Overview of the Universe

Informative Tables

Physical Constants, Astronomical Symbols,
Galaxy & Solar System, Constellations, Stars and a Celestial Atlas

Monthly Star Charts

Telescopes & Binoculars

Observing the Moon & its Phases

Observing the Planets

Observing Tips ✦ Monthly Sunrise & Sunset Positions,
Oppositions, Elongations & Conjunctions

Observing Meteors, Comets, our Sun & Eclipses

Observing Deep Sky Objects

Star Clusters, Nebulae & Galaxies
plus Double & Variable Stars

Sunrises & Sunsets

Time Zones, Universal Time and
Sunrise & Sunset for more than 200 North American Cities

Glossary, Mythology, History & Index

A Ken Press Book

"Bringing Astronomy to Everyone"

Published by Ken Press, Tucson, Arizona USA
(520) 743-3200 or ken@kenpress.com

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Our Earth and the Solar System
Our Galaxy and the Universe
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David H. Levy's Guide to the Stars (planispheres, co-author)

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Publisher's Cataloging-in-Publication Information

Graun, Ken.

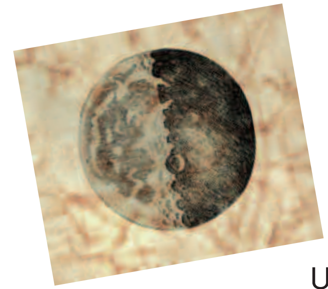
What's out tonight? : celestial almanac & astronomy field guide, 2000 to 2050 / Ken Graun. – 3rd ed. – Tucson, Ariz. : Ken Press, 2007.

p. ; cm.

ISBN-13: 978-1-928771-50-0
ISBN-10: 1-928771-50-5
First ed. published in 1999 as: What's out tonight? : 50 year astronomy field guide, 2000 to 2050.
Provides tables for selected celestial events, monthly star charts, charts of the moon, and information about the universe and the history of astronomy.
Includes index.

1. Astronomy–Observers' manuals. 2. Astronomy–Amateurs' manuals. I. Title.

QB64.G73 2007 2005937967
520–dc22 0107



Foreword

Astronomy has the entire Universe as its theater. Every night, we can go out, look onto the stage and see what's playing. It's the grandest show. There is none larger, more spectacular or more dynamic.

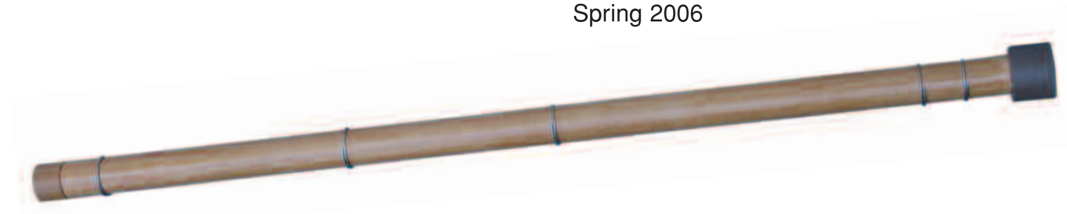
The show has been playing since the beginning of time. Our earliest ancestors watched it but understood little of what they saw. That changed in 1609 when Galileo and other scientists pointed the first telescopes upward. Now, 400 years later, we have a basic understanding of the Universe. We know that the cosmos is a magnificent symphony, but with many parts that we still must learn.

Astronomy is not a simple science. It draws upon every discipline, from biology to nuclear physics, and engages the most complex mathematics in order to make sense out of the Universe. Fortunately, no knowledge or understanding of these specialized fields is required to go out, look up and enjoy the heavens for all it has to offer.

This book is your 50 year playbill for heaven's cast of characters.

May you enjoy the performances and make friends with the stars.

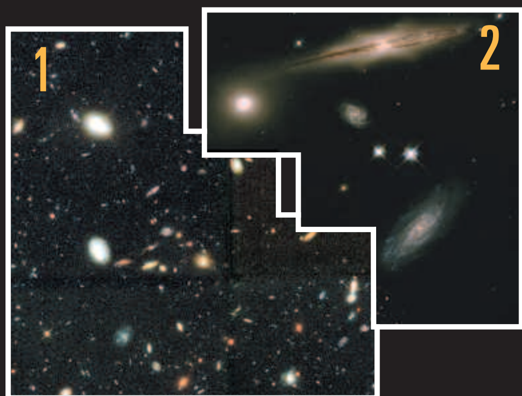
Ken Graun
Spring 2006



Top. One of Galileo's earliest Moon drawings made using a telescope.
Bottom. A reproduction of Galileo's telescope.

The Universe is Full of Galaxies

1 If you held the Universe in your hands, and looked close, you would see fuzzy specks everywhere. Each of these fuzzy spots would be a galaxy. There is estimated be about 125 billion galaxies in the Universe. A galaxy is a grouping of stars — anywhere from a billion to a trillion that are held together by their collective gravity. This *Hubble Space Telescope* photo is a snapshot of deep space. All of these specks are galaxies billions of light years away. EACH of these dots or blobs represent the collection of billions of stars. Galaxies are all that astronomers see when they look deep into space.



2 Galaxies cluster together. Our Milky Way Galaxy is a member of what astronomers call the Local Group which totals about three dozen galaxies, including the famous Andromeda Galaxy (M31)[1].

Clusters of galaxies are further organized into superclusters, configured somewhat like strands that stretch across huge expanses of the Universe.

There are 3 Basic Galaxy Shapes

3a Over 90% of all the galaxies in the Universe are of the elliptical type. These are shaped like balls or elongated balls and represent the largest and smallest galaxies. This galaxy (M87) is in the constellation Virgo[2].

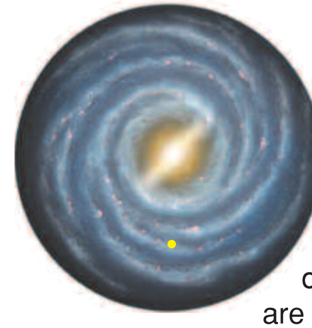
3b Spiral galaxies, like this one in Pisces[2] (M74) represent at most 5% of the galaxies. They are fairly large and strikingly visible. Shaped like dishes, they have a bulged center out of which curved arms radiate. Spirals have active star formation occurring in their arms. Our Sun is in a spiral galaxy.

3c Finally, there are irregular galaxies that have irregular shapes or scrambled insides. Some are the result of galaxies colliding and merging. Others get deformed by the gravity of larger galaxies pulling on them. Here is a closeup of an irregular galaxy (M82) with mixed-up insides, located in Ursa Major[2].

[1] This and the other "M" numbers used here are catalogue designations. See more about this on page 244.
[2] Galaxies are much farther outside our galaxy and are not actually in these constellations, but lie in their direction.

Continues on page 6

Universe Overview



An accurate illustration of our Milky Way Galaxy. The yellow dot marks our Sun.

The Universe contains everything that we know to exist. For a long time, it was thought that the Earth was at its center. However, today we know that Earth is just one small planet revolving around an average-size star that we call the Sun, residing with billions of other stars collectively referred to as a galaxy. And, there are billions of galaxies scattered throughout the Universe.

If you are not familiar with the kinds of objects that are in the Universe, I encourage you to read and reflect on the summary presented on pages 4, 6 and 7.

A Sense of Scale and Space

The size of the Universe as well as the distance between galaxies and even stars is unfathomable compared to the distances that we deal with on an everyday basis.

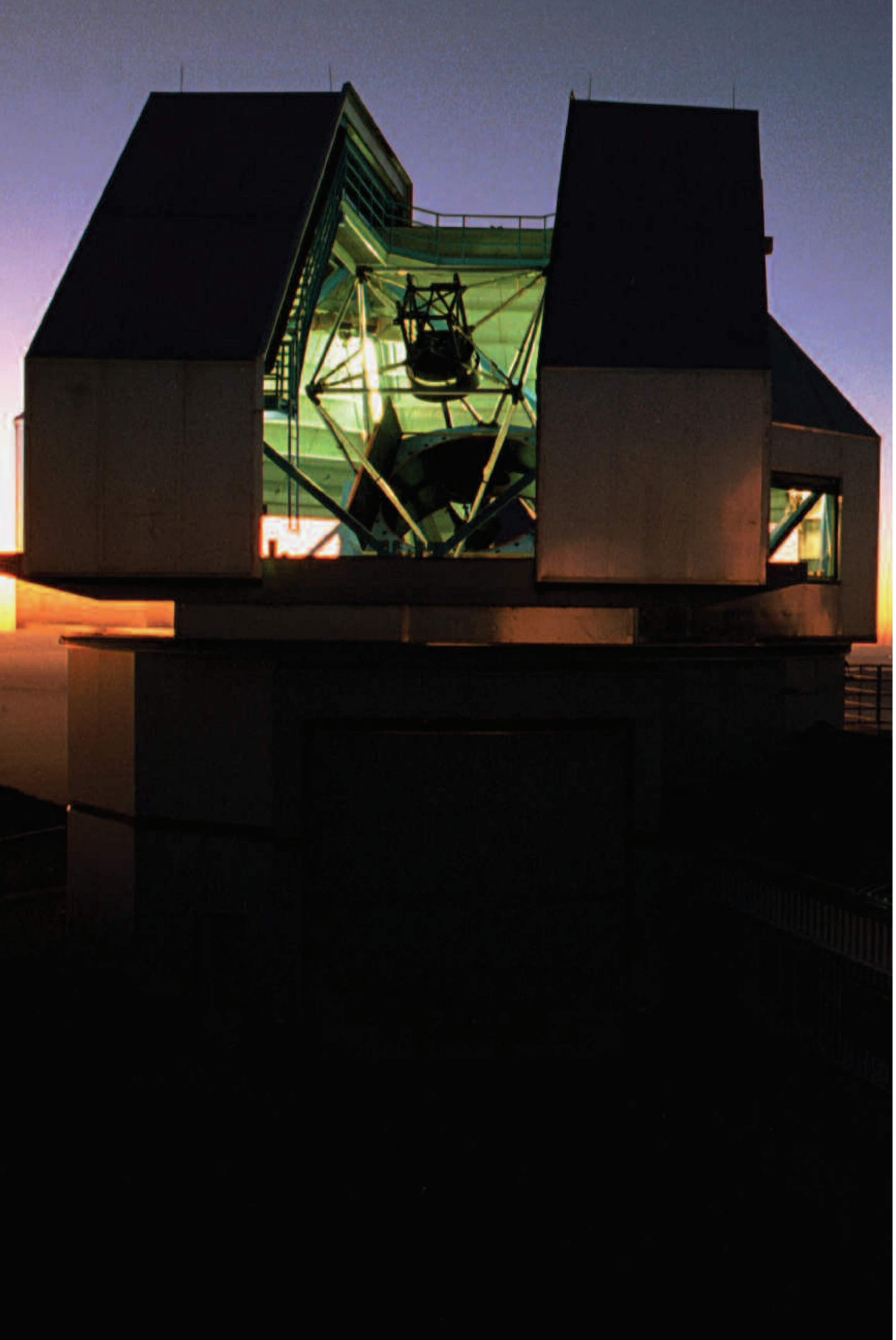
It is currently estimated that the Universe came into existence about 14 billion years ago and has since been expanding at the rate of the speed of light. Based on this, our Universe has a diameter of about 165,000,000,000,000,000,000,000 miles and growing every second.

The Universe is riddled with about 125 billion galaxies and for their size, the distance between them is not that great. For example, the diameter of our Milky Way Galaxy is about 80,000 light years and that of the nearby Andromeda Galaxy twice that, however, they are a "mere" 31 diameters of our Milky Way Galaxy from each other.

Proportionally, the distances between stars is incredible, hence the sometimes made statement that two galaxies could pass through one another without any of their stars colliding. The nearest star to our Sun, Proxima Centauri, is 4⅓ light years away. This is 29 million (29,000,000) diameters of our Sun, a truly big number compared to the *relative* distances and sizes of galaxies.

When I give talks about our Solar System, I model the size of our Solar System based on the Earth being the size of a penny. At this scale, the Sun would be 6¾ feet in diameter with the Earth 725 feet away, Pluto out at 5½ miles and Proxima Centauri, the closest star — 37,000 miles away.

When you look up into the night sky, almost everything that you see is part of our own Milky Way Galaxy.



Physical Constants & Measurements

Length

1 inch (in) = 25.4 millimeters exactly; 2.54 centimeters
1 centimeter (cm) = 0.394 inch; 10 millimeters
1 yard (yd) = 0.9144 meters; 36 inches
1 meter (m) = 1.094 yards; 39.37 inches; 100 centimeters; 1,000 millimeters
1 mile (mi) = 1.609344 kilometers; 5,280 feet; 1,760 yards
1 kilometer (km) = 0.621371 miles; 3,281 feet; 1,000 meters
1 astronomical unit (AU) = 92,955,778 miles; 149,597,871 kilometers; 8.3 light-minutes; this is the average distance from the Earth to the Sun
1 light year (ly) = 63,240 astronomical units; 5,879,000,000,000 miles which is nearly 6 trillion miles; 9,461,000,000,000 kilometers
1 parsec (pc) = 3.26 light years; 206,265 astronomical units

Weight/Mass

1 ounce (oz) = 28.35 grams
1 gram (g *or* gm) = 0.0353 ounces
1 pound (lb) = 0.454 kilograms; 16 ounces
1 kilogram (kg) = 2.205 pounds; 1,000 grams
1 ton = 2,000 pounds; 907 kilograms
1 metric ton (t) = 1,000 kilograms; 2,205 pounds

Temperature

0° Fahrenheit (F) = –17.8° C; lowest temperature for mixture of water/ice/salt
0° Celsius (C) = 32° F; 273.16K (Kelvin); pure water freezes
212° Fahrenheit = 100° C; 373.16K (Kelvin); pure water boils
Absolute Zero = 0K (Kelvin); –459.7° F; –273.16° C

Volume

1 cubic inch = 16.39 cubic centimeters
1 cubic centimeter (cc, ml *or* cm^3) = 0.061 cubic inches
1 cubic yard = 0.765 cubic meters
1 cubic meter (m^3) = 1.308 cubic yards

Speed of Light

Speed of Light = 186,282 miles/second; 299,792 kilometers/second

Facing page. *The WIYN telescope atop Kitt Peak, near Tucson, Arizona boasts a 3½ meter diameter telescope mirror. Telescopes like this help gather astronomical data. WIYN is an acronym for a consortium of four organizations that built this telescope.*

Abbreviations & Visible Light

Unit Abbreviations

Length

nm	Nanometer
mm	Millimeter
cm	Centimeter
in *or* **"**	Inch
ft *or* **'**	Feet
m	Meter
km	Kilometer
mi	Mile
AU	Astronomical Unit
ly	Light-Year
pc	Parsec

Weight/Mass

oz	Ounce
g *or* **gm**	Gram
lb	Pound
kg	Kilogram
t	Metric Ton

Angular Measurements

°	Degree
'	Minute
"	Second

Volume

ml	Milliliter

Temperature

F	Fahrenheit
C	Celsius
K	Kelvin

Time

s *or* **sec**	Second
m *or* **min**	Minute
h	Hour
d	Day
yr *or* **a**	Year

Power

W	Watt

Celestial Coordinates

RA or **α**	Right Ascension[1] (Expressed using h, m and s. Example: 8h 27m 05s)
Dec or **δ**	Declination[1] (Expressed using the ° ' " symbols. Example: 2° 04' 59")

[1]Right Ascension and Declination are used to define the position of all celestial objects. Right Ascension is analogous to longitude, except that it is based on 24 intervals, corresponding to the 24 hours of a day, or more precisely, the time it takes the celestial sphere to "rotate" one complete turn, which is about 4 minutes less than clock time (This is known as Sidereal time.). Declination is analogous to latitude and uses similar nomenclature.

Wavelengths of Visible Light & Eye Sensitivity

Wavelength of Visible Light[1]	
VIOLET	420 nm
BLUE	470 nm
GREEN	530 nm
YELLOW	580 nm
ORANGE	610 nm
RED	660 nm

Approximate Visible Light Sensitivity of Eyes	
Daytime ✦ RANGE Visible to Eyes	400 to 750 nm
Nighttime ✦ RANGE Visible to Eyes[2]	400 to 620 nm
Daytime PEAK Sensitivity of Eyes	555 nm
Nighttime PEAK Sensitivity of Eyes[2]	510 nm

[1]The wavelength of visible light is expressed in nanometers. A nanometer is 1 billionth (10^{-9}) of a meter. 500 nanometers is about 1/50,000 of an inch. [2]Nighttime dark-adapted eyes. It takes 15 or more minutes for the eyes to reach full dark adaptation.

Symbols

Greek Alphabet[1]

	Case[2] Lower	Upper		Case[2] Lower	Upper		Case[2] Lower	Upper
ALPHA	α	Α	**IOTA**	ι	Ι	**RHO**	ρ	Ρ
BETA	β	Β	**KAPPA**	κ	Κ	**SIGMA**	σ	Σ
GAMMA	γ	Γ	**LAMBDA**	λ	Λ	**TAU**	τ	Τ
DELTA	δ	Δ	**MU**	μ	Μ	**UPSILON**	υ	Υ
EPSILON	ε	Ε	**NU**	ν	Ν	**PHI**	φ	Φ
ZETA	ζ	Ζ	**XI**	ξ	Ξ	**CHI**	χ	Χ
ETA	η	Η	**OMICRON**	ο	Ο	**PSI**	ψ	Ψ
THETA	ϑ or θ	Θ	**PI**	π	Π	**OMEGA**	ω	Ω

[1]The lowercase letters of the Greek alphabet are used to designate the brightest stars within each constellation. For example, Polaris, the North Star is designated α Ursae Minoris. Ursae Minoris is the genitive form of Ursa Minor. This system of using the Greek letters is also known as Bayer letters. [2]Only the lowercase is used to designate stars.

Solar System Members

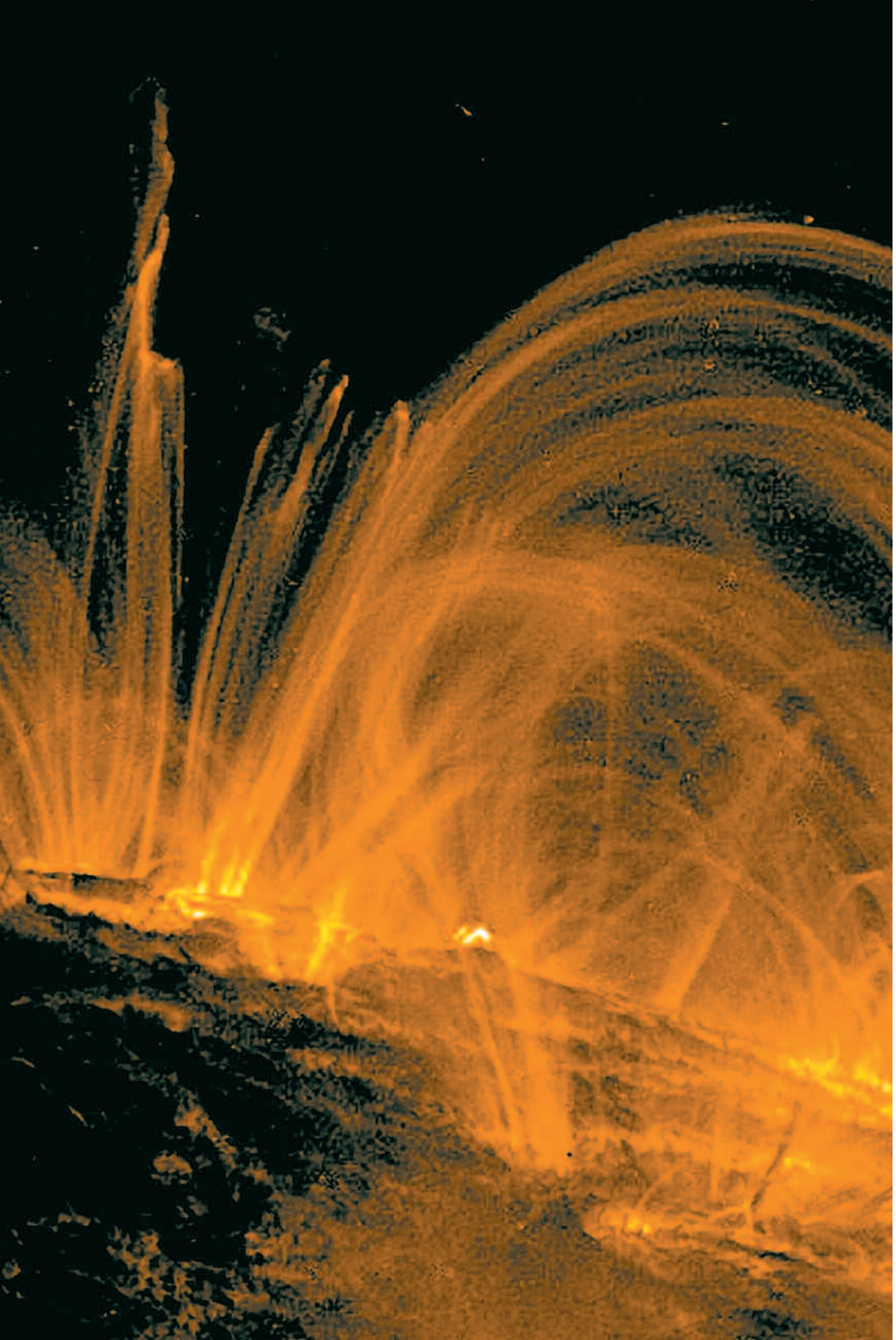
SUN	☉	JUPITER	♃	MOON in General	☾
MERCURY	☿	SATURN	♄	NEW MOON	●
VENUS	♀	URANUS	⛢	FIRST QUARTER	☽
EARTH	⊕	NEPTUNE	♆	FULL MOON	○
MARS	♂	PLUTO	♇	LAST QUARTER[1]	☾

[1]Also referred to as the Third Quarter.

Signs of the Zodiac[1]

1[2]	PISCES	♓	5	CANCER	♋	9	SCORPIUS	♏
2	ARIES	♈	6	LEO	♌	10	SAGITTARIUS	♐
3	TAURUS	♉	7	VIRGO	♍	11	CAPRICORNUS	♑
4	GEMINI	♊	8	LIBRA	♎	12	AQUARIUS	♒

[1]The zodiacal constellations lie on the ecliptic, the apparent path the Sun traces through the sky during a year. Although I have listed the traditional 12 constellations of the zodiac, there are actually 13 constellations that cross the ecliptic. The southern portion of Ophiuchus, the Snake Bearer, crosses the ecliptic between Scorpius and Sagittarius. [2]The numbers 1 through 12 represent the order the Sun passes through these constellations during the year. This list starts with Pisces, the constellation where the Sun resides at the start of Spring (vernal equinox).



Our Sun

Equatorial Diameter: 865,278 miles; 1,392,530 km
Mass: 332,946.0 Earth masses or 4.3860 x 10^{30} pounds; 1.9891 x 10^{30} kg
Average Density: 1.41 gm/cm^3 (water is 1.00 gm/cm^3)
Rotation: 25.38 days at the equator and 35 days near the poles. Below a depth of 124,000 miles (200,000 km) the Sun appears to rotate at a stable 27 days, from equator to poles.
Inclination of Axis to Earth's Orbit: 7.25°
Visual Magnitude: –26.75
Absolute Magnitude: +4.82 (This would be the magnitude of the Sun if it were placed at a distance of 10 parsecs from Earth. This distance is used to compare the actual magnitude of *all* stars.)
Temperatures: Surface temperature averages 10,000° F (5,500° C; 5,800K). Sunspots are cooler areas on the surface and average 6,300° F (3,500° C). The Sun's core is estimated to reach 27,000,000° F (15,000,000° C)
Star Classification: G2 V (The **G** refers to the spectral classification scale O•B•A•F•G•K•M•R•N•S where O are the hottest and S the coolest stars. The **2** refers to a finer 0–9 subtype of the spectral scale and the Roman numeral **V** indicates that the Sun is a typical star in its class.)
Energy Output: 3.85 x 10^{26} watts. Energy just outside Earth's atmosphere is 1.37 kilowatts per square meter.
Solar Wind Speed near Earth: about 280 miles/sec; 450 km/sec. Travel time from the Sun to the Earth is about 4 days.
Composition: 92.1% Hydrogen, 7.8% Helium, with traces of Oxygen (0.061%), Carbon (0.030%), Nitrogen (0.0084%), Neon (0.0076%), Iron (0.0037%), Silicon (0.0031%), Magnesium (0.0024%), Sulfur (0.0015%), and other elements (0.0015%)
Gravity: 27.9 times the gravity of Earth at its photosphere "surface"
Escape Velocity: 384 miles/sec (1.4 million miles/hour); 617.5 km/sec
Sunspot Cycle: about 11.1 years, but varying from 8 to 16 years
Location in Galaxy: See Our Milky Way Galaxy on page 15.
Nearest Neighbor: Proxima Centauri, a star in the constellation Centaurus, is 4.2 light years away. Proxima is an 11th magnitude star and is not visible to the naked eye.
Age: about 4.6 billion years

Facing page. *This image of the Sun's surface shows coronal loops which are composed of plasma (particles of electrons and positive ions) and shaped by intense magnetic fields. The large loop spans 30 Earth diameters.*

July Object Descriptions

Binocular & Telescope Objects

Numbers correspond to those on the Charts

32 Pretty orange and blue optical DOUBLE STAR that is also the "top" star in Cancer. Easy to separate in a telescope at low power. The challenge here is to spot the 5th magnitude top star with your unaided eyes. The distance to the brighter star is 188 ly. **TELESCOPE object that is a little challenging to locate with your unaided eyes. Start at 50x.**

FEATURED ON PAGE 281

33 "Beehive" CLUSTER M44, also known as the Praesepe. This is a wonderful cluster seen best with binoculars. It is similar in size to the Pleiades but its members are not as bright, so binoculars are needed to bring them to life. M44 is often found by scanning the area halfway between Regulus and Pollux. Dist: 580 ly. Width: 16 ly. Arc width in sky: 1.5°. Mag: 3.1. **A favorite!! Easy & best with BINOCULARS.**

34, 35 & 36 GALAXIES M95, M96 and M105 respectively. All three visible within two eyepiece views at low power. M95 & 96 are spirals, while M105 is an elliptical. Distances: 29 million ly, 29 million ly & 22 million ly. Diameters: 59,000 ly, 59,000 ly & 40,000 ly. Arc sizes in sky: 7' x 5', 7' x 5' & 5' x 4'. Mags: 9.7, 9.2 & 9.3. **Fairly easy with a TELESCOPE at 50x. Easiest to see in dark skies.**

37 & 38 Spiral GALAXIES M65 & M66 respectively. Visible in the same eyepiece view at low power, they are separated by about one Moon's diameter. Distances: 29 million ly & 21.5 million ly. Diameters: 84,000 ly & 65,000 ly. Arc sizes in sky: 10' x 3' & 9' x 4'. Mag: 9.3 & 9. **Fairly easy with a TELESCOPE at 50x if you have dark skies.**

FEATURED ON PAGE 283

39 CLUSTER of stars in Coma Berenices that can be seen as a haze with the naked eyes. Big loose group best seen with binoculars. **Easy & pops out with BINOCULARS.**

Greek Alphabet

- 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

40 GLOBULAR CLUSTER M3. Bright, plump cluster. Dist: 35,000 ly. Diameter: 165 ly. Arc diameter in sky: 16'. Mag: 6.2. **TELESCOPE object a little challenging to find but worth it. Start at 50x.**

41 GLOBULAR CLUSTER M53. Smaller and fainter than the nearby M3. Dist: 60,000 ly. Diameter: 220 ly. Arc diameter in sky: 13'. Mag: 7.6. **TELESCOPE object a little challenging to find. Start at 50x.**

42 GALAXY M64 is by far the biggest and brightest-looking galaxy in the area. Known as the "Black-Eye Galaxy," for its resemblance to a black eye. Dist: 13.5 million ly. Width: 35,000 ly. Arc size in sky: 9' x 5'. Mag: 8.5. **TELESCOPE object. Detail shows up better in darker skies. Start at 50x.**

A–D "Virgo" CLUSTER of GALAXIES totalling about 2,500 galaxies. Our "Local Group" of 40 galaxies, which includes the Andromeda Galaxy, is linked to this cluster and others to form the Local Supercluster. The galaxies in the Virgo

#56. Pillars of Creation, M16.

Distance to Named Stars

Alphekka	78 ly
Antares	522 ly
Graffias	522 ly
Komephoros	170 ly
Rasalhague	49 ly
Sabik	63 ly
Shaula	330 ly

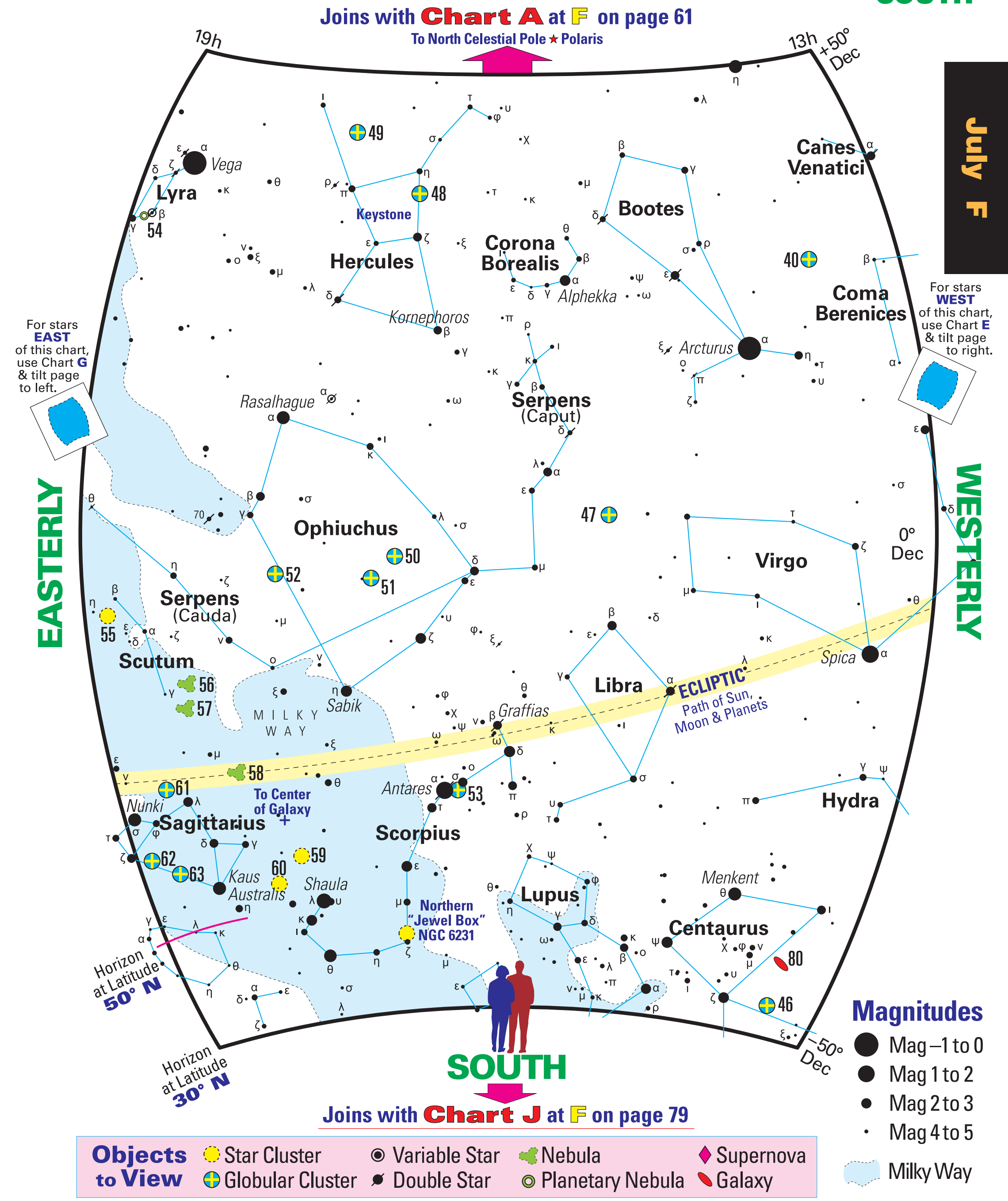
The "Dog Days" of Summer refer to *Sirius* rising with the Sun during this season.

July

June at 11 PM	**July at 9 PM**	Aug at 7:30 PM

CHART **F**

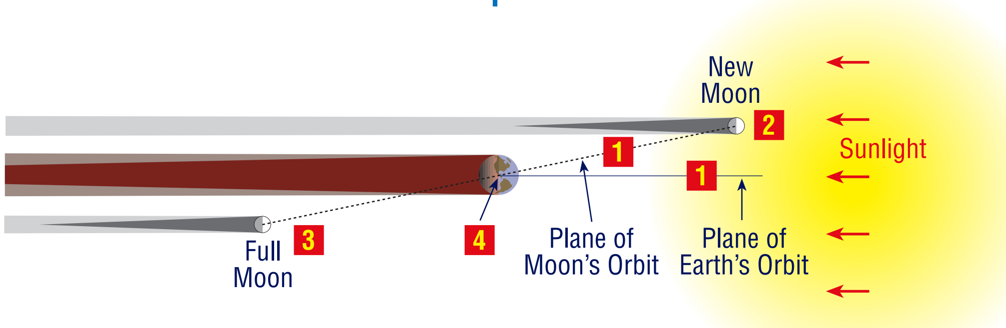
View Facing **SOUTH**



Lunar Eclipses
Lunar eclipses can be total, partial or penumbral, however, they do not share the characteristics of solar eclipses. Total lunar eclipses turn the Moon into a dark red-orange color instead of turning it completely black. The red-orange color is caused by sunlight refracted through the Earth's atmosphere. You see the same coloring at sunrise and sunset. Partial lunar eclipses may not be noticeable with the exception that an edge of the Moon may turn a little orange. Penumbral eclipses are usually not noticeable to the average observer.

Why Eclipses Do Not Happen Every Month
Solar and lunar eclipses do not happen every month because the Moon's orbit is tilted 5.1° to Earth's orbit, placing the Moon above or below the Sun or Earth's shadow at New Moon and Full Moon most of the time. The Moon must be positioned exactly at the point where its orbit crosses the Earth's orbit for an eclipse to occur. The Earth, Moon and Sun get perfectly aligned every 173 days, producing an eclipse somewhere on Earth.

Missed Eclipses



1 **The Moon's orbit is tilted 5.1∞ to the Earth's orbit.** This slight tilt is enough to place the shadows necessary for eclipses out of reach of the Earth or Moon.

2 The shadow of most **New Moons** falls either above or below the Earth.

3 At **Full Moon**, the Moon is usually above or below the Earth's shadow.

4 **Eclipses occur** when the Moon is either New or Full *and* the Moon crosses the plane of the Earth's orbit. This intersection happens every 173 days and this time interval is known as an eclipse season.

Frequency of Eclipses: The Saros
Up to two eclipses can occur during a 173-day eclipse season: one lunar and one solar. Anywhere from two to seven lunar and solar eclipses can therefore occur in a year. Eclipses also repeat themselves in 18 year cycles called Saros (actually 18 years, 11 days, 8 hours). So, all of the eclipses that happen in the year 2000 will repeat 18 years later in 2018. However, the 2018 eclipses will advance by 11 days and 8 hours, placing them one-third farther around the world than their previous locations. There are 42 Saros series running concurrently, providing us with an ongoing cycle of eclipses. The intensity of eclipses in a Saros (the ones that repeat every 18 years) waxes and wanes over time.

WARNING

Instant blindness or serious eye injury will result from looking at or near the Sun through telescopes, binoculars or cameras that are not properly equipped with solar filters.

OBSERVING SOLAR ECLIPSES

Safely Viewing an Eclipse. Safety of the eyes is of the utmost importance when viewing solar eclipses. Do not stare or even look directly at the Sun. Not only is this harmful to the eyes, but you cannot see the partially eclipsed Sun this way! I highly recommend using a solar or eclipse viewer/filter (like that pictured below). These inexpensive viewers are available at telescope shops, planetarium gift shops and from telescope dealers listed in the popular monthly astronomy magazines.

Eclipse viewers/filters like this are necessary for safely viewing the Sun during all solar eclipses. They can also be used to see large sunspots.

Lunar Eclipses

The multitude of crescents in this picture are the eclipsed Sun, projected through pinholes formed from the interweaving of leaves on a tree.

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minutes of totality, no solar filter is required. Everyone stands and stares in wonder. Many things happen during totality. The sky darkens a little (it does not get completely dark), and almost immediately, the white shimmering corona is seen surrounding the Moon. Around the Moon's edge, the thin red ring of the chromosphere may be visible along with prominences and flares protruding outward. If you look at the sky around the Moon, you will probably see a few stars and Planets (usually Venus and Mercury) and if you scan the whole sky, you will see the umbra shadow circling the sky and extending almost to the horizon. The sky near the horizon is still light but may have a red coloring like that at sunset. The entire scene is incredible. There is nothing like it! No camera can capture the experience of totality, and everyone is touched differently. People clap, cheer, cry and pray. I recommend that everyone experience a total solar eclipse!

OBSERVING LUNAR ECLIPSES

No special equipment or caution is necessary to view lunar eclipses but binoculars and telescopes can be used to enhance the event. Lunar eclipses are especially enjoyable when you can sit outside, talk with others and casually watch the event unfold.

For the most part, the Moon will turn a dark red-orange when it is completely in Earth's umbra shadow. Various hues of red and orange will slowly dance across the Moon's surface as it enters, passes through and exits the umbra. Since the umbra is considerably larger than the Moon, total lunar eclipses can last up to 3½ hours. If the Moon crosses the umbra dead center, it takes about an hour to completely enter the umbra. It will stay in the umbra for 1½ hours and finish as it started, taking an hour to leave.

2000–2050 Solar and Lunar Eclipse Tables for North America on Pages 230–234

The solar and lunar eclipse tables on the following pages summarize the location and time of these events. Since the intensity of the event and the exact time vary considerably depending on your viewing location, please consult your local media, the internet or the popular monthly astronomy magazines for details. Enjoy.

SOLAR Eclipses 2000 – 2031

Solar Eclipses in North America

Date of Solar Eclipse	Type of Solar Eclipse	Time of Day to View[1]	Locations[2]
July 30, 2000	Partial	Around Sunset	*Alaska*, Western Canada, Northwest
December 25, 2000	Partial	Around Noon	*Midwest*, Continental US, Southern Canada
December 14, 2001	Partial	Early to Late Afternoon	*Hawaii*, Continental US
June 10, 2002	Partial	Late Afternoon	*West*, Midwest, Hawaii, Alaska, West Canada
May 30, 2003	Partial	Around Sunset	*Alaska*
April 8, 2005	Partial	Late Afternoon	*Florida*, South, Southwest
July 21, 2009	Partial	Around Sunset	*Hawaii*
May 20, 2012	**Annular**	**Around Sunset**	***West***, Hawaii, Alaska, Western Canada
May 9, 2013	Partial	Late Afternoon	*Hawaii*
October 23, 2014	Partial	Mid Afternoon	*West*, Midwest, Alaska, Western Canada
March 8, 2016	Partial	Around Sunset	*Hawaii*, Alaska
August 21, 2017	**Total**	**Around Noon**	***Across the US!*** Hawaii, Canada & Alaska
June 10, 2021	Partial	Early Morning	*Northeast*, East
October 14, 2023	**Annular**	**Late Morning**	***West***, Continental US, Canada
April 8, 2024	**Total**	**Around Noon**	***Midwest***, Continental US, Canada, Hawaii
October 2, 2024	Partial	Early Morning	*Hawaii*
August 12, 2026	Partial	Early to Late Morning	*Alaska* to Northeast
January 26, 2028	Partial	Late Morning	*Florida*, South, East, Midwest
January 14, 2029	Partial	Around Noon	*Canada*, Continental US
June 11, 2029	Partial	Around Sunset	*Alaska*, Canada, Northwest
November 14, 2031	Partial	Mid Afternoon	*Hawaii*, Southwest, South, Florida

[1]Check media sources for specific times for your location.
[2]First listed area is most favorable viewing location.

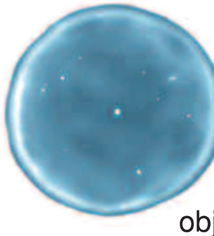
SOLAR Eclipses 2033 – 2051

Solar Eclipses in North America

Date of Solar Eclipse	Type of Solar Eclipse	Time of Day to View[1]	Locations[2]
March 30, 2033	**Total**	**Morning**	***Alaska***, Canada, Hawaii, West, Midwest
September 1, 2035	Partial	Around Sunset	*Hawaii*
August 21, 2036	Partial	Morning	*Alaska*
January 5, 2038	Partial	Early Morning	*East*, Florida
July 2, 2038	Partial	Early Morning	*Florida*, Southeast, East
June 21, 2039	**Annular**	**Early Morning**	***Alaska***, Canada, Hawaii, West, Midwest
November 4, 2040	Partial	Around Noon	*East*, Continental US, Canada
October 24, 2041	Partial	Late Afternoon	*Hawaii*
April 19, 2042	Partial	Around Sunset	*Alaska*, Northwest Canada, Hawaii
April 9, 2043	Partial	Around Noon	*Alaska*, Western Canada, Hawaii, Northwest
August 22, 2044	**Total**	**Around Sunset**	***Northwest***, Alaska, Canada, Hawaii, West
February 16, 2045	Partial	Late Afternoon	*Hawaii*
August 12, 2045	**Total**	**Around Noon**	***South to West***, Hawaii, Canada, Alaska
February 5, 2046	**Annular**	**Mid Afternoon**	**Hawaii**, Alaska, West
June 11, 2048	**Annular**	**Early Morning**	***Northern Midwest/ Canada***, East, South, Florida
May 31, 2049	Partial	Morning	*Florida*
November 14, 2050	Partial	Early Morning	*East Canada*, Northeast
April 10, 2051	Partial	Around Sunset	*Alaska*, Northwest Canada

[1]Check media sources for specific times for your location.
[2]First listed area is most favorable viewing location.

Deep Sky Objects



What's does one view after observing the Moon, Planets and Sun? Most move on to the brightest Deep Sky Objects (DSOs) which includes star clusters, nebulae, and galaxies, that is, distant objects beyond our Solar System. Everyone is familiar with these objects for the biggest and brightest are frequently pictured in the media and have names like the Pleiades, the Orion Nebula and the Andromeda Galaxy.

Traditionally, double and variable stars are not considered deep sky objects, but I have included them in this section, starting on page 254, to "round out" the kinds of objects that are observed after one's initial foray into astronomy.

The first catalogue of Deep Sky Objects was published in 1772 by the Frenchman Charles Messier and contained 45 entries.

STAR CLUSTERS

A star cluster is a group of stars born out of the same nebulae (see page 241). Most star clusters are easy to recognize because their stars are close together or bunched up, often forming a distinct pattern or shape, so they stand out from their surroundings. The term "star cluster" is a general term referring to an **open cluster**, **galactic cluster** or **globular cluster**.

Open Cluster. A star cluster containing several dozen to a thousand or so members. A few open clusters are visible to the naked eye but most require a telescope to see. The best examples of open clusters are the Pleiades (page 273), the Praesepe (page 279), M6 and M7 (page 293).

Galactic Cluster. Specific term for an open cluster that lies within an arm of a spiral galaxy. Galactic clusters are composed of young stars born from the nebulae located in the arms of spiral galaxies.

Facing page. *A barred-spiral galaxy located in the direction of the constellation Eridanus. It lies about 69 million light years away and has a length that extends for 130,000 light years, which makes it much bigger than our Milky Way Galaxy. Barred-spiral galaxies are a variation of "normal" spirals, and are characterized by curved arms connected to a "bar" of stars that contains the nucleus.*
Top of page. *A planetary nebula 7,000 light years away in the constellation Hercules.*