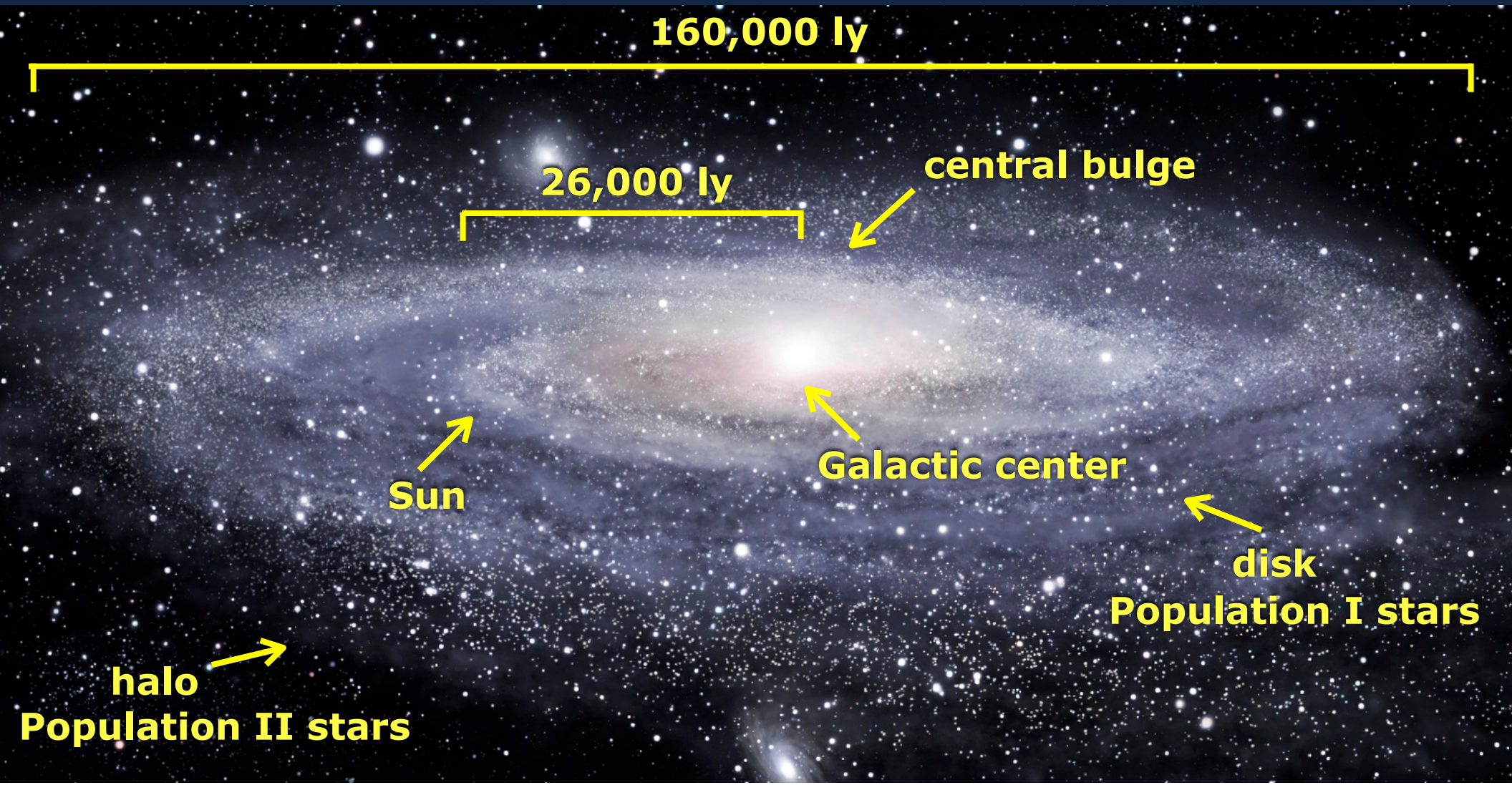
ASTR 322: The Contents of Our Galaxy



ASTR 322: The Contents of Our Galaxy

Prof. Emily Levesque

Topics

—coordinate systems
—light and spectra
—telescopes and instruments
—properties of stars
—stellar evolution
—supernovae and other oddities
—the rest of the Milky Way

Syllabus and Course Policies

Homework & Exams

Jan 14: Homework #1 (9%)

Jan 28: Homework #2 (9%)

Feb 4: Exam #1 (25%)

Feb 16: Homework #3 (9%)

Feb 25: Proposals & Presentations (14%)
(mini-observing proposals & group presentations)
Mar 8: Homework #4 (9%)

Mar 10: Exam #2??? (25%)

Syllabus and Course Policies

Course Details and Policies

- syllabus - grab a handout, note class website
- office hours - C327 PAB, TR 3-3:45PM
- textbook - Bob
- late work
- extra credit
- technology in class
- exam “cheat sheets”

Astro Terminology - Distances

Distances

- Astronomical Unit (AU) (earth-sun distance)
  ~93 million miles, 1.55×10^8 km
  (Sun-Pluto ~ 40 AU; Sun-nearest star ~ 300,000 AU)

- LY (distance light travels in a year)
  $\sim 10^{13}$ km ($c = 3 \times 10^5$ km/s)
  (Sun-nearest star ~ 4 LY; MW disk diameter ~ 160,000 LY)

- parsec (astronomers' unit *of distance*)
  3.3 LY, $\sim 3 \times 10^{13}$ km
  (MW disk diameter ~ 50 kpc,
  furthest observable single stars ~ 1Mpc)

- 1 pc ~ 206265 AU - why??

1 radian ~ 57.296° ~ 206265"

Astro Terminology - Distances

Quick Question

Proxima Centauri is the second-closest star to Earth (after the Sun). It is:

A) about 3 AU away

B) about 3 parsecs away

C) about 3 kpc away

D) about 3 lighthours away

Astro Terminology - Distances

Quick Question

The nearest galaxy to the Milky Way is:

A) about 50 AU away

B) about 50 lightyears away

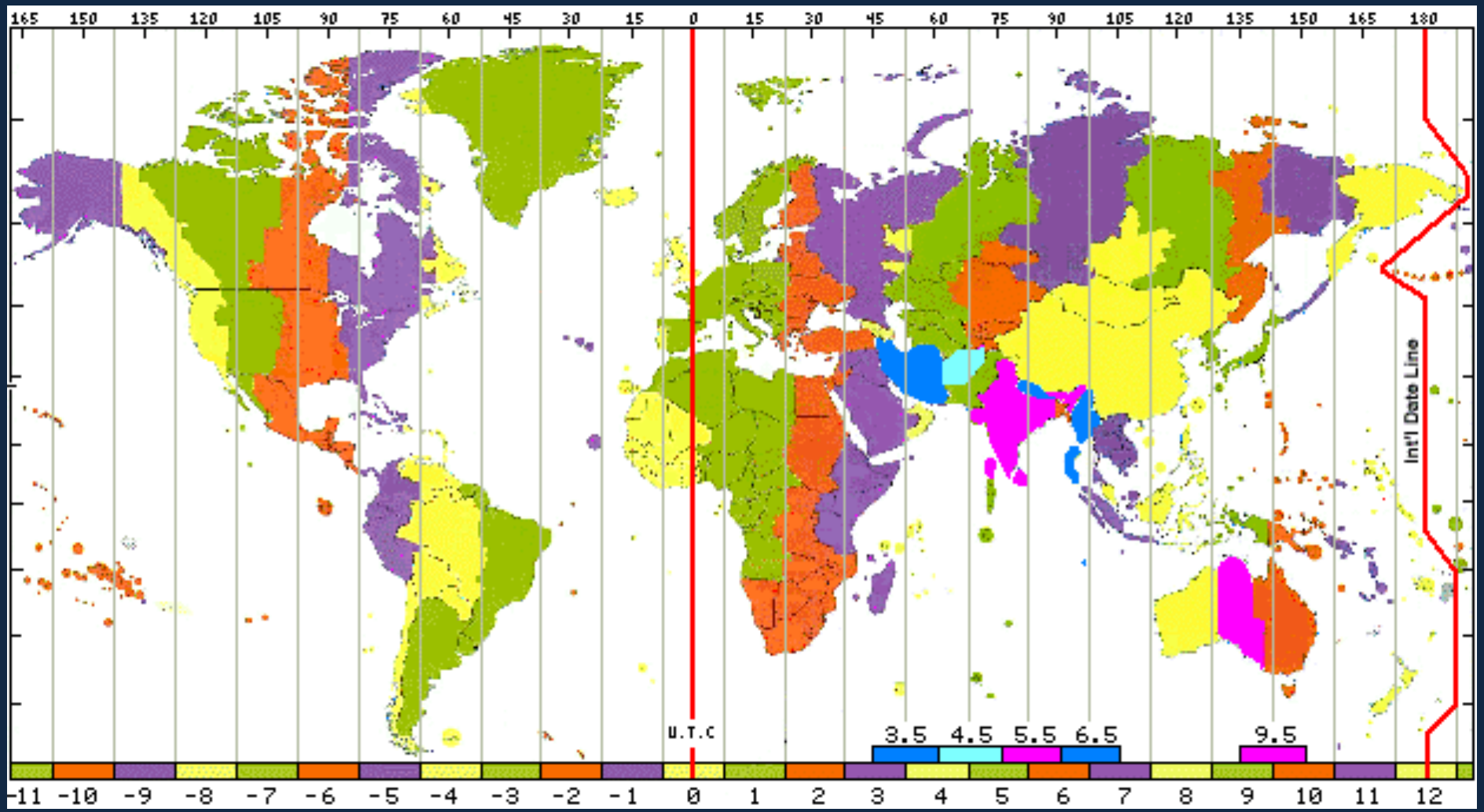
C) about 50 parsecs away

D) about 50 kpc away

Astro Terminology - time & sky

Time

— UT = GMT = local time at Greenwich
(UT = PST + 8hr = PDT + 7hr) **(prime meridian)**



Astro Terminology - time & sky

Time

— UT = GMT = local time at Greenwich
(UT = PST + 8hr = PDT + 7hr)

— JD = Julian Date
(Jan 5, 2016 0^h UT = 2,457,392.5)

— MJD = modified Julian Date
(MJD = JD - 2,400,000.5, used by spacecraft)

Astro Terminology - time & sky

Sky

- horizon
- zenith
- celestial sphere
- meridian
- altitude
- azimuth
- declination
- hour angle
- right ascension

celestial coordinate system

Astro Terminology - time & sky

Sky

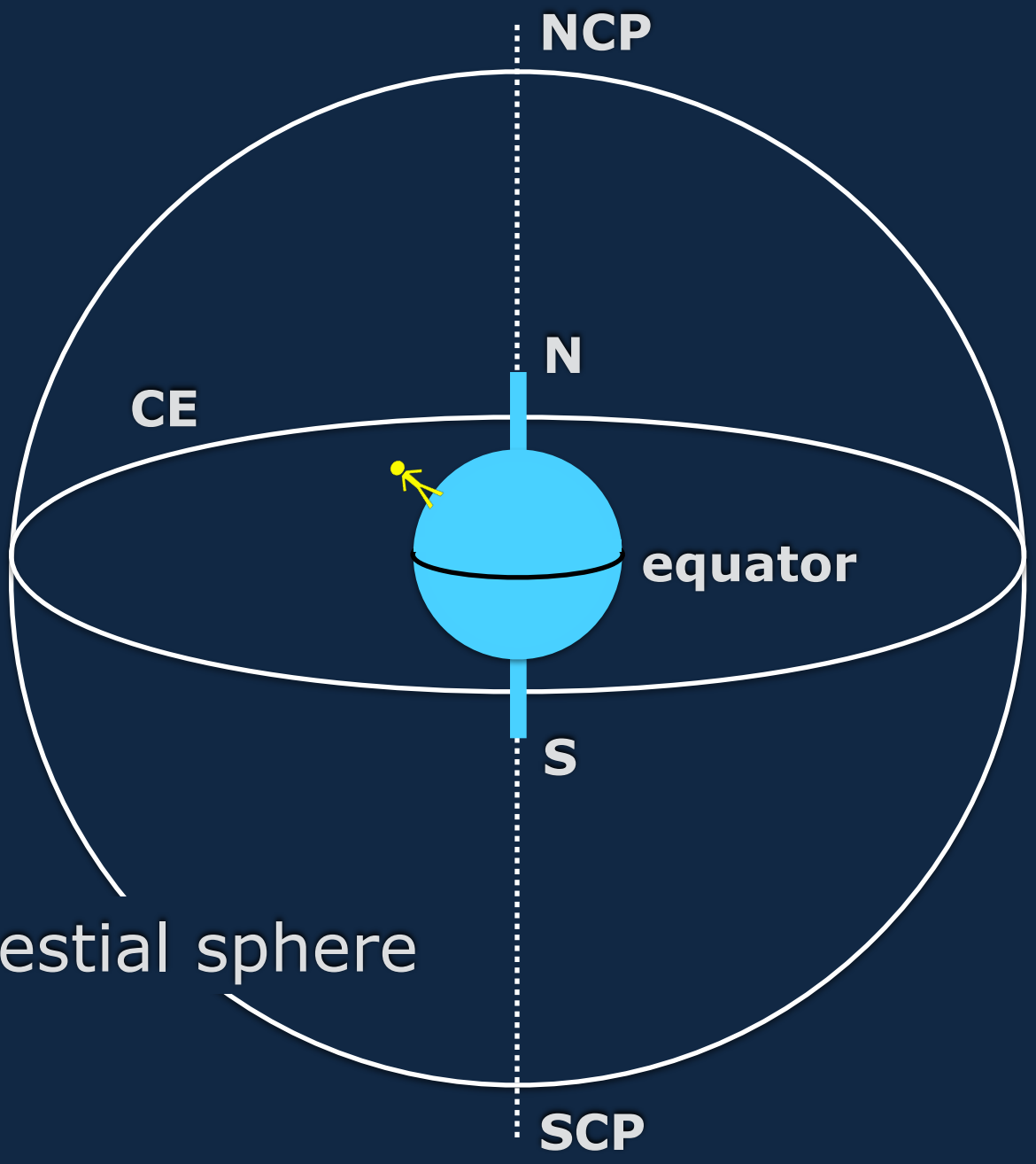
— horizon
— zenith
— celestial sphere
— meridian
— altitude
— azimuth
— declination
— hour angle
— right ascension

horizon coordinate system

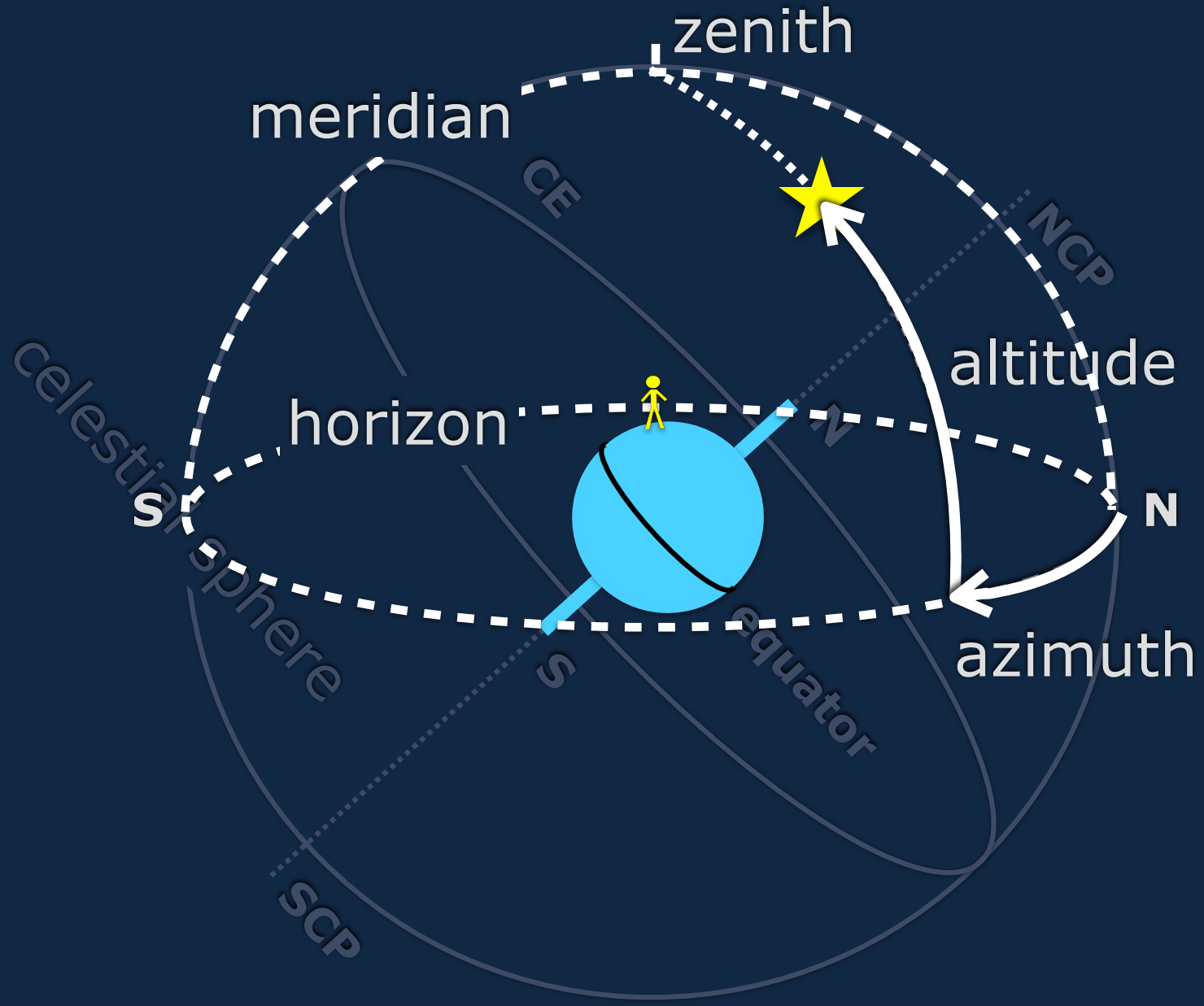
Coordinate Systems - Alt-Az

horizon
zenith

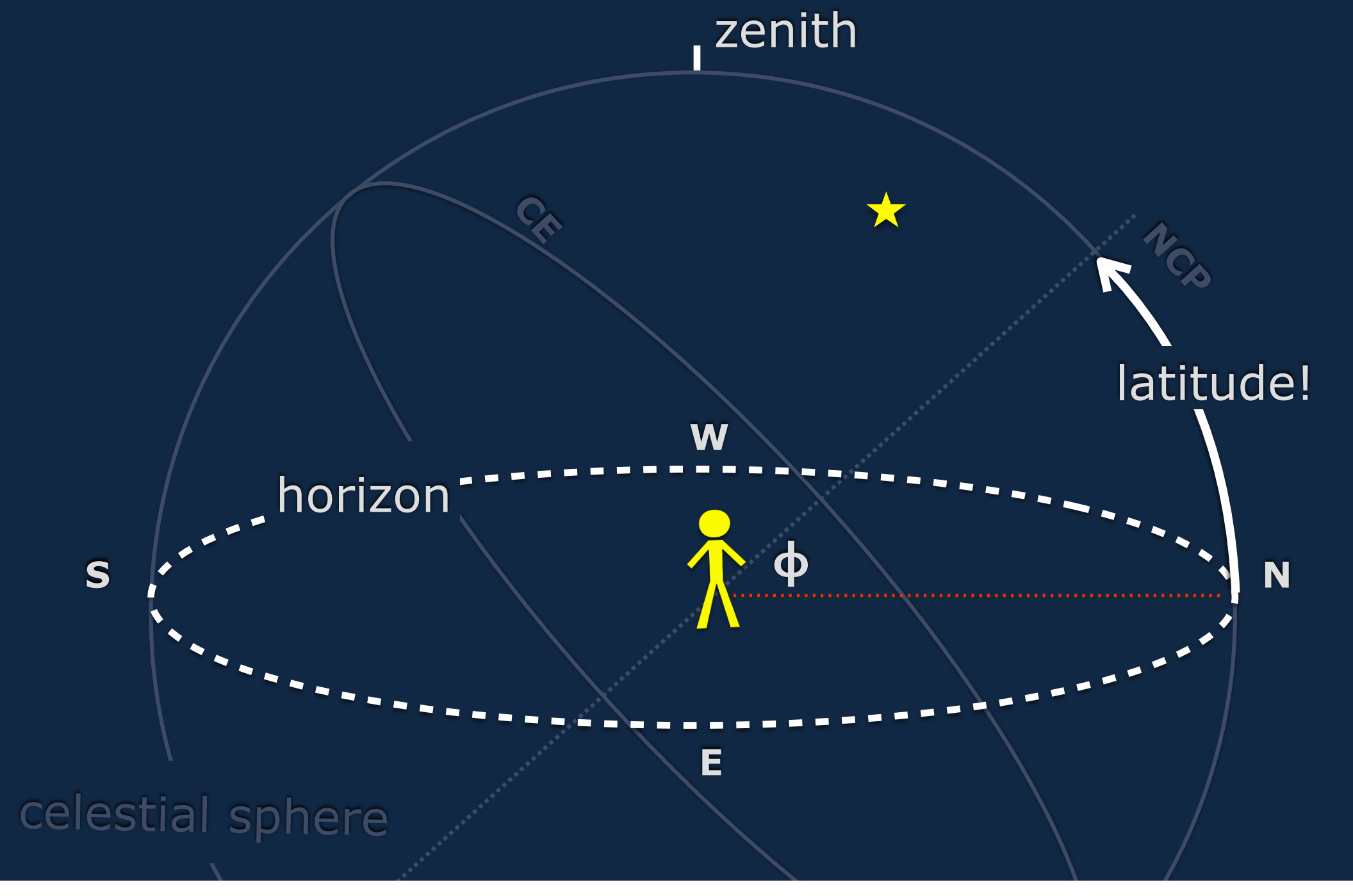
meridian
altitude
azimuth



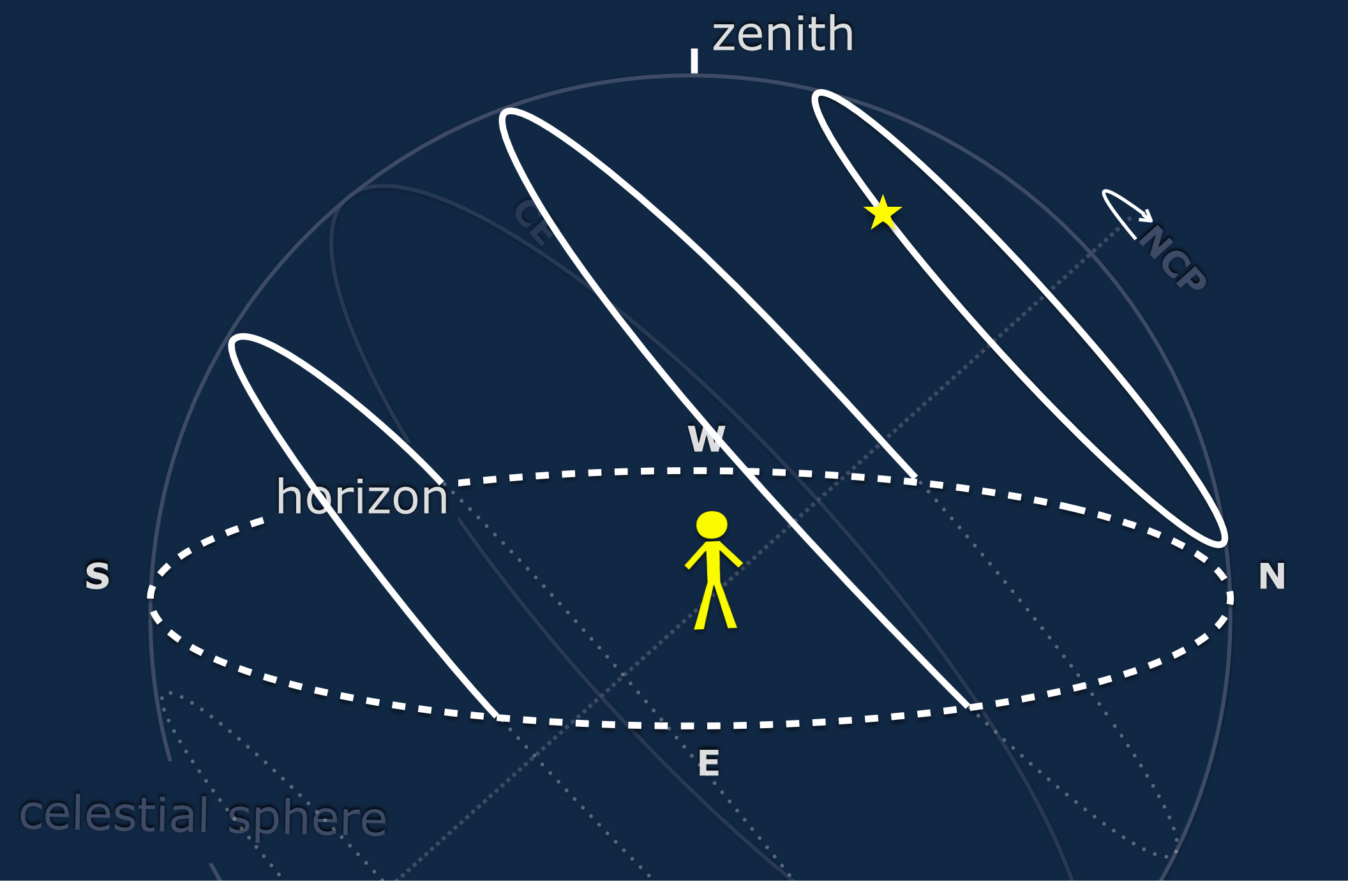
Coordinate Systems - Alt-Az



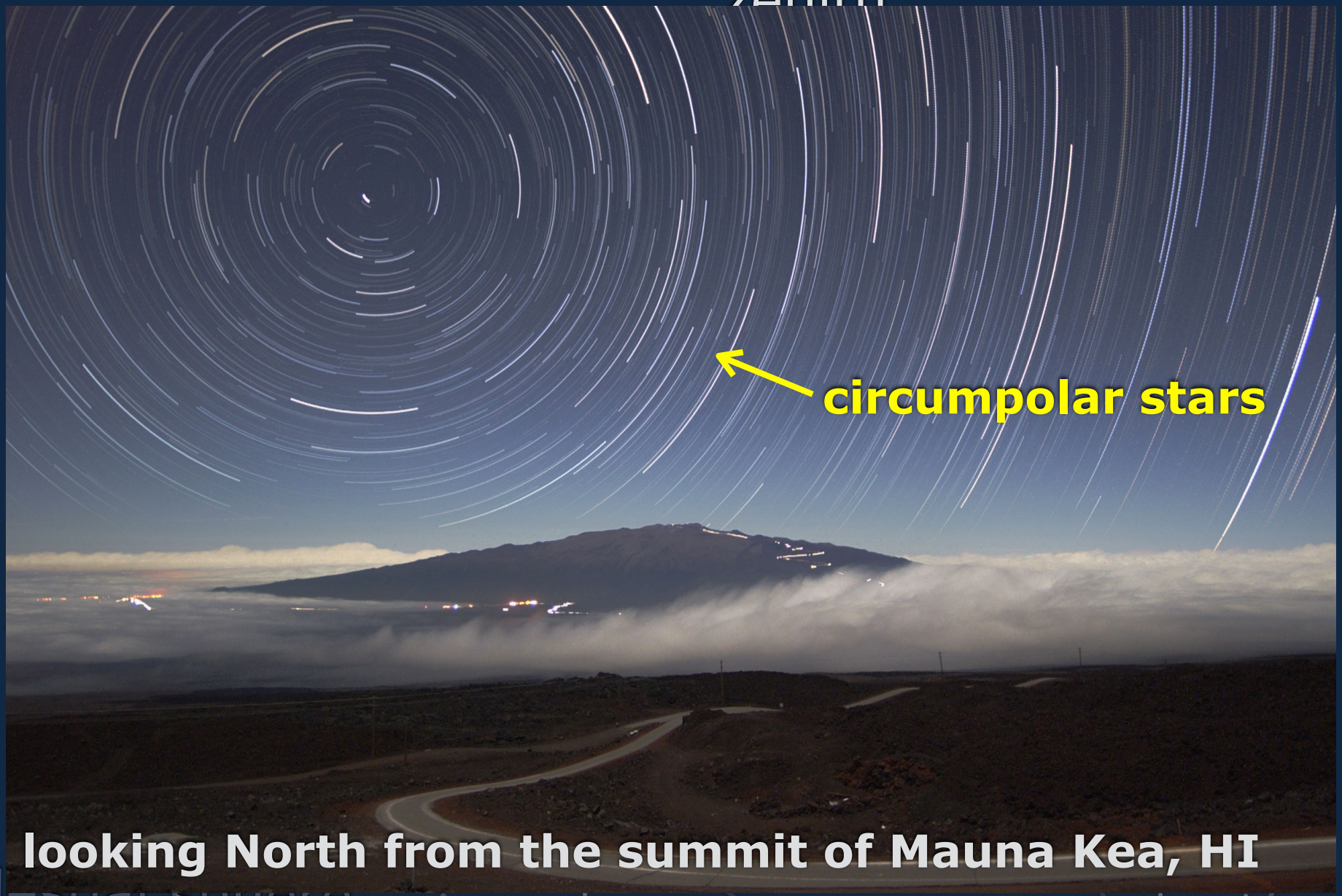
Coordinate Systems - Alt-Az



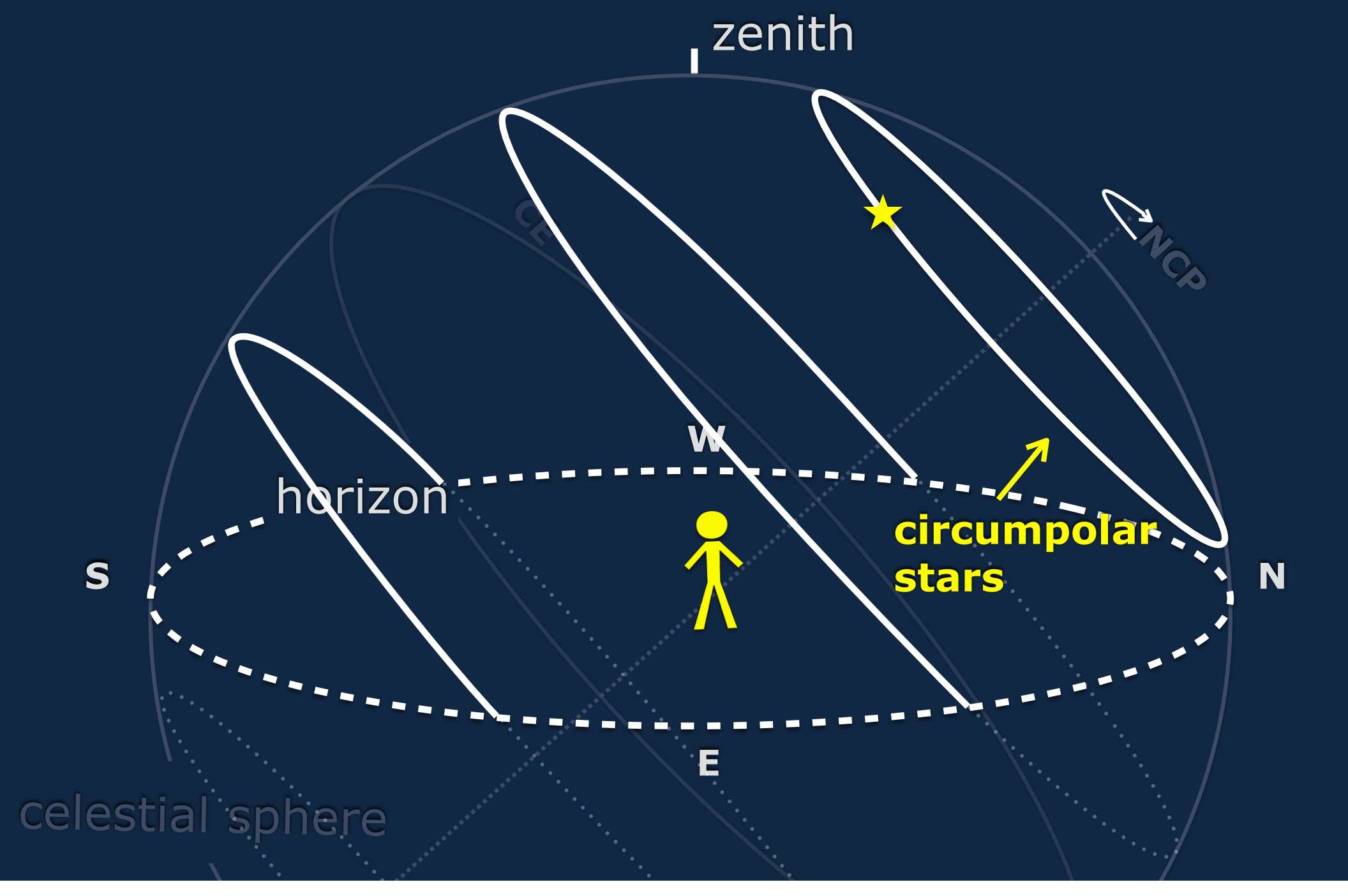
Coordinate Systems - Alt-Az



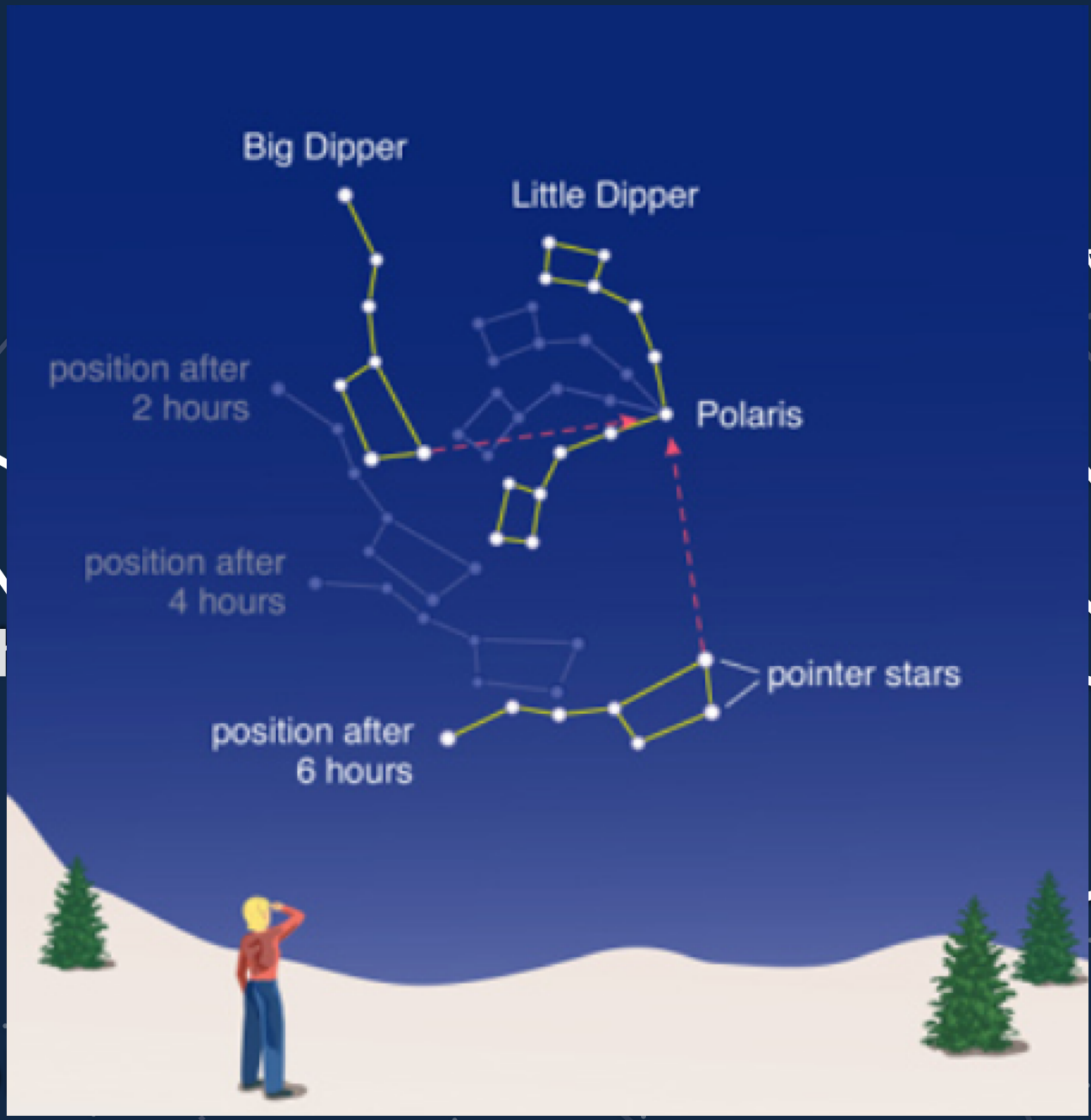
Coordinate Systems - Alt-Az



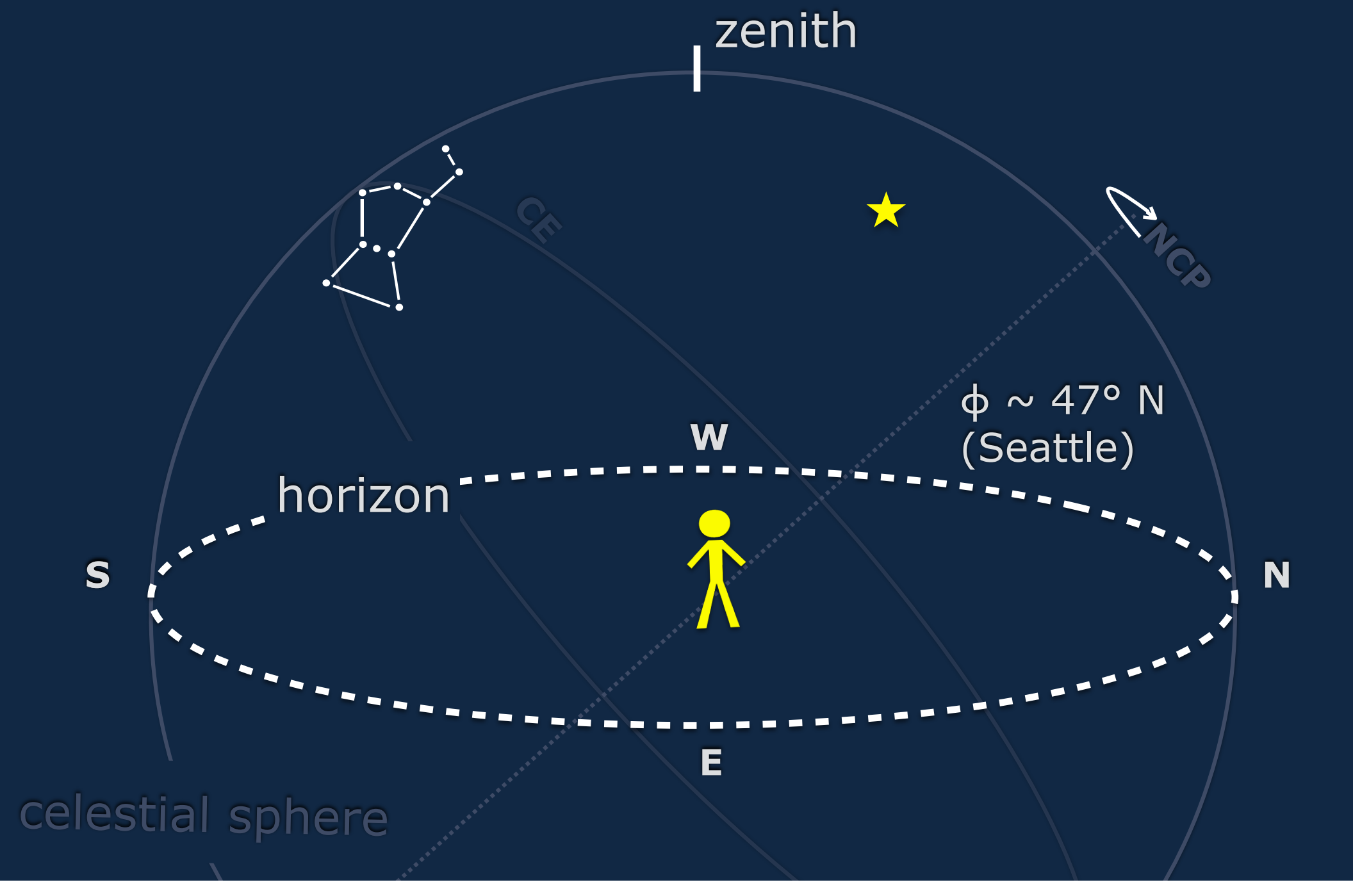
Coordinate Systems - Alt-Az



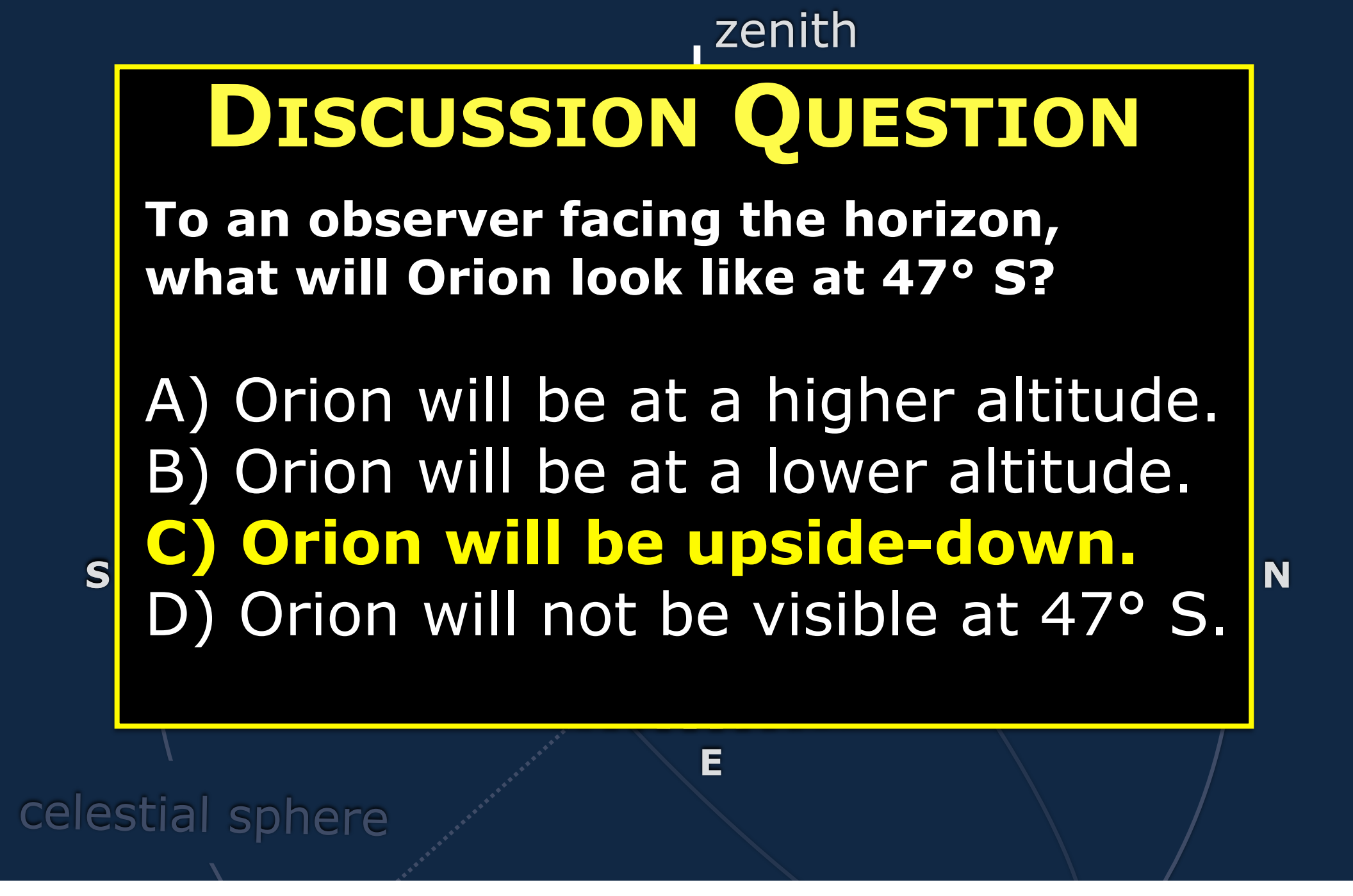
Coordinate Systems - Alt-Az



Coordinate Systems - Alt-Az



Coordinate Systems - Alt-Az

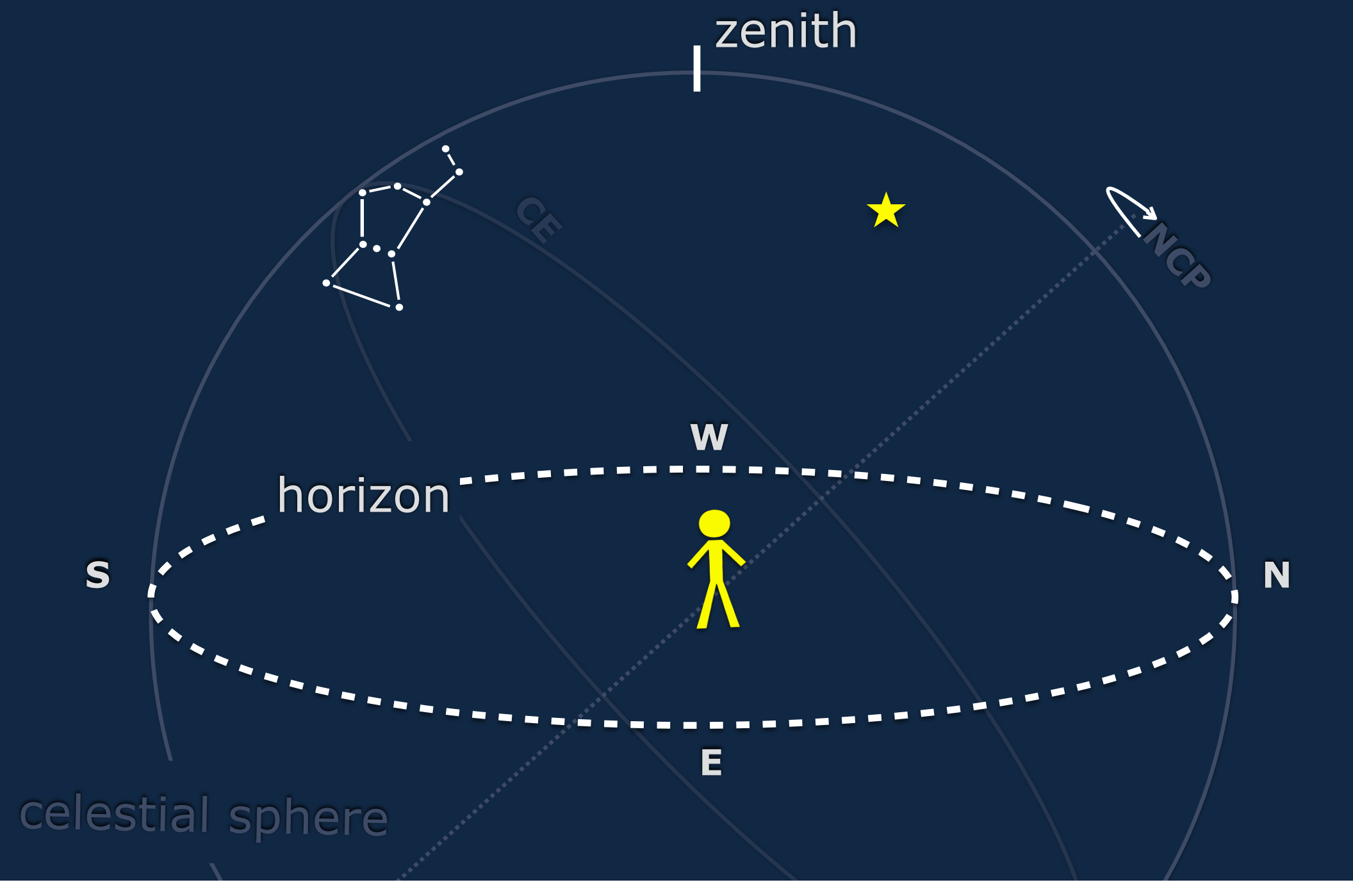


Discussion Question

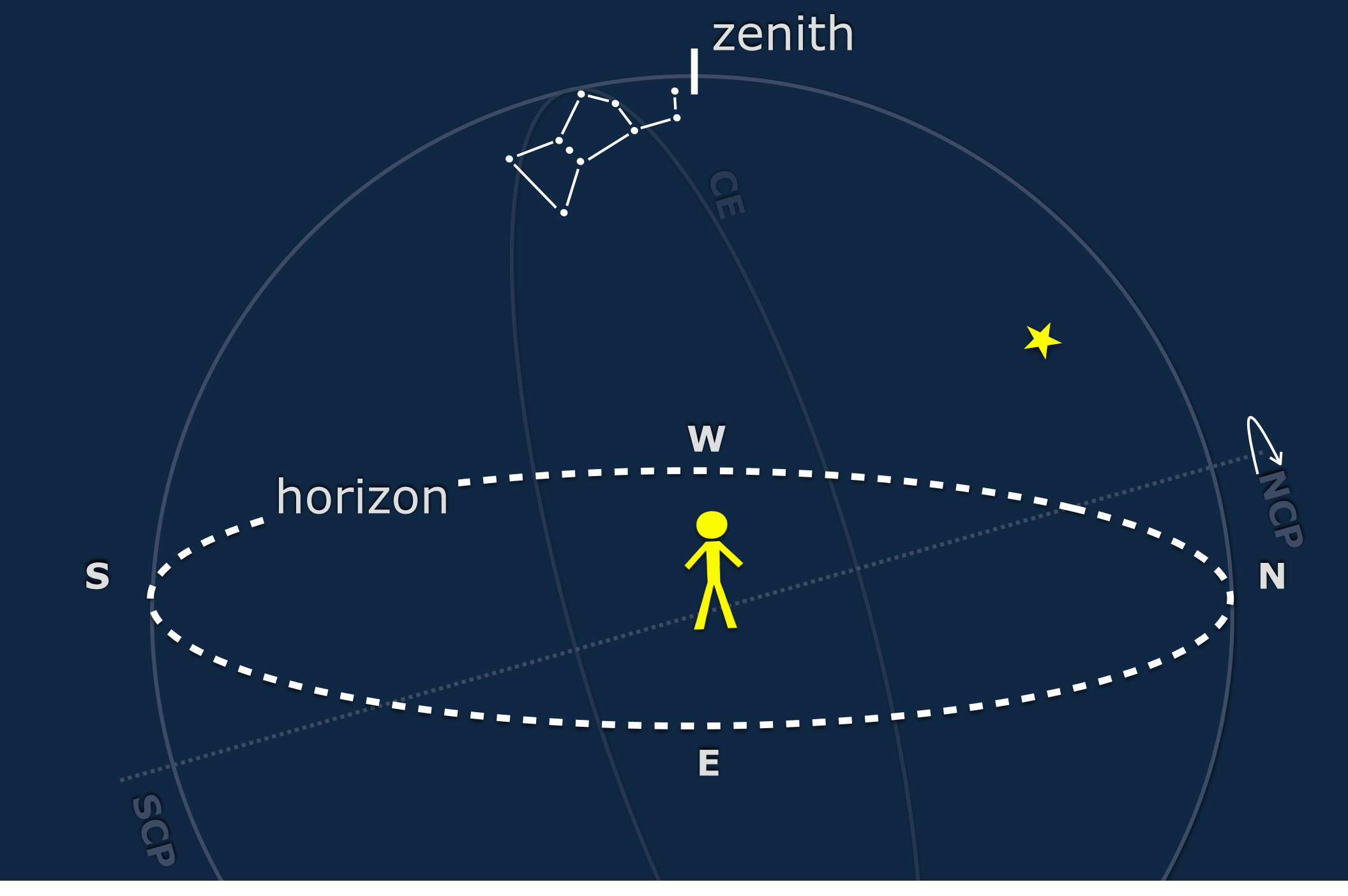
To an observer facing the horizon, what will Orion look like at 47° S?

A) Orion will be at a higher altitude.
B) Orion will be at a lower altitude.
C) Orion will be upside-down.
D) Orion will not be visible at 47° S.

Coordinate Systems - Alt-Az



Coordinate Systems - Alt-Az



Coordinate Systems - Alt-Az

Coordinate Systems

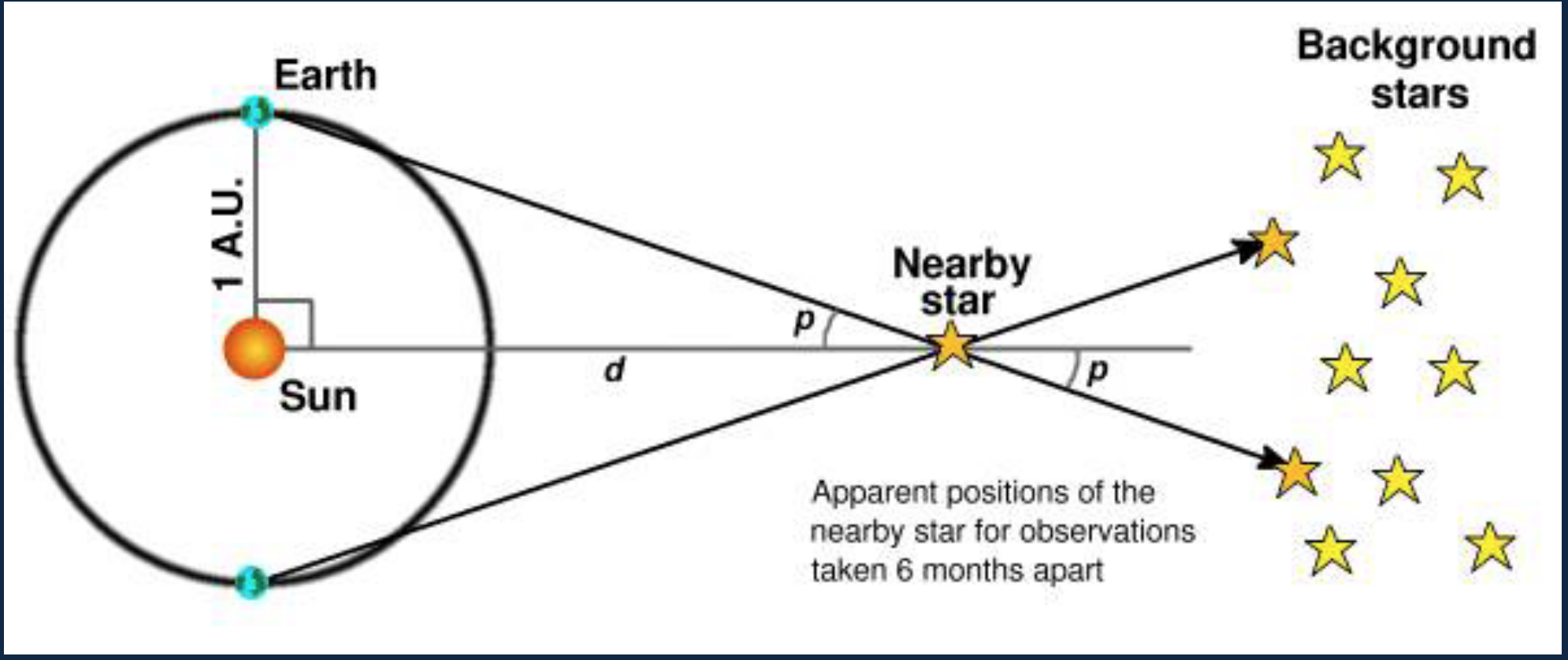
The earth orbits the sun (proof is **parallax**)…

$$d = \frac{1\ \text{AU}}{\tan(p)} \simeq \frac{1}{p}\ \text{AU} \rightarrow \frac{206265}{p''}\ \text{AU}$$

parsec!

$$d = \frac{1}{p''}\ \text{pc}$$

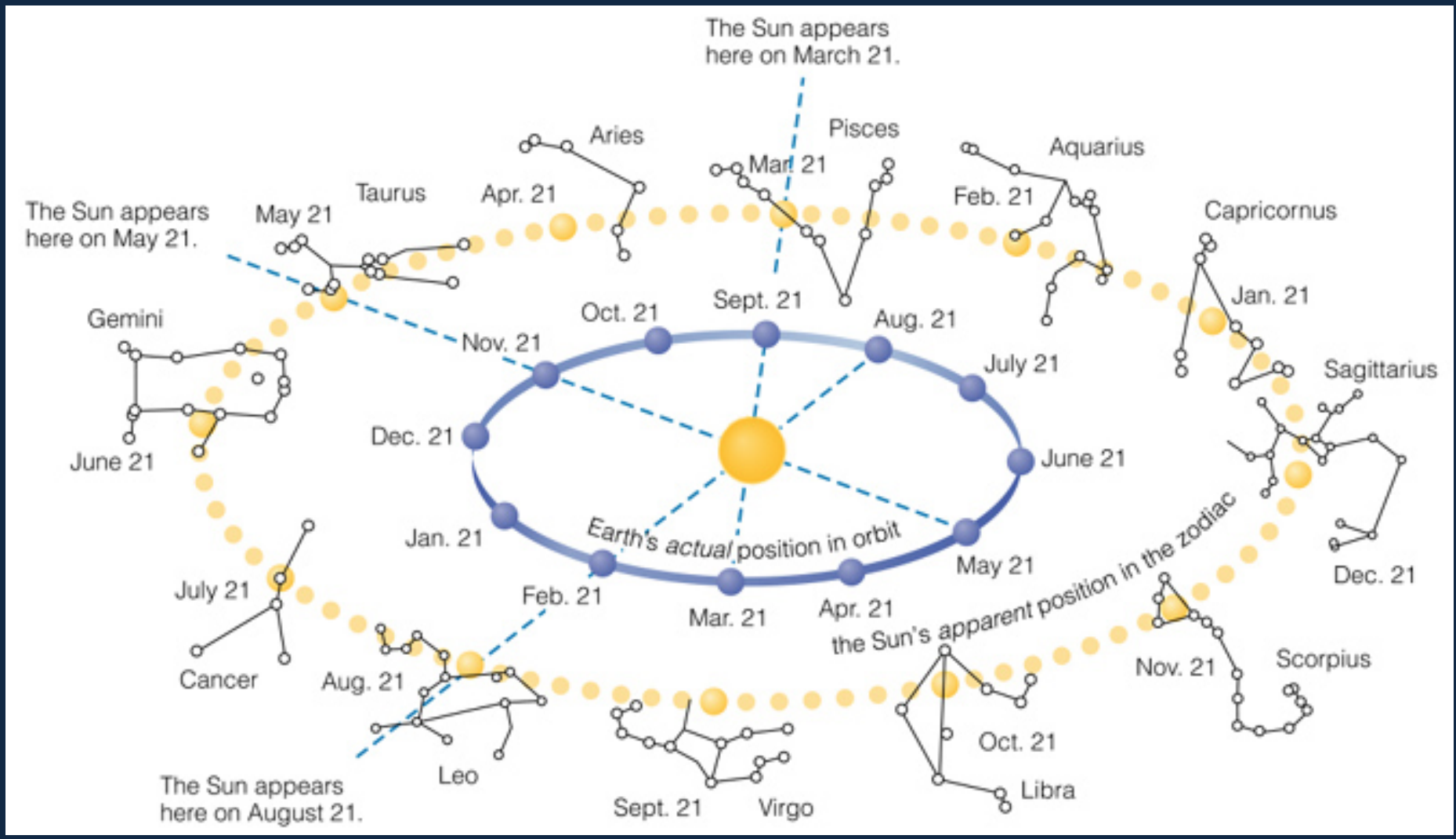
But p is in radians…
Remember 1 radian ~ 206265”…



Coordinate Systems

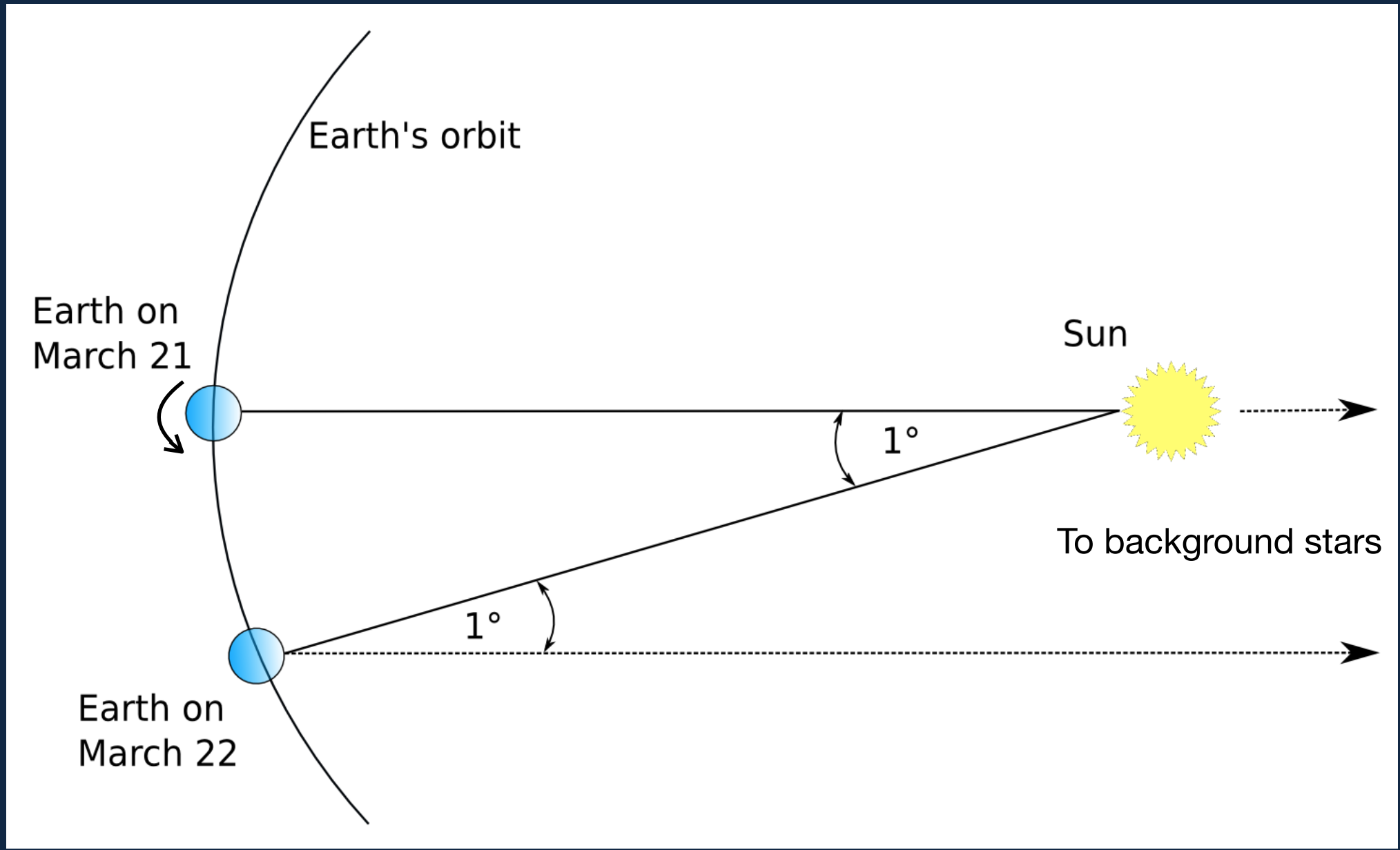
The earth orbits the sun (proof is parallax)…

…this is why constellations change w/ time of year.



Coordinate Systems

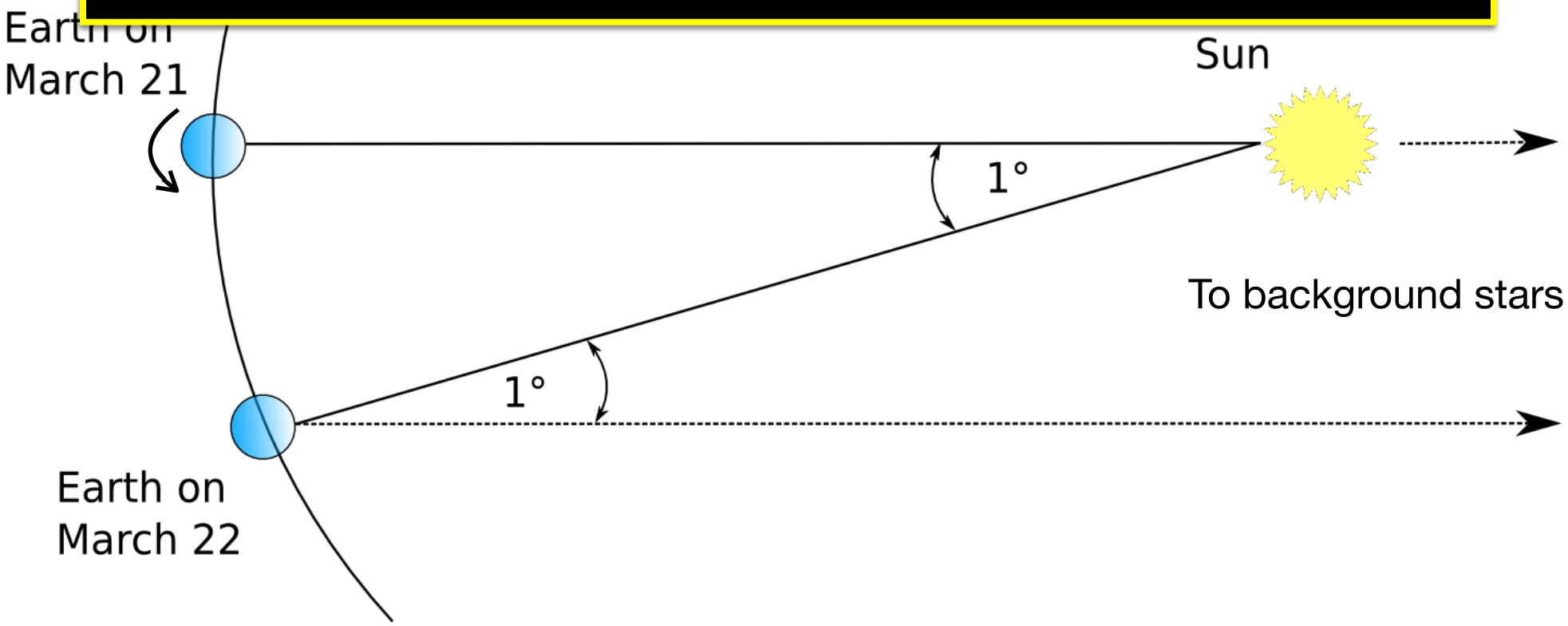
Earth’s orbit causes difference in **solar** vs. **sidereal** time.



Quick Question

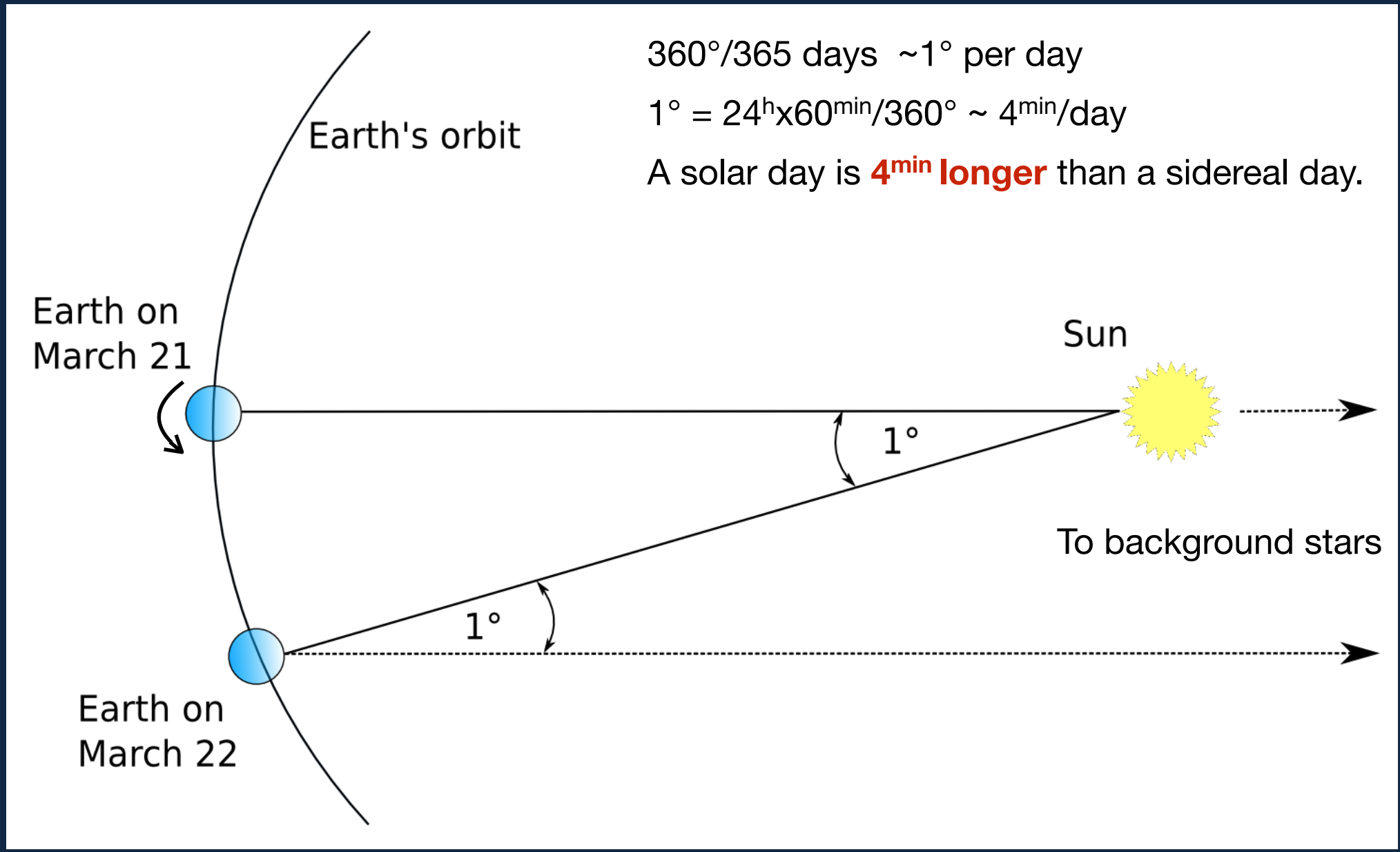
A solar day is...

A) shorter than a sidereal day
B) longer than a sidereal day
C) same length, date 6 months later
D) same length, date 12h later



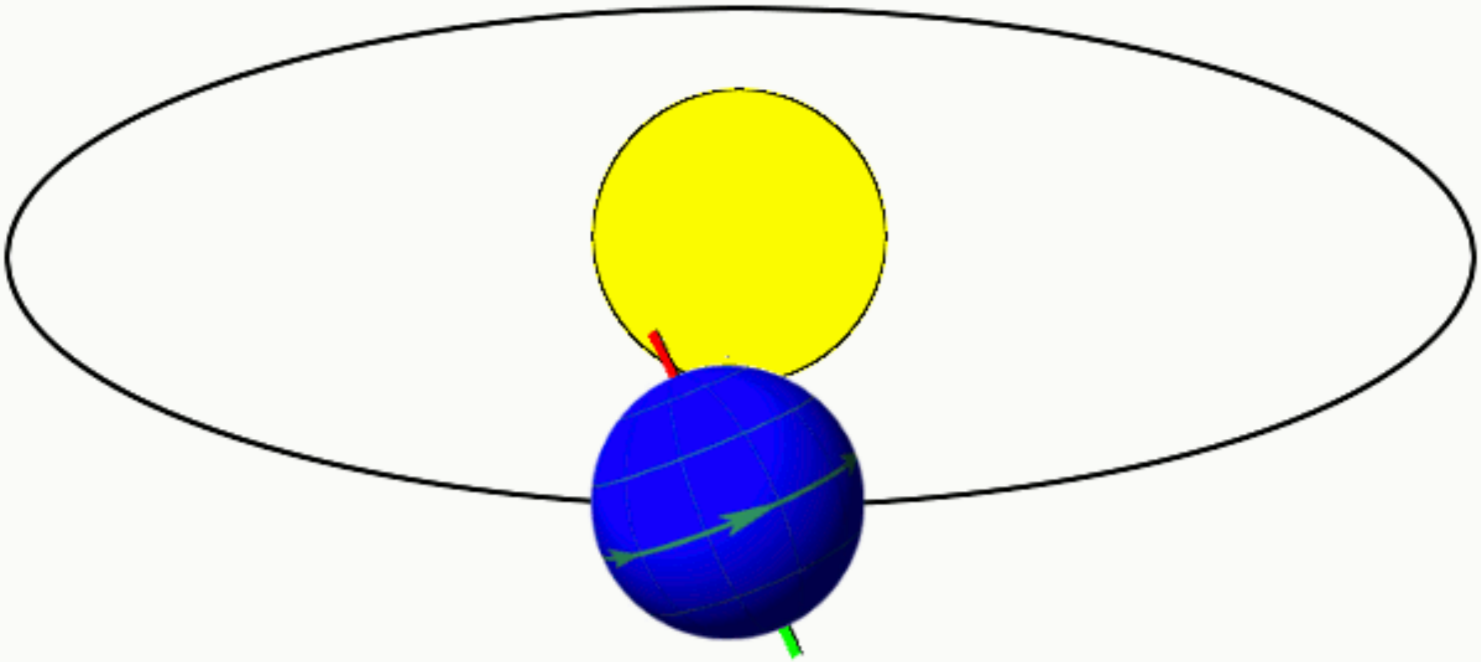
Coordinate Systems

Earth's orbit causes difference in **solar** vs. **sidereal** time.



Coordinate Systems

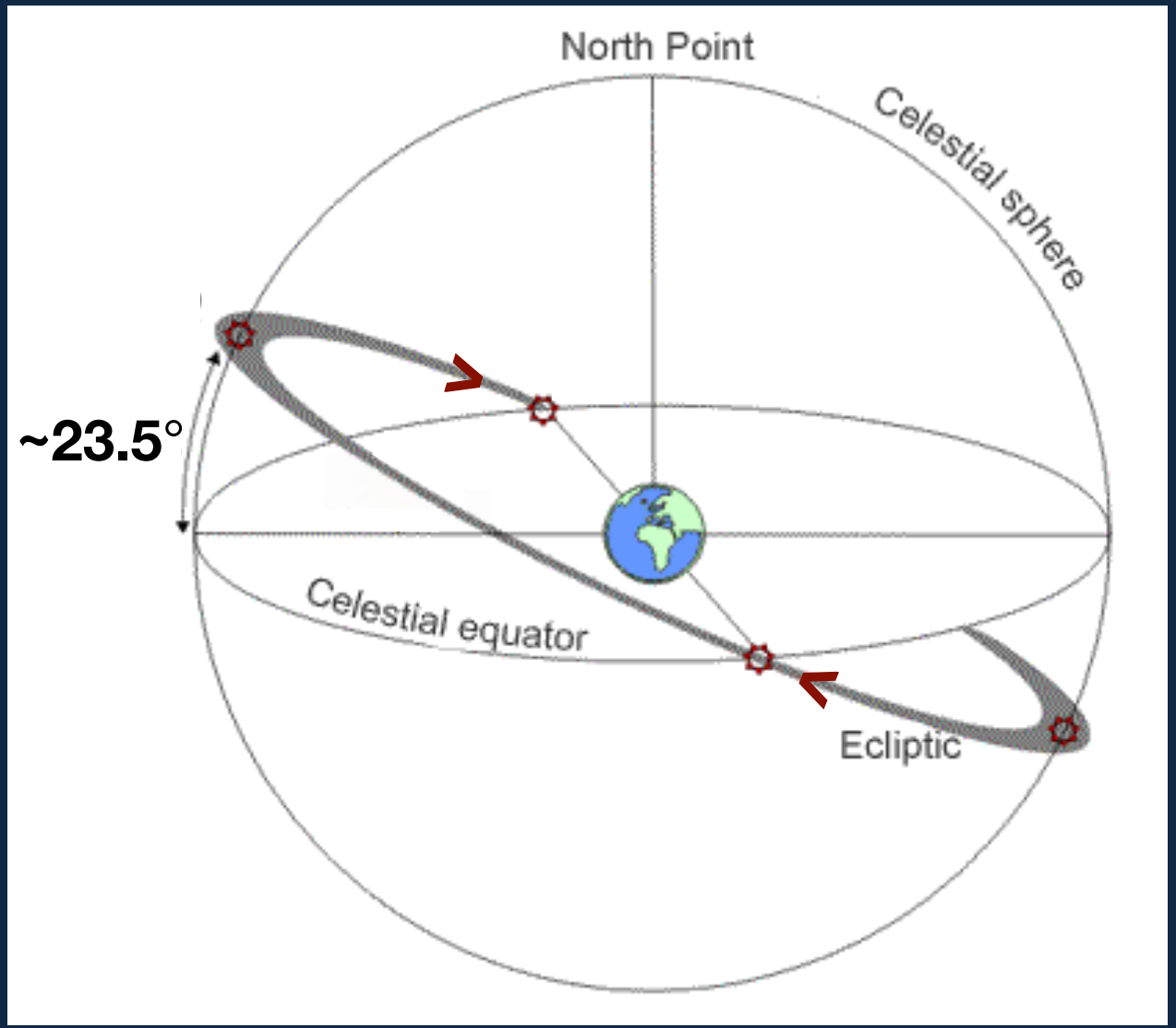
Tilt of Earth's axis relative to its orbital plane causes…



Coordinate Systems

Tilt of Earth's axis relative to its orbital plane causes…

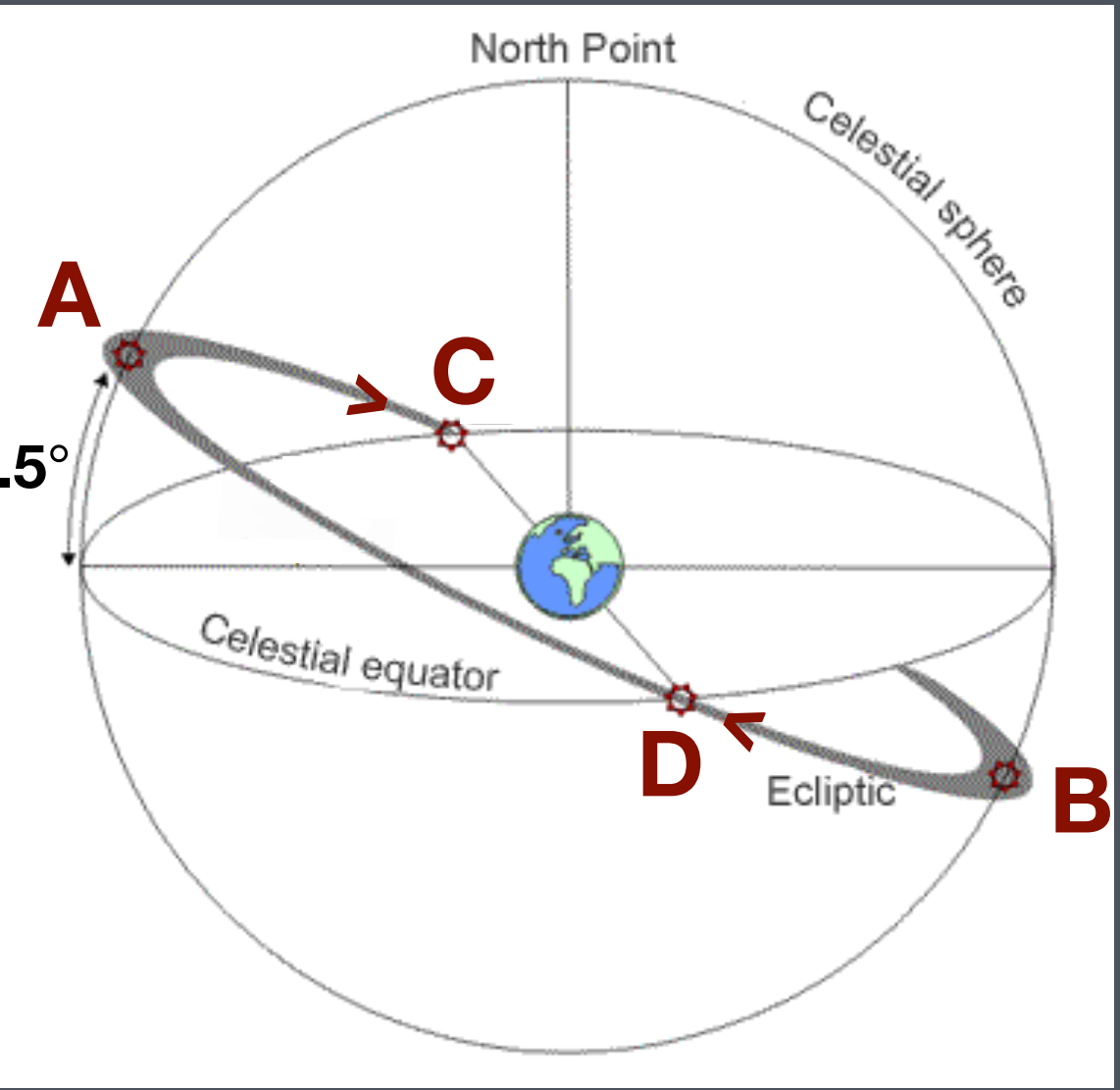
…the **ecliptic**



Discussion Question

Tilt of Earth's axis relative to its orbital plane causes…

…the **ecliptic**



Match the letters to the:

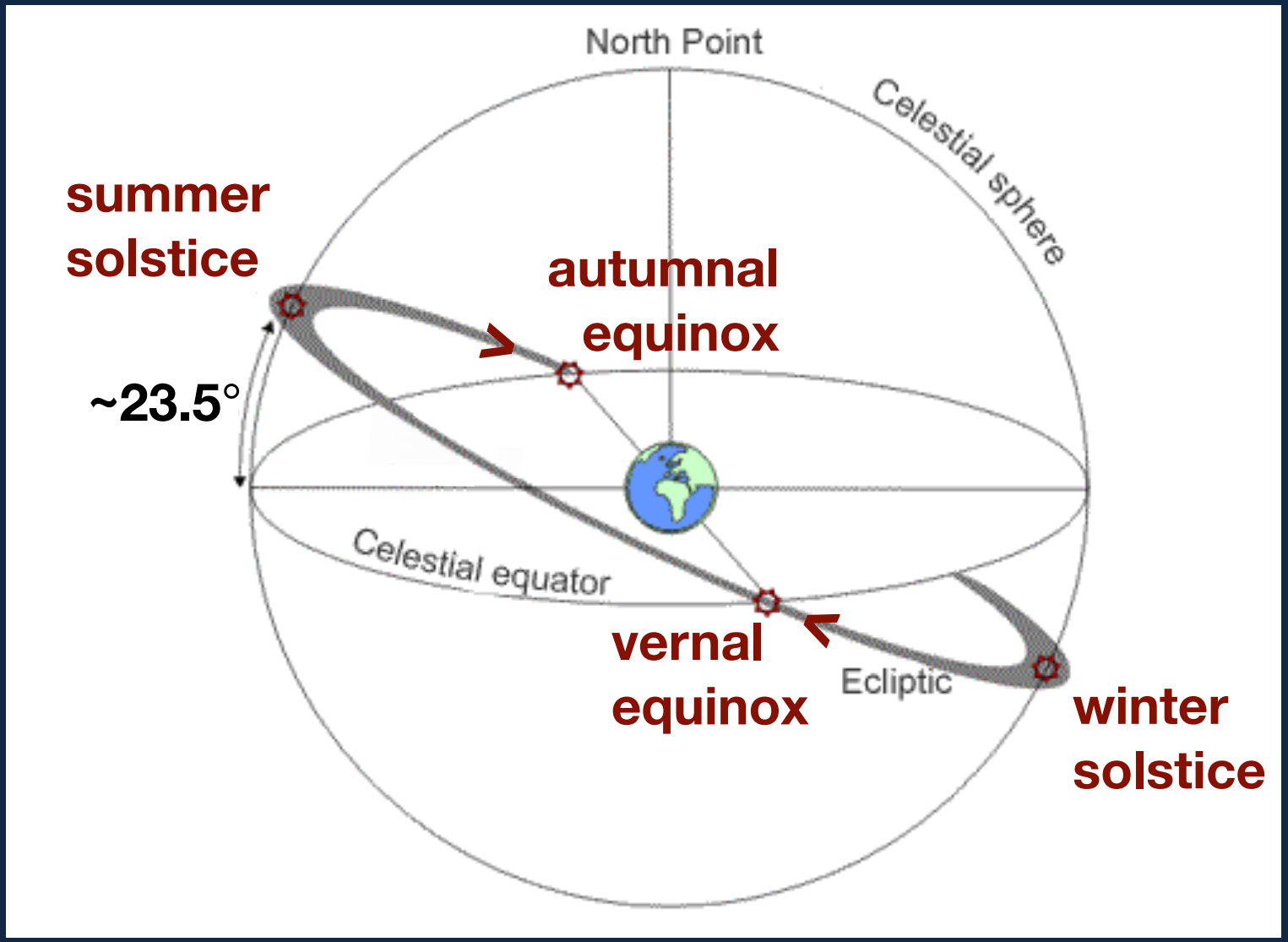
—vernal equinox
—autumnal equinox
—winter solstice
—summer solstice

(for the northern hemisphere)

Coordinate Systems

Tilt of Earth's axis relative to its orbital plane causes…

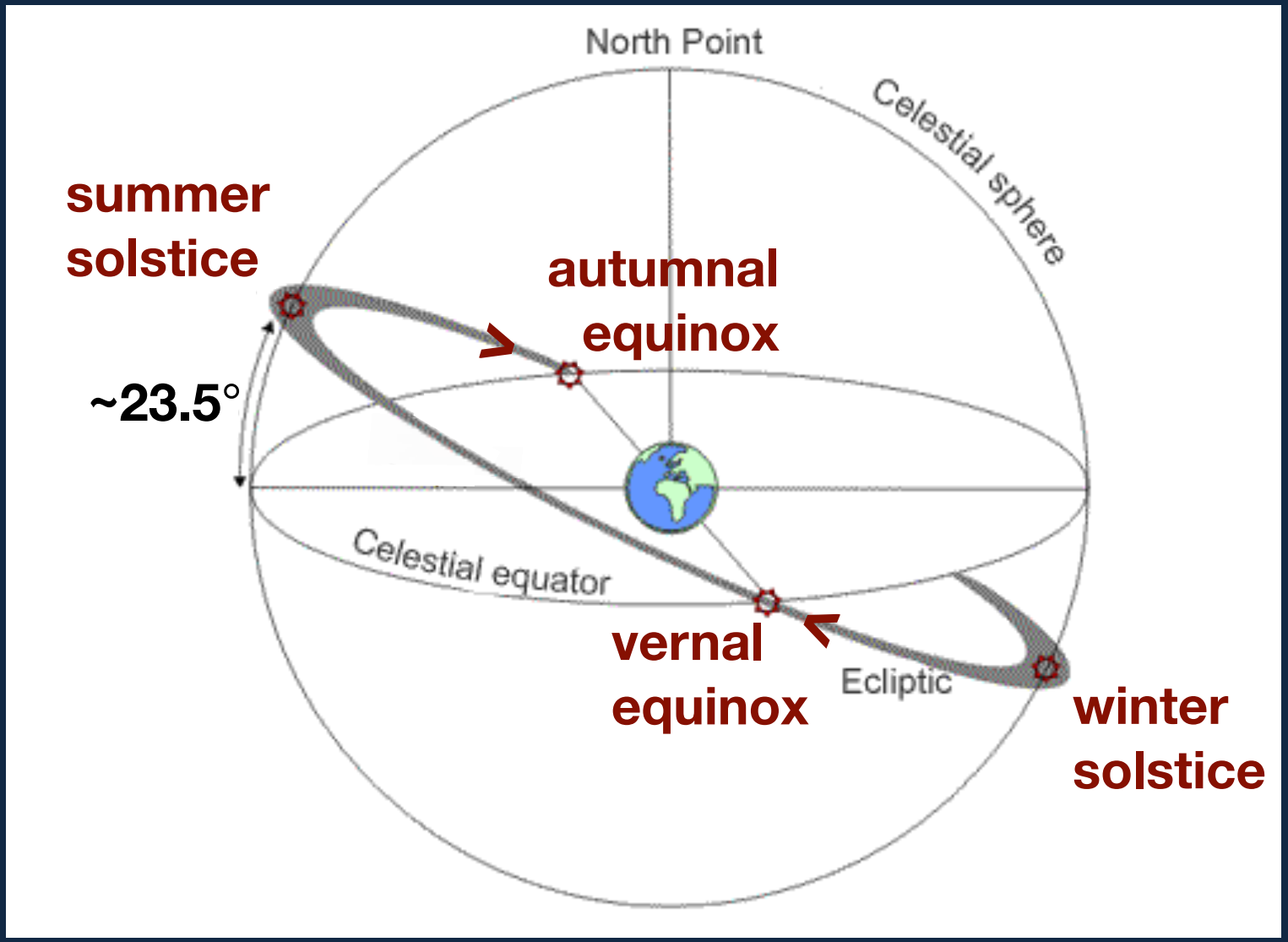
…the **ecliptic**



Coordinate Systems

Tilt of Earth's axis relative to its orbital plane causes…

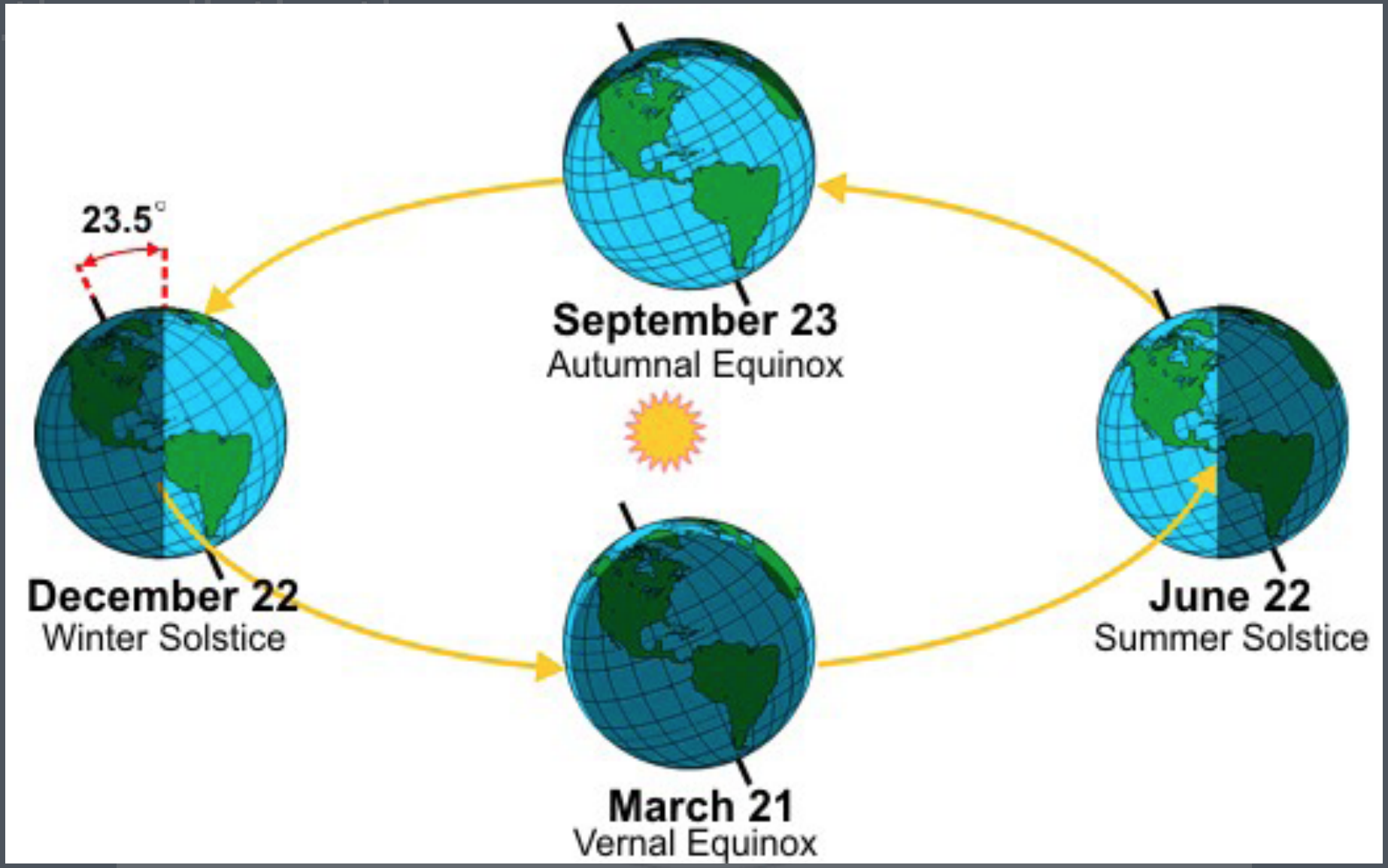
…the ecliptic, the **seasons**



Coordinate Systems

Tilt of Earth's axis relative to its orbital plane causes…

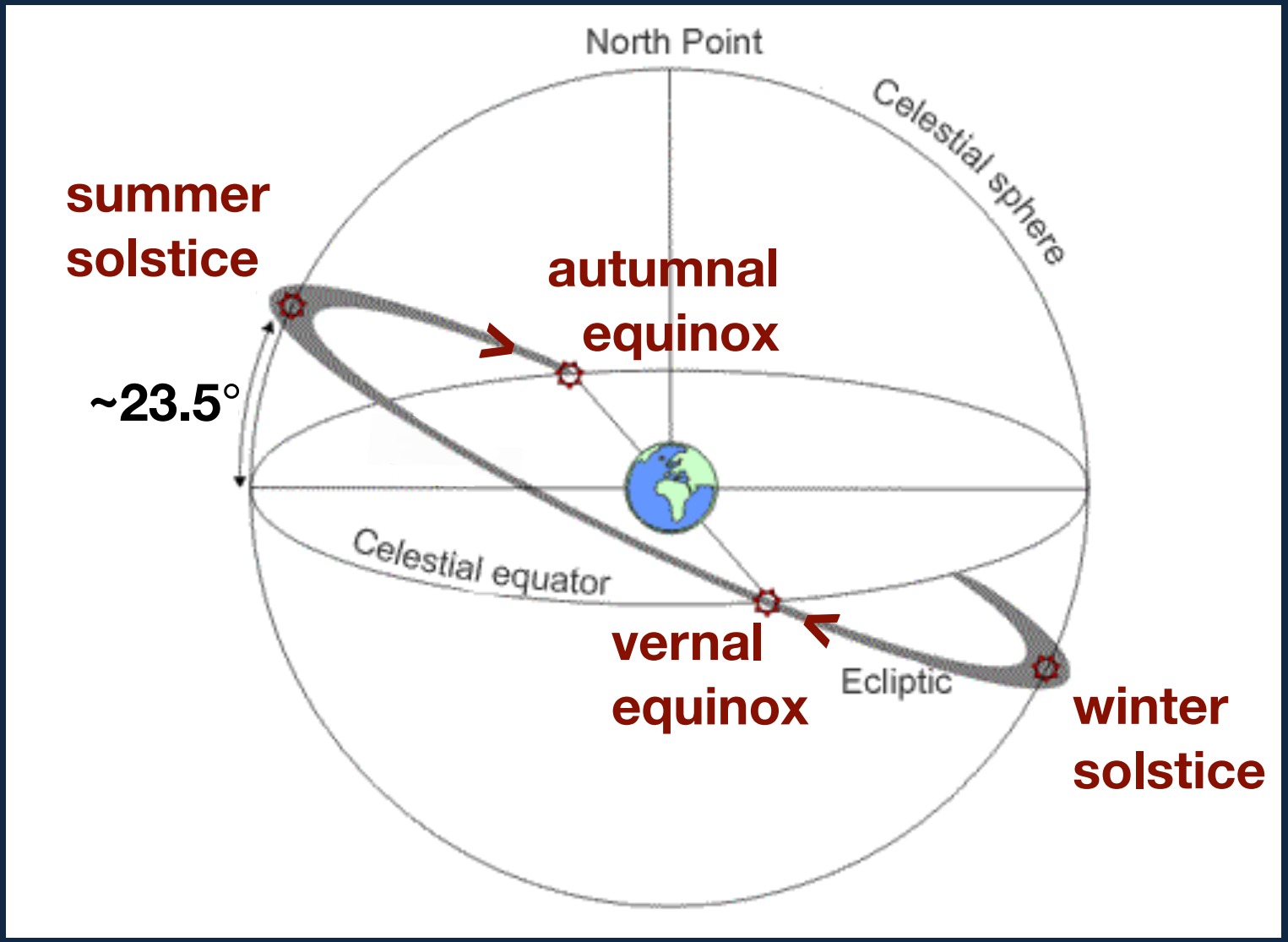
…



Coordinate Systems

Tilt of Earth's axis relative to its orbital plane causes…

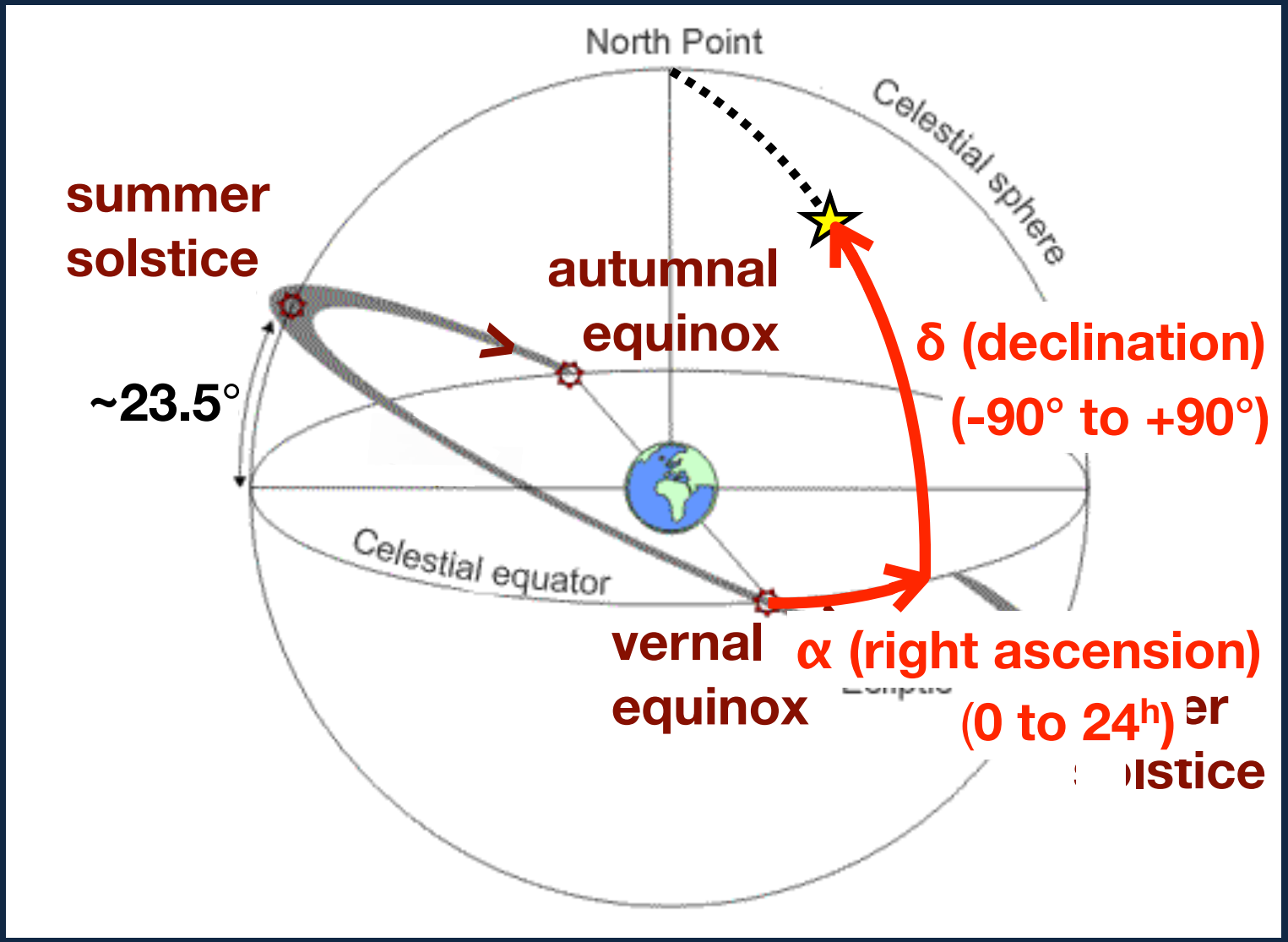
…the ecliptic, the seasons, **basis of celestial coords**



Coordinate Systems

Tilt of Earth's axis relative to its orbital plane causes…

…the ecliptic, the seasons, **basis of celestial coords**



Coordinate Systems - Celestial

α (right ascension): 0 to 24^h

δ (declination): -90° to +90°

Coordinate Systems - Celestial

α

δ

faculty.washington.edu/emsque/astr322/

SIMBAD DEMO ; check out the website!

ASTR 322: The Contents of Our Galaxy

Winter Quarter 2016 | TR 1:30-2:50pm

Instructor: Emily Levesque

Email: emsque@uw.edu

Office Hours: TR 3-3:45 or by appointment, C327 PAB

Required Text: *An Introduction to Modern Astrophysics* by Carroll & Ostlie (the "Big Orange Book")

COURSE OUTLINE (download syllabus here)

Week	Dates	Reading	Topic
1	Jan 5, 7	Chapters 1, 3.1	Obs. Perspectives: Catalogs, Coordinates
2	Jan 12, 14	Chapters 3.3-3.5, 5	Light and Spectra
3	Jan 19, 21	Chapters 3.2, 3.6, 6	Telescopes and Instruments
4	Jan 26, 28	Chapters 7.1-7.3, 8.1	Properties of Stars
5	Feb 2, 4	--	Review; Exam #1
6	Feb 9, 11	Chapters 8.2, 10.3, 10.6, 12.2-12.3, 13	Stellar Evolution: HRD & Low-Mass Stars
7	Feb 16, 18	Chapters 15.1-15.4, 16.2, 16.3, 16.6	Stellar Evolution: Massive Stars & SNe; Oddities
8	Feb 23, 25	Chapters 11, 14.4-14.5	The Sun; student presentations
9	Mar 1, 3	Chapter 24	What Makes the Milky Way
10	Mar 8, 10	--	Review; Exam #2

Coordinate Systems - Celestial

α

δ

Epochs

J2000 = Julian years

~~B1950 = Besselian years~~

$$\Delta\alpha = M + N\sin\alpha\tan\delta$$

$$\Delta\delta = N\cos\alpha$$

$$M = 1°.2812323T + 0°.0003879T^2 + 0°.0000101T^3$$

$$N = 0°.5567530T - 0°.0001185T^2 - 0°.0000116T^3$$

$$T = (t - 2000.0)/100$$

t is the date you want, in fractions of a year

(BOB, eq's 1.2-1.4)

Coordinate Systems - Celestial

α (right ascension): 0 to 24^h

Betelgeuse: 05h 55m 10.31s

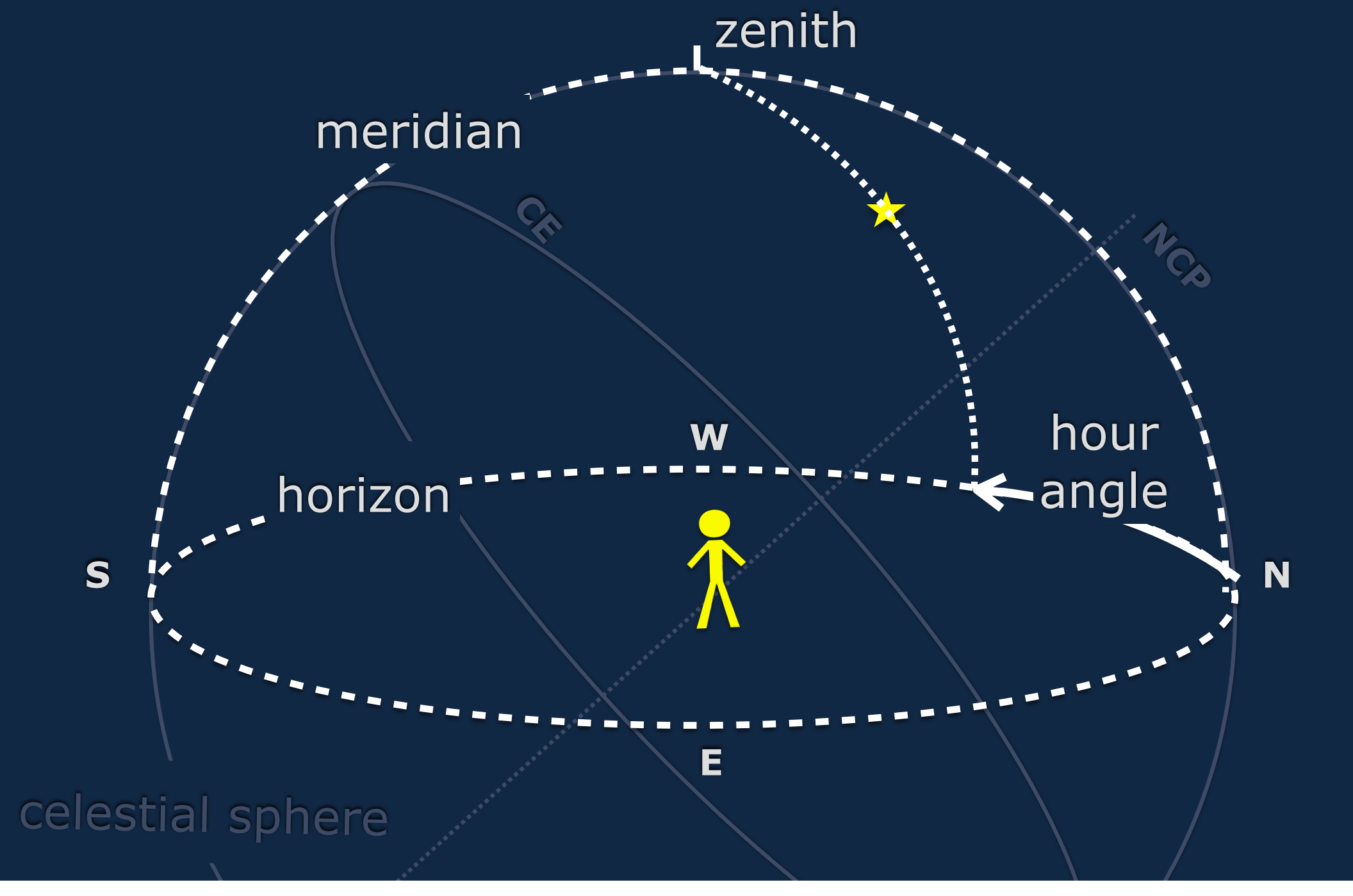
(360° = 24h ⟶ 15° = 1h)

HA = deg/hours W of meridian (local)

δ (declination): -90° to +90°

Betelgeuse: +07° 24′ 25.43″

Coordinate Systems - Celestial



Coordinate Systems - Celestial

α (right ascension): 0 to 24^h

Betelgeuse: 05h 55m 10.31s

(360° = 24h ⟶ 15° = 1h)

HA = deg/hours W of meridian (local)

GMT = HA + α

δ (declination): -90° to +90°

Betelgeuse: +07° 24′ 25.43″

Coordinate Systems - Celestial

α

δ (

l)

Discussion Question

Betelgeuse has a α of ~6h. It rises at 4h E of the meridian. What time will it rise today in Seattle? (PST = GMT - 8)

A) 6pm
B) 10pm
C) 2am
D) 10am

Coordinate Systems - Celestial

α

δ (

l)

Discussion Question

Betelgeuse has a α of ~6h. It rises at 4h E of the meridian. What time will it rise today in Seattle? (PST = GMT - 8)

At 4h E of meridian, HA = 20h

GMT = HA + α = 20 + 6 = 26h (2h)

PST = GMT - 8h, so 26h - 8h = 18h —> 6pm!

Coordinate Systems - Celestial

α (right ascension): 0 to 24^h

Betelgeuse: 05h 55m 10.31s

(360° = 24h ⟶ 15° = 1h)

HA = deg/hours W of meridian (local)

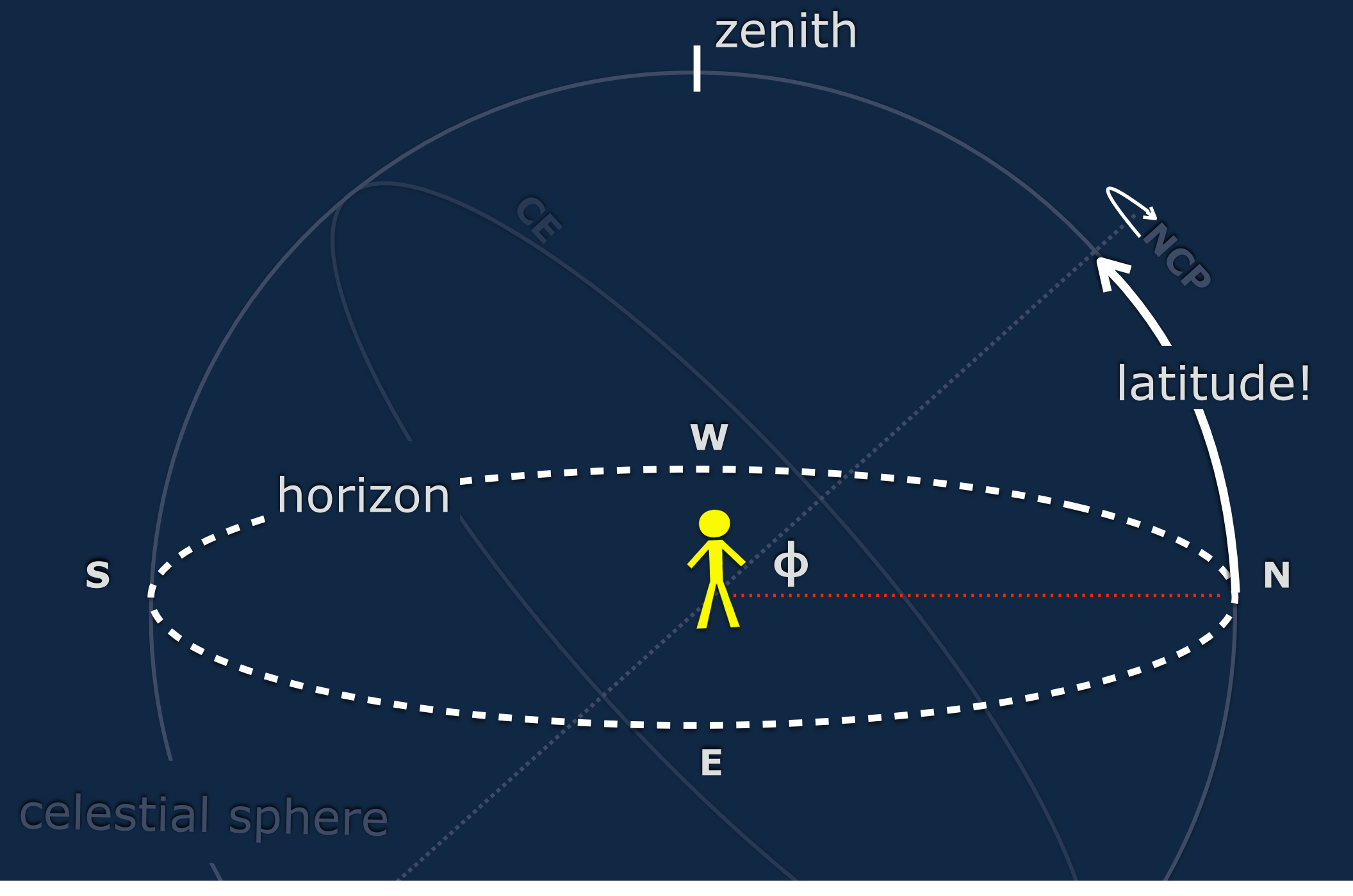
GMT = HA + α

δ (declination): -90° to +90°

Betelgeuse: +07° 24′ 25.43″

δ = degrees above CE

Coordinate Systems - Celestial



Coordinate Systems - Celestial

α (right ascension): 0 to 24^h

Betelgeuse: 05h 55m 10.31s

(360° = 24h ⟶ 15° = 1h)

HA = deg/hours W of meridian (local)

GMT = HA + α

δ (declination): -90° to +90°

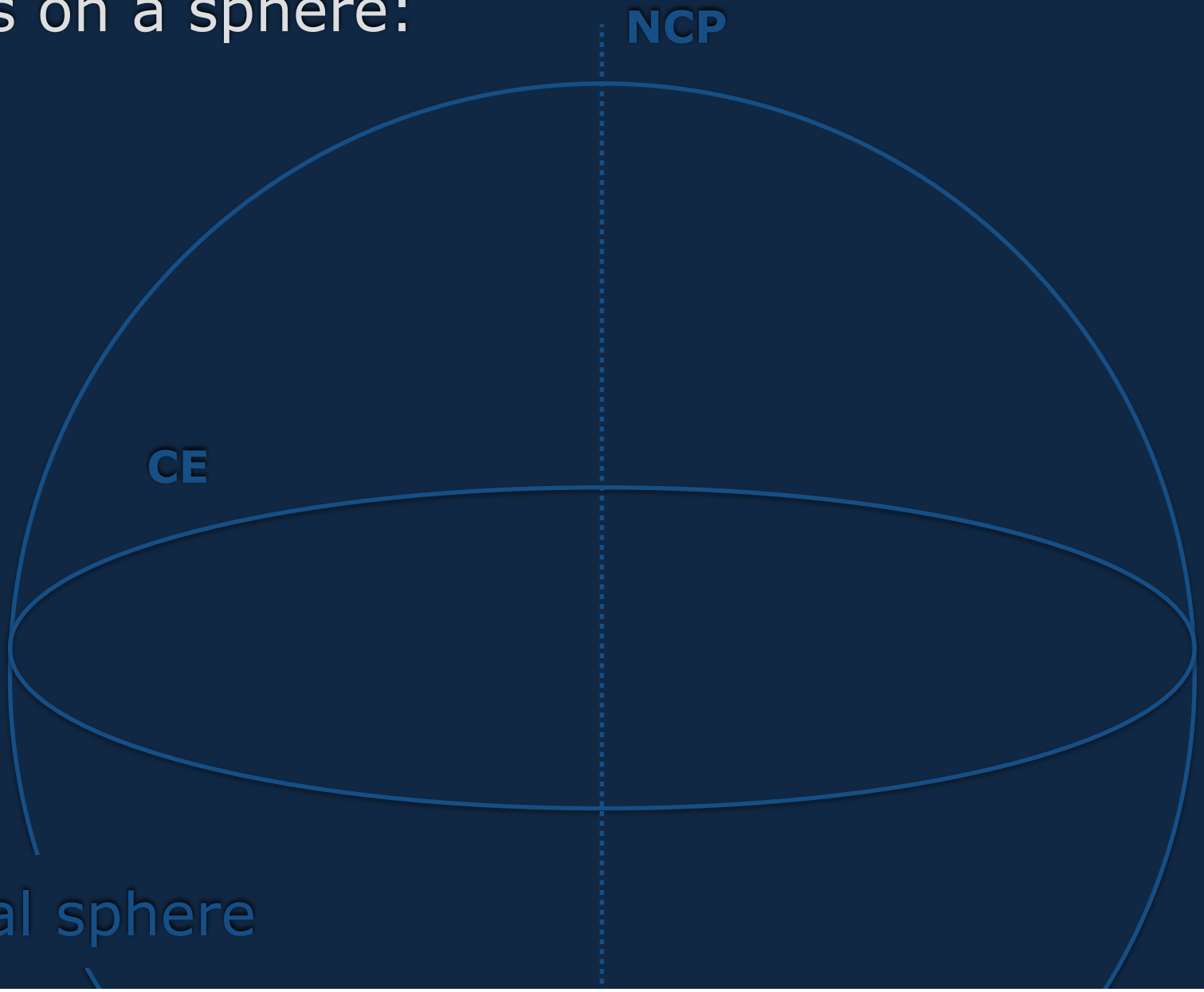
Betelgeuse: +07° 24′ 25.43″

δ = degrees above CE

CE = 90 - latitude

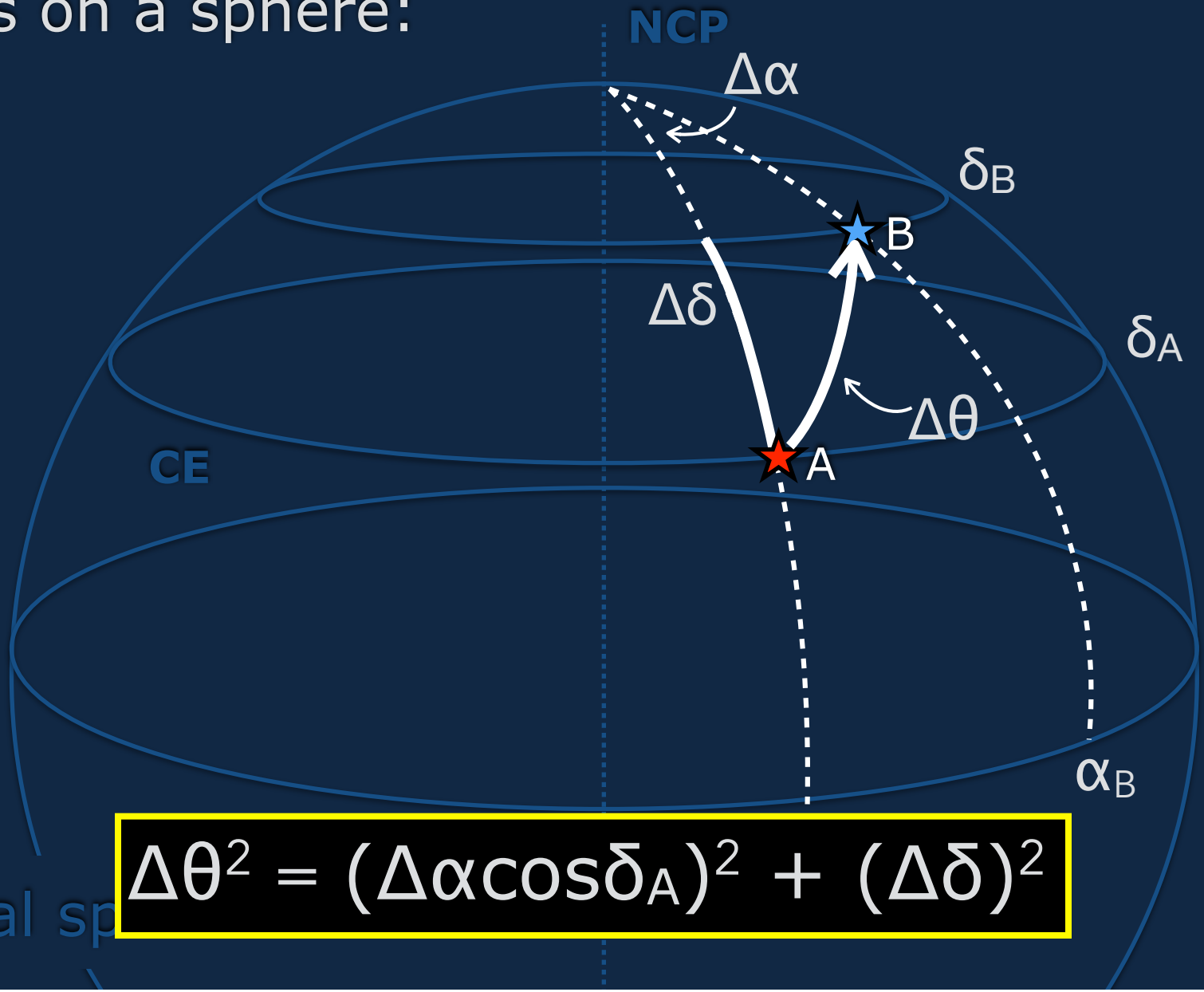
Coordinate Systems - Celestial

RA and Dec are useful for describing distances and motions on a sphere:



Coordinate Systems - Celestial

RA and Dec are useful for describing distances and motions on a sphere:

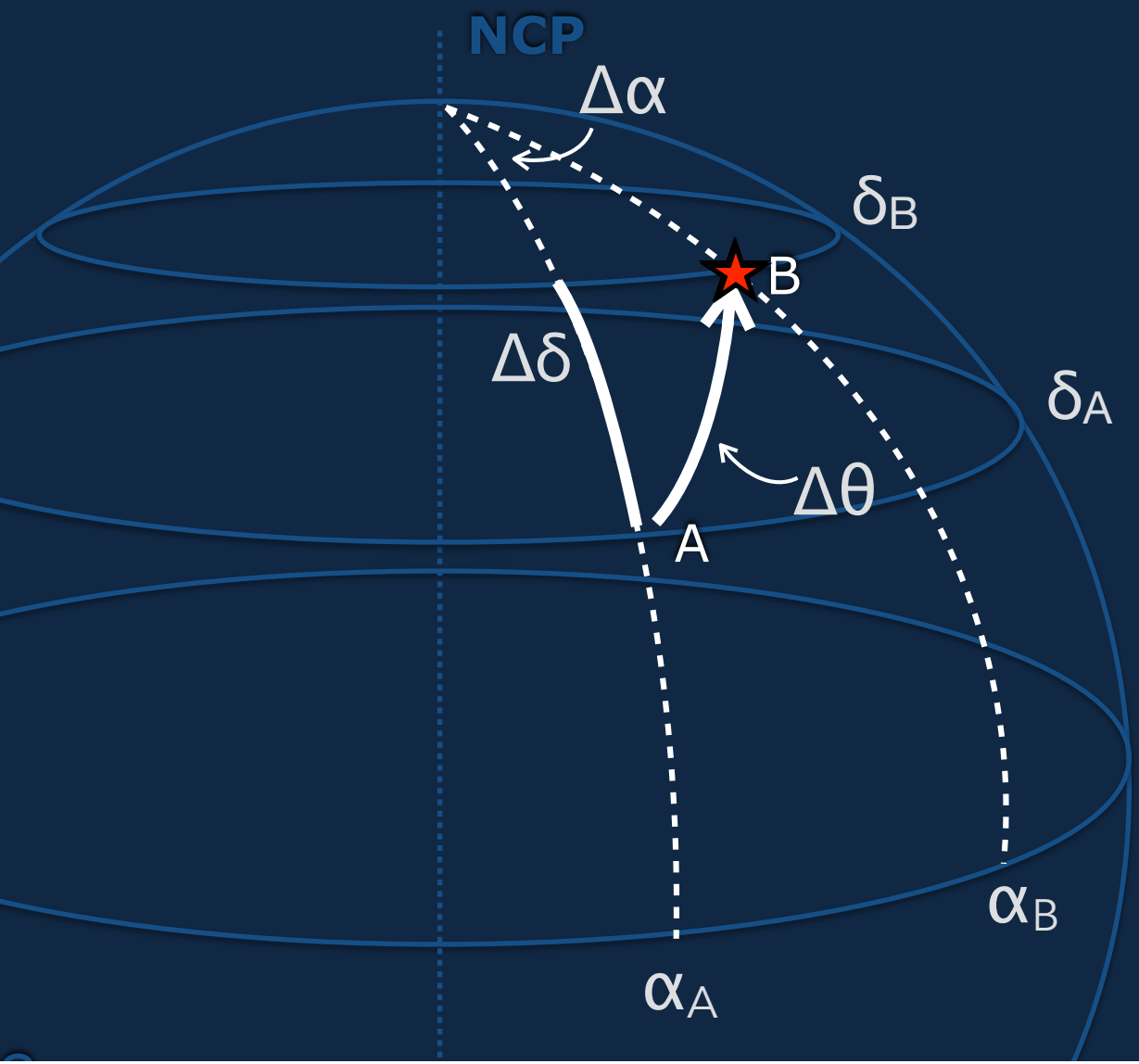


$$\Delta\theta^2 = (\Delta\alpha\cos\delta_A)^2 + (\Delta\delta)^2$$

celestial sp

Coordinate Systems - Celestial

RA and Dec are useful for describing distances and motions on a sphere:



Proper motion

If a star moves from point A to point B, then

$$\Delta d = v_\theta \Delta t$$

Since $\Delta\theta = \frac{\Delta d}{r} = \frac{v_\theta \Delta t}{r}$

We can define the star's proper motion μ as:

$$\mu \equiv \frac{d\theta}{dt} = \frac{v_\theta}{r}$$

Coordinate Systems - Celestial

RA and Dec are useful for describing distances and mot

Quick Question

Two stars, X and Y, are moving perpendicular to us at 50 km/s. X is 4 pc away; Y is 400 pc away. Which star will have traveled further on the night sky in one year?

A) Star X
B) Star Y
C) They'll cover the same distance
D) We need more information to answer

en

Δt

ar's

α_A

The Dual Nature of Light

Particle: photon w/ E (ergs)

Wave: wavelength λ, frequency ν, velocity c

$$\lambda = c/\nu$$

$$E = h\nu = hc/\lambda \text{ ergs}$$

(higher energy =
higher frequency =
shorter wavelength)

The E&M Spectrum