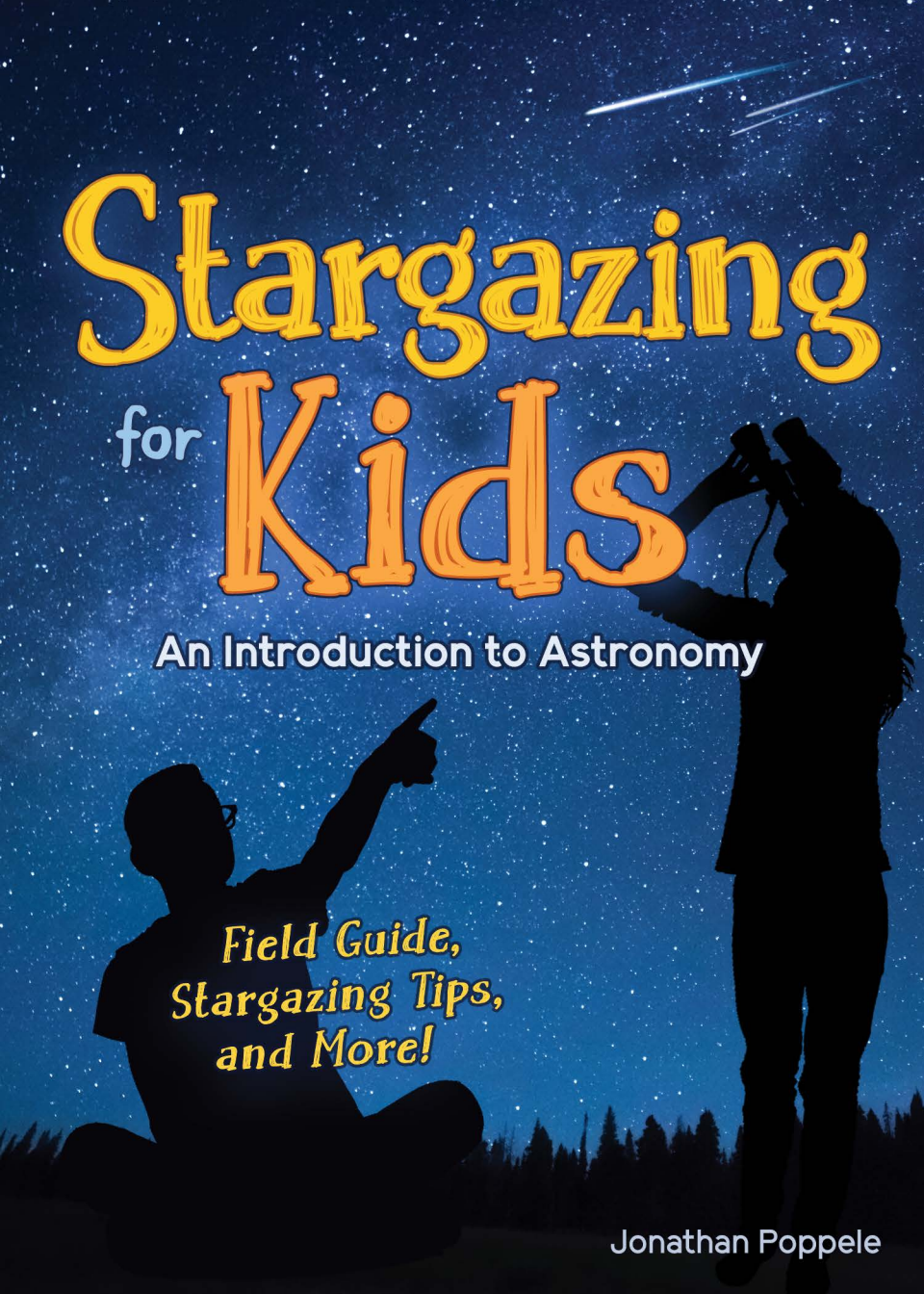




Stargazing for Kids

An Introduction to Astronomy

Field Guide,
Stargazing Tips,
and More!

Jonathan Poppele

Table of Contents

AN INTRODUCTION TO ASTRONOMY	6
Movement of the Stars at Night	8
Twilight	10
Light Pollution	11
Measuring the Brightness of Stars	13
Helpful Gear for Studying the Night Sky	15
Constellations: Mapping the Night Sky	19
OBJECTS IN THE NIGHT SKY	24
Our Solar System	28
The Sun	30
The Moon	32
Planets	37
Asteroids, Dwarf Planets, and Comets	52
Stars	58
Double Stars	60
Variable Stars	62
Exoplanets	65
Deep Sky Objects	67
Nebulae	69
Star Clusters	72
Galaxies	74
Closer to Home	76
Manmade Objects	76
Auroras	77
Meteor Showers	78
HOW DO WE KNOW?	80
Tools of Astronomy	81
How Far Away Are Celestial Objects?	85

How Far Away Is the Moon?	86
How Far Away Is the Sun?	88
How Far Away Are the Stars?	90
How Far Away Are Other Galaxies?	92
What Is the Mass of the Earth?	94
What Are Stars Made Of?	97
How Fast Does Light Travel?	98
When Did the Universe Begin?	100
Are We Alone in the Universe?	102
TOURS OF THE NIGHT SKY.....	107
Spring Tour	107
Big Dipper, Ursa Major, Whirlpool Galaxy, North Star, Little Dipper, Arcturus and Spica, Leo, Cancer, Beehive cluster	
Summer Tour.....	123
Summer Triangle, Cygnus, Lyra, Scorpius and Libra, Hercules, Sagittarius, Pillars of Creation	
Fall Tour	139
Great Square, Cassiopeia and Cepheus, Andromeda, Andromeda Galaxy, Perseus, Aquarius, Pisces, Aries	
Winter Tour	153
Orion, Orion Nebula, Winter Triangle, Gemini, Auriga, Taurus, Pleiades	
GLOSSARY.....	168
ADDITIONAL READING, RESOURCES, AND COMMUNITY SCIENCE	172
ABOUT THE AUTHOR.....	176

An Introduction to Astronomy

Have you ever looked up at the night sky filled with stars? Have you ever looked for patterns in the stars, or watched them move across the sky? Have you ever just gazed in amazement and wondered how far away they are? What they are made of? If there are other worlds out there somewhere? You're not alone.

Astronomy is the study of things beyond the Earth, like stars, planets, moons, comets, and galaxies. A person who studies astronomy is called an astronomer. Professional astronomers are scientists whose job it is to study objects in the sky. People who study the sky simply because they love it are amateur astronomers.

Although astronomy is the study of things beyond the Earth, most astronomy is done from Earth. This is where we live, after all. For thousands of years, people have been studying the cosmos by looking up into the night sky. You can do the same thing.

MOVEMENT OF THE STARS AT NIGHT

We all know how the sun appears to move across the sky. It rises in the east, arcs across the southern sky, and sets in the west.

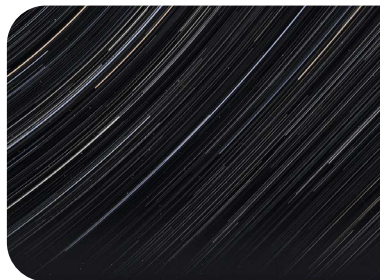
This movement is the result of the Earth rotating on its axis. The spin of the Earth causes the stars to move across the sky in much the same way.

Each night, the stars move in a large circle around Polaris, the North Star. Stars that are close to Polaris make small circles and are visible all night. Stars that are farther from Polaris rise in the east and set in the west, just like the sun. To the south, stars rise in the southeast, trace a low arc in the sky, and set in the southwest.

As the Earth orbits around the sun, it faces different parts of the sky. Each night, stars will appear to rise and set about four minutes earlier than the night before. The four Sky Tours (page 107) in this book will show you stars that are easiest to see in each of the four seasons.



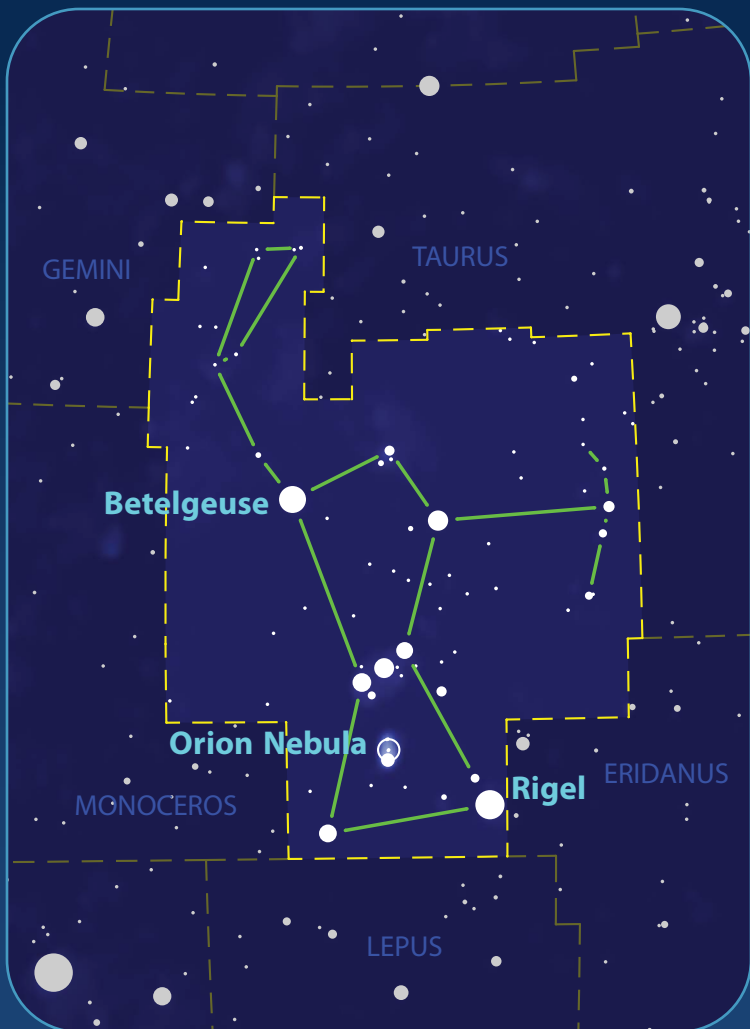
Star trails, looking north



Star trails, looking east



Star trails, looking south



Orion is one of the 88 modern constellations. Green lines show the pattern of stars that help us recognize the constellation in the sky. The dashed line is the official border. Everything inside that line is considered to be part of the constellation Orion. Everything outside that line is part of a different constellation. Five other constellations share a border with Orion: Gemini, Taurus, Eridanus, Lepus, and Monoceros.

You can use this chart to find the exact position of the sun on the day you were born and compare it to the ancient Greek zodiac dates shown below. As you can see, the dates are quite different than they were 2,000 years ago when the ancient Greeks used this.



Aries (see page 151)

*Traditional: Mar 21–Apr 19
Apr 17–May 11*



Libra (see page 131)

*Traditional: Sep 23–Oct 22
Oct 29–Nov 20*



Taurus (see page 165)

*Traditional: Apr 20–May 20
May 12–Jun 18*



Scorpio (see page 131)

*Traditional: Oct 23–Nov 21
Nov 21–Nov 28*



Gemini (see page 161)

*Traditional: May 21–Jun 20
Jun 19–Jul 18*



Sagittarius (see page 135)

*Traditional: Nov 22–Dec 21
Dec 16–Jan 17*



Cancer (see page 121)

*Traditional: Jun 21–Jul 22
Jul 19–Aug 7*



Capricorn (see page 123)

*Traditional: Dec 22–Jan 19
Jan 18–Feb 13*



Leo (see page 119)

*Traditional: Jul 23–Aug 22
Aug 8–Sep 14*



Aquarius (see page 151)

*Traditional: Jan 20–Feb 18
Feb 14–Mar 9*



Virgo (see page 117)

*Traditional: Aug 23–Sep 22
Sep 15–Oct 28*

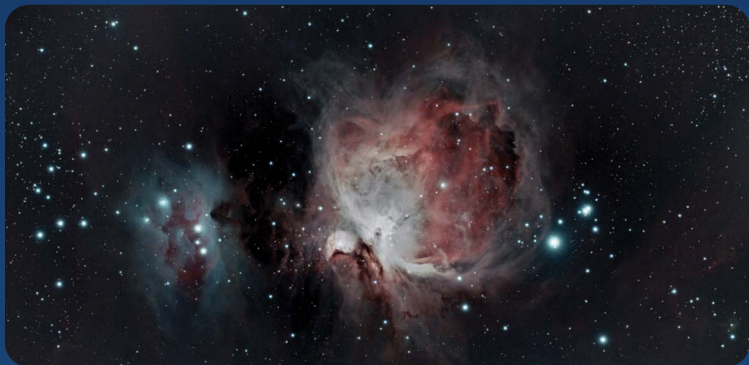


Pisces (see page 151)

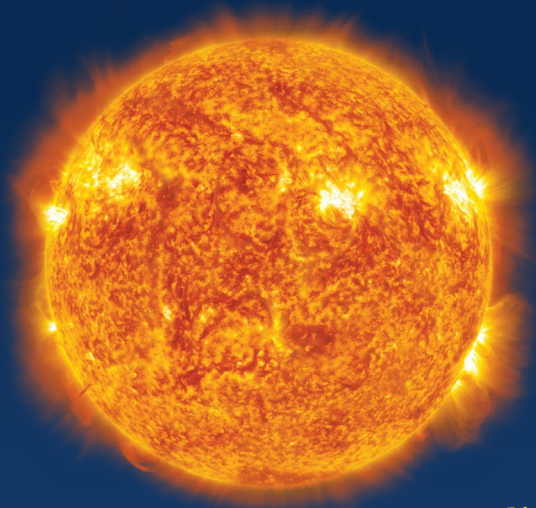
*Traditional: Feb 19–Mar 20
Mar 10–Apr 16*

Objects in the Night Sky

Some things we see in the night sky are small and close to the Earth. Others are unimaginably large and far away. It can be hard to tell the difference just by looking. It took astronomers thousands of years to figure out how far planets like Jupiter and Saturn are from the Earth. And it took hundreds of years after that to figure out how far away stars and galaxies are.



The constellation Orion, with the Orion Nebula, visible just below Orion's Belt; a photo of the nebula taken through a small telescope; and a high-resolution image taken through a larger telescope



Earth compared
to the sun



The Sun

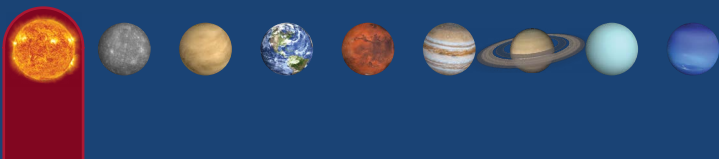
Diameter (in Earths):
109,298

Mass (in Earths): 330,000

The sun is our closest star, and the best-studied star in the universe. As stars go, it is extremely close—just 93 million miles from Earth (this distance is known as one astronomical unit, or AU). That's about 8 light minutes. The next closest star to Earth is 4.4 light-years, or about 280,000 times as far.

What Can I See?

Don't look directly at the sun without protective equipment. Always project its image or use a specially designed solar filter. The Stanford Solar Center (solar-center.stanford.edu) has a great web

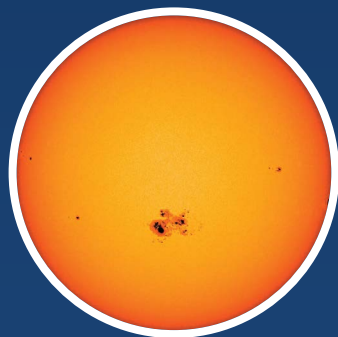


page about safe ways to observe the sun. With simple equipment, you may be able to see dark areas called sunspots. The number of sunspots varies on a cycle of about 11 years. At the peak of the cycle, there may be dozens of sunspots visible at a time.

How Do We Know?

Since ancient times, some astronomers believed that the sun was much larger than the Earth and extremely far away. But making accurate measurements wasn't possible until the invention of the telescope. In 1672, astronomers Giovanni Cassini and Jean Richer used the apparent change of position, or parallax, of Mars to calculate the size of the solar system (see *How Far Away Is the Sun?* page 88). They showed that the sun was indeed many millions of miles from Earth.

In 1925, Cecilia Payne used spectroscopy (careful study of color in sunlight) to show that the sun was made mostly of hydrogen and helium (see *What are Stars Made Of?* page 97). Prior to her work, most scientists assumed the sun was made of rock and metal, like the Earth. Her discovery revolutionized our understanding of not only the sun, but of the entire universe.



Sunspots (dark areas)
visible on the sun



Compared to Earth



Orbit: 27.322 days

**Distance from the Sun
(in AU):** 1

Diameter (in Earths):
0.273

Mass (in Earths): 0.012

1 AU = 93 million miles
(Earth's average distance from the sun)

The Moon

The moon is the brightest object in the night sky, our closest celestial neighbor, and the only natural object in orbit around the Earth. The full moon is about 30,000 times brighter than the brightest stars. The moon is much smaller than the sun, but it is also much closer to the Earth. By chance, the two appear the same size in our sky—roughly the size of your pinkie nail at arm's length.

Phases

The moon's most prominent feature is its sequence of phases. Half of the moon's surface is always lit,



but as the moon orbits the Earth we see different amounts of this lit surface.

When the moon is between the Earth and the sun, the side facing us is dark, making the moon invisible. This is called a “New Moon.”

As the moon orbits the Earth, we begin to see it as a slender crescent in the evening sky growing larger, or “waxing,” each night.

When the moon is a quarter of the way around the Earth, we see half of its disk illuminated. This “First Quarter” moon is visible in the evening sky and sets about midnight.

The moon continues to wax for another week becoming more round, or “gibbous,” each night.

When the moon is on the opposite side of the Earth from the sun, we see it completely lit. The “Full Moon” is up all night, rising around sunset and setting close to sunrise.

As the moon enters the second half of its orbit, it “waned,” showing less of its lit surface each night. It rises about an hour later each evening, giving us a period of moonless sky after sunset.

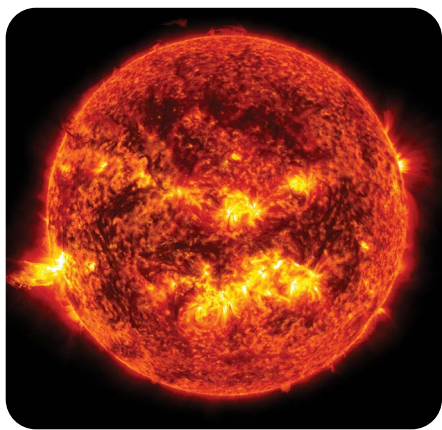
The waning gibbous moon gives way to the “Third Quarter,” then a waning crescent before disappearing from the sky on the next New Moon.

STARS

Stars look like pinpoints of light, sparkling in the night. Though they appear tiny, stars are actually distant suns, similar to our own. Each is an enormous ball of super-hot gas glowing from the heat of nuclear fusion. Fusion means “to join,” and during nuclear fusion elements (such as hydrogen) are compressed together, which creates new elements (such as helium). This process also releases a great deal of heat and light. No one knows how many stars there are, but the number must be unimaginably large. Astronomers estimate that there are about 200 billion stars in our galaxy alone.

What Can I See?

How many stars we can see depends on how dark the sky is. Under the clearest, darkest sky, you may be able to see about 4,000 stars spread across the sky. Light pollution, haze, or the light of the moon will all reduce that number. In a typical rural area, you might be able to see 3,000 stars. In the suburbs, you might be able to pick out 1,000. In urban areas, there are often fewer than 100 stars visible. Wherever



The best-studied star in the universe: our sun

How Do We Know?

Astronomers use science to learn about the universe. Science is the careful, first-hand study of nature. Scientists build on previous knowledge by asking questions, making observations, looking for patterns, and sharing with others. Here is how one ancient scientist measured the size of the Earth, more than 2,200 years ago.

Eratosthenes was a scientist who lived from 276 to 195 BCE. He was in charge of the Library of Alexandria, which was the largest and most complete collection of human knowledge in the ancient world.

Building on previous knowledge and asking questions

In his book *On the Heavens*, the Greek philosopher Aristotle explained how we can know the Earth is a sphere. Eratosthenes read Aristotle's work, and he knew the Earth was round. What he wanted to find out was how big it was.

ARISTOTLE OFFERED THREE POINTS:

1. Every portion of the Earth tends toward the center until by compression and convergence they form a sphere.
2. Travelers going south see southern constellations rise higher above the horizon.
3. The shadow of Earth on the moon during a lunar eclipse is round.

HOW MUCH WOULD YOU WEIGH ON...

Planet/Moon	Mass (kg)	Weight (lbs.)
Earth	22.7 / 31.8 / 45.5	50 / 70 / 100
Moon	22.7 / 31.8 / 45.5	8.3 / 12 / 17
Mercury	22.7 / 31.8 / 45.5	19 / 27 / 38
Venus	22.7 / 31.8 / 45.5	45 / 63 / 90
Mars	22.7 / 31.8 / 45.5	19 / 27 / 38
Jupiter	22.7 / 31.8 / 45.5	126 / 177 / 253
Saturn	22.7 / 31.8 / 45.5	53 / 75 / 107
Uranus	22.7 / 31.8 / 45.5	44 / 62 / 89
Neptune	22.7 / 31.8 / 45.5	57 / 80 / 114
Pluto	22.7 / 31.8 / 45.5	3.2 / 4.4 / 6.3

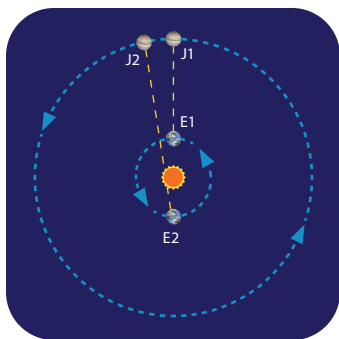
WHAT ARE STARS MADE OF?

Early astronomers could only guess about the nature of the sun and stars. Most assumed that stars were made of the same materials as the Earth—mostly rocks and metal. That began to change in 1925, thanks to the work of Cecilia Payne.

As a graduate student at Harvard University, Cecilia Payne wrote her PhD thesis on the spectra of stars. A spectrum is the rainbow of colors visible after light has passed through a prism.



By applying new ideas, Payne came to two conclusions. First, she showed that most of the differences in the spectra of different stars was because of their



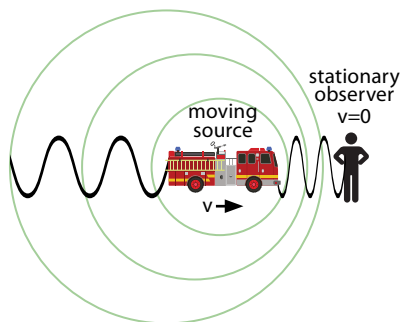
Orbits of Jupiter and Earth

WHEN DID THE UNIVERSE BEGIN?

Have you ever noticed that when an emergency vehicle is approaching, its siren sounds higher pitched, but when it's moving away, it sounds lower? This is called the Doppler effect, named for German scientist Christian Doppler who first described it in 1842.

We experience the Doppler effect whenever a source of waves, like sound waves, is moving toward or away from us. When the source is approaching, its waves get bunched together and we observe them at a higher frequency. When the source is moving away, waves get spread out and we observe them at lower frequency.

Try this for yourself. If you listen to a car driving by on a highway, you will hear its engine sound higher pitched as it approaches and lower pitched as it speeds away. It sounds a bit like "EEEEEEYAHHHH." The effect is even more pronounced with the sirens on emergency vehicles.



Ursa Minor

Ursa Major

Boötes

Cancer

Leo

Virgo



See the Stars of the Night Sky!

Become a young astronomer. Learn about Hercules, Pegasus, and more. Best-selling author, educator, and naturalist Jonathan Poppele presents a kids' introduction to the joys of stargazing. Young readers will quickly gain confidence by discovering when to look, where to look, and what to look for.

INSIDE YOU'LL FIND

- A guide to more than 25 important-to-know constellations
- Practical tips on locating each constellation
- The basics of astronomy, the solar system, and outer space
- Tips and tricks to help you spot the many amazing sights of the night sky



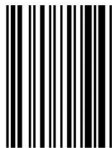
Find even more opportunities
to learn and explore with
the Simple Introductions
to Science series of books.

PUBLICATIONS
Adventure
an imprint of AdventureKEEN

CHILDREN'S / NATURE / ASTRONOMY



ISBN 978-1-64755-134-6



9 781647 551346