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by Stephen P. Maran, PhD

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Introduction

Astronomy is the study of the sky, the science of cosmic objects and celestial happenings. It's nothing less than the investigation of the nature of the universe we live in. Astronomers carry out the business of astronomy by using backyard telescopes, huge observatory instruments, radio telescopes that detect celestial radio emissions, and satellites orbiting Earth or positioned in space near Earth or another celestial body, such as the Moon or a planet. Scientists send up telescopes in sounding rockets and on unmanned balloons, some instruments travel far into the solar system aboard deep space probes, and some probes gather samples and return them to Earth.

Astronomy can be a professional or amateur activity. About 25,000 professional astronomers engage in space science worldwide, and an estimated 500,000 amateur astronomers live around the globe. Many of the amateurs belong to local or national astronomy clubs in their home countries.

Professional astronomers conduct research on the Sun and the solar system, the Milky Way galaxy, and the universe beyond. They teach in universities, design satellites in government labs, and operate planetariums. They also write books like this one (but maybe not as good). Most hold PhDs. Nowadays, many professional astronomers study abstruse physics of the cosmos or work with automated, remotely controlled telescopes, so they may not even know the constellations.

Amateur astronomers know the constellations. They share an exciting hobby. Some stargaze on their own; many others join astronomy clubs and organizations of every description. The clubs pass on know-how from old hands to new members, share telescopes and equipment, and hold meetings where members tell about their recent observations or hear lectures by visiting scientists.

Amateur astronomers also hold observing meetings where everyone brings a telescope (or looks through another observer's scope). The amateurs conduct these sessions at regular intervals (such as the first Saturday night of each month) or on special occasions (such as the return of a major meteor shower each August or the appearance of a bright comet like Hale-Bopp). And they save up for really big events, such as a total eclipse of the Sun, when thousands of amateurs and dozens of pros travel across Earth to position themselves in the path of totality and witness one of nature's greatest spectacles.

About This Book

This book explains all you need to know to launch into the great hobby of astronomy. It gives you a leg up on understanding the basic science of the universe as well. The latest space missions will make more sense to you: You'll understand why NASA and other organizations send space probes to planets like Saturn, why robot rovers land on Mars, and why scientists seek samples of the dust in the tail of a comet. You'll know why the Hubble Space Telescope peers out into space and how to check up on other space missions. And when astronomers show up in the newspaper or on television to report their latest discoveries — from space; from the big telescopes in Arizona, Hawaii, Chile, and California; or from radio telescopes in New Mexico, Puerto Rico, Australia, or other observatories around the world — you'll understand the background and appreciate the news. You'll even be able to explain it to your friends.

Read only the parts you want, in any order you want. I explain what you need as you go. Astronomy is fascinating and fun, so keep reading. Before you know it, you'll be pointing out Jupiter, spotting famous constellations and stars, and tracking the International Space Station as it whizzes by overhead. The neighbors may start calling you "stargazer." Police officers may ask you what you're doing in the park at night or why you're standing on the roof with binoculars. Tell 'em you're an astronomer. They probably haven't heard that one (I hope they believe you!).

Foolish Assumptions

You may be reading this book because you want to know what's up in the sky or what the scientists in the space program are doing. Perhaps you've heard that astronomy is a neat hobby, and you want to see whether the rumor is true. Perhaps you want to find out what equipment you need.

You're not a scientist. You just enjoy looking at the night sky and have fallen under its spell, wanting to see and understand the real beauty of the universe.

You want to observe the stars, but you also want to know what you're seeing. Maybe you even want to make a discovery of your own. You don't have to be an astronomer to spot a new comet, and you can even help listen for E.T. Whatever your goal, this book helps you achieve it.

Icons Used in This Book

Throughout this book, helpful icons highlight particularly useful information — even if they just tell you to not sweat the tough stuff. Here's what each symbol means.

The Remember icon points out information you should file away for future reference.

This nerdy guy appears beside discussions that you can skip if you just want to know the basics and start watching the skies. The scientific background can be good to know, but many people happily enjoy their stargazing without knowing about the physics of supernovas, the mathematics of galaxy chasing, and the ins and outs of dark energy.

This lightbulb puts you right on track to make use of some inside information as you start skywatching or make progress in the hobby.

How much trouble can you get into watching the stars? Not much, if you're careful. But some things you can't be too careful about. This icon alerts you to pay attention so you don't get burned.

Beyond the Book

In addition to the book you're reading right now, be sure to check out the free Cheat Sheet online. It offers a timeline of notable astronomical events and a list of famous female astronomers. To get this Cheat Sheet, simply go to `www.dummies.com` and enter "Astronomy For Dummies" in the Search box.

If you want to test your astronomy knowledge, check out the practice quizzes online. Each chapter has a corresponding quiz consisting of multiple choice and true/false questions. I've also turned the glossary into flashcards that let you test your knowledge of astronomy terms.

To gain access to the online content, all you have to do is register. Just follow these simple steps:

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If you do not receive this email within two hours, please check your spam folder before contacting us through our Technical Support website at `http://support.wiley.com` or by phone at 877-762-2974.

Now you're ready to go! You can come back to the practice material as often as you want — simply log on with the username and password you created during your initial login. No need to enter the access code a second time.

Your registration is good for one year from the day you activate your PIN.

Where to Go from Here

You can start anywhere you want. Worried about the fate of the universe? Start off with the Big Bang (see Chapter 16 if you're really interested).

Or you may want to begin with what's in store for you as you pursue your passion for the stars.

Wherever you start, I hope you continue your cosmic exploration and experience the joy, excitement, enlightenment, and enchantment that people have always found in the skies.

1 Getting Started with Astronomy

IN THIS PART . . .

Discover the basic elements of astronomy, check out a list of constellations, and get a crash course on gravity.

Find out about the resources available to help you check out the night sky, including organizations, facilities, and equipment.

Get an introduction to astronomical and artificial phenomena that sweep across the night sky, such as meteors, comets, and artificial satellites.

IN THIS CHAPTER

- Understanding the observational nature of astronomy
- Focusing on astronomy's language of light
- Weighing in on gravity
- Recognizing the movements of objects in space

Chapter 1

Seeing the Light: The Art and Science of Astronomy

Step outside on a clear night and look at the sky. If you're a city dweller or live in a cramped suburb, you see dozens, maybe hundreds, of twinkling stars. Depending on the time of the month, you may also see a full Moon and up to five of the eight planets that revolve around the Sun.

A shooting star or "meteor" may appear overhead. What you actually see is the flash of light from a tiny piece of space dust streaking through the upper atmosphere.

Another pinpoint of light moves slowly and steadily across the sky. Is it a space satellite, such as the Hubble Space Telescope, the International Space Station, or just a high-altitude airliner? If you have a pair of binoculars, you may be able to see the difference. Most airliners have running lights, and their shapes may be perceptible.

If you live in the country — on the seashore away from resorts and developments, on the plains, or in the mountains far from any floodlit ski slope — you can see thousands of stars. The Milky Way appears as a beautiful pearly swath across the heavens. What you're seeing is the cumulative glow from millions of faint stars, individually indistinguishable with the naked eye. At a great observation place, such as Cerro Tololo in the Chilean Andes, you can see even more stars. They hang like brilliant lamps in a coal black sky, often not even twinkling, like in van Gogh's *Starry Night* painting.

When you look at the sky, you practice astronomy — you observe the universe that surrounds you and try to make sense of what you see. For thousands of years, everything people knew about the heavens they deduced by simply observing the sky. Almost everything that astronomy deals with

- Is seen from a distance
- Is discovered by studying the light that comes to you from objects in space
- Moves through space under the influence of gravity

This chapter introduces you to these concepts (and more).

Astronomy: The Science of Observation

Astronomy is the study of the sky, the science of cosmic objects and celestial happenings, and the investigation of the nature of the universe you live in. Professional astronomers carry out the business of astronomy by observing with telescopes that capture visible light from the stars or by tuning in to radio waves that come from space. They use backyard telescopes, huge observatory instruments, and satellites that orbit Earth collecting forms of light (such as ultraviolet radiation) that the atmosphere blocks from reaching the ground. They send up telescopes in sounding rockets (equipped with instruments for making high-altitude scientific observations) and on unmanned balloons. And they send some instruments into the solar system aboard deep-space probes.

Professional astronomers study the Sun and the solar system, the Milky Way, and the universe beyond. They teach in universities, design satellites in government labs, and operate planetariums. They also write books (like me, your loyal *For Dummies* hero). Most have completed years of schooling to hold PhDs. Many of them study complex physics or work with automated, robotic telescopes that reach far beyond the night sky recognizable to our eyes. They may never have studied the *constellations* (groups of stars, such as Ursa Major, the Great Bear, named by ancient stargazers) that amateur or hobbyist astronomers first explore.

You may already be familiar with the Big Dipper, an asterism in Ursa Major. An *asterism* is a named star pattern that's not identical to one of the 88 recognized constellations. An asterism may be wholly within a single constellation or may include stars from more than one constellation. For example, the four corners of the Great Square of Pegasus, a large asterism, are marked by three stars of the Pegasus constellation and a fourth from Andromeda. Figure 1-1 shows the Big Dipper in the night sky. (In the United Kingdom, some people call the Big Dipper *the Plough.*)

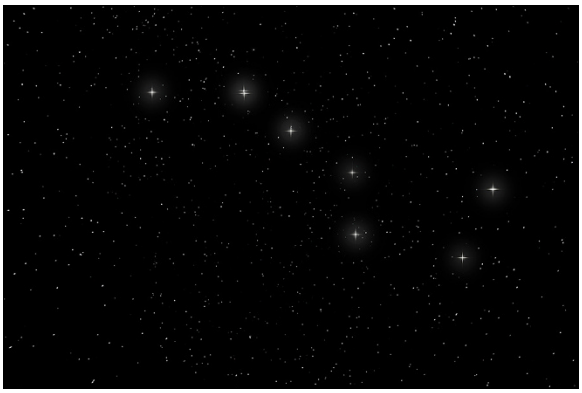

FIGURE 1-1: The Big Dipper, found in Ursa Major, is an asterism.

Photo © Jerry Lodriguss

In addition to the roughly 30,000 professional astronomers worldwide, several hundred thousand amateur astronomers enjoy watching the skies. Amateur astronomers usually know the constellations and use them as guideposts when exploring the sky by eye, with binoculars, and with telescopes. Many amateurs also make useful scientific contributions. They monitor the changing brightness of variable stars; discover asteroids, comets, and exploding stars; and crisscross Earth to catch the shadows cast as asteroids pass in front of bright stars (thereby helping astronomers map the asteroids' shapes). They even join in professional research efforts with their home computers and smartphones through Citizen Science projects, which I describe in Chapter 2 and elsewhere throughout the book.

In the rest of Part 1, I provide you with information on how to observe the skies effectively and enjoyably.

What You See: The Language of Light

Light brings us information about the planets, moons, and comets in our solar system; the stars, star clusters, and nebulae in our galaxy; and the objects beyond.

In ancient times, folks didn't think about the physics and chemistry of the stars; they absorbed and passed down folk tales and myths: the Great Bear, the Demon star, the Man in the Moon, the dragon eating the Sun during a solar eclipse, and more. The tales varied from culture to culture. But many people did discover the patterns of the stars. In Polynesia, skilled navigators rowed across hundreds of miles of open ocean with no landmarks in view and no compass. They sailed by the stars, the Sun, and their knowledge of prevailing winds and currents.

Gazing at the light from a star, the ancients noted its brightness, position in the sky, and color. This information helps people distinguish one sky object from

another, and the ancients (and now people today) got to know them like old friends. Some basics of recognizing and describing what you see in the sky are

- Distinguishing stars from planets
- Identifying constellations, individual stars, and other sky objects by name
- Observing brightness (given as magnitudes)
- Understanding the concept of a light-year
- Charting sky position (measured in special units called *RA* and *Dec*)

They wondered as they wandered: Understanding planets versus stars

The term *planet* comes from the ancient Greek word *planetes*, meaning "wanderer." The Greeks (and other ancient people) noticed that five spots of light moved across the pattern of stars in the sky. Some moved steadily ahead; others occasionally looped back on their own paths. Nobody knew why. And these spots of light didn't twinkle like the stars did; no one understood that difference, either. Every culture had a name for those five spots of light — what we now call planets. Their English names are Mercury, Venus, Mars, Jupiter, and Saturn. These celestial bodies aren't wandering through the stars; they orbit around the Sun, our solar system's central star.

Today astronomers know that planets can be smaller or bigger than Earth, but they all are much smaller than the Sun. The planets in our solar system are so close to Earth that they have perceptible disks — at least, when viewed through a telescope — so we can see their shapes and sizes. The stars are so far away from Earth that even if you view them through a powerful telescope, they show up only as points of light. (For more about the planets in the solar system, flip to Part 2. I cover the planets of stars beyond the Sun in Part 4.)

If you see a Great Bear, start worrying: Naming stars and constellations

I used to tell planetarium audiences who craned their necks to look at stars projected above them, "If you can't see a Great Bear up there, don't worry. Maybe those who *do* see a Great Bear should worry."

Ancient astronomers divided the sky into imaginary figures, such as Ursa Major (Latin for "Great Bear"); Cygnus, the Swan; Andromeda, the Chained Lady; and Perseus, the Hero. The ancients identified each figure with a pattern of stars.

The truth is, to most people, Andromeda doesn't look much like a chained lady at all — or anything else, for that matter (see Figure 1-2).

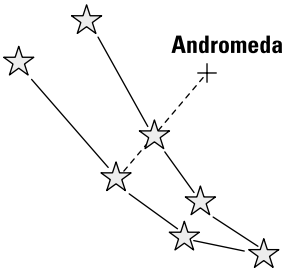

FIGURE 1-2: Andromeda is also known as the Chained Lady.

Today astronomers have divided the sky into 88 constellations, which contain all the stars you can see. The International Astronomical Union, which governs the science, set boundaries for the constellations so astronomers can agree on which star is in which constellation. Previously, sky maps drawn by different astronomers often disagreed. Now when you read that the Tarantula Nebula is in Dorado (see Chapter 12), you know that, to see this nebula, you must seek it in the Southern Hemisphere constellation Dorado, the Goldfish.

The largest constellation is Hydra, the Water Snake. The smallest is Crux, the Cross, which most people call the Southern Cross. You can see a Northern Cross, too, but you can't find it in a list of constellations; it's an asterism within Cygnus, the Swan. Although astronomers generally agree on the names of the constellations, they don't have a consensus on what each name means. For example, some astronomers call Dorado the Swordfish, but I'd like to skewer that name. One constellation, Serpens, the Serpent, is broken into two sections that aren't connected. The two sections, located on either side of Ophiuchus, the Serpent Bearer, are Serpens Caput (the Serpent's Head) and Serpens Cauda (the Serpent's Tail).

The individual stars in a constellation often have no relation to each other except for their proximity in the sky as visible from Earth. In space, the stars that make up a constellation may be completely unrelated to one another, with some located relatively near Earth and others located at much greater distances in space. But they make a simple pattern for observers on Earth to enjoy.

As a rule, the brighter stars in a constellation were assigned a Greek letter, either by the ancient Greeks or by astronomers of later civilizations. In each constellation, the brightest star was labeled alpha, the first letter of the Greek alphabet. The next brightest star was beta, the second Greek letter, and so on down to omega, the final letter of the 24-character Greek alphabet. (The astronomers used only lowercase Greek letters, so you see them written as α, β, . . . ω.)

So Sirius, the brightest star in the night sky — in Canis Major, the Great Dog — is called Alpha Canis Majoris. (Astronomers add a suffix here or there to put star names in the Latin genitive case; scientists have always liked Latin.) Table 1-1 shows a list of the Greek alphabet, in order, with the names of the letters and their corresponding symbols.

TABLE 1-1 The Greek Alphabet

Letter	Name
α	Alpha
β	Beta
γ	Gamma
δ	Delta
ε	Epsilon
ζ	Zeta
η	Eta
θ	Theta
ι	Iota
κ	Kappa
λ	Lambda
μ	Mu
ν	Nu
ξ	Xi
ο	Omicron
π	Pi
ρ	Rho
σ	Sigma
τ	Tau
υ	Upsilon
φ	Phi
χ	Chi
ψ	Psi
ω	Omega

TIP

When you look at a star atlas, you discover that the individual stars in a constellation aren't marked α Canis Majoris, β Canis Majoris, and so on. Usually, the creator of the atlas marks the area of the whole constellation as Canis Major and labels the individual stars α, β, and so on. When you read about a star in a list of objects to observe, say, in an astronomy magazine (see Chapter 2), you probably won't see it listed in the style of Alpha Canis Majoris or even α Canis Majoris. Instead, to save space, the magazine prints it as α CMa; *CMa* is the three-letter abbreviation for Canis Majoris (and also the abbreviation for Canis Major). I give the abbreviation for each of the constellations in Table 1-2.

Astronomers didn't coin special names such as Sirius for every star in Canis Major, so they named them with Greek letters or other symbols. In fact, some constellations don't have a single named star. (Don't fall for those advertisements that offer to name a star for a fee. The International Astronomical Union doesn't recognize purchased star names.) In other constellations, astronomers assigned Greek letters, but they could see more stars than the 24 Greek letters. Therefore, astronomers gave some stars Arabic numbers or letters from the Roman alphabet, or numbers in professional catalogues. So you see star names such as 61 Cygni, b Vulpeculae, HR 1516, and more. You may even run across the star names RU Lupi and YY Sex. (I'm not making this up.) But as with any other star, you can recognize them by their positions in the sky (as tabulated in star lists), their brightness, their color, or other properties, if not their names.

When you look at the constellations today, you see many exceptions to the rule that the Greek-letter star names correspond to the respective brightness of the stars in a constellation. The exceptions exist because

- The letter names were based on inaccurate naked-eye observations of brightness.
- Over the years, star atlas authors changed constellation boundaries, moving some stars from one constellation into another that included previously named stars.
- Some astronomers mapped out small and Southern Hemisphere constellations long after the Greek period, and they didn't always follow the lettering practice.
- The brightness of some stars has changed over the centuries since the ancient Greeks charted them.

A good (or bad) example is the constellation Vulpecula, the Fox, in which only one of the stars (alpha) has a Greek letter.

Because alpha isn't always the brightest star in a constellation, astronomers needed another term to describe that exalted status, and *lucida* is the word (from the Latin word *lucidus*, meaning "bright" or "shining"). The lucida of Canis Major is Sirius, the alpha star, but the lucida of Orion, the Hunter, is Rigel, which is Beta Orionis. The lucida of Leo Minor, the Little Lion (a particularly inconspicuous constellation), is 46 Leo Minoris.

Table 1-2 lists the 88 constellations, the brightest star in each, and the magnitude of that star. *Magnitude* is a measure of a star's brightness. (I talk about magnitudes in the later section "The smaller, the brighter: Getting to the root of magnitudes.") When the lucida of a constellation is the alpha star and has a name, I list only the name. For example, in Auriga, the Charioteer, the brightest star (Alpha Aurigae) is Capella. But when the lucida isn't an alpha, I give its Greek letter or other designation in parentheses. For example, the lucida of Cancer, the Crab, is Al Tarf, which is Beta Cancri.


TIP

If you're a long-time *Astronomy For Dummies* reader (possessing at least one of the three previous editions of the book as well as this edition), you may notice some changes in Table 1-2. In 2016, the International Astronomical Union issued a list of official names for bright stars. Seven stars in Table 1-2 were affected, with minor changes in spelling or a whole new name. In one case, a star was named after its constellation: Alpha Pavonis, in Pavo the Peacock, was itself named Peacock.

TABLE 1-2 The Constellations and Their Brightest Stars

Name	Abbreviation	Meaning	Star	Magnitude
Andromeda	And	Chained Lady	Alpheratz	2.1
Antlia	Ant	Air Pump	Alpha Antliae	4.3
Apus	Aps	Bird of Paradise	Alpha Apodis	3.8
Aquarius	Aqr	Water Bearer	Sadalsuud (Beta Aquarii)	2.9
Aquila	Aql	Eagle	Altair	0.8
Ara	Ara	Altar	Beta Arae	2.9
Aries	Ari	Ram	Hamal	2.0
Auriga	Aur	Charioteer	Capella	0.1
Bootes	Boo	Herdsman	Arcturus	–0.04

Name	Abbreviation	Meaning	Star	Magnitude
Caelum	Cae	Chisel	Alpha Caeli	4.5
Camelopardalis	Cam	Giraffe	Beta Camelopardalis	4.0
Cancer	Cnc	Crab	Al Tarf (Beta Cancri)	3.5
Canes Venatici	CVn	Hunting Dogs	Cor Caroli	2.9
Canis Major	CMa	Great Dog	Sirius	–1.5
Canis Minor	CMi	Little Dog	Procyon	0.4
Capricornus	Cap	Goat	Deneb Algedi (Delta Capricorni)	2.9
Carina	Car	Ship's Keel	Canopus	–0.7
Cassiopeia	Cas	Queen	Schedar	2.2
Centaurus	Cen	Centaur	Rigil Kentaurus	–0.01
Cepheus	Cep	King	Alderamin	2.4
Cetus	Cet	Whale	Diphda (Beta Ceti)	2.0
Chamaeleon	Cha	Chameleon	Alpha Chamaeleontis	4.1
Circinus	Cir	Compasses	Alpha Circini	3.2
Columba	Col	Dove	Phact	2.6
Coma Berenices	Com	Berenice's Hair	Beta Comae Berenices	4.3
Corona Australis	CrA	Southern Crown	Alphecca Meridiana	4.1
Corona Borealis	CrB	Northern Crown	Alphecca	2.2
Corvus	Crv	Crow	Gienah (Gamma Corvi)	2.6
Crater	Crt	Cup	Delta Crateris	3.6
Crux	Cru	Cross	Acrux	1.3
Cygnus	Cyg	Swan	Deneb	1.3
Delphinus	Del	Dolphin	Rotanev (Beta Delphini)	3.6
Dorado	Dor	Goldfish	Alpha Doradus	3.3
Draco	Dra	Dragon	Eltanin (Gamma Draconis)	2.2
Equuleus	Equ	Little Horse	Kitalpha	3.9
Eridanus	Eri	River	Achernar	0.5

(continued)

TABLE 1-2 ***(continued)***

Name	Abbreviation	Meaning	Star	Magnitude
Fornax	For	Furnace	Alpha Fornacis	3.9
Gemini	Gem	Twins	Pollux (Beta Geminorum)	1.1
Grus	Gru	Crane	Alnair	1.7
Hercules	Her	Hercules	Kornephoros (Beta Herculis)	2.8
Horologium	Hor	Clock	Alpha Horologii	3.9
Hydra	Hya	Water Snake	Alphard	2.0
Hydrus	Hyi	Little Water Snake	Beta Hydri	2.8
Indus	Ind	Indian	Alpha Indi	3.1
Lacerta	Lac	Lizard	Alpha Lacertae	3.8
Leo	Leo	Lion	Regulus	1.4
Leo Minor	LMi	Little Lion	Praecipua (46 Leonis Minoris)	3.8
Lepus	Lep	Hare	Arneb	2.6
Libra	Lib	Scales	Zubeneschamali (Beta Librae)	2.6
Lupus	Lup	Wolf	Alpha Lupi	2.3
Lynx	Lyn	Lynx	Alpha Lyncis	3.1
Lyra	Lyr	Lyre	Vega	0.0
Mensa	Men	Table	Alpha Mensae	5.1
Microscopium	Mic	Microscope	Gamma Microscopii	4.7
Monoceros	Mon	Unicorn	Beta Monocerotis	3.7
Musca	Mus	Fly	Alpha Muscae	2.7
Norma	Nor	Level and Square	Gamma Normae	4.0
Octans	Oct	Octant	Nu Octantis	3.8
Ophiuchus	Oph	Serpent Bearer	Rasalhague	2.1
Orion	Ori	Hunter	Rigel (Beta Orionis)	0.1
Pavo	Pav	Peacock	Peacock	1.9
Pegasus	Peg	Winged Horse	Enif (Epsilon Pegasi)	2.4
Perseus	Per	Hero	Mirfak	1.8