AST 301
Introduction to Astronomy

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AST 301 (Lacy), course website

Assignment for this week

Read Chapters 1 and 2.

If you haven't yet, find a place where you can see the western horizon and look for Venus, Mars, and Spica.

If it is clear enough to see them, make a sketch and write down the date, time, place, weather, and names of companions.

The homework due this Friday is on www.as.utexas.edu and in one of the mailboxes outside of the classroom.

What should you remember?

Don’t memorize all of the numbers.

But do remember roughly how things compare in size and distance from us.

The Sun is roughly 100 times as big as the Earth.

The astronomical unit is roughly 100 times as big as the Sun.

The solar system is roughly 100 AU across.

The nearest star is more than 1000 times that far away.

The Milky Way galaxy is roughly 10,000 times as big as the distance to the nearest star, so it is more than 10,000,000 times bigger than the solar system.

And the Universe is more than 100,000 times bigger than the Milky Way.

Big numbers

Numbers like 1,000,000 are hard to work with.

It is more convenient to use an abbreviation:

$1{,}000{,}000 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 10^6$

And we write $2{,}000{,}000$ as 2×10^6

And sometimes we will write $1/10^6$ as 10^{-6}

We can leave numbers written this way while multiplying and dividing. For example:

$2 \times 10^3 \times 3 \times 10^2 = 2 \times 10 \times 10 \times 10 \times 3 \times 10 \times 10$

$= 2 \times 3 \times 10 \times 10 \times 10 \times 10 \times 10 = 6 \times 10^5$

$2 \times 10^3 / 10^2 = 2 \times 10 \times 10 \times 10 / 10 \times 10$

$= 2 \times 10 = 2 \times 10^1 = 20$

The age of the Universe

I gave the age of the Universe as 14,000,000,000 (14×10^9, or 14 billion years, or 14 Gyr).

How did I know that?

We know the age of the Earth quite well because some rocks change as they age by radioactive decay.

The Earth is about 4.5 Gyr old.

There must be stars older than this since the Earth is made of elements that were made inside of stars that lived before the Earth formed.

We can date some stars from how they change as they age, and some are at least 10 Gyr old.

The age of the Universe

The determination of the age of the Universe is more difficult.

Distant galaxies are moving away from us.

From their speeds we can calculate when they were in the same place as we were.

We'll talk more about that during the last week of classes.

The answer comes out to about 14 Gyr.

We think that was the beginning of the Universe, or at least the part of the Universe we can see.

Our motion through space

We aren't standing still.

The Earth is rotating.

An object at the equator moves 24,000 miles (the circumference of the Earth) every 24 hours, or 1000 mph.

That's about 0.5 km/s.

In addition, the Earth is orbiting around the Sun.

Can you figure out how fast it's going?

Use the formula speed = distance / time.

What is the distance around the Earth's orbit?

Hint: the Earth's orbit is nearly a circle with a radius of 1 AU, or 150×10^6 km.

The speed of the Earth

The answer comes out to about 9×10^8 km.

You can do it more accurately on your homework.

We can get the Earth's speed in km/s by dividing the distance it travels in km by the time in seconds.

There are about 3×10^7 seconds in a year, and the Earth travels about 9×10^8 km around the Sun in a year.

Speed = 9×10^8 km / 3×10^7 sec = 30 km/s.

The Sun isn't standing still either.

It is orbiting around the center of the Milky Way at about 200 km/s.

How can the Earth go around the Sun at only 30 km/s while the Sun is moving at 200 km/s? Why doesn't the Earth get left behind?

The speed of the Milky Way

The Milky Way is moving too.

It moves relative to the nearby galaxies at a few 100 km/s.

Is it moving due to the expansion of the Universe?

How can we tell that the distant galaxies are moving away from us rather than us moving away from them?

If they are moving away from us, why are we so special?

We'll talk more about that later.

Motions in the sky during a night

Use sky gazer or find a planetarium program on the web.

Stellarium (www.stellarium.org) looks pretty good.

Set the location to Austin.

Use it to see how stars appear to move across the sky during a night.

General pattern:

- Most objects rise in east, follow an arc across sky, and set in west.
- Although some rise in the southeast and set in the southwest, and others rise in the northeast and set in the northwest.
- And some circle the North Star and never set.

Why? What causes this motion of objects across the sky?

Motions of objects in the sky

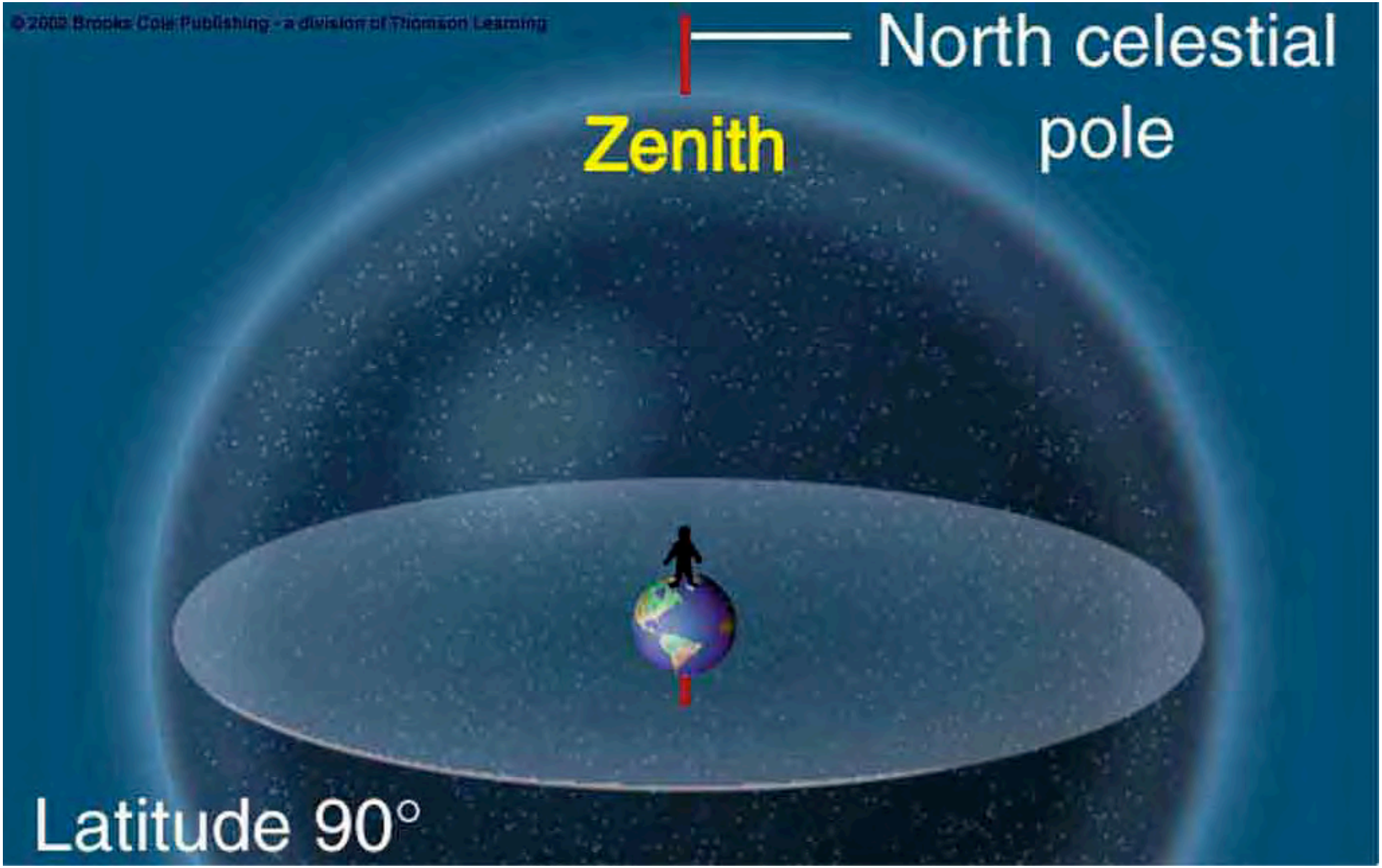
The Earth rotates on its axis once each day.

The Earth's axis passes through the north and south poles, and points at the north star (Polaris) above the north pole.

The rotation of the Earth on its axis makes the stars appear to move around the sky during the night.

It may be easiest to pretend that the sky rotates around the Earth instead of the Earth rotating.

Think of the stars as tiny lights on a glass sphere surrounding the Earth. The sphere rotates about a line through the Earth's poles and through the north star.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North celestial pole
Zenith
Latitude 90°

Quiz

If you were standing on the pack ice at the north pole in the wintertime and watched the sky for 24 hours, you would see Polaris ..

A. remain directly overhead

B. circle the horizon

C. rise in the east and set in the west, passing directly overhead

Imagine you are standing on a rotating platform.

An object directly overhead will remain directly overhead.

Or think of the imaginary sphere rotating about a line from the Earth to Polaris. Polaris is on the axis so it doesn't move.

Quiz

If you were standing at the north pole and watched the sky for 24 hours, you would see the big dipper …

A. remain stationary in the sky

B. circle around the sky

C. rise in the east and set in the west, passing directly overhead

D. rise in the east and set in the west, passing south of overhead

This is easier to figure out with the imaginary sphere picture.

Apparent motion of stars during a night

The Earth rotates on its axis through the poles once a day.

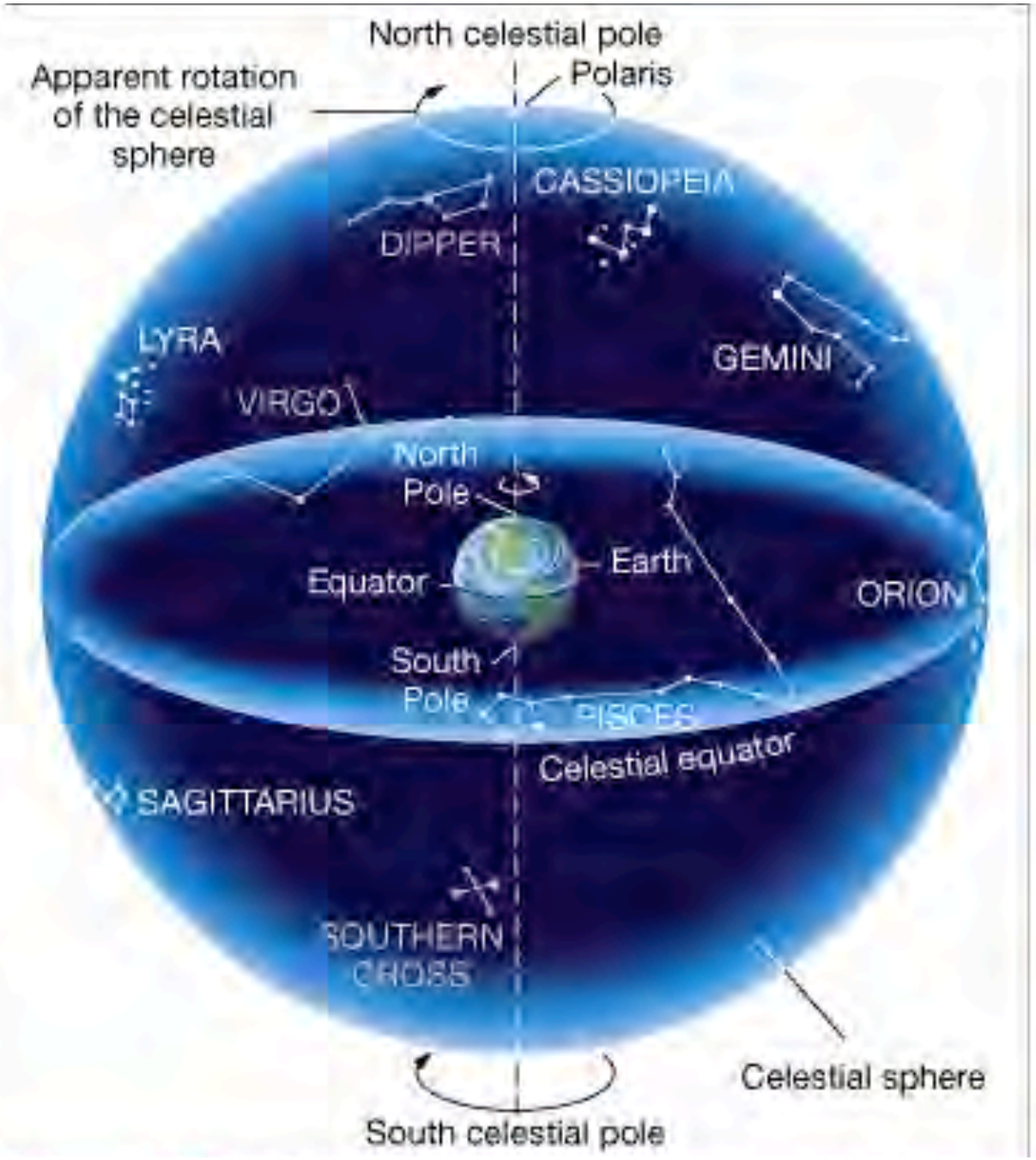
The west-to-east rotation makes stars appear to move east-to-west, generally rising in the east and setting in the west.

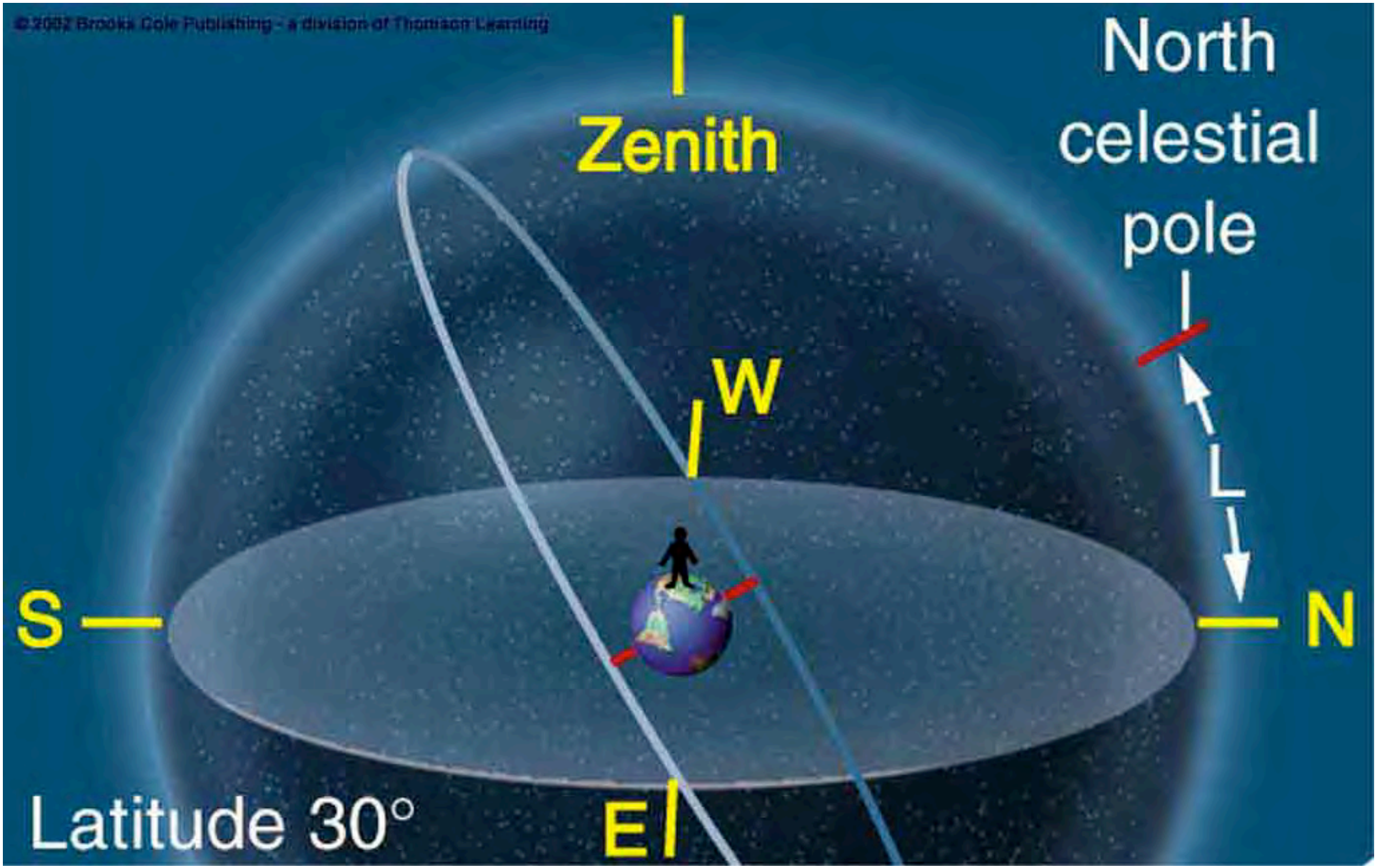
The appearance is the same as if the stars were on a giant sphere surrounding the Earth, which rotates east-to-west about an axis running through the Earth's poles.

This imaginary sphere is referred to as the celestial sphere.

The axis of rotation passes through the celestial poles, which are directly above the Earth's poles.

The celestial equator is a line on the celestial sphere above the Earth's equator.


North celestial pole
Polaris
Apparent rotation of the celestial sphere
CASSIOPEIA
DIPPER
LYRA
GEMINI
VIRGO
North Pole
Earth
Equator
ORION
South Pole
PISCES
Celestial equator
SAGITTARIUS
SOUTHERN CROSS
Celestial sphere
South celestial pole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Zenith
North
celestial
pole
W
L
S
N
Latitude 30°
E

Quiz

If you watch the sky during a night in Austin, Polaris will…

A. rise in the northeast, pass north of overhead, and set in the northwest

B. rise due east, pass near overhead, and set due west

C. rise due east, pass north of overhead, and set due west

D. remain stationary near overhead

E. remain stationary about 30^{o} above the north horizon

Quiz

As seen from Austin, Orion rises near due east. During a night it …

A. passes near overhead and sets near due west

B. passes south of overhead and sets near due west

C. passes near overhead and sets in the southwest

D. passes south of overhead and sets in the southwest