

Atlas of the Messier Objects

Highlights of the Deep Sky

Second Edition

Messier's catalog of 110 star clusters, nebulae, and galaxies is the most popular list of deep sky gems. The first edition of this stunning reference atlas was hailed as the most comprehensive, detailed, and beautiful account of the Messier objects then available and the second edition continues this trend. Each object is presented with:

- Updated historical information, including from new sources, featuring accounts and anecdotes from Messier and other prominent visual observers who followed him.
- Thoroughly researched astrophysical information, the results of an investigation of more than 500 recent scientific papers including, for the first time, fully consistent distance data from the Gaia space observatory.
- Extensive information on visual observing using the naked eye, binoculars, and amateur telescopes from modest sizes up to 20 inches aperture.
- New large-scale color photos from some of the world's best amateurs displaying the objects' splendor, as well as close-up images from the Hubble Space Telescope, for most objects, showing the fine details.

The introductory section includes an extensive biographical portrait of the life of Charles Messier, his observations and his telescopes, and his contemporaries, and a complete translation of Messier's original catalog. There is also detailed information on how to observe the Messier objects and advice on how to conduct a Messier Marathon. For those seeking even more, the author provides the Herschel 100 list. In addition, many objects feature historical sketches from classical observers from the nineteenth century alongside the author's modern deep-sky drawings.

Astronomers of all abilities will delight in the Atlas's return as your guide to the sky's finest objects.

RONALD STOYAN was born in Dresden in 1972. A geographer by education, he became interested in visual astronomical observation at the age of 16. He has since developed an international reputation as an experienced planetary and deep-sky observer and drawer. He was the founding director of the German deep-sky organization 'Fachgruppe Deep-Sky' and served as Jupiter and Saturn recorder for the German-speaking planetary observers. For twenty-four years he was editor-in-chief of *interstellarum*, one of the country's main astronomical magazines, which he founded in 1994, and senior editor for its successor, *Abenteuer Astronomie*. In 2000, he founded *Oculum-Verlag* as Germany's first exclusive astronomical publishing company. He has authored and coauthored more than a dozen books on practical astronomy, the best known of which are the *interstellarum Deep Sky Atlas* and its companion, the *interstellarum Deep Sky Guide*.

KLAUS-PETER SCHROEDER is a professor of astrophysics at the Universidad de Guanajuato, Mexico. His research is focused on stellar activity, spectroscopy, stellar evolution and red giant stars, using the TIGRE robotic telescope since 2013. His work has been published in over 100 articles in refereed astrophysical journals of high impact. As an avid amateur astronomer and photographer since youth, he has also written several books on astrophotography and is a regular contributor to amateur astronomy magazines.

Cover illustration: A majestic view of M 51, the magnificent Whirlpool Galaxy. This image was taken by Adam Block with a 32-inch telescope at 5692mm focal length at Mount Lemmon, USA. He used a SBIG STX 16803 camera, exposure time was 390/72/72/72 min in LRGB channels.

Praise for the first edition

“... Everything you want to know about Messier and his catalogue and more – it is amazingly comprehensive. The fullplate photographs are truly magnificent. ... there are also excellent drawings. This book is worth every penny – and more. There have been many Messier books, but in my view this is the best I have ever seen.”

Sir Patrick Moore, *Sky at Night*

“... this superb, monumental work takes things to a new level and will become the standard work for years to come. It would probably be worth buying the book just for the pictures alone but there is so much great stuff packed in that this masterful volume is a must for any astronomer. If this book doesn't make you want to get out there and observe the wonderful Messier objects then nothing will.”

Mark Armstrong, *Astronomy Now*

“Ronald Stoyan's *Atlas of the Messier Objects* should be required reading for amateur astronomers. Its impressive content, textually and visually, makes it a definitive work on the catalog and its objects. This book should be on the shelf of every observer.”

David Eicher, Editor-in-Chief, *Astronomy*

“*Atlas of the Messier Objects* is more comprehensive, detailed, and beautiful than any other book showcasing the objects cataloged by Charles Messier. The art of observing is practiced as much with the mind as with the eye, and this book gathers into one volume diverse aspects that both enrich the experience and serve as a valuable reference. No other book does such a masterful job of gathering all that is fascinating about the Messier objects and weaving it into a book that is both so enlightening and handsome.”

Susan French, author of *Celestial Sampler: 60 Small-scope Tours for Starlit Nights*

“I received your book and must say that it is absolutely beautiful! You have created an amazing review of the Messier objects. Congratulations on a breathtaking publication!”

Philip S. Harrington, author of *Star Ware* and *Touring the Universe through Binoculars*

“Imagine the result merging books such as *The Messier Album* from Mallas & Kreimer, *The Messier Objects* by O'Meara, *Messier's Nebulae and Star Clusters* by Glyn Jones. 'A glorious chaotic mess' you might think? Certainly not. The authors have put all this together in good shape, with a very clear presentation in order to produce an innovative book, easy to read or just to browse.”

Yann Pothier, *Ciel Extreme*

“There are several good books that cover Charles Messier's famous catalogue, but none are as beautiful or comprehensive as this spectacular volume. There is a very fine biography of the 'ferret of comets' himself which not only brings the man to life, but also places him in context of the turbulent times in which he lived. Ronald Stoyan is to be congratulated for putting together a most beautiful and helpful volume on Messier and his catalogue, one that all deep sky enthusiasts will wish to own, and which is unlikely to be surpassed for many years.”

Nick Hewitt, *Journal of the British Astronomical Association*

ATLAS of the MESSIER OBJECTS

HIGHLIGHTS OF THE DEEP SKY

Second Edition

Ronald Stoyan
with contributions by Klaus-Peter Schroeder





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Dedicated to the memory of my brother Norman Stoyan (1975–2003)

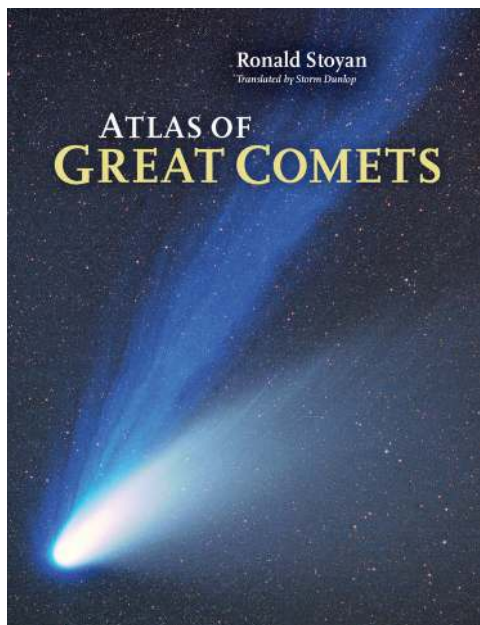
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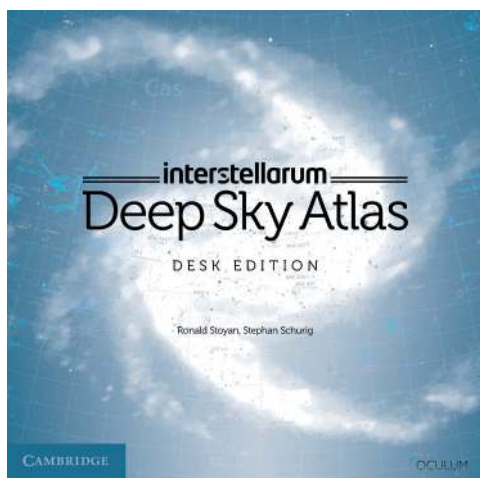
Also by the author



Atlas of Great Comets

Throughout the ages, comets, enigmatic and beautiful wandering objects that appear for weeks or months, have alternately fascinated and terrified humankind. The result of five years of careful research, *Atlas of Great Comets* is a generously illustrated reference on thirty of the greatest comets that have been witnessed and documented since the Middle Ages. Special attention is given to the cultural and scientific impact of each appearance, supported by a wealth of images, from woodcuts, engravings, historical paintings, and artifacts, to a showcase of the best astronomical photos and images. Following the introduction, giving the broad historical context and a modern scientific interpretation, the Great Comets feature in chronological order. For each, there is a contemporary description of its appearance along with its scientific, cultural, and historical significance. Whether you are an armchair astronomer or a seasoned comet-chaser, this spectacular reference deserves a place on your shelf.

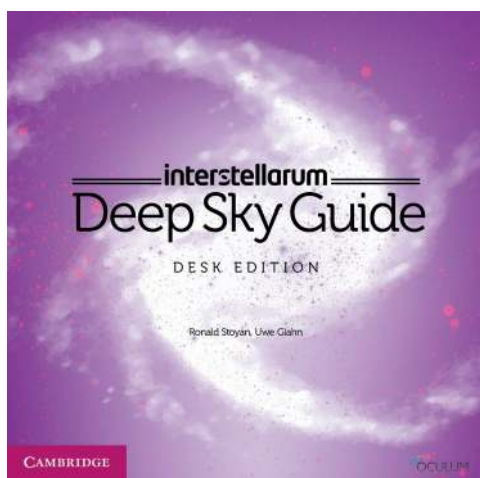
Ronald Stoyan, ISBN 978-1-107-09349-2 Hardback



interstellarum Deep Sky Atlas

The *interstellarum Deep Sky Atlas* heralds a new era of celestial cartography. It is an innovative, practical tool to choose and find stars, star clusters, nebulae and galaxies. Usually, deep sky objects are shown with just a standard symbol in the star charts. This atlas is different: all objects are shown according to their actual visibility. Four main visibility classes separate out objects that can be seen through 4-, 8- and 12-inch telescopes. Within each visibility class, the objects are labeled in different type weights and using graduated shades and colors for the symbols - the bolder the label or the darker the symbol, the easier it is to see the object. Spiral-bound and printed in red-light friendly colors on dew-resistant paper, this full-sky atlas has a limiting magnitude of 9.5, plotting over 200,000 stars. It is the ideal companion for amateur observers of all levels.

Ronald Stoyan, Stephan Schurig, ISBN 978-1-107-50338-0 Desk Edition



interstellarum Deep Sky Guide

The *interstellarum Deep Sky Atlas* set a new high standard for modern celestial cartography. The same team now presents the *interstellarum Deep Sky Guide*, its unique observing companion. Taking an intuitive visual approach, for each spread of the Atlas, the Guide focuses on carefully selected objects, either as colored composite POSS plates or through the authors' own eyepiece sketches. They allow you to estimate the visibility of features in the telescope while planning observations. Stars and other objects in the vicinity are highlighted, so they also serve as finder charts at night. An index map on each spread allows you to quickly find each object's location in the Atlas. The *interstellarum Deep Sky Guide* takes all the hassle out of preparing for observing sessions - there's no need to print star charts or photos. Simply grab your Atlas and your Guide, and go observe!

Ronald Stoyan, Uwe Glahn, ISBN 978-1-108-45313-4 Desk Edition

Preface

The catalog gathered by the French astronomer Charles Messier (1730–1817) has been the most popular compilation of astronomical objects beyond our Solar System for more than 200 years. It contains 110 star clusters, nebulae, and galaxies, among them most of the brightest and finest deep sky highlights that are visible from northern skies.

Amateur and professional astronomers alike have turned their telescopes time and again to the Messier objects. Numerous books have covered them, and numerous websites attest to their unwavering popularity. However, a current overall picture of the catalog and its objects was missing, as much information currently disseminated is actually outdated. So, for the first time since Robert Burnham's famous *Celestial Handbook*, a thoroughly investigated new account with historical, astrophysical, and observational information on all the objects was published in 2006 in Germany as *Atlas der Messier-Objekte*, while the English edition *Atlas of the Messier Objects* followed in 2008.

While the first edition received much praise and had soon sold out, its contents got more out of date with every year that passed. Ongoing interest in both the Messier objects themselves and an up-to-date publication of them led to the idea of revising the original edition.

During the 15 years that passed since the publication of the first edition, astrophysical knowledge on many objects has vastly improved. This is especially true for distance data; the latest results from the Gaia astrometry satellite revolutionized accuracy and reliability of distances within our own Milky Way. In many cases, distance values have changed greatly compared to the first edition, but also a lot of other research had to be incorporated. More than 500 scientific papers were read and evaluated by the main author in addition to the 500 already investigated for the first edition, and put into new 110 astrophysics sections by Prof. Klaus-Peter Schroeder, a professional astronomer who has

worked in the United Kingdom and the United States for decades. He also revised the glossary of technical terms.

Historical research has also advanced. This is especially true for the observational records of William Herschel, which have been made available by new publications. There's also new insight on the discovery timeline of some objects, as a result the discoverers' credits had to be changed on some objects compared to the first edition.

Astrophotography had just gone digital in the early 2000s. Imaging and image editing have undergone great changes in the past 15 years as well, resulting in much deeper and prettier images available today. The photos displayed in the chapters on the 110 individual objects have been reselected completely: 150 new images from 89 astrophotographers show the Messier objects in unparalleled beauty. In addition, stunning images from the Hubble Space Telescope are now available for most Messier objects; they have been incorporated where appropriate.

I would like to thank Klaus-Peter Schroeder for his contributions to the book. A big thank-you is owed to the contributing astrophotographers from all around the world. For individual help on specific issues, Heinz Andernach, Adam Block, Bernd Flach-Wilken, Stefan Hannabach, Scott Harrington, Jan Hattenbach, Bernhard Hubl (CCD Guide), Bernd Liebscher, and Wolfgang Steinicke deserve credits. Finally, I would like to thank Vince Higgs and the team at Cambridge University Press for their ongoing support.

May this book give you new insights into your favorite deep sky highlights, once again.

Ronald Stoyan
Erlangen, Germany

User guide

The data files

Degree of difficulty: rating of the observational difficulty:

- 1 object easily visible to the naked eye
- 2 object difficult to see with the naked eye
- 3 object easily visible in 8×30 binoculars
- 4 object easily visible in 10×50 binoculars
- 5 object difficult to see with 10×50 binoculars

For more information about visual and photographic difficulty, see page 63.

Minimum Aperture: minimum aperture required to see the object under a dark mountain sky, according to the personal experience of the first author. There are four categories:

- naked eye
- 15mm
- 30mm
- 50mm

Designation: catalog number in the NGC (New General Catalogue) or the IC (Index Catalogue).

Type: Object type. For a more detailed introduction to the different types, see page 53.

Class: Classification of the object, specific to its type:

- Galactic nebulae: distinction between emission nebula and reflection nebula, see page 53
- Open clusters: Trumpler classification, see page 55
- Globular clusters: concentration class, see page 56
- Galaxies: Hubble classification scheme, see page 61

Distance: Distance from Earth in light-years. As far as possible, uniform sources have been used:

- Open clusters: Poggio, E. et al: Galactic spiral structure revealed by Gaia EDR3, *Astronomy and Astrophysics* 651A, 104 (2021)
- Globular clusters: Baumgardt, H., Vassiliev, E.: Accurate distances to Galactic globular clusters through a combination of Gaia EDR3, HST and literature data, *Monthly Notices of the Royal Astronomical Society* 505, 5978V (2021)
- Galaxies: Anand, G.S. et al: Distances to PHANGS Galaxies: New Tip of the Red Giant Branch Measurements and Adopted Distances, *Monthly Notices of the Royal Astronomical Society* 501, 3621A (2021)
- Galaxies: Steer, I.: Mean Estimate Distances for Galaxies with Multiple Estimates in NED-D, *Astronomical Journal* 160, 199S (2020)

In addition, alternative results have been quoted, in order to demonstrate the uncertainty of the distances given.

Size: physical diameter of the object, as calculated from its actual distance and angular diameter. The resulting values may differ from the ones stated by original sources. Spiral galaxies seen under some inclination may be underestimated.

Constellation: Latin name of the constellation in which the object is located

R.A.: Right ascension for the equinox 2000.0

Decl.: Declination for the equinox 2000.0

Magnitude: apparent total visual brightness

Surface brightness: mean visual brightness in magnitudes per square arcsecond (not given for star clusters)

Apparent diameter: apparent (angular) photographic diameter

The texts

History

The historical sections include translations from the original quotations of historic observers from the seventeenth to the early twentieth century. In part, these have been translated from the original. Where not available, they had to be taken as quotes from secondary literature. English quotations are given, as far as available, in their original wording.

Frequently, the term “resolution” (of an object) is used in historic texts – not just for star clusters, but for galaxies and nebulae as well. In the nineteenth century, that did not necessarily mean the resolution into individual stars, as we use the term today, but rather resolution of any kind of detail.

A short introduction to every historic observer quoted in this book can be found on page 28.

Astrophysics

Ever since the publication of the famous *Burnham’s Celestial Handbook* in the 1970s, amateur astronomers have been waiting for a new, up-to-date compilation of astrophysical data on all Messier objects. Unfortunately, a lot of printed and internet sources refer to outdated values.

For this book, the content of over 1000 professional, up-to-date publications was researched. This was made possible by the use of the Internet and the free NASA service, the Astrophysical Data System (ADS), which is an on-line collection of almost all scientific publications in astronomy. The exact citations are given in the appendix.

Where possible, no sources older than 10 years were used, but a few objects have received little attention in modern references. Other objects (M 1, M 31, M 42) capture a lot of professional attention, and the vast amount of literature dealing with them would easily permit a much more detailed treatment. However, space restrictions limited this book to the most relevant information.

In many cases, the research presents surprises: modern scientific results often disagree completely with what is commonly believed as the result of outdated literature. This trend will continue, as there is a steady stream of new observations and their astrophysical interpretation. Hence, the statements made in this book must be regarded as only a momentary picture of our knowledge from the years before 2023. Many questions remain unanswered, and we expect new insight into topics such as dark matter, black holes, or the age of the Universe. This may affect how some aspects of the Messier objects will be explained in the future.

Another common problem is the disagreement of modern sources from one another. Different authors have different opinions, and different methods yield different results. Generally accepted knowledge grows out of long debate and testing. This is part of the lively nature of a quickly developing science such as modern astrophysics.

Observation

The information and advice given for the visual observation of each object is based on the personal experience and observation of the first author, using telescopes of different apertures. Each object has been observed on several occasions over the past 35 years, many more than a dozen times. The instrumentation used consisted of:

- 2×54 opera glass “Ultra Wide Angle” distributed by Orion
- 3.5×15 opera glass, “Theatis” made by Carl Zeiss Jena
- 8×25 binoculars, “Pocket CL” made by Swarovski Optics
- 8×30 binoculars, “Deltrintem” made by Carl Zeiss Jena
- 10×50 binoculars, “Dekarem” made by Carl Zeiss Jena
- 15×56 binoculars, “SLC WB HD” made by Swarovski Optics
- 20×100 binoculars, made by Miyauchi
- 70/560mm (2.7-inch) refractor “FL70S” made by Vixen, magnifications from 14× to 280×
- 105/600mm (4.1-inch) refractor “Traveler” made by Astro-Physics, magnifications from 19× to 236×,
- 120/1020mm (4.7-inch) refractor “Star 12ED” made by Astro-Physics, magnifications from 25× to 255×, in exceptional cases 340× and more
- 120/900mm (4.7-inch) refractor “TSA” made by Takahashi, magnifications from 45× to 354×
- 360/1780mm (14-inch) Newtonian on a Dobsonian mount, magnifications from 45× to 593×, various observing sites in the German countryside (naked-eye limiting magnitude 6.5, sky surface brightness 21.2 mag/arcsecond²) and Austrian Alps (naked-eye limiting magnitude 7.0 mag, sky surface brightness 21.6 mag/arcsecond²)
- 500/2000mm (20-inch) Newtonian on a Dobsonian mount, magnifications from 65× to 1000×, various observing sites in the German countryside (naked-eye limiting magnitude 6.5, sky surface brightness 21.2 mag/arcsecond²) and Austrian Alps (naked-eye limiting magnitude 7.0 mag, sky surface brightness 21.6 mag/arcsecond²)
- 500/2500mm (20-inch) Newtonian on a Dobsonian mount, magnifications from 63× to 625×, Farm Tivoli, Namibia (naked-eye limiting magnitude 7.5, sky surface brightness 21.8 mag/arcsecond²)

Observing comments refer to a very experienced observer and excellent observing sites with a dark, moonless sky. We have purposely omitted star charts and all advice on finding the objects, since there is already a vast literature on these aspects, useful even to the first-time observer. However, we recommend the *interstellarum Deep Sky Atlas* and *interstellarum Deep Sky Guide* as comprehensible resources to locate and observe deep-sky objects.

The astrophotos

The 150 selected images showcase the fantastic results of the world-wide astrophotographer's community. This book deliberately focuses on "amateur" results: images obtained by photographers in their spare time, obtained with their own or rented telescopes, and commercially available cameras. The images from professional institutions, mainly from the Hubble Space Telescope, play only a supporting role.

Some Messier objects are particularly popular with amateurs, and good images are abundant. Others grab almost no attention and only a few pictures are available, so it's virtually impossible to get photos of uniform quality for all 110 objects. For this reason, the scale and depth (i.e., limiting magnitude) of the photos vary from object to object.

The color reproduction of the images is neither uniform, nor should it be regarded as quantitatively correct. Color-balance and saturation depend on a number of factors, such as detector characteristics, filter transmission, software and personal judgment during image processing. The result is often subjective, perhaps aimed at reproducing the colors of professional photos. After all, techniques of absolute color calibration are time-consuming and do not apply to some types of astronomical objects, most notably the emission nebulae.

The techniques used by amateur astronomers for their image-processing work differ a lot from person to person, and there are no general standards. Some photographers would remove traces of planetoids, satellites or ghost-images, others accept them as part of the authentic picture. Composite images made from several different exposures change the perception of the intensity range. This technique is used to accommodate large intensity variations and to avoid "burnt-out" central regions. But it may make stars on bright nebulous backgrounds appear significantly less brilliant than they are in reality. A good example is

the Trapezium in the Orion Nebula. Hence, a quantitative interpretation of such a photo is impossible, but amateur astrophotographers are happy to accept that, in order to produce the most appealing image of an object.

Most photos printed in this book were taken in the years between 2012 and 2023 by astrophotographers from all over the world. Most are using DSLR or bespoke CMOS astro-cameras. Standard image acquisition methods include RGB, LRGB and imaging in selected emission lines (notably H α , [OIII], SII). The instruments used vary from small portable lenses for objects with large angular diameters to permanently mounted telescopes in large observatories.

During the last couple of years, a growing number of photographers have been using image data obtained from remote-controlled observatories, which might even be located on a different continent. These remote observatories offer the possibility of getting results independent of weather conditions at home, and with much larger or better telescopes and cameras than available to most amateurs. While some of them have been built by co-operatives of astrophotographers joining their forces, others are commercial enterprises offering image data on request. Both have led to a change in the way images are obtained today, with the effect of releasing amateurs from the limitation of using only privately owned and comparatively small equipment. On the other hand, imaging is no longer a part of modern astrophotography in these cases.

Each contributing astrophotographer is featured on page 360. For accurate technical information on each picture, refer to the image credits in the appendix section starting on page 362.



A photo in its work stages: M 72. At left is a single image taken with the blue filter, in the middle the calibrated blue image, at right the fully processed LRGB composite.

The drawings

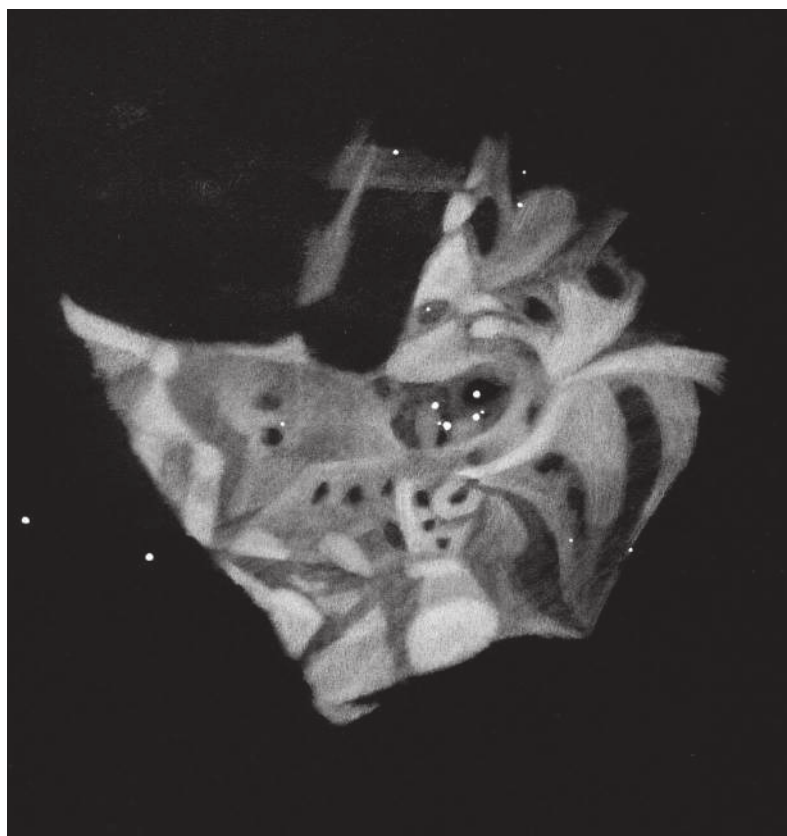
Alongside the photographs, historical and modern drawings have been reproduced in this book. The manual sketch of an object as perceived through the telescope eyepiece was the only scientific method of recording until the late nineteenth century, after which photography finally took over. This book shows a large number of fine sketches from the pre-photographic era. Differentiating real physical changes in the objects from artistically diverse sketching styles and personal perceptions has been a continual problem. Today, amateurs keep the tradition of astronomical drawings alive, in order to sketch their visual impression of a specific object.

Drawings are subjective and contain erroneous perceptions. Nevertheless, this method is an independent recording technique, complementary to the capabilities of photography. Before criticizing historical drawings for their misconceptions, we should keep in mind that it is always easier to verify a known feature than to discover it. In that sense, the historic drawings must be regarded as more “honest” than their modern counterparts. Even the most critical modern observer cannot avoid the subconscious knowledge of an object by modern photography and its influence on his or her perception of it.

Drawings differ from photographs in a number of ways. For one, the eye can not accumulate light over a long time, as a photographic emulsion or chip can. Furthermore, the visual response to a large brightness range is much more logarithmic than the photographic response. And finally, the spectral response of the eye also differs from that of digital detectors. With emission nebulae, in particular, visual and photographic views emphasize different features.

The author’s drawings were specifically made for this book. The objects were observed several times with different apertures. Frequently, several attempts were required before an acceptable result was achieved. All the sketches are of a cumulative nature: each drawing summarizes the visual impressions of an object collected over many hours or even nights under a dark sky in the countryside, in the mountains or in the Namibian desert. The results are not to be confused with a quick sketch made by the eyepiece! The observing time involved was at least an hour, as for a simple elliptical galaxy, and up to three nights for large objects with a lot of detail.

The original sketches are drawn with pencil, black on white. So are the proper drawings, using in addition an eraser and a smudging tool. For an inversion to white on black, the drawing is scanned and the tonal range adjusted, but no further digital manipulations are made. Subtle contrasts are over-pronounced by the drawings, as they would otherwise be lost in print.



A drawing in its work-stages: M 42. Above is the original pencil sketch, below the properly redrawn and then inverted result.

