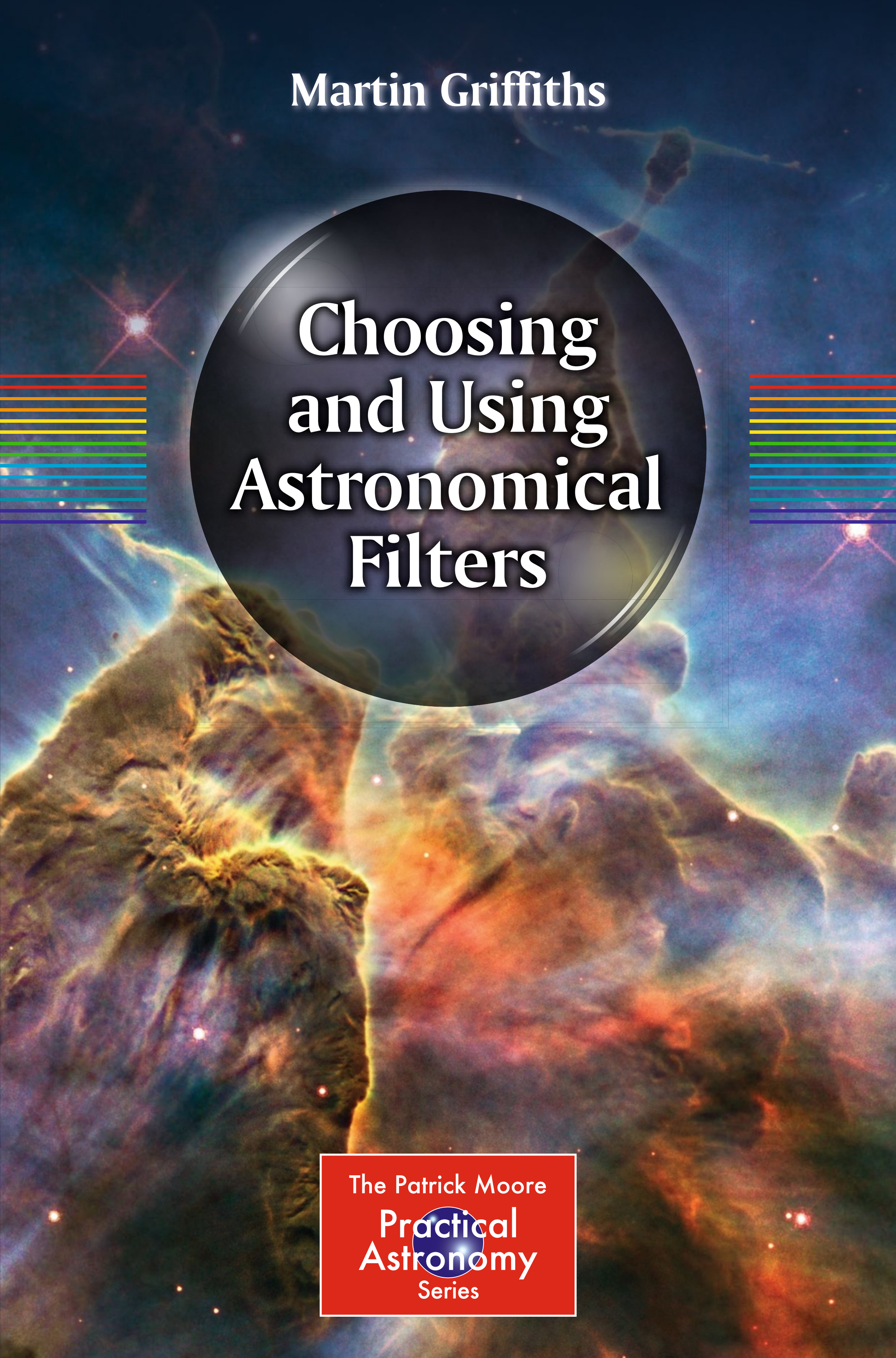

Martin Griffiths

Choosing and Using Astronomical Filters

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Globular cluster Messier 5 in Serpens. Image by Martin Griffiths courtesy of LCOGT

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Springer

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ISSN 1431-9756 ISSN 2197-6562 (electronic)
ISBN 978-1-4939-1043-4 ISBN 978-1-4939-1044-1 (eBook)
DOI 10.1007/978-1-4939-1044-1
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2014940529

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Cover illustration: The Carina Nebula photograph, credit: NASA, ESA, and M. Livio and the Hubble 20th Anniversary Team (STScI).

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This book is dedicated to:
Dena, Harry, Yoda and Gloria
All of them are stars in their own special way…

About the Author

Martin Griffiths is an enthusiastic science communicator, writer and professional astronomer. Over his career he has utilized history, astronomy and science fiction as tools to encourage greater public understanding of science. He is a recipient of the Astrobiology Society of Britain's Public Outreach Award (2008) and the Astronomical League's Outreach Master Award (2010). He also holds the League's Master Observer certificate and has written or contributed to over 100 published science articles for many journals. He is currently an astronomer and senior lecturer at the University of South Wales in the UK.

He was one of the founding members of NASA's Astrobiology Institute Science Communication Group, which was active in 2003–2006. He also managed a large ESF program in Astrobiology for adult learners across Wales in 2003–2008. Since then he has been involved in promoting adult education, assisting in the development of a new observational astronomy award at the University of South Wales, and various other projects, including initial consultation on the setup of an educational observatory in Andalucia, Spain, now run by Andy Burns and Kath Griffiths.

He is a consultant to the Welsh Government through his involvement with the Dark Sky Discovery initiative, enabling public access to dark sky sites in association with Dark Sky Wales, Dark Sky Scotland and Natural England. He was also responsible for surveying the sky quality of the Brecon Beacons National Park in their successful bid to gain International Dark Sky Association Dark Sky Reserve status in 2013 and is a consultant to the Hay Tourism Board for their annual dark sky festivals.

Martin is a Fellow of the Royal Astronomical Society; a Fellow of the Higher Education Academy and a member of the Astrobiology Society of Britain; the European Society for the History of Science; the British Astronomical Association; the British Science Association; the Webb Deep-Sky Society; the Society for Popular Astronomy and the Astronomical League. Martin is also a local representative for the BAA Campaign for Dark Skies and lectures in astronomy to anyone who will listen.

Preface

Taking a quality image of the night sky used to be a daunting task for any photographer and was a valid achievement in its own right. Capturing the beauty of the astronomical objects involved real skills.

In the past, achieving this was always something that engendered pride in the photographer and the admiration of peers. But with the advent of inexpensive digital SLR and CCD cameras, achieving good quality images is now within reach for all astronomers whatever their experience is and is relatively simple to accomplish. And, there are filters that can help them get even better pictures.

Alternatively, there are many amateur astronomers out there who still prefer to observe astronomical objects directly but use filters to enhance their visual acuity and render the objects visible via the medium of sketching. Coloured filters that enhance the visibility of features in planetary atmospheres and surfaces are still commercially available and are regularly offered with some telescopes. “Moon” filters and “solar” filters are still making an impact on new generations of observers who wish to know the sky in as much visual detail as possible.

The manufacturing and supply of filters for astrophotography and visual observing is now a large industry. The purpose of this book is to introduce these filters and give some basic advice on their use and application. This book will serve as a reference point for the observer who wishes to gain experience in CCD or DSLR imaging or in simply looking for faint detail in heavenly objects.

A wealth of material exists on the Internet, from the purchasing of filters through to information on the properties of various astronomical filters. By making these disparate items of information easily accessible in one handy book, the author hopes that the matter conveyed here will be a ready guide to the application and use of filters in visual astronomy and astrophotography.

This work cannot by its very nature as a book keep up with everything available in the market, as new technology or enhancement of current materials goes on continuously. However, it will be a useful source for how to use and properly apply filters to the task at hand. In addition, we have supplied a tempting list of objects to observe or image with such filters. This selection of Astronomical Objects takes into account both the size of the observer's telescope and his or her geographical location, as many Messier objects are included and bright NGC objects across both the Northern and Southern Hemisphere.

The photographs, unless otherwise indicated, were taken by myself.

I hope that you find this book to be a useful addition to your astronomical library.

Glyntaf, United Kingdom Martin Griffiths
2014

Acknowledgements

When I started observing and photographing the night sky, I never thought that many of the things I had seen and imaged could become the focus of a book. As a professional astronomer who started as an amateur observer, I am aware of the importance of filters in astrophotography and visual work. It was a chance conversation with Dr Mike Inglis at Springer that became the foundation of this book and I thank him for his trust and support.

I would like to thank the Las Cumbres Global Observatory Global Telescope (LCOGT) and the Faulkes telescope team for their assistance and access to the Faulkes telescopes and archive to provide the images, especially Dr Ed Gomez and Professor Paul Roche for their help and credit for the images. I would also like to thank Nick Howes and Andy Burns of the Wiltshire Astronomical Society for their contributions in supplying advice and some of the images. I would also like to thank the editorial staff at Springer for their helpful comments and suggestions.

Unless otherwise acknowledged in the text, all photographs have been taken by the author and are copyright as are the images of the LCOGT and Faulkes telescope archive and those of Nick Howes and Andy Burns.

Contents

Chapter 1

A Brief History of Astronomical Imaging

The activity of photographing and imaging the objects in the sky has an illustrious but very short history. For centuries after the invention of the telescope astronomers relied upon their eyes to record astronomical details, with wildly varying results.

The problem with astronomical observing at the time of the early nineteenth century was simply this: large telescopes were readily available, but recording any image required an astronomer at the eyepiece who would then sketch the image visible through the telescope.

This technique inevitably led to differences in appearance of the same objects drawn by various observers, since the size of the telescopes may have differed, as well as seeing conditions and elevation of the object. Above all, the dependence on the artistic ability of the astronomer rendered objects liable to disparity in appearance due to the diverse ability of the observer's hand–eye–brain coordination and a tendency to over-exaggerate the image with details that were barely visible, yet rendered out of proportion to their actual values. It was essential that a standard tool be found to record astronomical images as faithfully as possible.

From the first tentative steps into photography made by pioneers such as Louis Daguerre, William Fox Talbot and John Herschel it was realized that is this process could be improved and perfected, that it would make a very useful technological tool for astronomers looking for an absolute standard in observatory work. However, most photographic processes during the early nineteenth century were too slow for astronomical purposes. Daguerre's original process was painstakingly slow, with a polished silver layer on a copper base being exposed to iodine vapor and thus creating an image of silver iodide that then had to undergo further processing. William Fox Talbot made a valuable contribution by substituting the copper base for paper. It was John Herschel's seminal paper, however, "Note on the art of Photography, or The Application of the Chemical Rays of Light to the Purpose of

M. Griffiths, *Choosing and Using Astronomical Filters*, The Patrick Moore Practical Astronomy Series, DOI 10.1007/978-1-4939-1044-1_1,

Pictorial Representation," to the Royal Society on March 14, 1839, that made everyone sit up and explore the possibilities of this new technology.

Astronomical application followed shortly thereafter. The first daguerreotype of the Moon was obtained in 1840 by the American J. W. Draper in a 20-min exposure (the plate was later destroyed in a fire), and the Sun was photographed by Leon Foucault in 1845. The first star to be recorded photographically was captured in 1850 by the astronomer William Cranch Bond at Harvard, with the star Vega as his subject, and in 1851 the Sun's corona was photographed for the first time by August Busch at Konigsberg observatory. Nevertheless, it was obvious that the photographic process needed a boost to obtain faster speeds.

A year after Bond took his starry photograph; the French inventor Gustav le Grey invented the wet collodion process that remarkably increased the speed and efficiency of photographic emulsions. The problem was that the film had to be prepared very carefully and used immediately, as the materials could not be stored. This would have led to observatories becoming large photographic shops in their own right by using chemicals such as sulfuric acid and potassium nitrate, which were then reacted on a small quantity of cotton to create nitrocellulose. The whole was then mixed with alcohol, bromide, cadmium, ammonia and iodine and then spread onto glass plates for immediate use. The plate was then developed in silver nitrates and silver iodides, making the whole process a nightmare of preparation requiring the use of noxious chemicals by a large staff specially trained in this type of work.

Unsurprisingly, the wet collodion process did not catch on in astronomy despite being suggested for this use by the British photographer Frederick Scott-Archer. The system was improved considerably by the Welsh landowner John Dillwyn Llewellyn in 1856, who invented the Oxymel process that enabled the plates to be stored for longer, and it was with this improved system that he and his daughter Thereza Took the first photograph of the Moon from Wales. Cementing the relationship with astronomy, Thereza later married the grandson of Neville Maskelyne, the fifth Astronomer Royal, although her astronomical pursuits did not continue after her marriage.

The collodion process did have some success under the application of Warren de la Rue, who took several exquisitely detailed pictures of the Moon during the years 1851–1856. de la Rue's great contribution to celestial photography came with his invention of the photoheliograph, which he presented to the Royal Society. This device enabled him to obtain photographs of the Sun, and in 1858 regular work photographing the Sun was inaugurated at Kew before the process was moved to the Royal Observatory at Greenwich in 1873. In 1860 de la Rue took the photoheliograph to Spain to view the solar eclipse of that year, and the resultant photographs proved beyond doubt that the prominences seen during former eclipses were definitely associated with activity on the solar surface.

Warren de la Rue's contribution to celestial photography in the nineteenth century put imaging at the forefront of astronomical techniques, though by 1873 he had given up photography due to ill health. He donated his telescopes and instruments to the Oxford college observatory and ensured the success of astronomical photography by donating a 13-in. refractor to the college to enable it to take part in the international photographic survey of the heavens that provided data for the French astrographic catalog detailed below. Thanks to his wonderful contributions to this emerging craft, a crater on the Moon is named in his honor.

Advancing Technology

A better dry process was invented that enabled photographers and astronomers to store the plates until ready for use. In 1871 the British inventor Richard L. Maddox produced a dry process using silver salts, and 4 years later J. Johnson and W. Bolton made the first true negative emulsion for photographic use. This system, using the first good photographic quality dry plates, was used for astronomical purposes by the husband and wife team Sir William and Lady Margaret Huggins in 1876, though Huggins and his assistant, the chemist William Miller, had used the wet collodion process to obtain spectrograms of the stars Sirius and Capella back in 1863. In America the irrepressible Henry Draper photographed the spectrum of Vega directly and obtained a good image of the absorption lines. It was becoming obvious to all what an important astronomical tool photography could be.

By 1878 the dry astronomical plate became a widespread medium. C.E. Bennett combined the salts with a neutral medium and produced faster dry plates for astrophotography. The next year (1879) George Eastman (of Eastman Kodak fame) built a machine that would coat glass plates with silver salts at a prodigious rate, effectively mass producing a quick standardized process of photography with faster emulsions ready for commercial use.

That same year the first quality photographs of Jupiter and Saturn were obtained, and in 1881 the first photographs of a comet (Tebbutt's comet) were made. The Orion Nebula had been photographed in 1880 by Henry Draper and revealed the power of the new photographic tools by giving the most detailed look at the gas and individual stars of the nebula yet produced. So good was the dry plate process that the first spectra of stars were photographed, again by Draper, enabling studies to be done at leisure.

Photography in astronomy took a quantum leap forward in 1899 when Julius Scheiner working at the Potsdam Observatory photographed the Andromeda Galaxy—or what he at the time referred to as a "spiral nebula." The exposure was 7.5 h long! By this time the observatory at Harvard was already completing its first photographic surveys of the sky, detecting stars down to the eighth magnitude.

The only problems with the early dry systems were the graininess of the images. With grain sizes within the solutions being almost 10 m there were limits to the details obtainable in any image. Notwithstanding this problem, the first survey of the starry sky implemented as an international project was begun in France in 1887 by Amedee Mouchez, the director of the Paris Observatory. The *Astrographic Catalogue* enabled stars to 11th magnitude to be recorded to provide an absolute standard reference for all astronomers. The dry plate process had come of age.

Coupled to the giant reflectors being built in the United States at the beginning of the nineteenth century, photography as a standard reference medium was becoming the pinnacle of astronomical recording.

Problems with graininess and faster speeds were eventually overcome by ongoing research until the whole photographic field was overtaken by CCD technology in the late twentieth century. Photography took a great leap forward with the development of large reflector telescopes in the early twentieth century and the production of purpose-built Schmidt cameras to obtain wide field images of the sky.

It was quickly realized that the color of an object was related to several astrophysical properties that were important, with some unexpected relationships being uncovered between various parts of an astronomical object, including differences in gas composition or dust content. Up to this point most astronomical photographs were monochrome, so to untangle these relationships a system of full color imaging had to be found.

Color photography is almost as old as the monochrome process itself. It was the physicist James Clark Maxwell that suggested three-color photography in the red, green and blue bands in 1855. However it was not obvious how this could be achieved until Thomas Sutton used a color separation process in 1861 that involved photographing a ribbon in monochrome through three colored filters—red, green and blue and combining the final image. However the process was not sensitive enough to red light, and Sutton's pioneering experiment was forgotten before it re-emerged in a reformatted technique used by the Lumiere brothers in 1903. Their process involved a three-filter system of red, green and blue dyed potato starch underlain with photosensitive silver halides to produce what they termed autochrome plates. This was a popular addition to ordinary photography up until the 1930 advent of the subtractive color film, but it was still not sensitive enough for astronomical use.

The inception of subtractive color film was a revolution in photography. The film layer was now a sandwich of three layers, each sensitive to red, green or blue areas of the spectrum and could then be processed, enlarged and turned into a photographic positive in a relatively easy chemical process. During the 1970s and 1980s color reversal film (slide film) and color negative film became a bit hit among amateur astronomers as the better technology, decreasing grain size and increasing sensitivity, coupled to driven telescopes and mounts, made astrophotography accessible. However for the professionals the three-filter system originating with James Clark Maxwell became the preferred method of astronomical photography, as it enabled them to produce standard images that revealed the subtleties of the underlying chemistry of astronomical subjects.

Once again Eastman Kodak was in the vanguard of these developments. By 1937 the company was offering astronomers photographic plates using a variety of photographic emulsions that were sensitive to over 20 spectral ranges. These were sold to observatories worldwide along with the recommendations on their uses in the in-house booklet, *Photographic Plates for use in Spectroscopy and Astronomy.* All of these emulsions were monochrome and were to be used with the correct filters to render as correct an image as possible. Thus the development of filters and astronomical emulsions went hand in hand.

Color photography at observatories then followed the familiar pattern of taking a monochrome image through three filters with red, green or blue sensitive emulsions underlying the filters. The negatives would then be contact copied together to make a color positive and then enlarged to give a final color image that could be studied. Such techniques attained their apogee under the hand of David Malin at the Anglo-Australian Observatory, where Malin's techniques of color stacking and unsharp masking brought hitherto unseen detail out of astronomical objects.

Reciprocity failure, blue and red sensitivity on emulsions, infrared absorption and a host of other potential problems were improved upon, and new photographic techniques such as the use of gas hypersensitization, cold cameras and the introduction of unsharp masking and image stacking made astronomical imaging an art in itself. Looking back on much of this development it is surprising to realize that all this would be swept away in a few short decades. Such wonders as T-grain technology in tech pan 2415 and others of its ilk seem now consigned to the dustbin of history, but in their day they were a great addition to the astrophotographer's toolbox and were a wonderful hand-down from the development of professional astronomical imaging and the evolution of chemical technology applied to photography.

CCD and DSLR Systems

The CCD, or charged coupled device, was invented at Bell Telephone laboratories by Willard Boyle and George Smith in 1969. Both were thinking of a chip that could store information for use in computers and were not thinking of imaging at that time, but by 1971 the image-processing power of the early devices became clear when they were demonstrated in national reconnaissance satellites in the mid-1970s. Due to their high efficiency at capturing photons of light they quickly became adopted by professional astronomy observatories worldwide and found application across a wide range of wavelengths from UV to infrared.

There are many CCD cameras on the market for novices and advanced amateur astronomers. Manufacturers such as SBIG (Santa Barbara Instruments Group), Starlight Express, Atik, Orion, Celestron and many others provide good quality cameras to suit most budgets. A typical example of a CCD camera is shown here in Fig. 1.1.

CCD cameras have a multitude of uses, from imaging an object to obtaining information and data through photometry, astrometry and spectroscopy. All require coupling to a computer, and most astronomers use laptops in the field or in purpose-built observatories to maximize the use of these excellent image capture technologies.

CCD cameras come in a bewildering array of chip sizes and shapes; one can have a square CCD chip containing 2,048 × 2,048 pixels or rectangular ones with pixel sizes varying from 1,500 × 800 and upward. Most professional CCD devices are enormous and have great sensitivity and resolution.

Fig. 1.1 Atik CCD camera

To obtain a full color image it is necessary to use a variety of filter systems with a typical monochrome CCD camera. Rendering the image through red green and blue (RGB) filters gives a natural color to most astronomical objects. However, as the sensitivity of CCD chips has increased so has the application to UV and infrared wavelengths, leading to CCD photography filters that cover these ranges. One would then have a set of filters covering UV between 320 and 400 nm (U), blue light between 400 and 500 nm (B), green or visible light at the center of the visible spectrum between 500 and 700 nm (V) red light and infrared light at increasing wavelengths from 800 to 950 nm (I), resulting in the combination of all these generally being referred to as UBVRI.

Ideally the observer who wishes to image the sky should be equipped with either a CCD camera or digital single lens reflex camera (DSLR). Choosing such equipment can involve a long process of comparison and getting advice from experts in the field, but such advice is well worth considering so as to avoid common mistakes. A DSLR is a versatile tool, and of course is very useful for photography outside that of astrophotography, whereas a CCD camera is not. There are many manufacturers, but the general consensus is to purchase either Nikon, Canon or Olympus cameras, as these manufacturers have a wide range of auxiliary equipment available such as lenses, T-mounts, adapters, focusing screens and filters. Although digital, these cameras follow a similar format as 35-mm film cameras in that their sizes, weights and controls are flexible, and they are easy to set and control once one has had some experience with them.

Fig. 1.2 Summer Milky Way in Hα

It is not our intention in this book to recommend any particular brand Excellent results can be had with all the above types; it is merely a choice of preference and cost. In addition to the camera, the observer will require a purchased cable release inimical to their camera system, to prevent shaking. If the observer intends to connect the camera to a telescope, then a T-mount and an adapter sleeve are also essential. Some suppliers provide readymade T-mounts fitted with a contrast or Baader or a Hα filter, depending on their prospective use. Conversely, several companies sell filters that fit over the front element of particular lenses for wide-field photography, which enables some spectacularly different pictures of objects such as the Milky Way, as can be seen in Fig. 1.2, where Andy Burns of the Wilshire Astronomical Society took an Hα shot of our galaxy in summer.

There are several advantages of the DSLR camera over that of the CCD, such as the quick response time of displaying the image, the amount of technical control over the camera by an experienced observer, the ability to take wide-field shots through a variety of lenses and the ability to vary the ISO ratings is an advantage. The lower thermal noise in a short exposure and the storage on an SD or CF card for later use make the laptop superfluous at the telescope and provide a good option in favor of a DSLR. However, on balance the sensitivity and range of a CCD camera and its cooled chip with small thermal noise in long exposures make the CCD camera a preferred tool among astrophotographers.

Filters for Astronomy

To provide these filters a specialist industry has grown up to serve both professional and amateur astronomers alike. The technology has enabled filters to be built that can target particular areas of the spectrum and look at narrow bandwidths or block out areas of the spectrum where extraneous external light could interfere with the observations. However these are not the only filters available, and many visual astronomers, especially in the amateur market, use colored filters to enhance their view of planets and some deep sky objects.

Again, it is not the intention of the author to recommend any particular filter or system of filters, as there are so many commercially available. As the reader will discover as one reads this book, filters can be object specific or generalized for photography. There are filters for the Moon, filters for the Sun and filters for the planets that can all be used for visual or photographic work. Broadband and narrowband filters for observation and imaging are ubiquitous in today's astronomy marketplace.

It is up to the individual to determine their field of study and to decide which, if any, filters to opt for. Visual observing, apart from observing the Sun, needs very little from a general viewpoint. Amateur astronomers who contribute greatly to fields of study such as planetary work regularly use filtration systems based on colored filters that have come to the fore for photographic use. Other astronomers will opt for narrow and broadband filters to perform imaging and use techniques that give so many today observatory-quality images at a fraction of the cost and time of obtaining images in the past from photography alone.

This author hopes that the following sections will enable readers to make a choice, or at the very least to be informed of the filter systems available today for their chosen craft.

Further Reading

Pedro Re (2009) History of astrophotography timeline. http://www.astrosurf.com/re/history_astrophotography_timeline.pdf

Royal Astronomical Society (2012) The history of astronomical imaging (specialist discussion meeting, January 2012)

Trow A (2006) Photography was Hijacked by astronomers. Astronomy Now Magazine (March 2006)

Chapter 2

Filters and General Equipment for Astronomical Observing

If you are an avid visual astronomer, it may come as little surprise to find that colored filters make a world of difference to your observing clarity, and their use brings out detail from the subtle shadings found on Solar System objects.

On occasion, a telescope manufacturer will include a set of colored filters along with the telescope you have purchased, although many amateur astronomers tend to ignore their use, and the filters just gather dust as the telescope becomes well used. If the filters are of good quality then they can be used to enhance the view of some objects quite easily after a little patience and trial.

Colored filters with a wide bandpass are a very useful tool and should not be abandoned simply because one has not yet used them or has had a little practice. They can make a great difference between seeing or recording an object or missing it completely in the sky background. Many planetary observers rely on filters commercially available, as they report that they really do make a difference in seeing faint details and also assist with reducing glare, as many of the planets and especially the Moon are very bright and suffer from the enormous contrast between their sunlit surface and the dark background sky.

Filters for Visual Observation

Astronomical filters for visual observing are a specialized piece of the astronomer's armory. They work by blocking a specific part of the color spectrum, usually an "opposite color," which then leaves the remaining wavelengths a little more open to view. The color of the filter lets through wavelengths that correspond to that color while darkening or providing more contrast to wavelengths outside of the filter

M. Griffiths, *Choosing and Using Astronomical Filters*, The Patrick Moore
Practical Astronomy Series, DOI 10.1007/978-1-4939-1044-1_2,

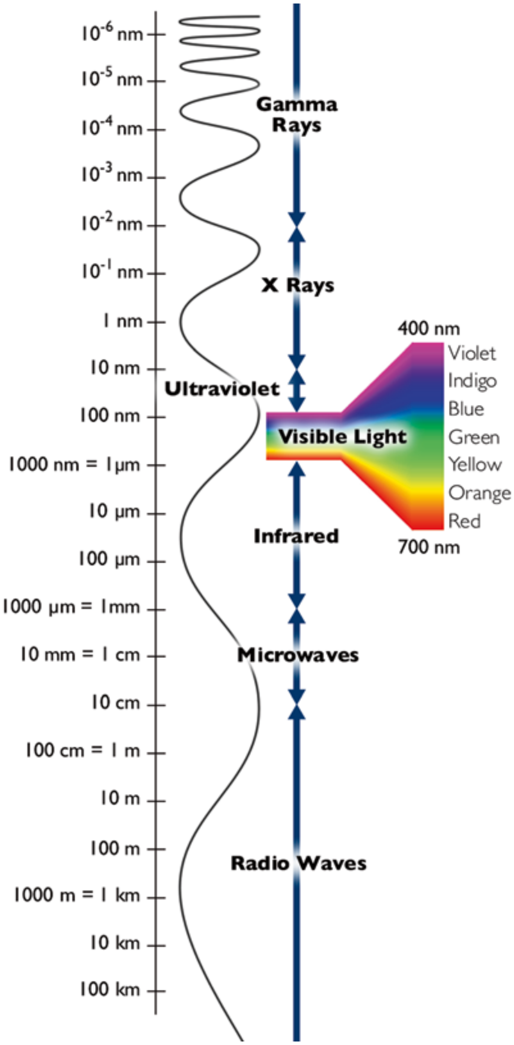

Fig. 2.1 EM spectrum

range or blocking them altogether. The visual element of the electromagnetic spectrum can be seen from the accompanying Fig. 2.1.

As can be seen the visual part of the spectrum lies in a narrow range between 400 and 700 nanometers (nm), with blue at the shorter wavelengths and red at the longer. Using a red filter, for example, with a bandpass longer than 600 nm will block wavelengths of light short of 600 nm and will render such shorter wavelengths as black or at least darker and give increased contrast to details in an astronomical object. One must also remember that many of these details are subtle, and use of filters may enhance some features but render others almost invisible. It's a matter of trial and error.

The colored filters that will be mentioned shortly are best used on Solar System objects via visual observing. They do not necessarily work on CCD imaging systems outside of the BVR (RGB) range, and neither do they work for DSLR cameras unless used with the planets and augmented with skills in image processing. For deep sky work they also have their limitations until you get into the range of narrowband filters where the specific bandpass enables the photographer to build an image based on true color and wavelength rather than relying on color or BVR, as one would in terrestrial photography. Please note that the filters detailed below are largely for visual work only. We shall deal with the use of filters in photography in another chapter.

Wratten Filters for Lunar and Planetary Observing

Although there are several astronomical suppliers that provide these filters with generic names such as Meade, Agena or Orion, all such filters are evident by their color and are usually marked with particular numbers known as Wratten numbers, which allow the observer to choose which parts of the EM spectrum they are going to enhance in order to make planetary and lunar definition and contrast easier to discern through the eyepiece.

The Wratten system was developed in Britain in the early twentieth century by Fredrick Wratten and Kenneth Mees, who founded a company in 1906 that produced gelatin solutions for photography. Mees then developed gelatin filters dyed with tartrazine to produce a yellow filter, but soon developed other colors and a panchromatic process of photography. In 1912 they sold the company to Kodak at Harrow in England, and Mees moved to New York to found the Eastman Kodak laboratories there. In honor of his partner and mentor, Kenneth Mees named the burgeoning number of colored filters "Wratten" and introduced the complex numbering system that is still in use today.

Not all the Wratten filters are suitable for astronomical use, but the main colors are still widely used in visual astronomy and terrestrial photography work and are detailed below.

These colored filters are known as broadband or "longpass" in that they allow a large variety of wavelengths through but block wavelengths above or below a certain range in the EM spectrum. As the spectrum in visible light lies between 390 and 700 nm, with the blue wavelengths being the shortest (~400 nm) and the red being the longest (~700 nm), then anything with a wavelength range above or below a particular filter will be blocked and increased contrast in compensating colors will be noticed.

Most astronomical suppliers sell complete sets of filters for Solar System observing, and naturally such sets are known as lunar and planetary filters.

Fig. 2.2 Meade lunar and planetary filters

They have a range from red to blue across the spectrum and cover the broad bandwidths associated with such colors in addition to covering some of the wavelengths of the Wratten filters that are discussed below. A typical set will include a neutral density filter for lunar observing and a No. 25 red, No.12 yellow and No. 80A blue for as full coverage as possible. A Meade filter set can be seen in Fig. 2.2, although each manufacturer generally follows the same colour set for such work.

In the following section you should note that the Wratten number comes first followed by its color. However, we have grouped the filters under their color rather than put them in number order, as color is their most obvious feature when using them. We will use the spectral sequence from long to short wavelengths as the basis of the description, so we shall follow the standard ROYGBIV spectra that you probably encountered in school. There is also included some brief advice on the usefulness of the filter in visual astronomy before we move on to exploring the use of such filters in greater detail. All of these filters are available to purchase in 37.1 mm (1.25″) or 50 mm (2″) fittings for the observer's eyepiece range and are commonly available from astronomical suppliers (Fig. 2.3).

Fig. 2.3 Wratten colored filters

No. 25A Red

The No. 25A filter reduces blue and green wavelengths, which when used on planets such as Jupiter or Saturn result in well-defined contrast between some cloud formations and the lighter surface features of these gas giants. However, it needs to be used judiciously, as the light transmission is only 15 % and requires quite a large aperture, at least 150 mm+ for visual observation. It is also used to enhance infrared photography on a terrestrial scale, but for astronomical purposes it blocks light shorter than 580 nm wavelength.

No. 23A Light Red

This is a good filter for use on Mars, Jupiter and Saturn and may be useful for daylight observations of Venus as it has a 25 % light transmission through this rather dark filter, and, as it is an “opposite” color to blue, it darkens the sky very effectively in daylight. Some astronomers report that it also works well on Mercury, but this author would not recommend viewing this planet in general during daylight due to its proximity to the Sun, unless one is confident of their observing ability and equipped with a GOTO system. This filter blocks wavelengths of light shorter than 550 nm in the visible EM spectrum.

No. 21 Orange

This orange filter reduces the transmission of blue and green wavelengths and increases contrast between red, yellow and orange areas on planets such as Jupiter, Saturn and Mars. It brings out the glories of the Great Red Spot on Jupiter very well under conditions of good seeing on a modestly sized ‘scope (150-mm aperture) with a median magnification. It also blocks glare and provides a lesser contrast between a bright planet and the background of space, as this filter only transmits about 50 % of the light and blocks wavelengths short of 530 nm.

No. 8 Light Yellow

This filter can be used for enhancing details in red and orange features in the belts of Jupiter. It is also useful in increasing the contrast on the surface of Mars, and can under good sky conditions aid the visual resolution of detail on Uranus and Neptune in telescopes of 250 mm of aperture or larger. The No. 8 is also quite useful in cutting down glare from the Moon during visual sweeps of this object and works much better than the “moon filters” usually included with some cheaper telescopes on the market. The No. 8 filter allows 80 % light transmission and blocks light short of 465 nm.

No. 12 Yellow

This filter works on the principle of opposites described above, blocking the light in the blue and green region and making the red and orange features on Jupiter and Saturn stand out more clearly. Deeper in color than the No. 8 filter, it is the filter most astronomers recommend for visual work on the gas giants. It has a 70 % light transmission and cancels some of the contrasting glare on Jupiter when seen against a dark background sky. It blocks visible wavelengths short of 500 nm.

No. 15 Deep Yellow

This filter can be used again to bring out Martian surface features and the polar caps in addition to bringing out detail in the red areas of Jupiter and Saturn. Some astronomers also have reported some success using this filter to see low-contrast detail on Venus. Other astronomers, including the author, have used this filter on Venus during the day to add more contrast to the image. This filter is particularly useful, as Venus is a very bright object, and the filter has a 65 % light transmission with a longpass blocking light short of 500 nm and can considerably reduce the glare of this very bright planet.