DEEP-SKY COMPANIONS

The Caldwell Objects

To Donna,

My Eternal Flame.

And in memory of Milky Way, Miranda-Pywackett, and Pele.

Your time never ceased in my heart;

I will always love you.

DEEP-SKY COMPANIONS

The Caldwell Objects

Stephen James O'Meara

With a Foreword by Patrick Moore

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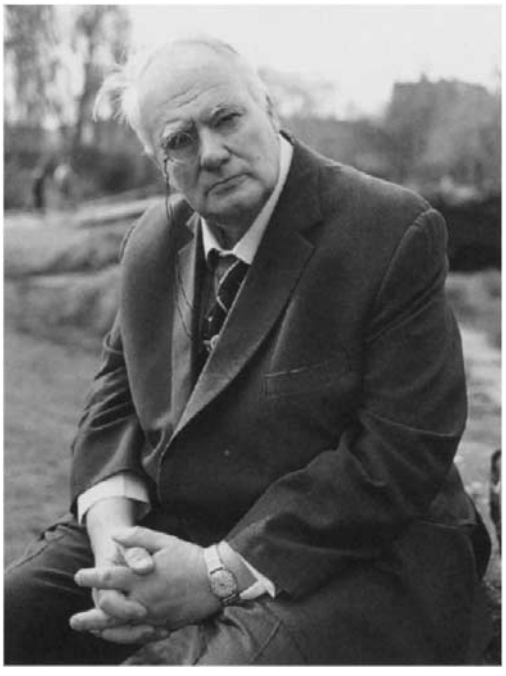
Foreword

THE STORY BEHIND THE MESSIER CATALOG is familiar to many. In 1758 a French comet hunter named Charles Messier began compiling a list of star clusters and nebulae that would enable him to distinguish these objects from his beloved comets. His final catalog, published in the French almanac *Connaissance des Temps* for 1784, listed 103 objects. Since then, 7 more have been added, and 1, a duplicate entry, has been removed; the number of unique entries now totals 109. In themselves, the nebulae and clusters interested Messier not at all — they were merely "objects to avoid." Therefore, he omitted those that could not possibly lead to confusion or that he could not see rise above his Paris horizon.

In fact, from the seasoned observer's point of view, the catalog is incomplete. This fact struck me forcibly one evening, not so long ago, while I was out browsing around the sky. I looked casually at NGC 7293, the Helix Nebula in Aquarius, and wondered why it did not have a Messier number; it could easily be taken for a large comet. And there are many other objects of equal or greater interest than those with "M" designations. Many of these non-Messier sights are shamefully neglected.

I am not a reputed deep-sky observer. My subject is the Moon, and I like to joke that anything beyond the orbit of Neptune is rather too remote for me. But I do enjoy looking at the deep sky. Chasing Messier objects is most interesting, and there are countless Messier clubs. Almost every long-time deep-sky observer has made a round of the objects in the Messier Catalog. Why not draw up a catalog to list objects not identified by Messier? Why not extend that list so that it includes objects below the Paris horizon? The southern night sky has many spectacular sights. Why not list them as well? Amateurs are continually on the move today, traveling to star parties and



expanding their observing horizons. The sizes of amateurs' telescopes are also expanding, allowing them to peer deeper into the night, to see things unimagined by Messier. Why not add a few of these challenging objects as well?

On the following morning I sat at my desk and began work. I decided to list 109 objects (the same number as in the Messier Catalog) but to arrange them in order of declination, beginning in the far north and ending in the far south — from Cepheus to Chamaeleon. The arrangement, of course, has utilitarian value. For example, from my home at Selsey, in South England (latitude 51° N), I could theoretically see to my colatitude (–39°), making the 72nd object in my list, the edge-on galaxy NGC 55 in Sculptor, theoretically within my grasp. A more reasonable object would be one, say, 5° above the horizon.

All the objects had to be accessible to amateurs using modern 4-inch and larger telescopes under a dark sky, but some would have

to be more difficult than others, so that any observer setting out to survey them all would be faced with something of a challenge. I decided to include objects of all kinds: open star clusters, globular star clusters, galaxies, planetary nebulae, bright nebulae, and dark nebulae. Possibly the most elusive is the very last, C109 (NGC 3195), a decidedly dim planetary nebula in Chamaeleon. I had personally observed all these, and, as I say, I am a lunar cartographer first and foremost.

Next, the question of a name, like Messier, to go along with the numbering system. I could hardly use M (for Moore), because Messier begins with that letter. Fortunately my proper name is a double-barreled one: I am officially Patrick Alfred Caldwell-Moore. In official documents I have to use my full name, and you will find me listed under the C's. But from sheer laziness I generally sign myself simply "Patrick Moore." For the present purpose I would have to use the full name, so it became the Caldwell Catalog.

Having completed my list, I put it in an envelope and sent it off to *Sky & Telescope*. To be candid, I thought very little more about it. Creating the list had been an interesting exercise, but would anyone else be interested in it? I was absolutely taken aback by the reaction. *Sky & Telescope* gave it full space in its December 1995 issue; other observers took it up, and before long I realized that the Caldwell Catalog had really taken off. It became more or less official within a few months. Caldwell clubs, along the lines of Messier clubs, sprang up, and books were planned. Stephen James O'Meara's is particularly useful because he has taken the trouble to observe nearly all of the objects with the same telescope.

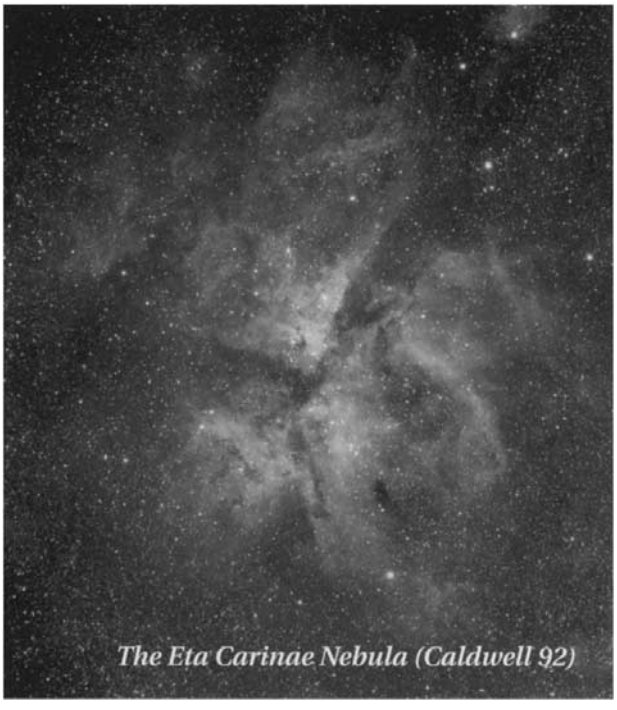
Will the Caldwell Catalog be really useful? I hope so, and the indications are that it will, because anyone who surveys all the objects will end up with a good knowledge of the nebular sky — and, as we know, amateurs can be very useful in observational branches of the science of astronomy such as supernova hunting. There is a certain wry humor in the fact that the catalog was drawn up more or less on the spur of the moment by an observer of the Moon, but at least it seems that my choice of objects has been approved. At any rate, I have so far had no adverse criticism.

So here is the Caldwell Catalog. I am grateful to Steve O'Meara for his hard work, and to *Sky & Telescope* for producing it so expertly. If you decide to set out and observe all 109 objects, I wish you well. One extra challenge: who will be the first to survey all the Messier and all the Caldwell objects in the fewest possible nights?

Patrick Moore
Selsey, Sussex
April 4, 2000

Preface

ISN'T IT IRONIC THAT A LUNAR EXPERT would draw up a catalog of 109 deep-sky objects that a planetary observer would then turn into a book? Actually it's not. In fact, it makes sense. Do not be fooled by Patrick Moore's humble confession of a passion for the Moon. Moore is his generation's most outstanding figure in astronomy. Born in Middlesex, England, in 1923, Moore was an astronomical child prodigy. By the age of 11 he had been elected a member of the British Astronomical Association; he became its president 50 years later. He is a Renaissance observer and has authored more than 100 books on astronomy, books whose titles range from *How to Make and Use a Telescope* to *Life on Mars*. His BBC television show, *The Sky at Night*, has been on the air now for more than four decades. It is among the most successful and long-running television shows in history. Moore is a consummate popularizer of astronomy, and he is a seasoned observer of both the solar system and the deep sky; he can address any astronomical topic with a sparkling air of authority. In 1988 Moore was made a Commander of the British Empire for his enduring service to astronomy, and in 2000 the Council of the Royal Astronomical Society bestowed a special Millennial Award on Moore in recognition of his unique contribution to the field.



The Eta Carinae Nebula (Caldwell 92)

In his "Star Trails" column for *Sky & Telescope* (May 1997), comet hunter David H. Levy called Moore the "ultimate amateur." Moore's been at it long enough to know what skywatchers like him desire. As Moore told Levy, "I have never pretended to be anything but an amateur. My only role now is spreading the word." The Caldwell Catalog is Moore's latest "word" — a stellar smorgasbord of celestial delights destined to whet our appetites and enrich our observing experiences.

I've known Patrick Moore since I was about 10 — not personally (until recently) but through his books. I grew up on a special diet of Moore: on the naked-eye sky, on satellite watching, on Moon and planet watching. Then, in 1970 — when I first seriously started hunting down the Messier objects and other deep-sky wonders with my newly acquired 4½-inch Tasco reflector — I used Moore's 1960 *Guide to the Stars* to acquaint me with the deep, dark night. In that book you will find many of the deep-sky objects that now appear in the Caldwell Catalog: wonders like the Double Cluster in Perseus, the spiral galaxy NGC 7331 in Pegasus, the R Coronae Australis Nebula, the Jewel Box Cluster, the dark Coalsack in Crux, and so on. The foundation for the Caldwell Catalog, then, was not laid down on a whim. It was the culmination in print of 40

years of thought and observation arising from the simple yet profound revelation that there's more to observe in the night sky than the Messier objects.

When *Sky & Telescope* introduced the Caldwell Catalog in its December 1995 issue, I had just completed the manuscript for *Deep-Sky Companions: The Messier Objects*, my own first foray away from the planets and into the fascinating realm of the deep sky. I suppose, like Moore, I too am hard to pigeonhole as an observer. But that's really nothing new. Two of history's most revered "deep-sky observers" were, well, solar-system observers. Messier was an experienced lunar and solar observer and, of course, a comet aficionado. In fact, Messier was not at all interested in the deep sky; the objects we now admire in his list were nothing but celestial mosquitoes to him — pests. And, as Larry Mitchell, a member of the Houston Astronomical Society, explains in his biography of William Herschel (Appendix C), Herschel was a "prolific observer of everything in the heavens." Herschel was fascinated by transient phenomena on the Moon, the polar caps and "luminous spots" of Mars, Saturn's rings, and the belts and flattened poles of Jupiter. It was Herschel, that great deep-sky observer, who discovered the planet Uranus, one of its moons, and two moons of Saturn. Herschel also cataloged double stars, tracked variable stars, and investigated stellar distances. So Moore and I are simply a part of an extended family of observers, a melting pot of people who love to look at all manner of heavenly wonders. What we like to observe is merely a reflection of what soothes our hearts and inflames our souls. (Besides, *what* you observe is not nearly as important as *how* you observe.)

Since the Caldwell Catalog was advertised as a list of 109 objects "beyond Messier," it seemed a natural candidate for the second book in my *Deep-Sky Companions* series. As soon as the Messier manuscript was mailed, I grabbed my 4-inch Tele Vue Genesis refractor and began another long but exhilarating visual journey across the night sky. Soon I learned that some observers believed the words "beyond Messier" were shorthand for "Here's a list of incredible deep-sky objects missed by Messier." Neither Moore nor *Sky & Telescope* ever intended to promote that view. A quick scan of the catalog's contents, which include irregular dwarf galaxies, prodigious sources of cosmic radio waves, and dim bubbles of gas blown off of Wolf-Rayet stars, proves otherwise, as does the simple fact that more than half of the Caldwell objects lie south of the celestial equator. In fact, I hope no one ever publishes a catalog of objects "missed" by Messier, because that would be a grave injustice to the famed ferret of comets. As I explain in *Deep-Sky Companions: The Messier Objects*, Charles Messier was first and foremost a comet hunter. His primary goal was to discover comets, not deep-sky objects. He did not systematically survey the night sky to discover every nebula and cluster in it, as did William Herschel. Messier explains as much in the *Connaissance des Temps* for 1801: "After me, the celebrated Herschel published a catalog of 2,000 [nebulae] which he has observed. This unveiling of the sky, made with instruments of great aperture, does not help in a perusal of the sky for faint comets. Thus my object[ive] is different from his, as I only need nebulae visible in a telescope of two feet [in length]." To fault Messier for excluding objects he would never have confused with comets — or that were beyond the visible limit of his modest telescopes — would be like faulting treasure hunters for not listing the names of birds hopping around the piles of gold and diamonds they discover. No, the Caldwell Catalog is a list

of some of the most incredible non-Messier objects in the entire sky, *plus* a sprinkling of delights that will challenge small-telescope users or excite us with astrophysical intrigue.

The 109 Caldwell objects comprise 35 galaxies, 28 open star clusters, 18 globular star clusters, 13 planetary nebulae, 12 bright nebulae, two segments of a single supernova remnant, and one dark nebula. It includes many of our favorite non-Messier objects: Omega Centauri, 47 Tucanae, the Tarantula Nebula, the Eta Carinae Nebula, Centaurus A, the Helix Nebula, the Ghost of Jupiter Nebula, the Saturn Nebula, the Jewel Box, the North America Nebula, the Double Cluster, the Cat's Eye, and more. It includes the largest and most massive globular star clusters in our Milky Way; the shredded remains of a 15,000-year-old stellar explosion that blasted several solar masses of material across nearly 1,600 trillion kilometers of space; an enigmatic galaxy voraciously consuming a smaller spiral some 500 million years after the two collided; and an enormous star-forming region centered on the bloated body of a star that experienced the biggest explosion any star is known to have survived. And these are just a few of the species of celestial "wildlife" populating the Caldwell Catalog. In it you'll also find interacting sheets of cold, black molecular matter; flickering emission nebulae; planetary nebulae that "blink"; ancient globular clusters with young stars; black holes at the centers of galaxies; and open star clusters that may or may not exist. LINERs, FLIERs, Seyferts, Cepheids, and starbursts, they're all here. What's more, every Caldwell object can be seen in a 4-inch telescope under a dark sky. Most are visible with binoculars, and many can be seen with the unaided eye.

As with *Deep-Sky Companions: The Messier Objects*, the purpose of this book is to offer you a fresh perspective on the history and visual appearance of each Caldwell object; to help you find each object; and to summarize the latest research findings on each. In Chapter 1, "About This Book," I discuss the telescopes I used to observe the Caldwell objects, my observing sites and methods, helpful observing hints, and more. Since the history, astrophysics, and visual descriptions of many of these objects (especially the southernmost ones) have never been described at length in any other popular work, this chapter also explains my approach to presenting the information. The 109 Caldwell objects are detailed in Chapter 2. In many cases the essays describe recent observations from the world's largest ground-based telescopes, the Hubble Space Telescope, and an armada of spacecraft that have peered into the universe with X-ray- and infrared-sensitive "eyes." The essays are flush with historical anecdotes, including solutions to many outstanding mysteries; observational challenges; and descriptions of other interesting objects that happen to lie nearby on the dome of the sky.

Chapter 3 briefly describes 20 spectacular non-Caldwell (and non-Messier) objects — yet more proof that the heavens are replete with wonders beyond the realm of any single catalog of reasonable proportions. In fact, if you take the 109 Caldwell objects, add my 20 extras, and string them together with the other objects mentioned in this book, you'll find that this book contains perhaps 300 interesting telescopic targets. Add those to the roughly 250 objects mentioned in my book *Deep-Sky Companions: The Messier Objects*, and you'll realize that the two books introduce you to half a thousand celestial wonders — potentially enough for a lifetime of observing.

The appendixes round off the work. Appendix A tabulates each Caldwell object's

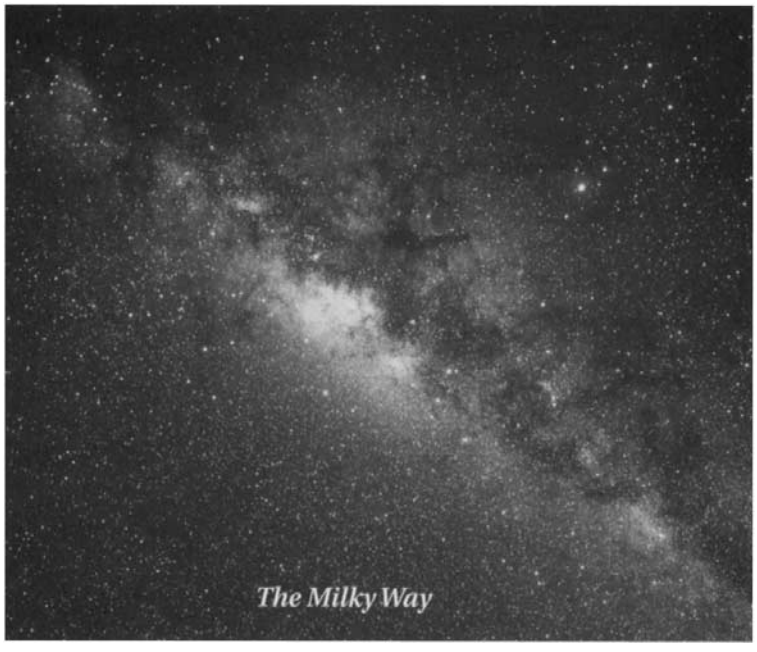
position, type, angular size, and apparent magnitude. Appendix B explores why Charles Messier did not include the Double Cluster in Perseus (Caldwell 14) in his catalog; though everyone talks about it, I'm not aware of any detailed discussion of this "omission" in the amateur literature. And since William Herschel discovered more than half of the objects in this catalog — and his sister Caroline and son John found several of the others — you'll find a new and informative biography of the great 18th-century astronomer in Appendix C. The esteemed deep-sky observer Larry Mitchell wrote it. The most apparent living successor to William Herschel, Mitchell owns a portable 36-inch reflector; has observed every object that William Herschel discovered; and has compiled the positions of about 100,000 otherwise anonymous galaxies, which have not been published anywhere. This list has since become known as "Mitchell's Anonymous Catalogue," and the positions have been included in the *MegaStar* software package. Appendix D credits the talented astrophotographers whose work graces the book's pages.

As always, my desire in creating the *Deep-Sky Companions* books is to help you progress as an observer; to expand your visual envelope; and to make observing a fun and memorable experience, one that will inspire you to share the love, joy, and romance of the night sky with others. For this is what has made Patrick Moore so special in the eyes of millions. As David Williams, a former president of the Royal Astronomical Society, said about Moore receiving the Millennial Award: "Patrick Moore has been the foremost popularizer of astronomy [in the United Kingdom] for more than 40 years, and has served as an exemplary ambassador for our science to the British public and around the world. He was responsible for first sparking the interest in many of us who went on to become astronomers and he has always encouraged young people, giving generously of his time and expertise." The accolades have not ended, for as the year 2000 drew to a close, the ever-humble Moore was "astounded" to learn that he had been knighted for his services to science and broadcasting. And thanks to Sir Patrick Moore's Caldwell Catalog, we can now go out under the stars and, in a systematic manner not unlike William Herschel's, behold what beauty the night has to offer beyond the Messier objects.

Acknowledgments

FIRST AND FOREMOST I would like to thank Patrick Caldwell-Moore for originating the concept of a Caldwell Catalog and the editors of *Sky & Telescope* for having the foresight to publish it in the magazine — otherwise, this book might not have happened.

Starting to work on *Deep-Sky Companions: The Caldwell Objects* was a bit like starting my first job at *Sky & Telescope*; I first had to create my office, which meant putting up sheet rock, plastering the walls, painting, laying the carpet, and moving in the furniture. Only once everything was in order, and the typewriter (yes, a typewriter) was on the desk, could I begin the long process of thinking about how to put a story together. The point is, before I could begin writing about each Caldwell object, I had to first observe and draw it, research the literature on it, gather observations of it, and sort out all kinds of conflicting details. Only then could I start to think about what I was going to say, especially about the more perplexing cases involving historical mysteries.



The Milky Way

That said, I cannot bow low enough to thank Brent Archinal for invaluable research and insights into nearly every Caldwell mystery. Had it not been for his keen knowledge of astronomical history, or for his access to many old volumes of forgotten astronomical lore, my essays on these objects would not have been nearly as interesting or as complete. Barbara Wilson, Brian Skiff, and Hal Corwin also were instrumental in helping me solve many mysteries. A big "thank you" also goes to my long-time friend and observing companion Daniel W. E. Green, who helped me find historical passages that appeared in books 6,000 miles away from me but a few hundred yards away from him at the Harvard College Observatory library. I also have to thank Barbara for supplying me with William Herschel's original observing notes, the original description of Herschel's classification system, and the object descriptions listed in the 1864 *General Catalogue of Nebulae*. I also am very indebted to Larry Mitchell, who created the outstanding history of William Herschel for this book — a work that has not been published anywhere before. (Larry, Sir William would have been proud.) Barbara and Larry also were responsible for hog-tying me at the Texas Star Party years ago and turning me into a Wild Child of the Deep Sky. Another TSPer, Jay McNeil, was a great help in sorting out some of the planetary-nebula observations and mysteries.

To me, amateur astronomy is a global family of friends who love to look at the night

sky and share its splendors. There are too many faces (sometimes "faceless" ones in the night) to thank, but I appreciate all of you for showing me your favorite deep-sky wonders or inspiring me along the way. That being said, I would like to call out special attention to Graham Blow, Rob and Leslie Hall, Grant Christie, and Gordon Herdman for opening their homes to me during my stays in New Zealand; they also were instrumental in opening the doors to the Carter and Auckland observatories. A warm *aloha* and *mahalo* also go out to Ian Cooper, New Zealand's finest deep-sky observer, and to my good friends and extended families in Florida, Texas, Guatemala, El Salvador, Panama, and Honduras: thank you, thank you, thank you — you make observing fun!

Helping me to keep all the facts straight — so that, in the end, each essay made sense — was the job of *Sky & Telescope*'s Joshua Roth. Josh is a rare bird; he is a professionally trained research astronomer with the heart and soul of an amateur. For this project, he was a godsend. As he edited this work, Josh not only massaged or corrected the astrophysics and the text; he also took his telescope outside to look at as many Caldwell objects as he could (in part to inspect my instructions, in part to enjoy the view). Josh also checked every fact in this book, and I say that in complete sincerity. It is almost inconceivable how many facts appear here: celestial directions, coordinates, sizes, object types, magnitudes, dimensions, distances, historical quotes, catalog entries, dates, translations, names, places, and reams of astrophysical data gleaned from professional journals and other sources. Thanks to Josh's monumental fact-checking efforts, any errors that had the potential to appear in this book all but vanished. Of course, nothing in life is perfect, and I take full responsibility for any *faux pas* that might remain.

The production team at Sky Publishing, headed by Derek Corson and managing editor Bud Sadler, was a tour de force. Foremost I must thank Sally MacGillivray, who helped to organize the project from its inception. Her substantial experience in book publishing was invaluable to the project, and she was a tremendous help to the production crew. Imelda Joson, my "little sister," did extensive research in *Sky & Telescope*'s photo archives and, with the help of veteran observer and jack-of-all-trades Tal Mentall, hunted down all the Caldwell photographs that eluded detection. Imelda and Tal selected photos that would best benefit a visual observer behind the telescope. On that note, I must send a global "thank you" to all the highly talented photographers listed in Appendix D, some of whom went out of their way to shoot particular Caldwell objects by request. I deeply thank all of you for making such a valuable contribution to this work. *Sky & Telescope* staff photographer Craig Michael Utter scanned all the photos, as well as my drawings, which was no easy task, especially since the faintest details in my drawings are a challenge to reproduce; yet, he did an incredible job in preserving the finest details.

Roger Sinnott wrote the software that created all the star charts; he also created the wide-field and polar star maps of the Caldwell objects that appear as endpapers. Thank you. And thank you, Tal, for slogging through the copy, tabulating all the objects, checking object orientations, and generating the charts, which illustrator Gregg Dinderman then transformed into works of art. Nina Barron proofread the manuscript. *Deep-Sky Companions: The Caldwell Objects* is the fourth book she has copy-edited or proofed for me. I admire her sensitive eye, which never seems to falter.

Likewise, thank you, Sue Bryant, for proofing Larry Mitchell's Herschel history. Special thanks go to Linda Kenny Sloan and Joshua Roth for putting together the labor-intensive index. And thank you, Lynn Sternbergh, for your most elegant design — the book looks beautiful.

Thank you, Al Nagler, for creating such a wonderful and versatile telescope. Thank you, Kilauea volcano, for continuing to erupt, because as long as you do so, the skies on my side of the island will remain dark. And thank you, Donna, for your love and support during this long journey. You are the brightest star in my eyes. And thank you, Pele, Milky Way, and Mandy, for your constant companionship in the dungeon of my office.

Finally, thank you, Rick Fienberg (Sky Publishing) and Simon Mitton (Cambridge University Press) for believing in this project and publishing the work. I also must thank you for your understanding, patience, and support, as this project sailed on through an eternal night. But look — the voyage has ended. We are somewhere over the rainbow, and the skies are blue!