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Night Sky

A guide to field identification

NIGHT SKY

A FIELD GUIDE TO THE HEAVENS

a Golden Field Guide from St. Martin's Press

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by

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PREFACE

The sky is a part of nature available to all people, yet how the sky appears is very localized and very personal: No one sees the sky in exactly the same way or the same time as you do. This guidebook provides an introduction to the natural sky for those with little knowledge of astronomy, so that they can begin to appreciate the beauty of the sky and of the laws of nature that determine the motions and appearances of celestial objects. It is hoped that readers will find this book useful even when they have graduated to more technical, more detailed works.

Mark R. Chartrand

Helmut K. Wimmer

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INTRODUCTION

> Look up at the bright and unsullied hue of heaven and the stars which it holds within it, wandering all about, and the moon and the sun's light of dazzling brilliancy: if all these things were now for the first time, if, I say, they were now suddenly presented to mortals beyond all expectation, what could have been named that would be more marvelous than these things, or that nations beforehand would less venture to believe could be? Nothing, me thinks: so wonderous strange had been this sight. Yet how little, you know, wearied as all are to satiety with seeing, any one now cares to look up into heaven's glittering quarters!

This quotation could very well describe the present common disregard for the sky, yet it was writte around 55 B.C. by the scholar Lucretius in his great work *De Rerum Natura.* Some things just don change.

The sky is that part of the natural environment which we all share, no matter where we are on Ear —or even in space. Yet many people who can identify birds or rocks, trees or ferns, cannot point t any constellations by name, or find the planets in their wanderings among the stars. Few can tell wl the Sun rises where it does or why the Moon has phases. This book is for them, and for all others wl have ever wondered at the beauty of the night sky, watched the solemn progress of a lunar eclipse, stood breathless for the timeless moments of the totality of a solar eclipse.

Lucretius refers to "the bright unsullied hue of heaven," and here he had an advantage over u Modern people live, for the most part, under canopies of polluted air and urban lighting; these cut off from the crystal clarity of the night sky seen in areas far from cities. But there is still much to I seen, even from cities.

If you can, get to a park, beach, or other area as far as possible from cities. Campers in tl Southwest probably enjoy the best skies, but merely getting 50 miles from a city can be a great hel But be warned: If you have learned your constellations in a city (which is possible, at least for tl brighter ones), you may get lost in the skies of the country. There are so many more stars! They we there all the time, of course, but in the city they couldn't be seen.

Another important factor in viewing, especially with a telescope, is what astronomers call "seeing This refers to the steadiness of the images, rather than the transparency of the sky. If the stars a twinkling a lot, this is poor seeing, and a telescope will only exaggerate the poor images further. A objects in the sky appear to twinkle when near the horizon because their light is passing through mo atmosphere before it reaches your eyes. With good seeing, objects high in the sky will seem stead Ironically, some nights when there is just a bit of haze, and the transparency is not perfect, are tl times of best seeing, at least in cities, because air turbulence is not distorting the image. Astronome reduce this problem by placing their major instruments high atop mountains in carefully selecte locations to get above as much of the atmosphere as possible.

Throughout this book references are made to "amateur" instruments. This is not meant to disparag but simply to refer to telescopes and other equipment that are within the range of the nonprofession stargazer. It definitely does not imply inferior quality, for many small telescopes are of high quality.

Astronomy is one of those rare sciences in which the serious amateur can make importa contributions. Here, "amateur" means only "not getting paid for it." Yearly, amateur astronome contribute over 100,000 observations of variable stars, discover new comets, watch grazing lun

occultations, discover novae and supernovae, and count sunspots. All these add to the store of astronomical data from which professional astronomers draw to check their theories and calculations. In few fields can the amateur make such contributions.

You should try to make contact with a local amateur astronomical society. Many hold regular meetings with speakers, and occasionally have "star parties" at which many telescopes are set up to observe the sky. Here you will have an excellent opportunity to compare many instruments, observe many astronomical sights, and make friends.

Local science museums and even some public libraries often have telescopes available for public viewing on a regular basis, as well as introductory classes on astronomy. To learn your way around the night sky, there is no better place to start than your local planetarium, where the sky and the weather can be controlled. If you are traveling anywhere near one of the major observatories, you should try to plan to stop in on one of their public nights. A list of many of the major observatories and planetariums can be found here.

A word of advice about buying telescopes: Decide first if your interest in the subject is serious and permanent, or if you just wish an occasional view of the sky. For a first instrument, binoculars are ideal. They are less expensive than a telescope of comparable size, easy to hold, have a wide field of view, and, if your interest wanes, can always be used for watching sports or birds! After you have had a little experience, ask local amateur astronomers for recommendations on what to buy, after reading here. Some local amateur astronomical societies even offer used telescopes for sale.

A second word of advice about buying telescopes: Avoid any telescopes sold in department stores or by opticians. The telescopes are almost invariably of poor quality and not worth the price, and the salespeople know little or nothing about them. There are only a few shops around the country specializing in amateur astronomy equipment, but these are easy to identify. By and large, the better amateur instruments are available from mail-order firms (see here).

When you first look through a telescope at, say, Mars or Saturn, or the Ring Nebula, don't expect it to look like the photographs you see in many astronomy books. These photos were taken through the world's largest and best instruments. Your 6-inch reflector is not going to yield an image of comparable size and quality. Your telescope excels, however, in giving you a view that is particularly yours, is real, and is now. That intangible quality is something you can't get from staring at a picture.

Lastly, remember that astronomy is unique in that you can appreciate it on many levels, from just enjoying the sparkling beauty of the night sky, to keeping track of variable stars, to learning relativistic astrophysics. The depth to which you go is up to you. And although the same stars will appear in your skies in the same places year after year, all your life the planets will keep shifting in the heavens, comets will come and go, meteors will flash ephemerally across the sky, and new discoveries will be made, adding depth to your understanding of the old familiar sky.

Good observing!

ASTRONOMICAL SYMBOLS AND ABBREVIATIONS

SUN, MOON AND PLANETS

⊙ The Sun	♀ Venus	♃ Jupiter	♆ Neptune
☾ The Moon	⊕ Earth	♄ Saturn	♇ Pluto
☿ Mercury	♂ Mars	♅ Uranus	

SIGNS OF THE ZODIAC

♈ Aries	♋ Cancer	♎ Libra	♑ Capricornus
♉ Taurus	♌ Leo	♏ Scorpius	♒ Aquarius
♊ Gemini	♍ Virgo	♐ Sagittarius	♓ Pisces

TERMS INDICATING RELATIVE POSITION

☌ Conjunction	☐ Quadrature	☊ Ascending Node
☍ Opposition		☋ Descending Node

ABBREVIATIONS

h, m, s—Hours, minutes, seconds of time	A.U. or a.u.—Astronomical units
° ′ ″—Degrees, minutes, seconds of arc	α or R.A.—Right ascension
	δ or Dec.—Declination
	lt-yr—Light-year

THE GREEK ALPHABET

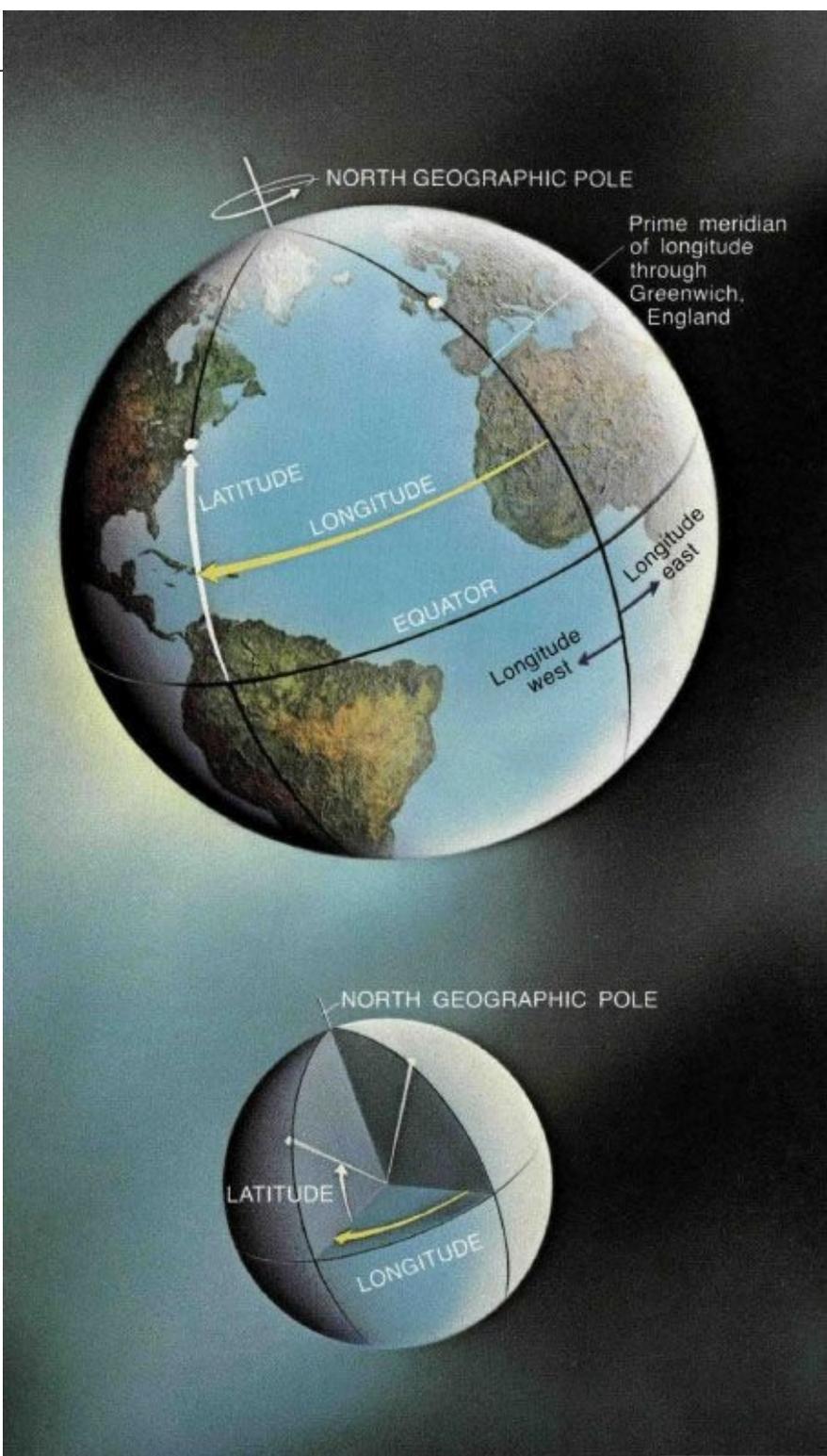|			
A, α Alpha	H, η Eta	N, ν Nu	T, τ Tau
B, β Beta	Θ, θ Theta	Ξ, ξ Xi	γ, υ Upsilon
Γ, γ Gamma	I, ι Iota	O, o Omicron	Φ, φ Phi
Δ, δ Delta	K, κ Kappa	Π, π Pi	X, χ Chi
E, ε Epsilon	Λ, λ Lambda	P, ρ Rho	Ψ, ψ Psi
Z, ζ Zeta	M, μ Mu	Σ, σ Sigma	Ω, ω Omega

TERRESTRIAL COORDINATES

How you see the sky depends upon where you are on Earth. Even the way the sky seems to mov
overhead depends upon your terrestrial location. To specify a location on Earth precisely, tw
coordinates are used—two because Earth's surface is two-dimensional.

Latitude is the north-south coordinate, measured in degrees north and south of the equator, which
the imaginary line around our planet midway between the poles. The poles are the ends of the planet
axis of rotation, and for our purposes can be considered fixed. The equator is at latitude 0°. Norther
latitudes are positive, southern ones negative. The north geographic pole is at latitude +90°, the sou
geographic pole at − 90°. Locations having the same latitude are said to be on the same *parallel*
latitude.

Longitude is the east-west coordinate. A line from one pole to the other is called a *meridian*
longitude. (Such a line is an example of a *great circle:* a line on the surface of a sphere which is pa
of a circle whose center coincides with the center of the sphere.) A *prime meridian* is needed fro
which to start measurements eastward or westward. A century ago, different prime meridians were
use by different countries, each wanting the prime meridian to go through its capital. Since th
situation was confusing to navigators and astronomers, all nations finally adopted the present prim
meridian, which runs through Greenwich, England. Sometimes called the *Greenwich meridian,* it
marked at the Greenwich Observatory by a brass line in the pavement, so that you can stand with yo
feet in different hemispheres.

Longitude, like latitude, can be measured in degrees—from the prime meridian east and west up
180°. At 180°, opposite the Greenwich meridian, is the *international date line,* which divides th
Pacific Ocean. (For political and practical reasons, the line zigs and zags near the 180° meridian
Along this line each new day begins and the previous day ends, so that, for example, when the time
12:01 a.m. Wednesday just east of the line it is 12:01 a.m. Thursday just west of the line. Since th
time of day when we see astronomical objects depends on Earth's rotation, longitude is ofte
measured in hours, one hour equaling 15°. (See here.)

Although Earth's surface is two-dimensional, the planet is three-dimensional. Latitude an
longitude are not just lines on the surface, but refer to angles measured at Earth's center. Latitude
the angle between the equator and the location referred to, and longitude is the angle between th
prime meridian and the meridian of the location referred to. Each degree of latitude or longitude ca
be divided into 60 minutes (abbreviated '), and each minute into 60 seconds ("). But navigators an
astronomers commonly use degrees with decimal fractions, rather than minutes and seconds, becau
they make computations easier.

NORTH GEOGRAPHIC POLE

Prime meridian of longitude through Greenwich, England

LATITUDE

LONGITUDE

Longitude east

EQUATOR

Longitude west

NORTH GEOGRAPHIC POLE

LATITUDE

LONGITUDE

HORIZON COORDINATES

Looking up at the sky from a plain, we seem to be at the center of the universe, with a flat Earth stretching off to infinity in all directions. We are at the center of the *celestial sphere,* an imaginary globe of indefinitely large size, on the inner surface of which all heavenly bodies and their motions appear as if projected onto a screen. This concept allows us to ignore *distances* of celestial objects except when relevant, heeding only their *directions.*

Often an observer wants to specify the direction of a celestial object with respect to *his* location. One convenient way is by means of *horizon coordinates,* sometimes called *topocentric coordinates.*

First, imagine a flat plane tangent to Earth's surface at your location. This is your *horizon plane.* The line along which it intersects the celestial sphere is your *horizon.* This divides the universe into the part you see above the horizon, and the invisible part below it. North is the point on the horizon in the direction of the geographic north pole; south is opposite. Facing south, east is on your left, west on your right.
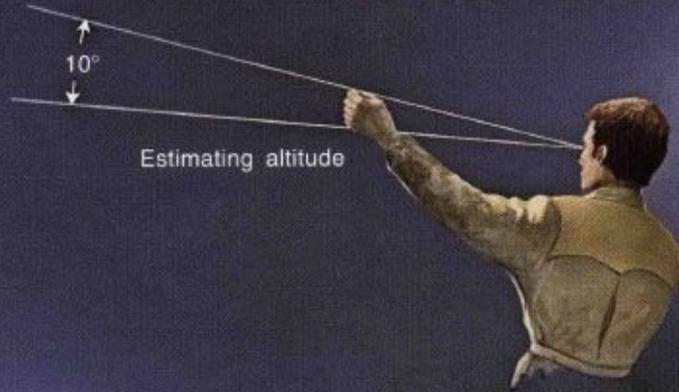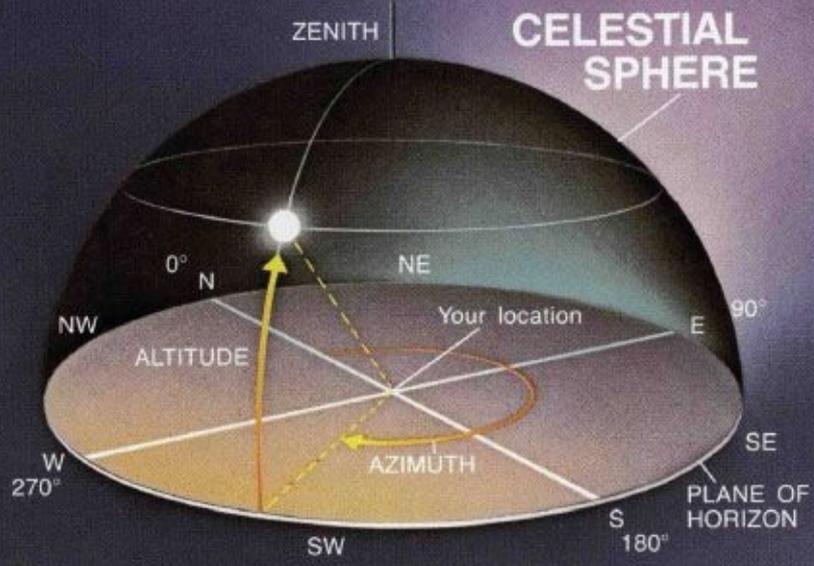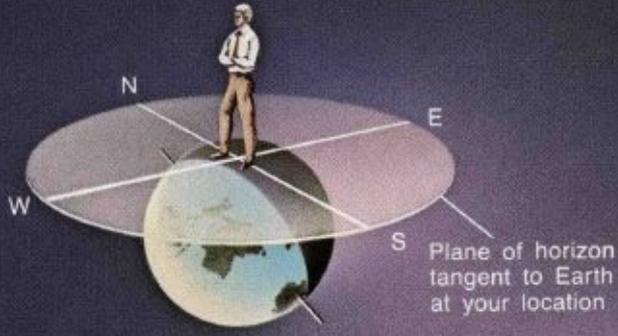
Your celestial sphere has a spot unique for you: the point directly overhead, the *zenith.* If you move, your zenith moves. No other location on Earth has the same zenith as yours. The point opposite the zenith on the celestial sphere is the *nadir.*

The location of a celestial object with respect to the observer's location is described by the two angles called altitude and azimuth.

Altitude is the angle between the horizon and the object. This angle is measured from the horizon and perpendicular to it. Altitude is not height above the ground, as of an aircraft. It is an angle centered on you; or, an arc along the celestial sphere. Altitude ranges from 0° at the horizon to +90° at the zenith. Objects below the horizon have negative altitudes. Objects at the same altitude are said to be on a *parallel of altitude.* A line of constant altitude around the sky is called an *almucantar.*

Azimuth is the compass direction toward an object. More precisely, it is the angle measured around the horizon, beginning at north (0°) through east (90°) and so on until you reach a line drawn perpendicular from the object to the horizon. Thus east is azimuth 90°, south 180°, west 270°, and north 360°—the same as 0°.

You can estimate altitude or azimuth simply by extending your fist to arm's length. At this distance your fist will appear to be about 10° wide. If you align the bottom of your fist with the horizon, the top is at about 10° altitude. Stacking fist on fist, you can estimate wider angles. This method of approximately measuring distances across the sky is convenient when you are attempting to locate a star or other object that is a known number of degrees from an object you have already identified. A navigator uses a sextant to determine altitude and azimuth accurately.

Plane of horizon tangent to Earth at your location

CELESTIAL SPHERE

ZENITH

0° N
NW
NE
ALTITUDE
Your location
W 270°
E 90°
AZIMUTH
SE
SW
S 180°
PLANE OF HORIZON

10°
Estimating altitude

THE CELESTIAL SPHERE

Imagine Earth as surrounded by a very large sphere on the surface of which all stars, planets, and oth
celestial objects are placed. This is similar to the observer's celestial sphere mentioned here, but n
exactly the same. Now we are imagining the astronomer's celestial sphere, with the center of Earth
the center of the sphere.

Next, imagine Earth's equator expanding outward until it intersects the sphere. The intersection wi
be a great circle on the sphere called the *celestial equator.* It is halfway between the *north celestia
pole* (NCP) and the *south celestial pole* (SCP), which are the locations on the celestial sphere direct
above the north and south geographic poles on Earth's surface.

In the sky there are counterparts to meridians of longitude, but for reasons explained more ful
here, they are usually called *hour circles.* You should keep in mind that as Earth turns, the meridian o
longitude under a given hour circle changes continuously.

Another fundamental plane in the sky is the plane of Earth's orbit, called the *ecliptic plane,*
ecliptic. As seen by us on Earth, the ecliptic is an imaginary line in the sky along which the Sun mov
during a year's journey around the sky against the background of stars. As seen by an observer sittin
"on the NCP," the Sun would move counterclockwise. Perpendicular to the plane of the ecliptic are th
north and south *ecliptic poles.*

When Earth formed from a cloud of gas and dust about five thousand million years ago, its axis
rotation did not coincide with the axis of the ecliptic poles. The two axes, and hence the plane of th
equator and the plane of the ecliptic, are inclined to one another at an angle of about 23½°. This ang
is called the *obliquity of the ecliptic.* Thus the north ecliptic pole is at R.A. 18h, Dec. + 66½°, whi
the south ecliptic pole is located opposite at R.A. 6h, Dec. – 66½°.

The two points on the celestial sphere where the equatorial and ecliptic planes meet are termed th
equinoxes. The point at which the Sun crosses the celestial equator when going north in spring
called the *vernal equinox.* The point where the Sun crosses when going south in autumn is th
autumnal equinox. (See here for the relationship of the equinoxes to the seasons.)

Keep in mind that the celestial sphere is indefinitely large. All that concerns us are the *directions*
celestial objects from us. For most purposes, it makes no difference whether the center of the celesti
sphere is assumed to be at the center of Earth or at our location. Remember also that the illustratio
here and on other pages shows the celestial sphere as seen from the "outside," while we on Earth a
looking out from inside. The celestial sphere is the "screen" on which the drama of the sky is played.
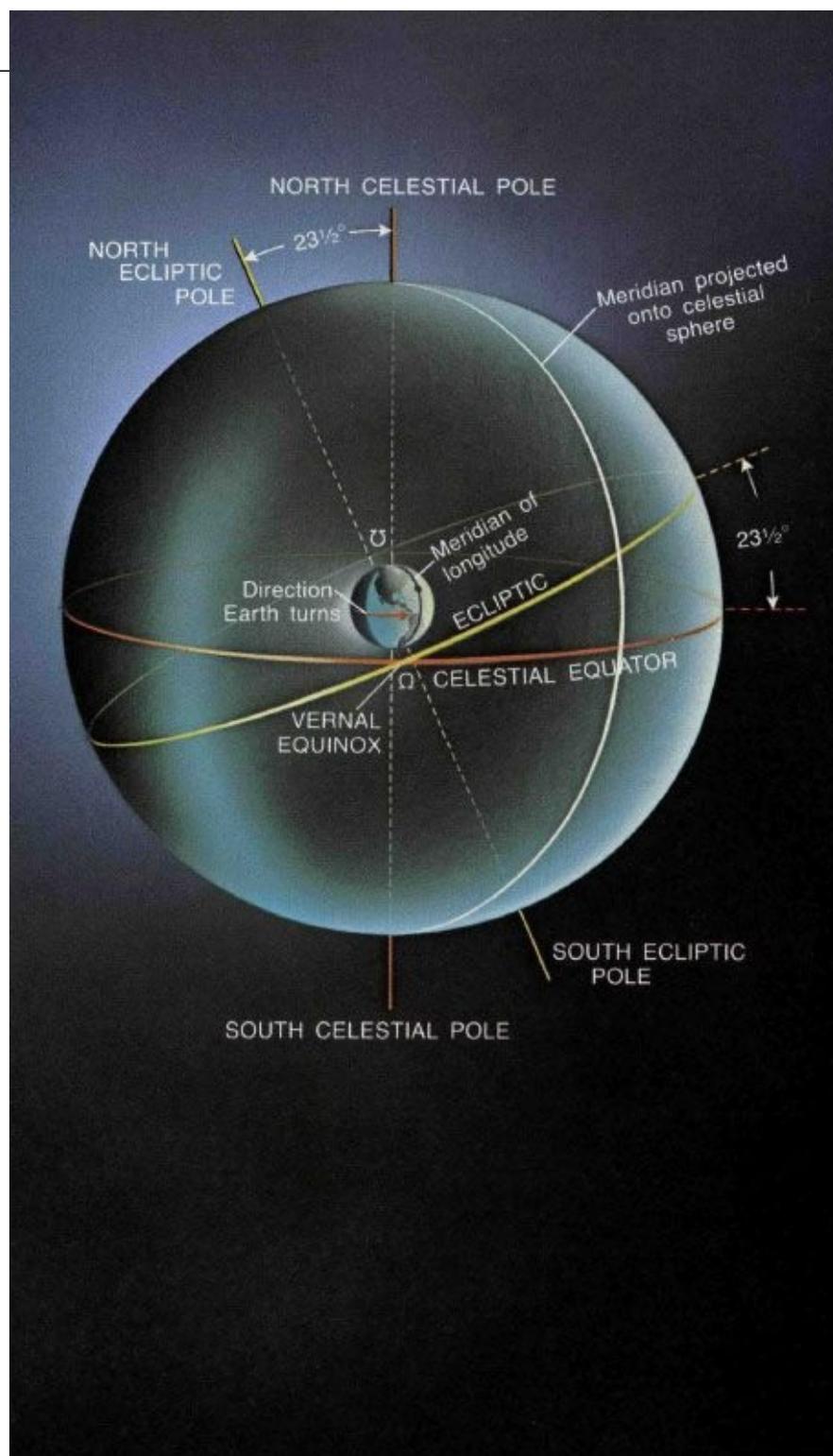
CELESTIAL COORDINATES

To specify an object's location on the celestial sphere, *equatorial coordinates* are used. These refer [to] the celestial equator.

The north-south coordinate (similar to latitude) is called *declination* (Dec, or δ, the lower-ca[se] Greek letter "delta"), measured in degrees north (+) and south (–) of the celestial equator, which [is] at declination 0°. The celestial poles are at + 90° and – 90°.

The east-west coordinate is called *right ascension* (R.A., or a, the lower-case Greek letter "alpha'[). Its zero-point is the vernal equinox. Right ascension is expressed sometimes in degrees, but mo[re] commonly and usefully in hours, minutes, and seconds. Since Earth turns 360° in about 24 hours, o[ne] hour (1h) of right ascension (or time) is 15° of arc, one minute of time (1m) is 15 minutes of a[rc] (written 15'), and one second of time (1s) is 15 seconds of arc (15").

A degree of declination always represents the same distance on the celestial sphere, but an hour [of] right ascension represents a shorter distance on the celestial sphere as we move farther away from t[he] celestial equator. In other terms, 1° of arc in R.A. always equals 4m of time, but represents a short[er] distance on the celestial sphere as declination increases. Thus an object at Dec. 0° (that is, on t[he] celestial equator) seen in a fixed telescope with a field of 1° will cross the field in 4 minutes, but [at] Dec. 45° the object would be in the field about 6 minutes.

The vernal equinox is right ascension Oh, and the opposite point, the autumnal equinox, is 12[h,] from which we go on to 24h, which is the same as Oh. Right ascension increases counterclockwise—that is, toward the east—around the north celestial pole. As observers we are inside the sphere; hen[ce] the sky pattern is reversed compared to the illustration, which shows the pattern from outside.

In the illustration are two stars: #1 and #2. Their positions can be specified thus:

> Star #1: α = 2h45m00s, δ = + 62°26'56".
> Star #2: α = 22h40m55s, δ = – 36°44'05".

Celestial longitude is similar to right ascension, except that it is measured along the ecliptic rath[er] than along the celestial equator. *Celestial latitude* is the angular distance of an object from t[he] ecliptic. These coordinates are useful for specifying the positions of planets, since planets are alwa[ys] close to the ecliptic.

Because it is curved, when the celestial sphere is represented on a flat page, distortions occur—areas get squeezed or stretched out of shape. The bottom illustration shows a flat map with t[he] celestial equator and the ecliptic marked, along with one or two stars. Study carefully the two metho[ds] of showing the same thing. Both methods are useful in depicting the sky and will be used later in th[e] book.

NORTH CELESTIAL POLE

Star #1

Hour circle of Star #2

Declination of Star #1

AUTUMNAL EQUINOX
℧ 12
13   11   10   9
16 15 14   8 7 6

Right ascension of Star #2

17

18

CELESTIAL EQUATOR

19
20   21
22   23   0   1   2   3   4   5

VERNAL EQUINOX
♎

Right ascension of Star #1

Hour circle of Star #1

ECLIPTIC

Star #2

CELESTIAL SPHERE

SOUTH CELESTIAL POLE

To the north

Star #1

To the east
(higher right ascension)

23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0

EQUATOR

ECLIPTIC

Star #2

TIME AND THE SKY

Most timekeeping and calendrical schemes depend on celestial motions. A *day* is the time it takes f[...]
one complete rotation of Earth, a *month* for a complete cycle of Moon phases, a *year* for one circuit [...]
Earth's orbit.

Unlike common clocks, the "face" of the celestial clock moves while the "hand" stands still. F[...]
observers in the northern hemisphere, the center of the clock face is the NCP (north celestial pole[...]
marked approximately by the star Polaris. Since the plane of an observer's horizon is tangent [...]
Earth's surface at his location, the altitude of the NCP from his location is the same angle as h[...]
latitude. At latitude + 40°, the NCP is 40° above the north point on the horizon. All stars within th[...]
many degrees of the NCP will always be above the horizon. Similarly, all stars within that mar[...]
degrees of the SCP will never rise. Since the celestial equator is perpendicular to the axis between th[...]
celestial poles, for any observer anywhere it will cross the sky and intersect the horizon at the due-ea[...]
and due-west points, and its angle with the horizon will be 90° minus the observer's latitude.

For any observer, the "hand" on the clock is an imaginary line in the sky called the *celesti[...]
meridian,* or just *meridian.* It is the observer's meridian of longitude extended out to the celesti[...]
sphere. It runs from the due-north point, through his zenith, to the due-south point, and underneat[...]
Earth back to north. The meridian for one location is different from the meridian for any oth[...]
location to the east or west. An observer due north or south of you shares the same meridian, but f[...]
that observer the NCP is at a different altitude.

An imaginary circle drawn on the celestial sphere through the celestial poles and a celestial obje[...]
is the *hour circle* of that object. The angle, or arc, between the celestial meridian and the hour circle [...]
the object is the *hour angle.* Since the sky moves westward, the hour angle increases westward, fro[...]
0h on the meridian through 24h. It decreases eastward. Thus an object in the eastern sky has a[...]
eastern, or negative, hour angle. The hour angle is the measure of how long ago (or before) the obje[...]
was (or will be) on the meridian.

In the illustration, the Sun's hour angle is about 2h, since it is about 30° west of the meridian. Ou[...]
time of day is defined by the hour angle of the Sun, but since we want a new day to begin at midnigh[...]
when the Sun is crossing the invisible lower meridian, we use this definition: Local Apparent Time [...]
Hour Angle of the Sun + 12h. The time is *apparent* because it is according to where the Sun appear[...]
and local because it depends on the observer's location. A person east of you has a later local apparen[...]
time (a later time shown on a sundial), because the Sun crosses his meridian *before* it crosses yours. [...]
person west of you has an earlier local apparent time because the Sun will cross his meridian *after* [...]
crosses yours.

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