An Amateur's Guide to Observing and Imaging the Heavens

An Amateur's Guide to Observing and Imaging the Heavens is a highly comprehensive guidebook that bridges the gap between beginners' and hobbyists' books and the many specialised and subject-specific texts for more advanced amateur astronomers. Written by an experienced astronomer and educator, the book is a one-stop reference providing extensive information and advice about observing and imaging equipment, with detailed examples showing how best to use them. In addition to providing in-depth knowledge about every type of astronomical telescope and highlighting the strengths and weaknesses of each, the author offers advice on making visual observations of the Sun, Moon, planets, stars and galaxies. All types of modern astronomical imaging are covered, with step-by-step details given on the use of DSLRs and webcams for solar, lunar and planetary imaging and the use of DSLRs and cooled CCD cameras for deep-sky imaging.

Ian Morison spent his professional career as a radio astronomer at the Jodrell Bank Observatory. The International Astronomical Union has recognised his work by naming an asteroid in his honour. He is patron of the Macclesfield Astronomical Society, which he also helped found, and a council member and past president of the Society for Popular Astronomy, United Kingdom. In 2007 he was appointed professor of astronomy at Gresham College, the oldest chair of astronomy in the world. He is the author of numerous articles for the astronomical press and of a university astronomy textbook, and writes a monthly online sky guide and audio podcast for the Jodrell Bank Observatory.

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This book is dedicated to the many amateur astronomers worldwide
whose knowledge I have attempted to distil in these pages.

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Preface

Although I have been a radio astronomer all my working life, I have also greatly enjoyed observing the heavens. At the age of 12, I first observed the craters on the Moon and the moons of Jupiter with a simple telescope made from cardboard tubes and lenses given to me by my optician. I also made crystal and valve radios, and my friends and I set up our own telephone network across our village using former army telephones. Both of these activities were to have a major bearing on my later life.

As I write, I have my father's thin, red-bound copy of Fred Hoyle's book *The Nature of the Universe* on the desk beside me. It was this book that inspired me to become an astronomer.

I was able to study a little astronomy at Oxford but, continuing my interest in radios, was also in the signals unit of the Officers' Training Corps. As I was revising for my finals I spotted an advertisement for a new course in radio astronomy at the Jodrell Bank Observatory. Because I was interested in both astronomy and radios this seemed a good idea and I began to study there in 1965.

My PhD supervisor had been giving evening classes in astronomy at a local college and due to illness asked me if I would take them over from him. The university loaned me two telescopes, a brass 3.5-inch refractor and a 6-inch Newtonian, for use with the classes and I was allowed to keep these throughout the year, enabling me to begin observing the planets, stars and galaxies more seriously. Not long after, I was able to acquire a 10-inch Newtonian in a massive fork mount to see a little more.

In 1990, I helped found the Macclesfield Astronomical Society and am now its patron. I have enjoyed the company and help of its members over the succeeding years as, for example, when they helped me convert my Newtonian into a truss Dobsonian.

Around this time I began to assist with astronomy weekends held by the Society for Popular Astronomy, one of two national amateur astronomy societies in the United Kingdom, and was asked to become its president in 2000. When my term of office ended I remained on its council and, more recently, became its instrument advisor, helping members with their choice and use of telescopes.

With the giving of evening and weekend courses it seemed sensible to acquire additional telescopes of different types to demonstrate and use with the students, and so, over the years, their numbers increased. Reviewing telescopes and mounts for the three UK amateur astronomy magazines allowed me to sample even more, and I was sometimes tempted to purchase them!

Some years ago I co-wrote two books to join the many available for beginners to the hobby. There are also a very large number of books for advanced amateurs covering in detail the many aspects of the hobby. There seemed to be quite a wide gap between the two, and it is this gap which this book aims to fill – covering in some depth the types of telescopes with their strengths and weaknesses, as well as the wide variety of accessories and imaging equipment that can be used with them.

I do not believe that one can write about anything without having actual experience of its use, and so the writing of this book gave me a wonderful excuse to purchase items of equipment that I did not already own. I have really enjoyed trying out new things and hope that the book will encourage others to do so. For example, I had never even thought about doing any spectroscopy but found it a fascinating branch of the hobby – as I hope Chapter 17 will show.

Imaging is now a major part of amateur astronomy, and I have covered every type of imaging, giving many examples with step-by-step details of how the various imaging processes are carried out. In no way do I claim to be an expert imager – the superb images seen in books or on the Web may well be obtained by sophisticated equipment and take many hours of observing and processing – but what I have tried to do is to show how one can get quite reasonable results fairly quickly and so become encouraged to strive to do even better.

I most sincerely hope that this book will help you to increase your knowledge and develop your abilities in what I regard as the most fascinating of all pastimes.

Acknowledgements

As the dedication of this book implies, my first acknowledgement goes to the many amateur astronomers who have shared their wisdom both in their writing of books – many of which are referred to in this volume – and in their contributions to astronomy forums and Web sites. I have spent many enjoyable hours gleaning what I could from them and have tried to pass on what I have learnt.

My friends in the Macclesfield Astronomical Society have been a great source of help and encouragement, and I offer grateful thanks in particular to Stephen Wilcox and Roy Sturmy for the loan of equipment and to Andrew Greenwood, Christopher Hill and Paul Cannon for the use of images to help illustrate the book. Peter Shah, Damian Peach, Greg Peipol and Dr Fritz Hemmerich have also kindly allowed me to use their superb images. My thanks also go to them.

Specifically regarding the chapter on spectroscopy, I have to thank Tom Field for providing helpful comments and advice, Ken Elliot for loaning me his company's CCDSPEC spectrograph and William Wiethoff for the use of a superb spectrum of the quasar 3C 273.

I thank Rich Williams of the Sierra Stars Observatory Network in the United States, who kindly gave me imaging time on two of the Network's telescopes so that I could investigate remote observing.

I would also like to thank Vince Higgs, Sara Werden and the team at Cambridge University Press who have steered this book through to publication and Jayashree Prabhu and her team at Newgen Knowledge Works who have prepared the book for printing. Particular thanks go to Mary Becker who has carried out a superb task in the copyediting of what is a challenging and technical text.

Finally, but not least, I must thank my wife for supporting me as I spent far too many hours at the computer and for putting up with the fact that, far too often, mounts and telescopes were spread across the lounge and dining room ready for use and one complete bedroom was taken over for their storage.

Prologue: A Tale of Two Scopes

When Mars was closest to the Earth in August 2003, the Macclesfield Astronomical Society held a star party at Jodrell Bank Observatory with quite a number of telescopes set up to observe it. As the evening progressed a consensus arose that two scopes were giving particularly good images: my own FS102 4-inch Takahashi Fluorite Refractor (at around £3500, or $5000, with its mount) and an 8-inch Newtonian on a simple Dobsonian mount newly bought for just £200 ($300). I personally preferred the view through the f6 Newtonian but others thought that the f8 FS102 gave a slightly better image, so we will call it a draw. It is worth discussing why these performed so well and, just as importantly, why perhaps the others did not.

The majority of scopes had been set up on a large concrete patio outside our visitor centre, but the FS102 and Dobsonian were on grass and not observing over the patio. This, I believe, was the major reason these two scopes had performed so well. During the day (remember it was August) the concrete would have absorbed heat, which was then released during the evening, causing localised air turbulence through which the scopes mounted on the patio were viewing Mars. It is not, therefore, surprising that the two mounted on grass performed better. One of the world's top solar telescopes, the Big Bear Solar Observatory, rises out of a lake so that it is almost totally surrounded by water in order to minimise any local thermal effects. One of my friends went to Egypt to observe the transit of Venus in 2004. It was very hot in the holiday complex, and he said that it would have been nice to observe from the shallow end of the swimming pool. I suspect that, had he done so, he would have had steadier images too! An obvious piece of related advice is that when observing the planets, particularly in winter, one should not observe them over rooftops, as the turbulence caused by the escaping heat will severely degrade the image. Peter Shah, one of the country's leading astro-imagers, whose beautiful image of M31 is shown in Plate 15.8, has recently lagged the concrete pier on which his telescope is mounted to improve its imaging quality!

The second reason I suspect that the two scopes performed so well is that they are simple. The FS102 has a two-element objective, one element of which is made of fluorite to give it a virtually colour-free image. One key requirement for planetary imaging

is high contrast, and refractors excel at this with well-baffled tubes and multi-coated lens elements that scatter very little light. It happens that fluorite elements essentially absorb and scatter no light, and this is one reason the FS series of fluorite Takahashi scopes (sadly no longer made) are said to have the highest contrast of any telescope. The Dobsonian was brand new, and thus its mirrors would have been in very good condition.

The optical performance of a colour-free refractor is essentially perfect and limited solely by the aperture. This determines the resolution and so determines the finest detail that can be seen. A Newtonian has, however, two features that degrade the optical performance: the spider that supports the secondary mirror (which causes the rather pretty diffraction spikes seen with brighter star images) and the secondary mirror itself (which also degrades the image somewhat). Both effects spread light a little away from where it should be and so reduce what I call the micro-contrast of the image, as will be discussed in detail in Chapter 1. But wait. The Dobsonian had twice the aperture so, if theoretically perfect, would have twice the resolution of the FS102. The diffraction effects of the secondary depend somewhat on the 'seeing' – the steadiness of the atmosphere – but, even at worst, would still equal that of the 4-inch refractor. Newtonians suffer from 'coma' – stars begin to look like little comets away from the centre of the field of view, but of course when one is observing planets in the centre of the field this would have no effect. Finally the 8-inch Dobsonian will collect four times as much light as the 4-inch FS102 and that must help too, so it's not too surprising that the two gave comparable performances.

The Dobsonian came with two simple eyepieces made with just three elements rather than the four-, five- or even seven-element designs probably used with the more expensive telescopes. In one sense, the fewer elements the better, as there are fewer surfaces for light to scatter from and less glass to absorb it. A three-element eyepiece will not have as wide a field of view as more complex designs and will tend to show some false colour towards the field edges, but this is no problem when one is observing in the centre of the field and so a simple triplet eyepiece may actually perform better for planetary observing.

I have tried to explain why the two scopes could perform equally well and one reason the others may not have done so well – their location. But there could have been two further reasons, particularly with the more complex 'catadioptric' telescopes – those that use both lenses and mirrors to form an image. These tend to need a longer time for the tube interior to cool down to ambient temperature, and also the image quality falls off rapidly if the telescope is not well collimated. As discussed in Chapter 6, the ultimate test for this is to see the 'shadow' of the secondary mirror at the dead centre of an out-of-focus stellar image.

The lessons that come out of this tale are, firstly, think about where you site your telescope; secondly, make sure your scope is cooled down and is well collimated; and lastly (and by far most importantly), a simple telescope with simple eyepieces can outperform many a far more expensive one. You do not need to spend large amounts of money to achieve exquisite views of the heavens!