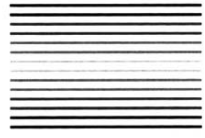
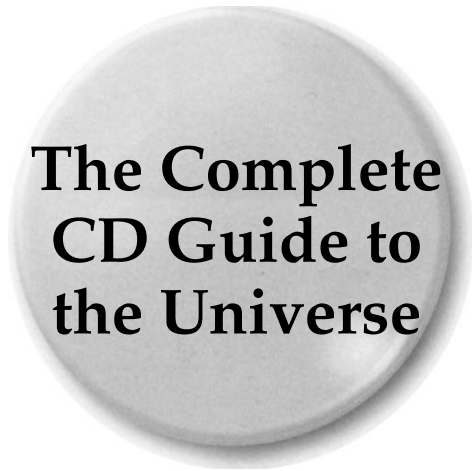


Patrick Moore's Practical Astronomy Series



The Complete CD Guide to the Universe

Practical Astronomy

Richard Harshaw

With 31 Figures



Springer

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To my best friend and constant companion, my wife Loretta, who indulges my crazy pursuit of one of the greatest hobbies in the world. She puts up with odd hours, strange travel plans, an unfathomable pursuit of gadgets and gizmos, and an incomprehensible vocabulary of stellar and galactic terminology. Yet she always has a gentle way of bringing me back to earth and taking the time to enjoy the simple daily pleasures of life too.

To my granddaughter, Alexis. Her five-year-old curiosity and endless parade of questions sometimes wears Grandpa down, but never do I tire of her desire to know. I hope the day comes when she can take up the observations of the skies over her head on her own. Until then, I am here to guide you, sweetheart. I love you more than two hundred billion galaxies!

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Preface

If you are looking for a book full of “eye candy”—stunning celestial images that can inspire your imagination and induce a sense of awe at the grand scale of our marvelous universe—this book is not for you.

If you are looking for a good “coffee table” book to lay out on your living room furniture so guests can thumb through the beautiful pages and perhaps ask you questions about what the book contains—this book is not for you either.

But if you are looking for a book that can help you observe more of the heavens than you ever thought possible, then this book might be what you are looking for.

I wrote this book after I upgraded my telescope and found myself with a much larger universe to observe than I had before. How do I plan an observing program that can help me make the most of my limited time and squeeze the most out of my new piece of finely figured glass?

It soon dawned on me that observing the sky by constellation—which is a very popular option—was not, in the Spockian sense, “logical” to me as many rich parts of the sky spill over the artificial constellation boundaries people have assigned to the sky. (For example, the Winter Milky Way sprawls across several constellations and if you are pursuing, let us say, open clusters along the Milky Way’s mid-plane, you may leave out several excellent views if you limit yourself to Canis Major, or Orion.) I decided to divide the sky into “zones” and study it by zone as the combination of seasons, weather, and lunar cycles permitted. The result is the format you will use in this book. (The astute reader will accuse me of substituting one set of man-made boundary lines for another, to which I reply.

True! You got me! But the zones I use are much smaller than the constellations so you can spend an entire evening in a small part of the sky and really enjoy all it has to offer at whatever pace you wish to use.

Indeed, some zones—which measure one hour of right ascension in width and 10 degrees of declination in height—may take you four or five nights, or more, to fully explore!)

All of the observations reported in this observing guide were made from suburban locations. Only a small number (less than 2%) were made from truly “dark sky sites,” and those records will be noted when you encounter them.

From 1987 to 1990, I made my observations in Columbia, Missouri using a Celestron C-8. Columbia at that time was a city of about 100,000 people. My residence was located on the southwest edge of town which put most of the light dome from the city to my east and north. This was fortunate because a long, low ridge lay between my home and the city. This ridge was high enough to block out the majority of the truly offensive night glow, with only a small fringe of faint sky glow extending up to about 20 degrees above the horizon. But since I did not have a clear view of the eastern sky from my residence, I did not need to observe in that direction anyway. My views

overhead, to the North, South, and West were clear with skies often having a naked eye limiting magnitude of 5.8 to 6.0.

In 1990, I moved to Kansas City, MO and built a home on the north side of the city. I was located about 12 miles due north of the center of the city, with a decent horizon all around me. But the awful sky glow from the millions of watts of high-pressure sodium street lighting was much more offensive than the modest glow of Columbia. So my southern sky below about -20° declination is almost always awash in a hopelessly bright glow. Skies to the East and West are better, the zenith good, and the North even better. On a good night from my location, the limited naked eye magnitude can reach as low as 5.5, but usually 4.0 or so on a typical night (at the zenith).

In 2000, I purchased a Celestron C-11 and have been observing with it ever since.

My main point to all of this is that *everything described in this book can be observed from suburban sites with instruments of moderate aperture*. Huge “light buckets” or wonderfully dark skies are not a requirement to detect the wonderful treasures described in this book. They help, of course, but the fact is that you can observe a lot of things in the sky from even brightly lit suburban sites. See the discussion on observing galaxies in Chapter 3.)

In this guide, you will have descriptions of 13,238 *objects* viewed from the sites I previously described. The majority of them—10,738—are double or multiple stars. The balance—2,500—are “deep sky” objects (as if double stars were not in the “deep sky”!).

Double stars dominate this work for several reasons. *First*, for the modest aperture telescope, there are far more of them than anything else in the sky. The Washington Double Star Catalog (or WDS as amateurs often call it) is considered to be the standard double star reference in the business today. It lists well over 100,000 pairs. If we filter the WDS and remove from it those pairs that are (a) too faint to see in scopes of 11-inches or less aperture, (b) too close to separate in such instruments, and (c) too far south to be seen from the north 40th parallel, we end up with about 20,000 pairs. I have chosen 10,596 of the best and have not included another 8000 or so pairs I have observed that are just too faint or difficult to be of much interest to a general observer. As much as possible, I have tried to include only true binary stars, not just chance alignments of two stars that happen to “look” close together. (For that reason, many of the popular “double” stars you may see on some lists are not included in this book.) Where a pair is in doubt, I will make remarks to that effect.

Second, double stars are usually bright enough to be easily observed from even urban sites. Double stars can often be seen in hazy, murky, moonlit skies, and in types of weather that render galaxies, planetary nebulae, and other faint and extended objects simply invisible.

The deep sky objects include many galaxies (1573 of them), and the point to be made is that although dark sky sites help in tracking down and bagging these elusively faint blotches of light, many of them can still be observed in what most amateurs would write off as hopeless skies for the task. True, dark skies reveal more detail in galaxies than suburban skies, but do not think that suburban skies mean your galaxy-hunting efforts will be limited to a handful of bright Messier objects!

You will also find 580 open clusters at your disposal, 109 globular clusters, 148 planetary nebulae, and a handful of other interstellar and intergalactic stuff.

Preface



If you are an urban or suburban amateur with limited observing time and want to get the most out of your telescope, let this book guide you to all the treasures that are within your grasp. I promise you a rich and rewarding journey and memories to last more than a lifetime!

Richard Harshaw
Kansas City, MO

Foreword

This is a book and CD-ROM for people with a telescope and who are interested in an organized study of the wondrous night sky, including its double stars, clusters, nebulae, and galaxies. While there are other books covering these topics in the amateur literature, this one is better suited to the amateur astronomer wanting to observe the sky with a systematic system and keep track of their observations.

This work starts out with the author recalling his early interest in astronomy (he has been watching the night sky for over 40 years) and works up to the topics that give a better understanding of the book and how to get more out of observing. There are some recommendations for supplemental reading if needed. Some important basics are covered to give the reader a foundation for the remainder of the book and CD-ROM.

A major theme of this book (and of the author's lifelong observing pursuits) is double stars. There is information on what measurements apply to a double star and how they are made, stellar color, and the dynamic nature of binary systems. Included is a helpful and detailed discussion on the naming and "coding" of double stars. There are biographical thumbnails of some of the more important double star observers—a very interesting historical footnote! Finally, there is a discussion about the use of scale models for doubles in a kinetic attempt to help the observer get a feel for what he or she is observing when viewing a binary star system.

But there are also a rich host of deep sky objects listed throughout the book. Here you will find an explanation of the nomenclature of galaxies, open clusters, globular clusters, and planetary nebulae.

After all of this introductory material, the real meat of the book begins—how to use the CD-ROM. There are, altogether, about 13,000 pages of material on the CD and a little time and care spent early on learning how to navigate it will save the reader a great deal of time later.

The heart of the system is in the finder charts and observing catalogs. There are four sections of maps and catalogs, one for each season. Each seasonal section is then divided into zones for each hour of *right ascension* and 10 degrees of *declination*, down to -40 degrees.

It is in the zones where you will find the most interesting data. Each zone, in Adobe Acrobat (PDF) format includes detailed maps covering its own area of sky. (For those who do not have Adobe Acrobat Reader installed on their computers, the CD has the Reader installation program on it.) A unique feature of Richard's work is that all maps (except the Zone Master Map) are given twice—one map being a "normal" image and the other a "mirror" image for use at the telescope. For those who have ever tried to mentally reverse or invert a field from a finder chart while at the telescope, the sheer ease and utility of the mirror image charts should bring a tear of joy to your eyes. (Just do not let that tear drop onto your eyepiece . . .)

Each zone has a detailed index. The index lists all the objects that are listed for that zone in alphabetical order, with references to which detailed finder chart in which the observer can find that object.

Last are the objects themselves. The double stars are listed first, followed by deep sky entries. In addition to name and location, other details about the object are given along with Richard's own observation notes for each object. (Yes, this is one observing guide where the writer has actually observed every object in the guide!)

Objects are presented in a unique way to facilitate observing and develop your observing skills. Easy objects (both double stars and deep sky) are listed first, followed by objects of moderate difficulty and culminating with difficult objects. Within each difficulty class, Richard has also ranked the objects in order of the eyepiece impact, with stunning objects being listed ahead of moderate ones, which in turn are listed ahead of those all-too-unimpressive views we often see as observers. There is great utility in this—one can decide on a night of moderate to poor seeing to focus on the easy objects and save the difficult ones for a night of better seeing. (This will especially be true of close and difficult double stars.)

Richard has also prepared a set of PDF files of objects by constellation for those who prefer to hunt the sky by constellation. As in the Zone format, each starts with easy double stars, works toward the more difficult, and then covers deep sky objects. The documents can be printed and used to keep track of observations.

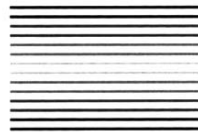
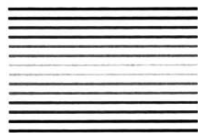
One of the more practical things about this book is that every object described in it has been observed from suburban skies, with only a few exceptions (and these are noted in the text when they occur). Too often in the past, I have seen observing guides that require skies that frankly are just not available to the majority of amateur astronomers in the world, and Richard's work says to all who will try, "these things can be seen with a modest scope (8 inches or large) from even well-lit suburbs!"

I have observed with Richard on numerous occasions when his travels bring him to Phoenix, AZ, and can attest to his experience. But what impresses me the most about Richard is his enthusiasm for the night sky and his willingness to share it with any who will listen. One night at our annual Sentinel Star Gaze, for instance, I was trying to locate one of the globular clusters in M31 with my 14.5-inch Dobsonian. Richard had observed it only a couple of months earlier in his C-11 from skies that were much more difficult to look through than our wonderful desert skies, and he helped me hunt down the illusive little beast. When I got to confirm my first view of a non-Milky Way globular, Richard was just as excited about my conquest as I was! I am sure that you will find that same spirit of excitement and adventure in the book you are about to take home.

As Richard would say, "Clear skies, and fully dilated pupils to you!"

A. J. Crayon
Phoenix, AZ.

CHAPTER ONE



First Light

It was his first look ever through a telescope, and he could hardly contain his excitement as he swung the tube on its alt-azimuth mount and pointed it in the direction of the first quarter moon. He locked the axis screws and peered through the finder scope. (He had spent part of the afternoon aligning it on a church steeple a mile away.) There, just a little below and to the left of the cross hairs, was the quarter moon! He unlocked the set screws and clumsily centered the cross hairs on the target and then—with the expectancy of a little child at Christmas—he looked into the eyepiece.

Words could not describe how that 14-year-old boy felt! There were craters, just like his astronomy book showed! And mountains, and maria! The jagged rip of the terminator was a source of incredible fascination to him.

After several minutes of absorbing his first telescopic views of the moon, he decided to try to conquer more ambitious targets. Being the late spring of the year, the youngster loosened the set screws and slewed the tube eastward to the vicinity of the Keystone in Hercules, low in the eastern sky. He wanted to look at the great globular star cluster, M13. (He was not sure what the M stood for, but the pictures of M13 in his astronomy book were breathtaking.) He pointed the tube at the spot on the western side of the Keystone where his little star chart said M13 was, and used his finder scope to fine tune his aim. When he thought he was in the right area, he went to the eyepiece and—no M13! Patiently, he worked his way back and forth in the field until suddenly a fuzzy ball of light emerged into view like a ghost on a foggy moor. “Is *that* it?” he mused to himself. “That is not how it looks in my book,” he thought. Where were the myriad dots of light his picture showed? This was not much at all—just a big, round patch of ill-defined fog!

He then spent 20 minutes in a fruitless effort to find M87 in Virgo. He then took several minutes to get Alcor and Mizar in the Big Dipper’s handle in the eyepiece before he could enjoy the first of over 21,000 “double stars.”

And so it went, the rest of the evening (although not very late—the next day was a school day), trying to locate things he had seen in his astronomy book and looking where the star charts said to look, as often as not failing to locate the object, but nonetheless not finding his enthusiasm dampened one bit by his failures.

It was the start of a rich and rewarding hobby.

Aperture Fever

That youngster was me, and the year was 1965. I had just bought my first telescope, a 60-mm refractor on an alt-azimuth mount, from a high-school senior who sold it to me for a hefty \$15 (which I had to scrape together from several months of allowances and chores), and it included a Barlow lens, a solar projection screen, and two 0.925-inch eyepieces, giving me magnifications of $30\times$ and $100\times$ ($60\times$ and $200\times$ with the Barlow). The alt-azimuth mount was smooth, even if it could not be used to locate objects by their sky coordinates, and the tripod was a fairly sturdy one. Such a telescope today would probably cost around \$300 new.

For the next 4 years, I used my little f-15 refractor to explore first the easy things (the moon, the planets, bright galaxies, star clusters, and easy double stars). Then, as my skills improved, I went for more and more difficult targets, eventually pushing the modest optics of my scope to their limits. I saw the polar caps of Mars, the Red Spot on mighty Jupiter (at that time, a light brick red, not the salmon pink of today), the Cassini Division in the rings of Saturn, the moon's Straight Wall and Alpine Valley. I spent many nights in awe gazing at the Pleiades or M11. I strained to make out the Crab Nebula and several faint galaxies. I even spent one bitterly cold winter night watching the moons of Jupiter go through their majestic, formal dance.

In my junior year at high school, I gave the refractor to a younger neighbor and bought my first “serious” scope—a 4.5-inch reflector with an equatorial mount. And thus began a new era of beginner's frustration!

I had never used an equatorial mount before but knew from my readings that if I ever hoped to easily locate the sky's more difficult (a euphemism for “faint”) objects, I would find one helpful. The frustration came in learning what the sky's coordinates were all about, and then learning how to accurately “polar align” the thing so I could find those faint fuzzies the books all talked about. I will cover in later pages how I now accurately polar align, but suffice it to say for now that my last years of high school were times when I had a love-hate relationship with my reflector!

What I Assume You Know

At this point, I assume you already have a fairly good *basic* understanding of the elements of visual astronomy. I assume you

- know the difference between a refracting telescope and a reflecting telescope,
- know what is meant (roughly) by “polar aligning,”
- know the difference between an alt-azimuth and an equatorial mount,

- understand how to use an equatorial mount and that you are conversant with astronomy's system of longitude (right ascension) and latitude (declination),
- have a fundamental grasp of the magnitude scale,
- know the basic types of things that there are to see in the sky with a telescope,
- know what is meant by “aperture,” and
- know how to compute the magnification of a telescope given the focal lengths of the objective and the oculars.

If these assumptions are beyond your present skill level, I suggest you first read any of the several excellent manuals on these topics for beginners, such as Phil Harrington's *Stare Ware*, David Eicher's *Beginner's Guide to Amateur Astronomy*, or Sam Brown's *All About Telescopes*. If you own a 20-cm (8-inch) Schmidt-Catadioptric telescope, as I do, you might also enjoy Peter Manly's *The 20-cm Schmidt-Cassegrain Telescope*.

Light Gathering Power

The 4.5-inch reflector offered me one great advantage over the 60-mm refractor—light gathering power, or in the vernacular of the amateurs, light grasp. I had learned that a manufacturer's claims about a telescope's magnifying power were secondary, and in most cases grossly exaggerated. The main thing an astronomer needs a telescope for is to gather photons, and for that the diameter of the *objective* is the governing factor. My 4.5-inch reflector had over 3.6 times the photon grasp of my refractor. Since each step of the Pogson or *magnitude* scale represents an increase of 2.54 times the light of the next level, this meant I could extend my reach a little over one full magnitude! Theoretically, my 4.5-inch reflector could reach magnitude 12.5 while the refractor could only reach down to 11.3. This meant, according to one of my astronomy books, an increase in the number of objects visible to me from about 870,000 with the refractor to 3,500,000 with the reflector.

The magnitude grasp of a telescope is given by the formula

$$M_F = 6.5 - 5(\log, \text{eye pupil diameter}) + 5(\log, \text{objective diameter})$$

where the eye pupil diameter and objective diameters are both measured in inches. If we use 0.20 inches for the typical dilated pupil (roughly 5 mm), we see that a 6-inch telescope, for example, should be able to reach all the way down to 13.9 magnitude.

Wow! In one fell swoop (at the cash register), I had almost quadrupled my visible universe!

I also knew that with increasing objective diameter came an increase in a telescope's ability to show detail—what astronomers call *resolving power*, or resolution. The simplified astronomy text I was using at the time gave a formula that I have since learned was a great simplification of the original *Rayleigh Formula*,¹ and it expressed a telescope's resolving power as its ability to discern details expressed in seconds of

¹The Rayleigh limit formula for the resolving power of a telescope is given by $2.5 \times 10^5 (\lambda/d)$ where λ and d are expressed in meters. For optical values of λ , the formula approximates to $0.13/d$ arcseconds. The Dawes limit, determined by empirical measurements, yields $0.12/d$ arcseconds. Converting these to English units of measurement shows that where Dawes shows $4.5/d$, Rayleigh shows $4.87/d$.