PHY 517 / AST 443:
Observational Techniques in Astronomy

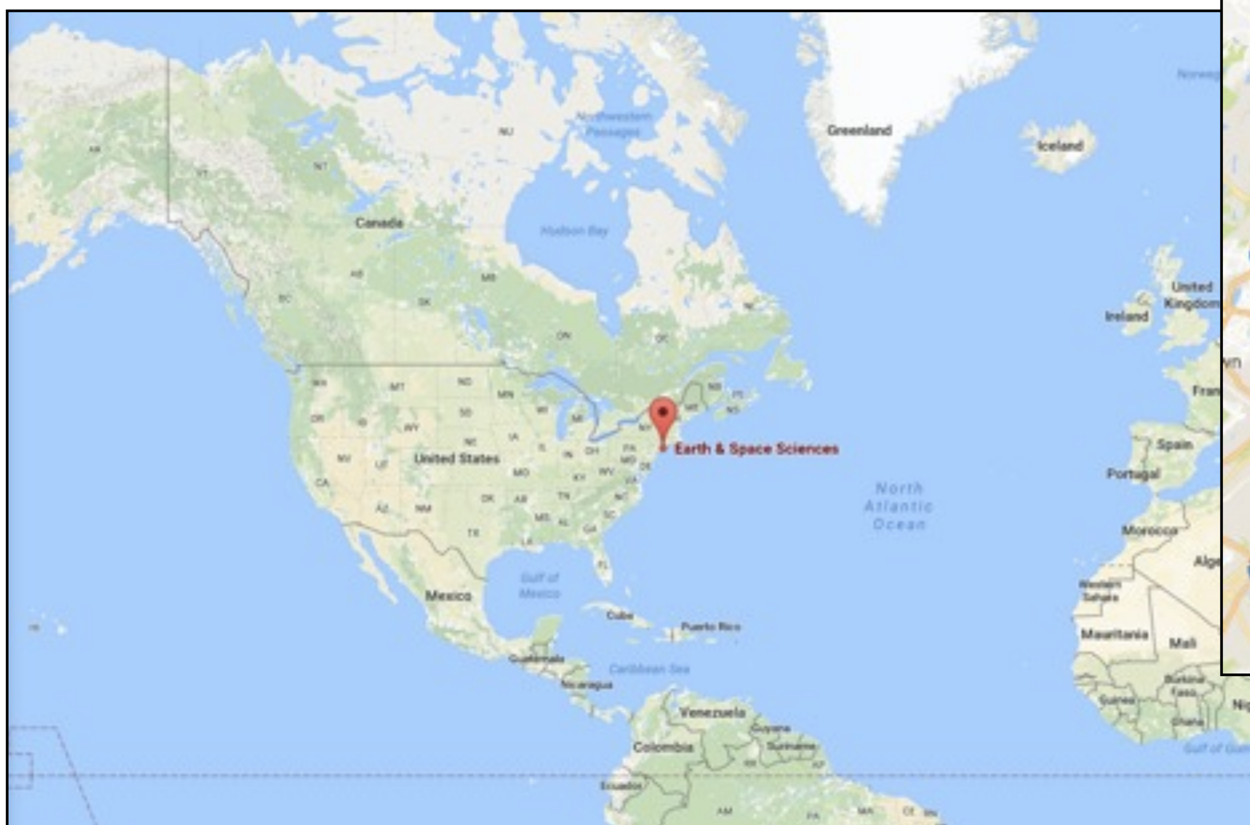
Lecture 1:
How to find things in the Sky /
Astronomical Coordinate Systems

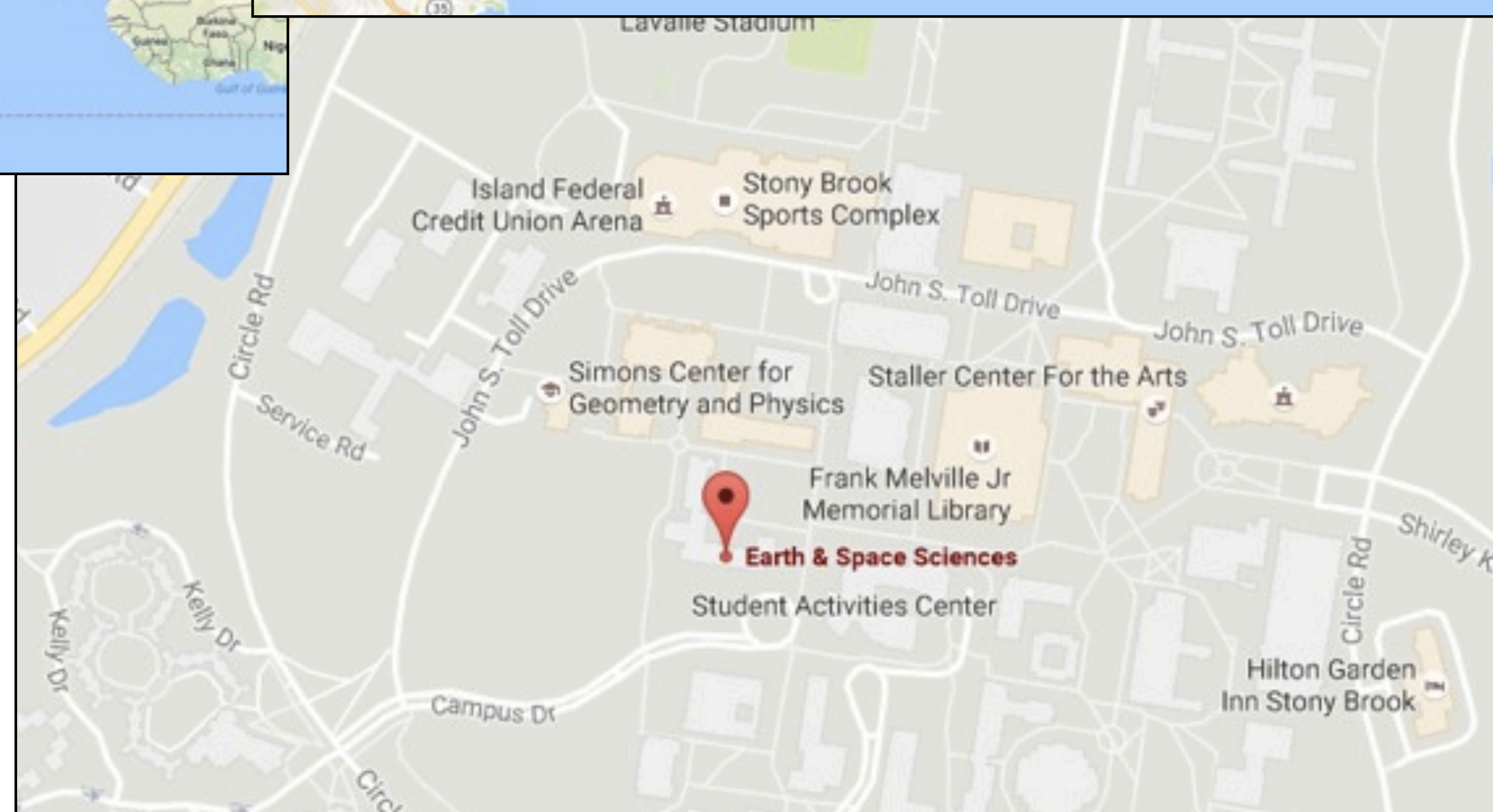
How do you find things in the Sky?

How do you find things on Earth?

How do you find things on Earth?

1. maps



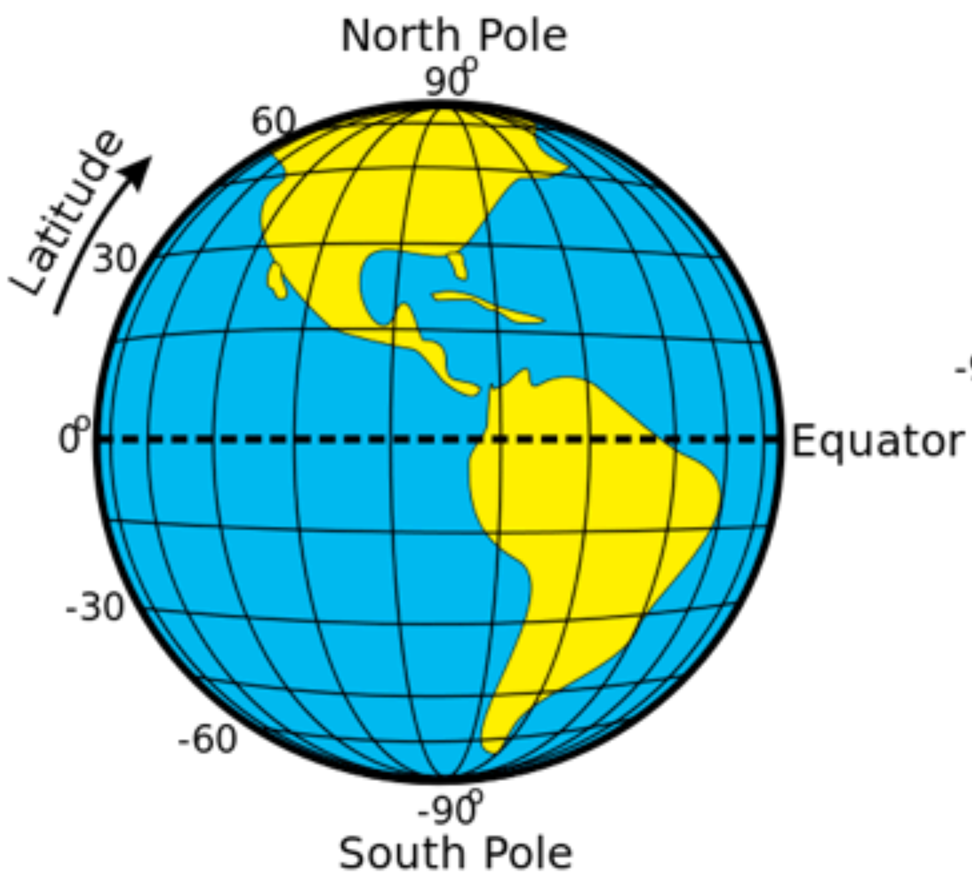


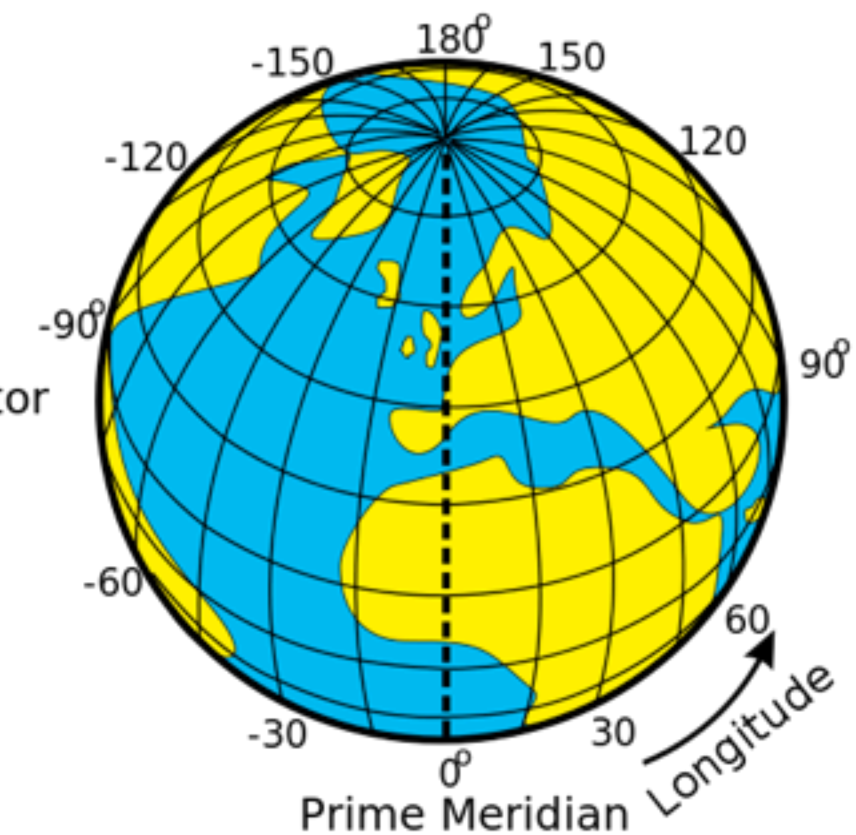
“pattern matching”

How do you find things on Earth?

Coordinates: 40.914224°N 73.11623°W

2. latitude and longitude: 2 angular coordinates, related to Earth's rotation





Stony Brook University

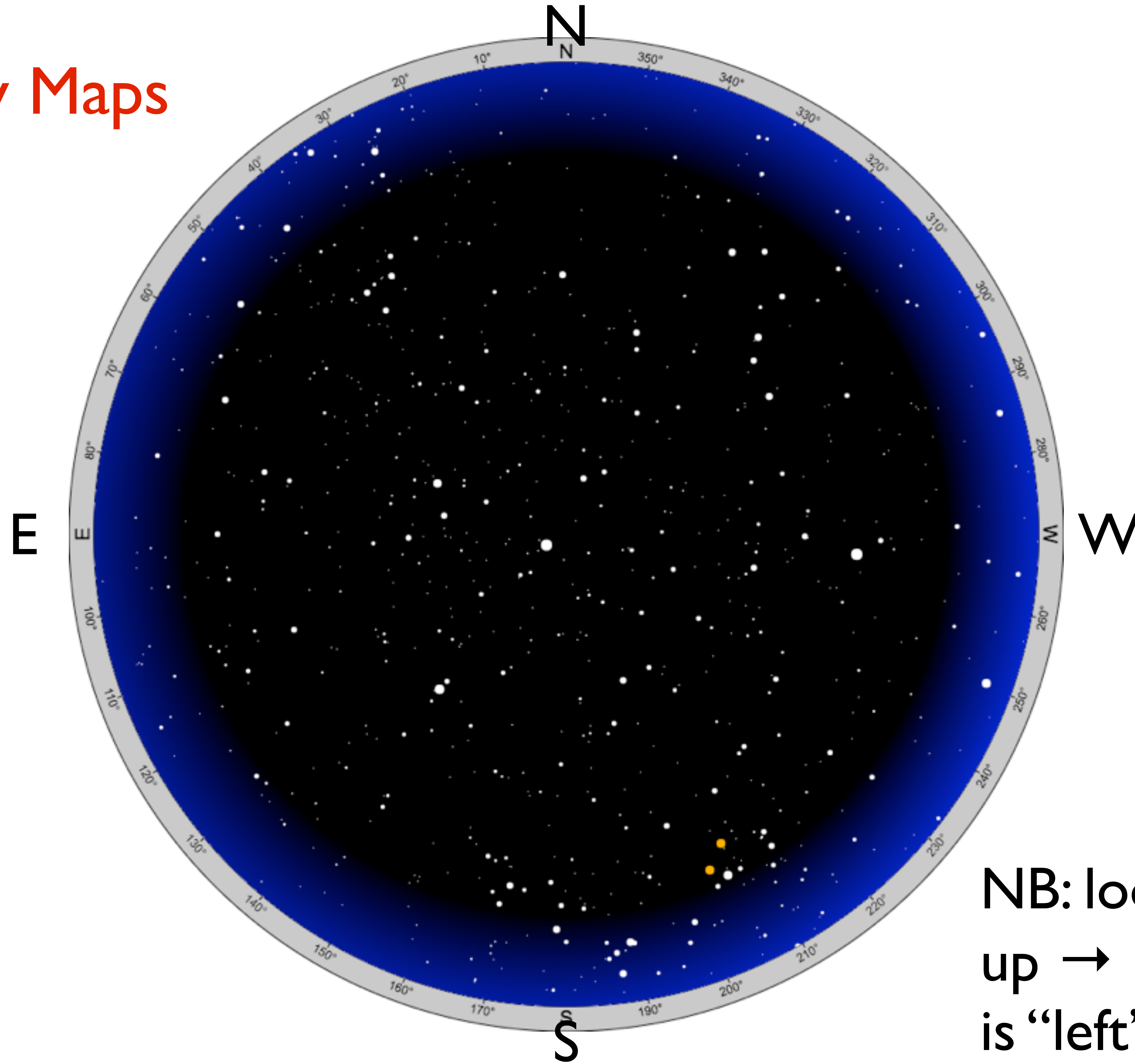
Former names	State University College on Long Island (1957–1962)
Type	• Public • Research university • Sea-grant • Space-grant
Established	1957
Endowment	$247.4 million (2015)[1]
President	Samuel L. Stanley
Provost	Dennis Assanis
Academic staff	2,471 (fall 2013)
Students	21,115 (West Campus)[2] 3,847 East Campus[2] 310 Southampton[2] 25,272 **Total**
Undergraduates	16,831 (2015 Fall)[2]
Postgraduates	8,441 (2015 Fall)
Location	Stony Brook, New York, U.S. 40.914224°N 73.11623°W

wikipedia

How do you find things on the Sky?

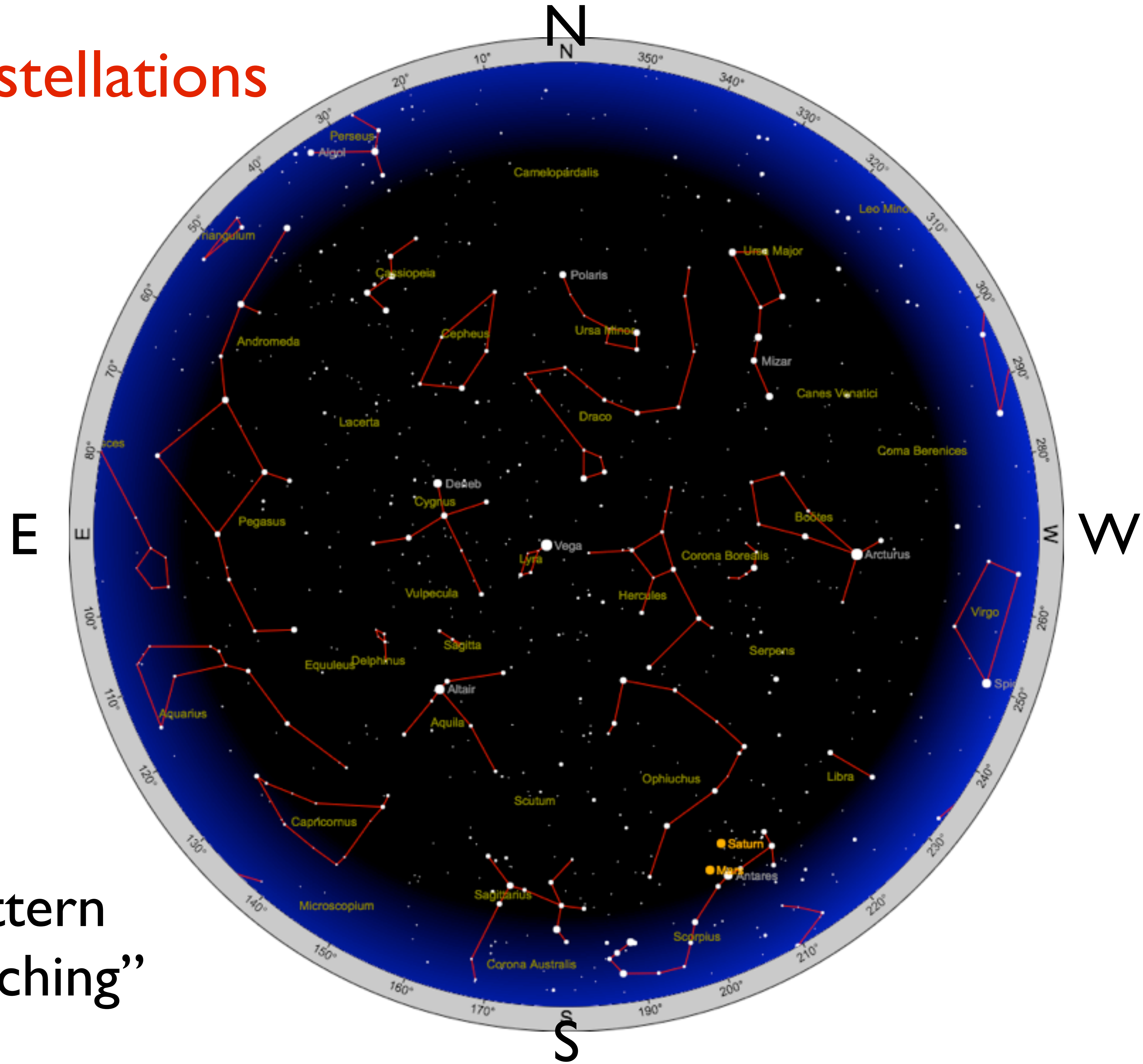
- similar to Earth:
    1. maps, “finding charts”, pattern matching
    2. angular coordinate systems

Sky Maps



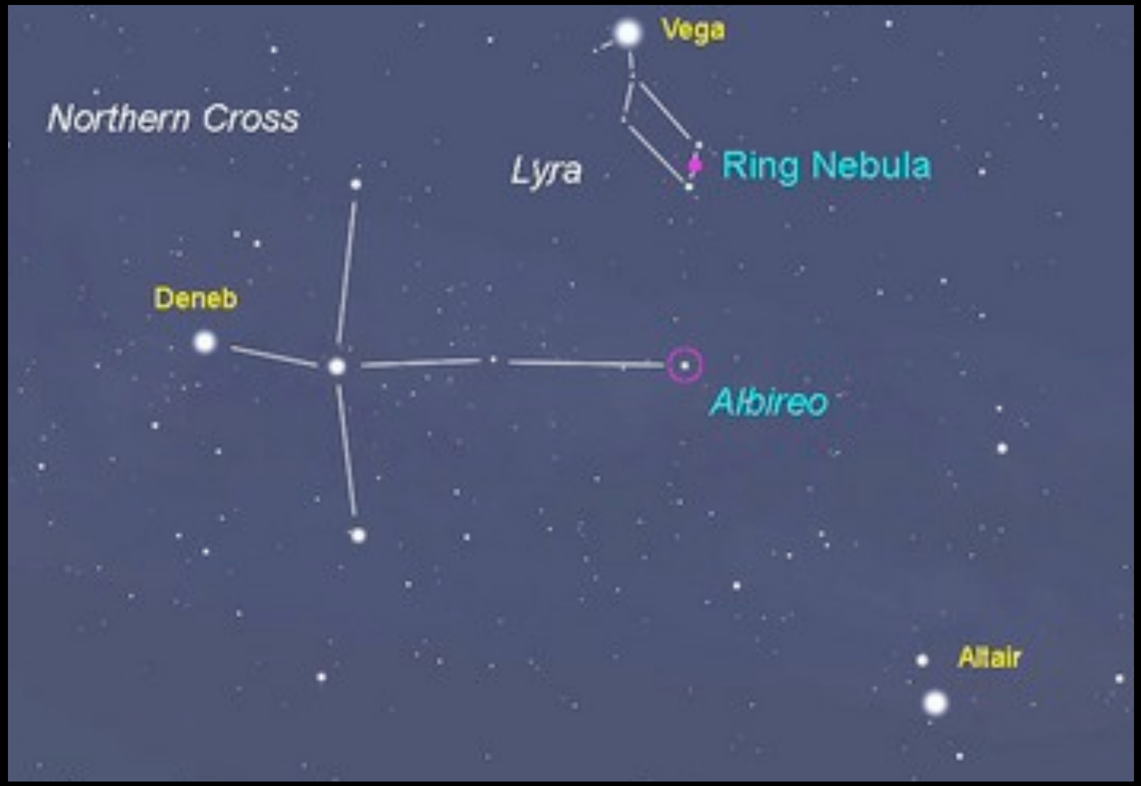
NB: looking up → East is “left”

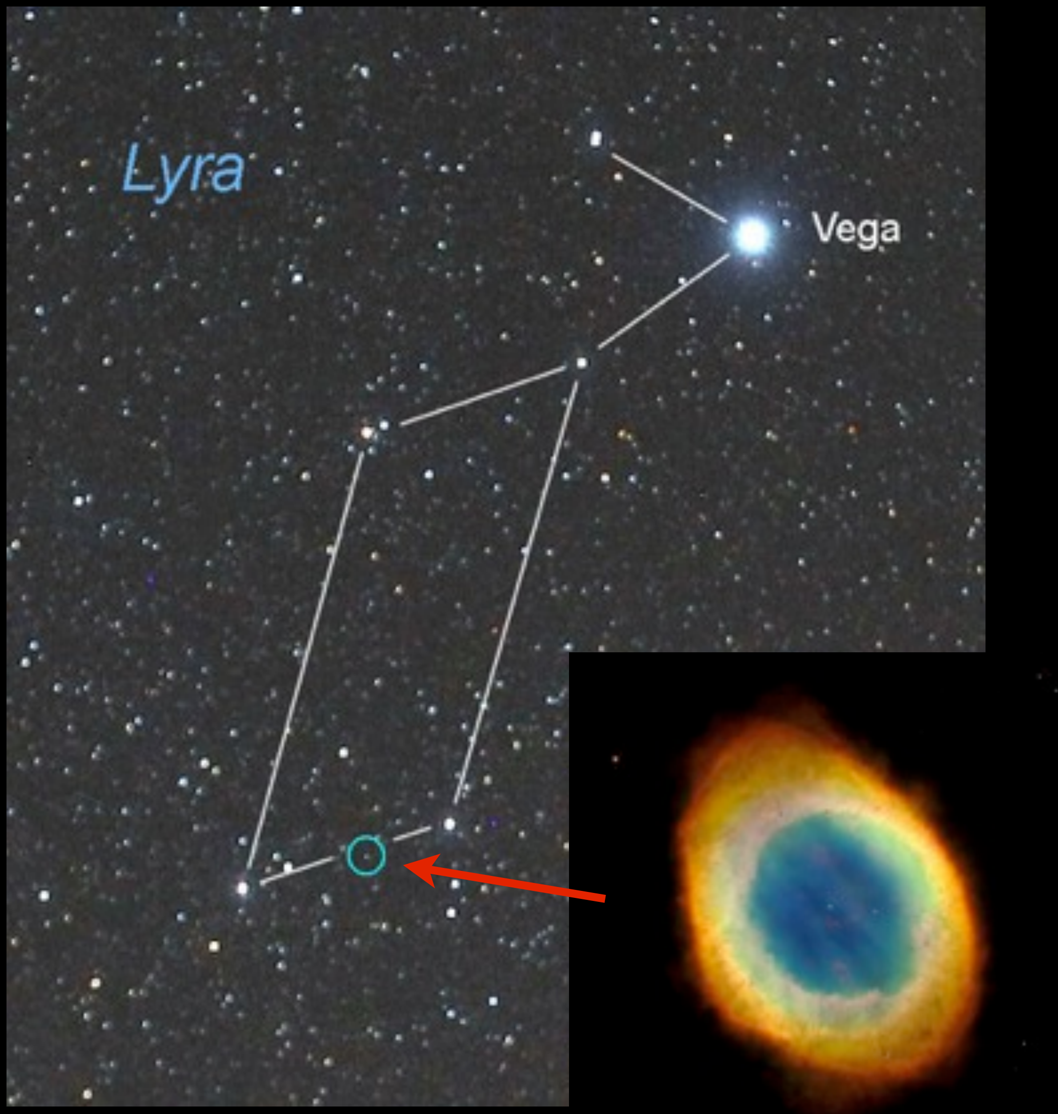
Constellations



"pattern matching"

How to find the Ring Nebula (M57)



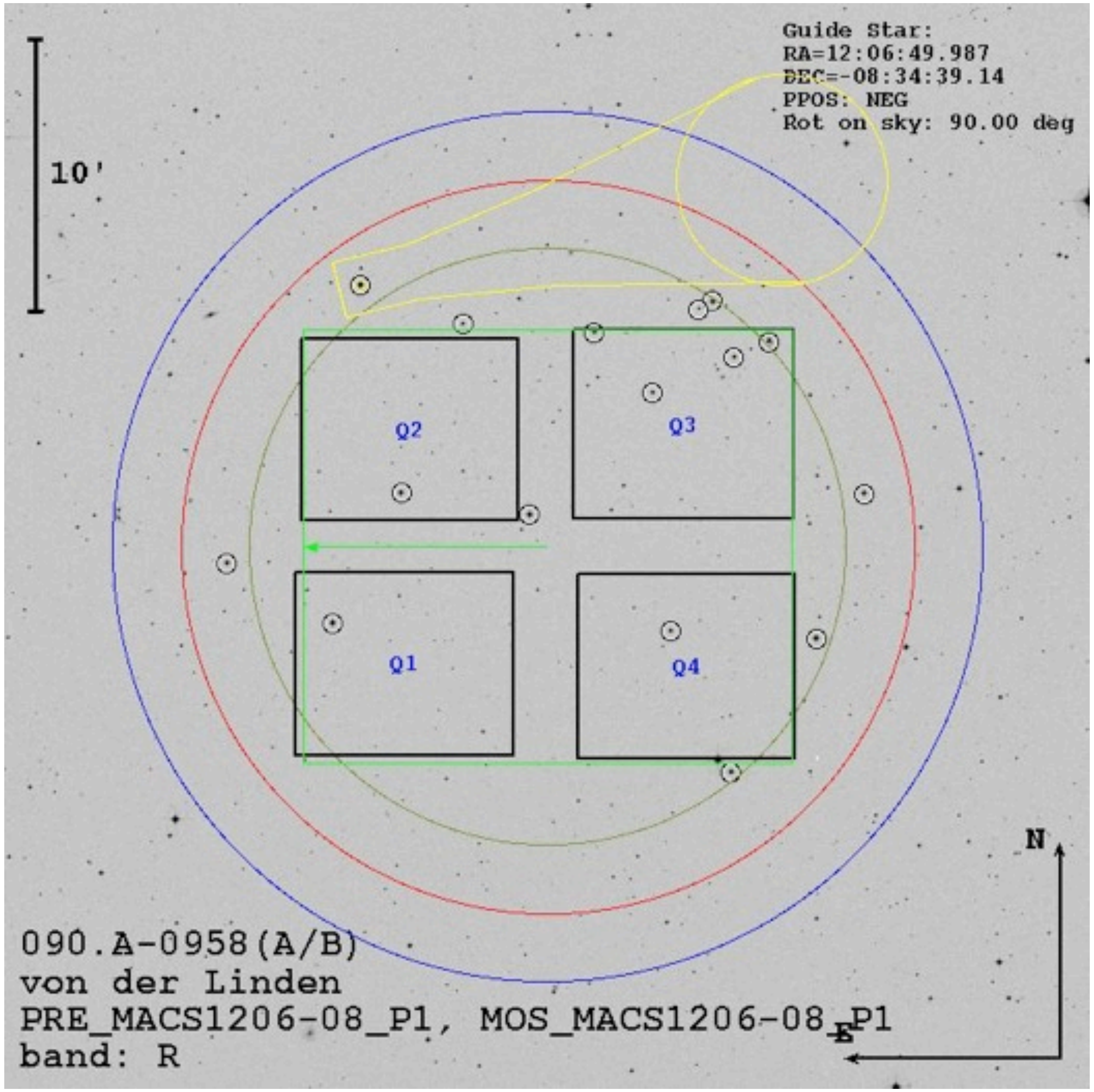


asterisms: easy-to-recognize star groupings
constellations: officially defined sky regions, based on historical asterims

Sky maps in professional astronomy

finding charts: big telescopes usually look at small sky regions; need to make sure you're looking at the right object!

include:
- scale
- direction
- identifiers / target
- instrument-specific features: field of view, guide star



Astronomical coordinate systems

Horizontal (or "Alt/Az") Coordinate System

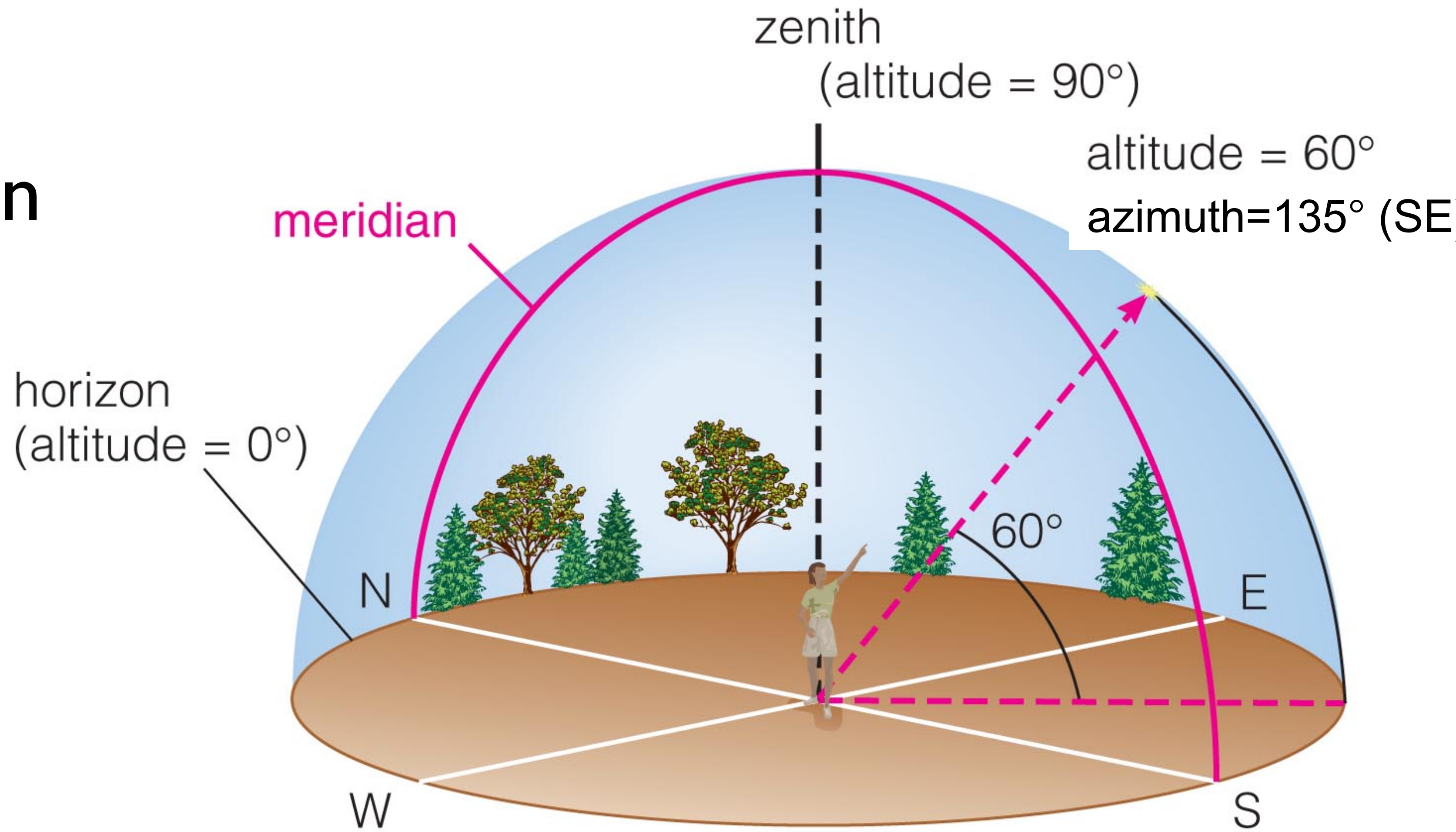
the sky above *a specific location*, *at a specific time*, is half a sphere - can be described with 2 (positive) angular coordinates

altitude: angular distance to the horizon

azimuth: angular distance from north

zenith: point overhead

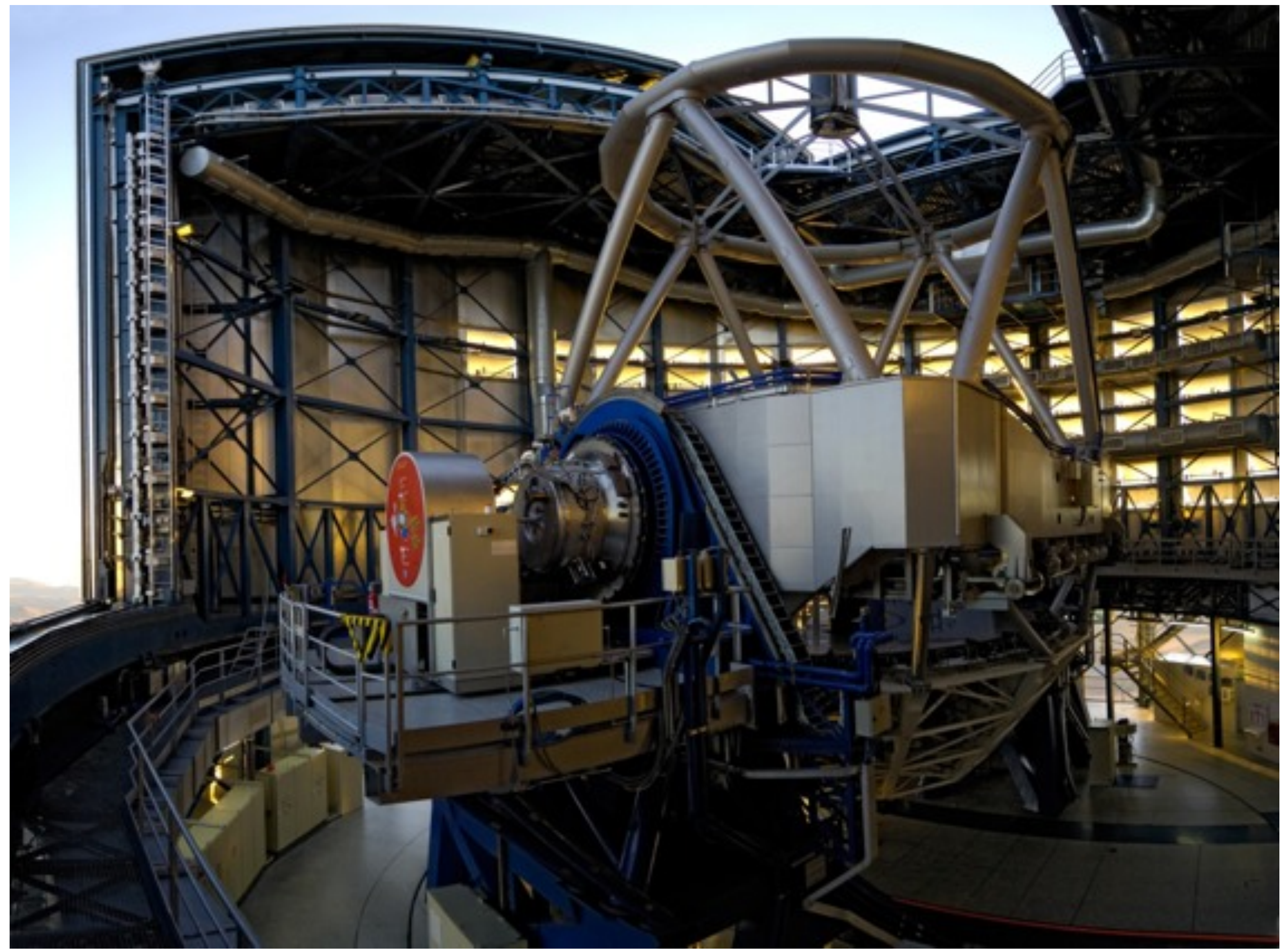
meridian: north-south line



Horizontal (or "Alt/Az") Coordinate System

alt-az telescope mounts: simple, very stable

Dobsonian-style telescope (~8 inch)



Very Large Telescope (8 meters)

An Alt-Az telescope mount in action:

http://sguisard.astrosurf.com/Anim-astro/P21-P22/P21-P22.html

Horizontal (or “Alt/Az”) Coordinate System

because of the rotation of the Earth: altitude and azimuth of a given object vary with time

in practice, we use “sky” coordinates to locate objects

you need to (approximately) know the altitude and azimuth of your target independent of the telescope mount and how you plan to find the target

is my target “up” ? (altitude > 0°)

is my target “observable” ? (altitude > 30° / 40° / 50°)

“Homework”

practice using altitude / azimuth to locate objects in the sky:

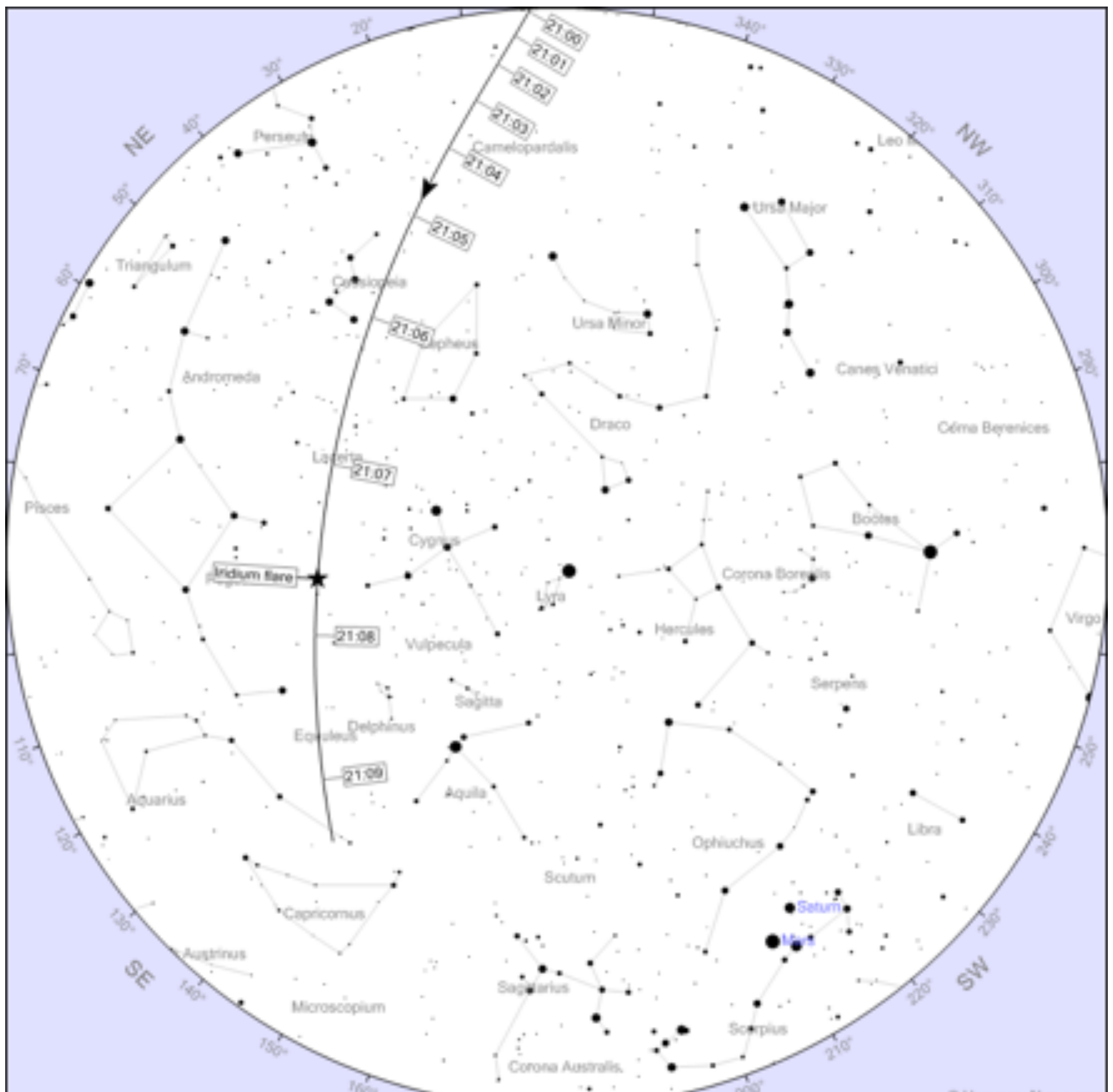
website for satellite pass predictions, e.g. when / where in the sky can you see the ISS:

http://www.heavens-above.com/

1. select your observing location (Stony Brook)
2. look through various satellite predictions to find something bright (the smaller the “magnitude”, the brighter)
3. note altitude + azimuth, figure out approximate location in the sky
4. try to observe it!

“Homework”

Time	Brightness	Altitude	Azimuth	Satellite	Distance to flare centre	Brightness at flare centre	Sun altitude
Aug 29, 21:07:39	-8.2	51°	95° (E)	Iridium 12	3 km (W)	-8.3	-18°

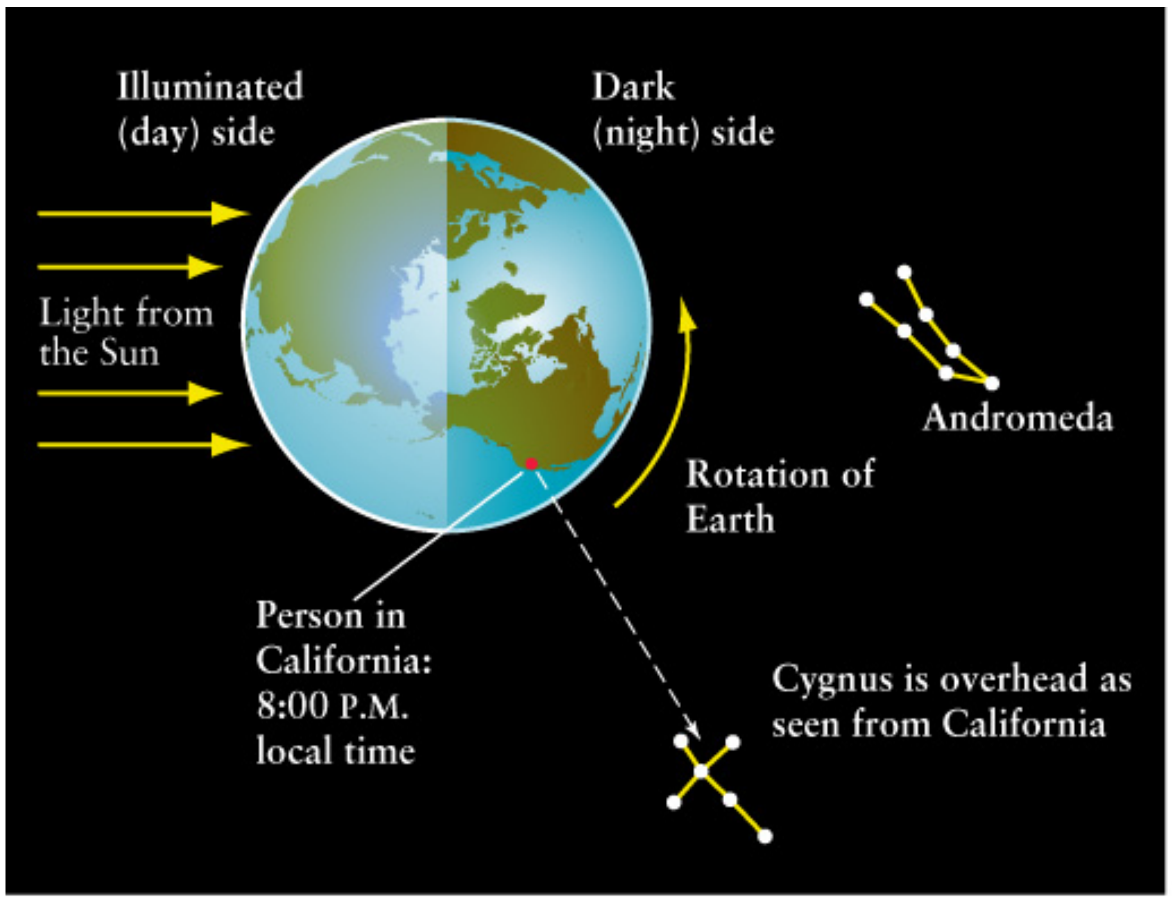


example for “Iridium flare” tonight

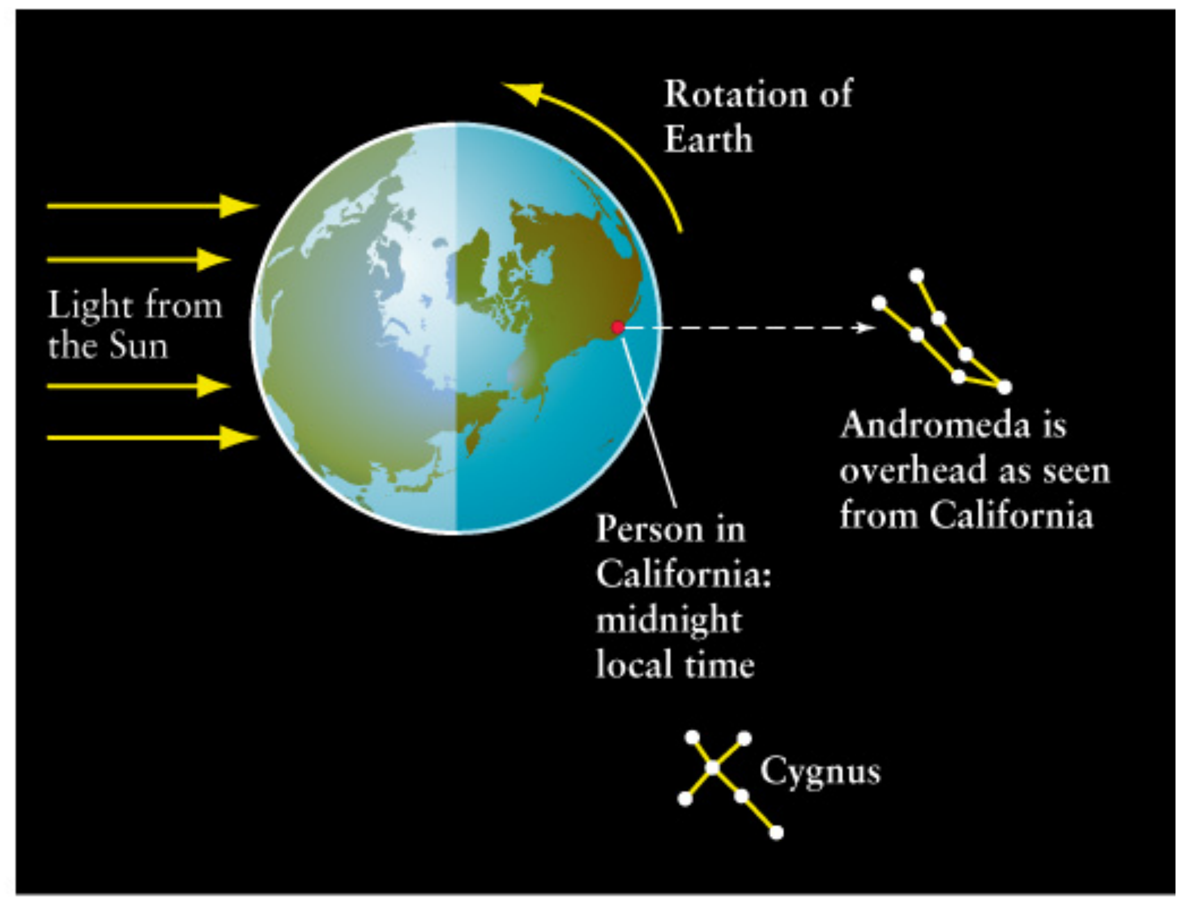
Flare Details	
Date:	29 August 2016
Time:	21:07:39
Brightness:	-8
Altitude:	51°
Azimuth:	95°
Satellite:	Iridium 12
Distance to satellite:	971 km
Angle off flare centre-line:	0.1°
Distance to flare centre:	3 km
Flare producing antenna:	right
Sun altitude:	-18.2°
Angular separation from Sun:	141.7°

Rotation of the Earth

looking down on the north pole, Earth rotates counter-clockwise



(a) Earth as seen from above the north pole



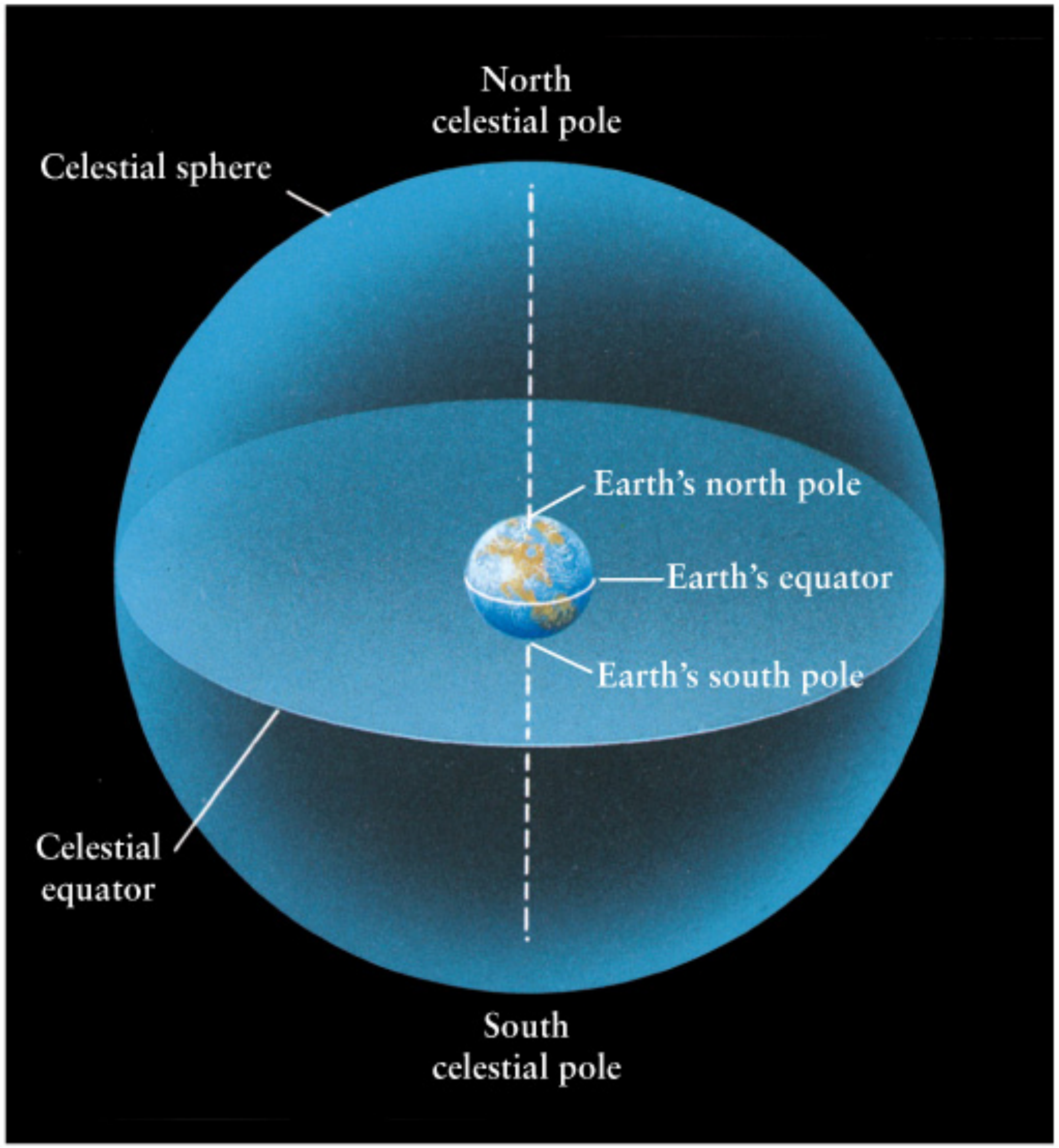
(b) 4 hours (one-sixth of a complete rotation) later

Andromeda is to the East; Cygnus is overhead

4 hrs later: Andromeda is overhead; Cygnus is to the West

the Sky appears to rotate East to West

Celestial Sphere

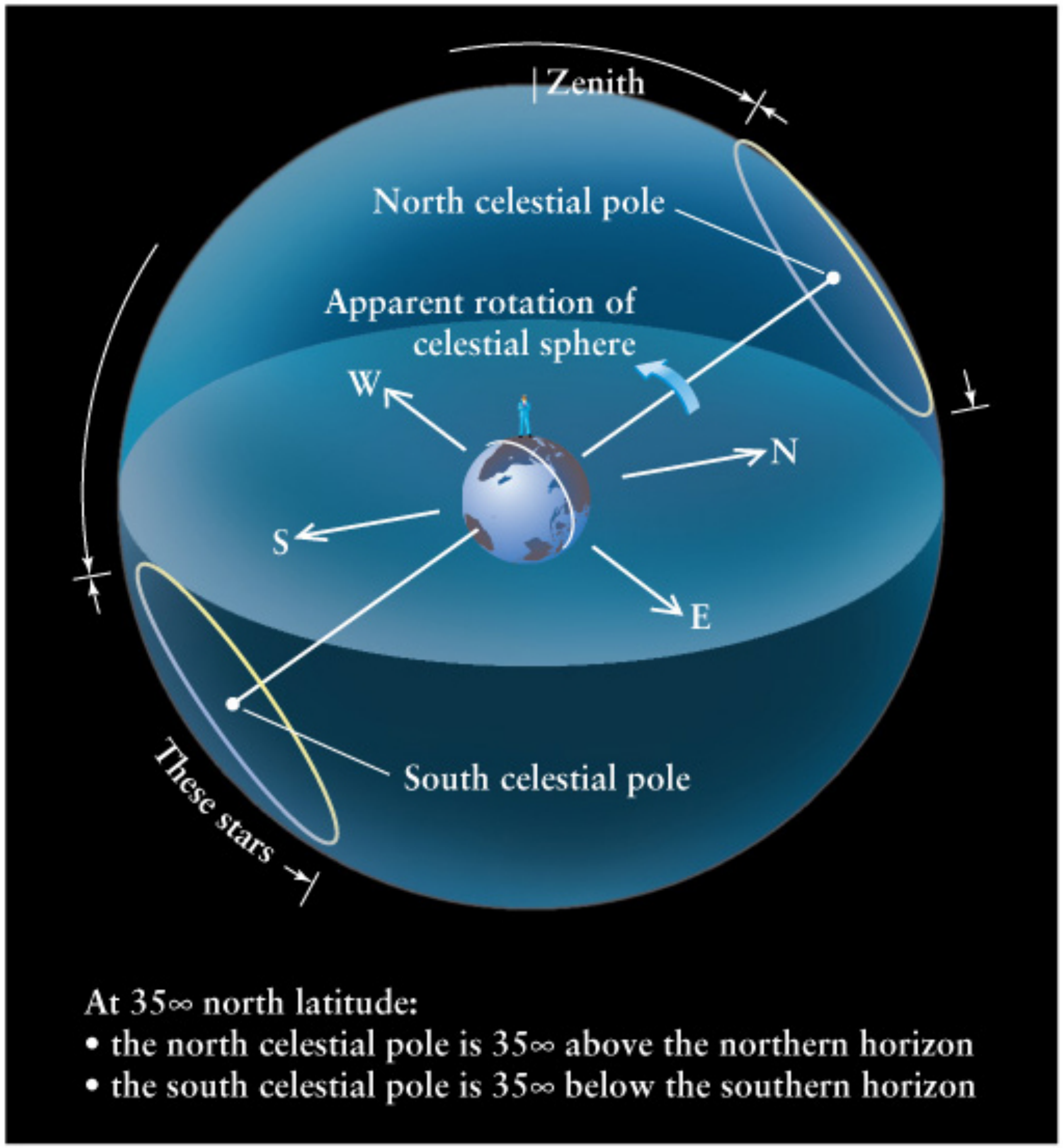


celestial sphere: describe objects by their position on a sphere centered on us

celestial north / south pole: projection of Earth's north / south pole

celestial equator: projection of Earth's equator

Apparent motion in the Sky



apparent sky motion depends on latitude of observer

e.g. SB is 41° north:

North Pole is at 41° altitude

objects within 41° of NP are always "up" - "circumpolar"

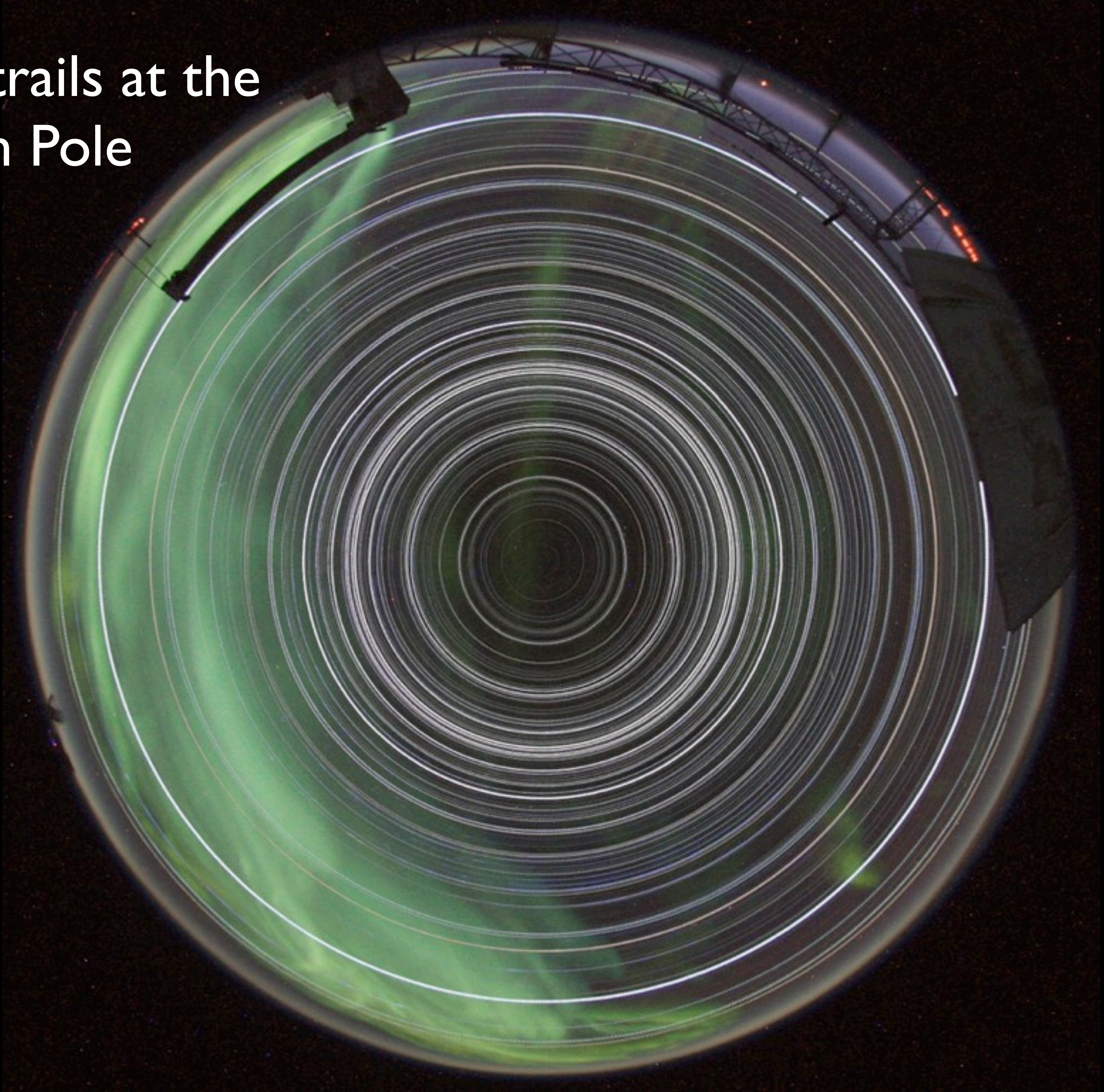
can never see objects within 41° of South Pole

all other objects rise in the East, set in the West

Star trails over CTIO, (c) Jose Delgado

Star trails at the equator

Star trails at the South Pole

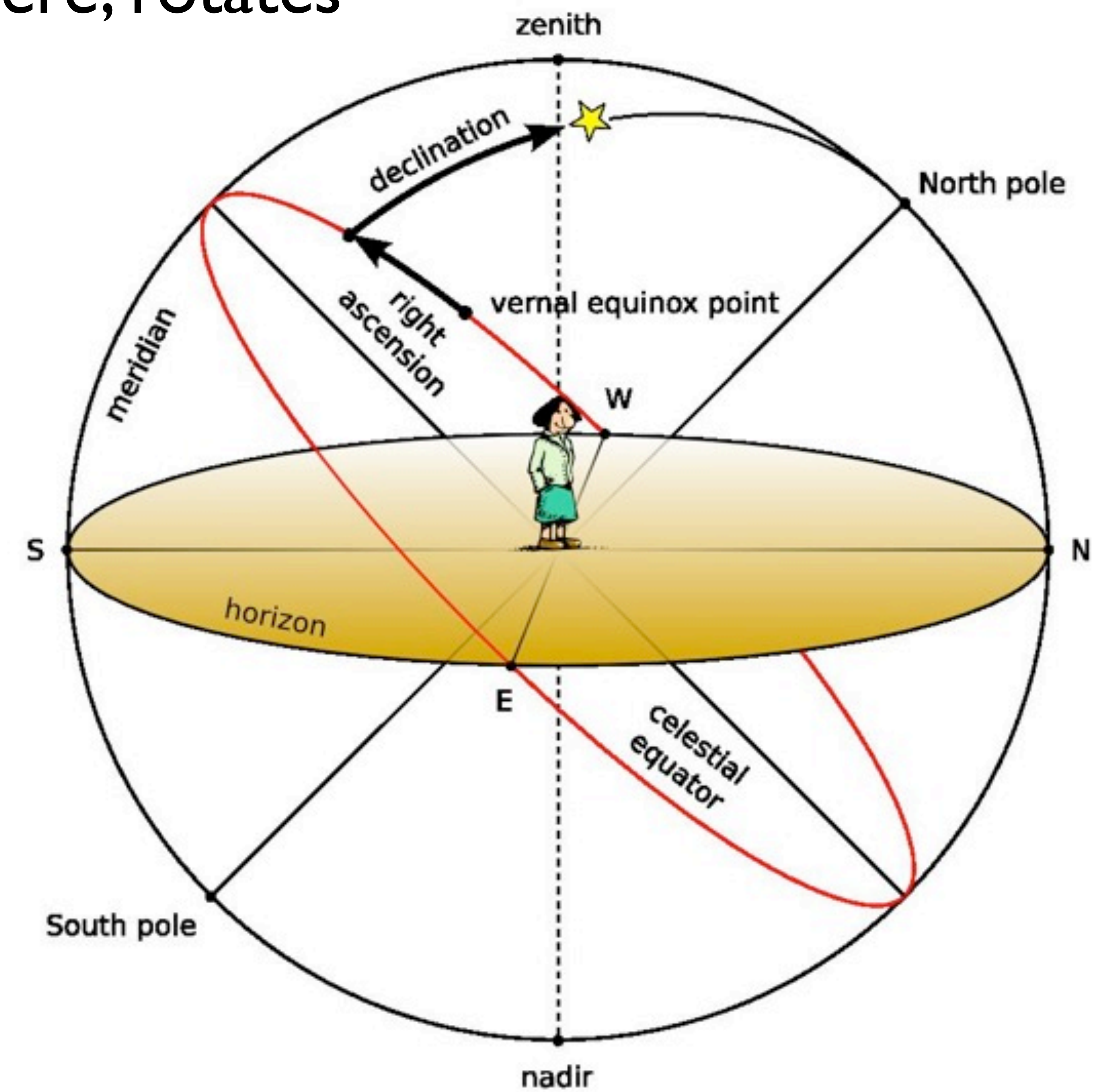


Equatorial (RA/Dec) Coordinate System

"fixed" to the celestial sphere, rotates with the sky

declination δ: angular distance from the celestial equator

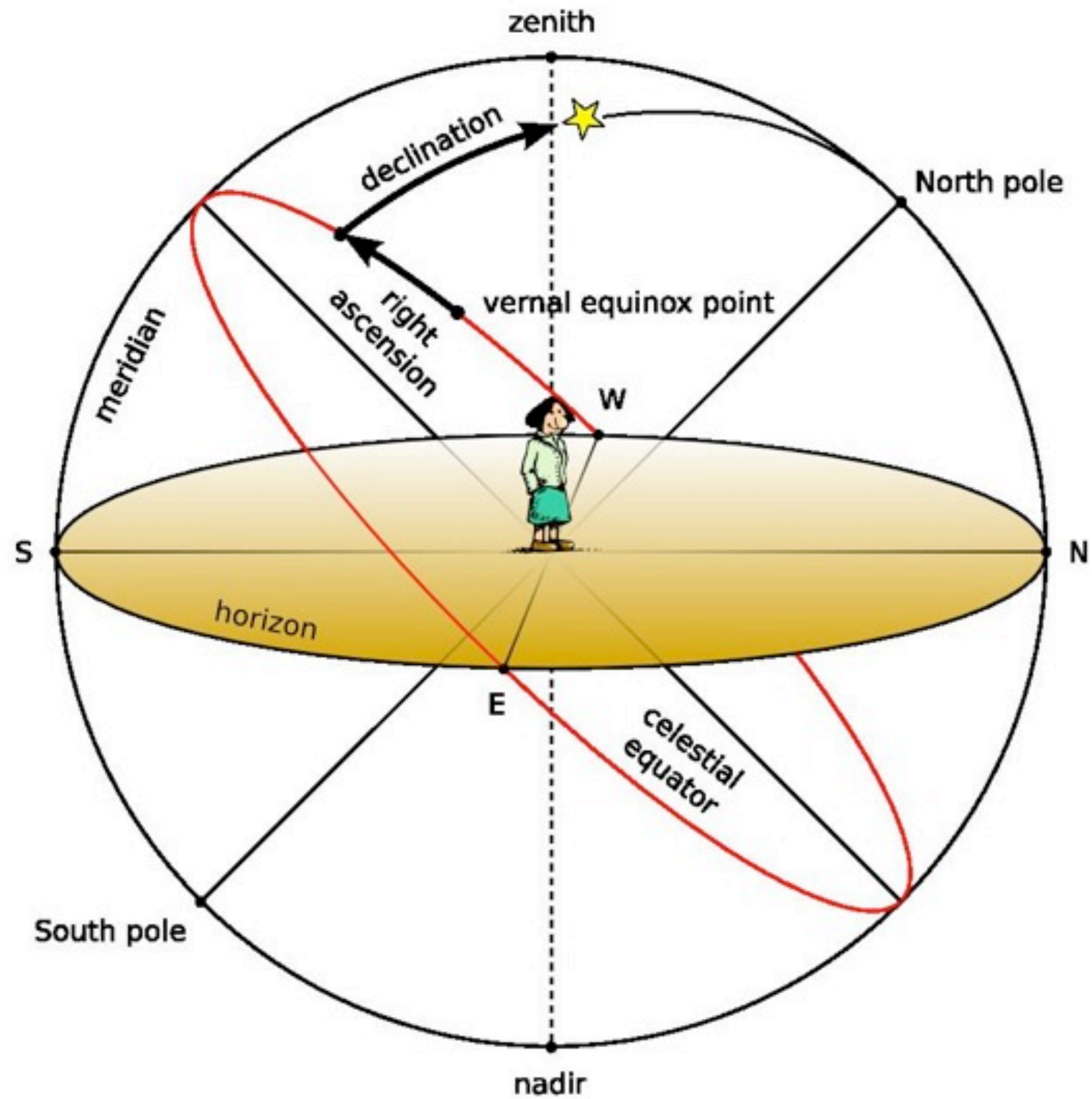
right ascension α: angular distance from vernal equinox (later; special point on equator)



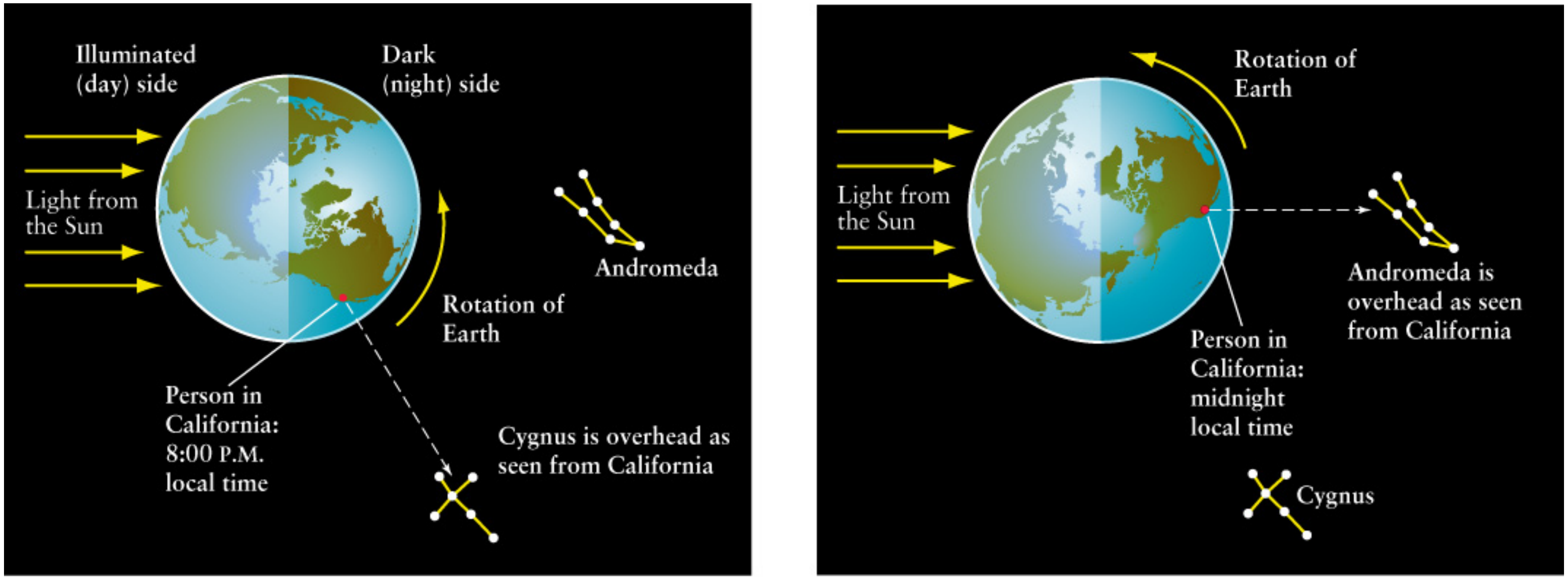
Equatorial (RA/Dec) Coordinate System

declination δ: measured in degrees, $-90^\circ \leq \delta \leq 90^\circ$ (like latitude)

right ascension α: can also be measured in degrees ($0^\circ \leq \alpha < 360^\circ$), however:



Right ascension (RA)



(a) Earth as seen from above the north pole

(b) 4 hours (one-sixth of a complete rotation) later

a “natural” way to define right ascension is in units of time:

“distance” between two points is given by the time interval between each of them passes the meridian

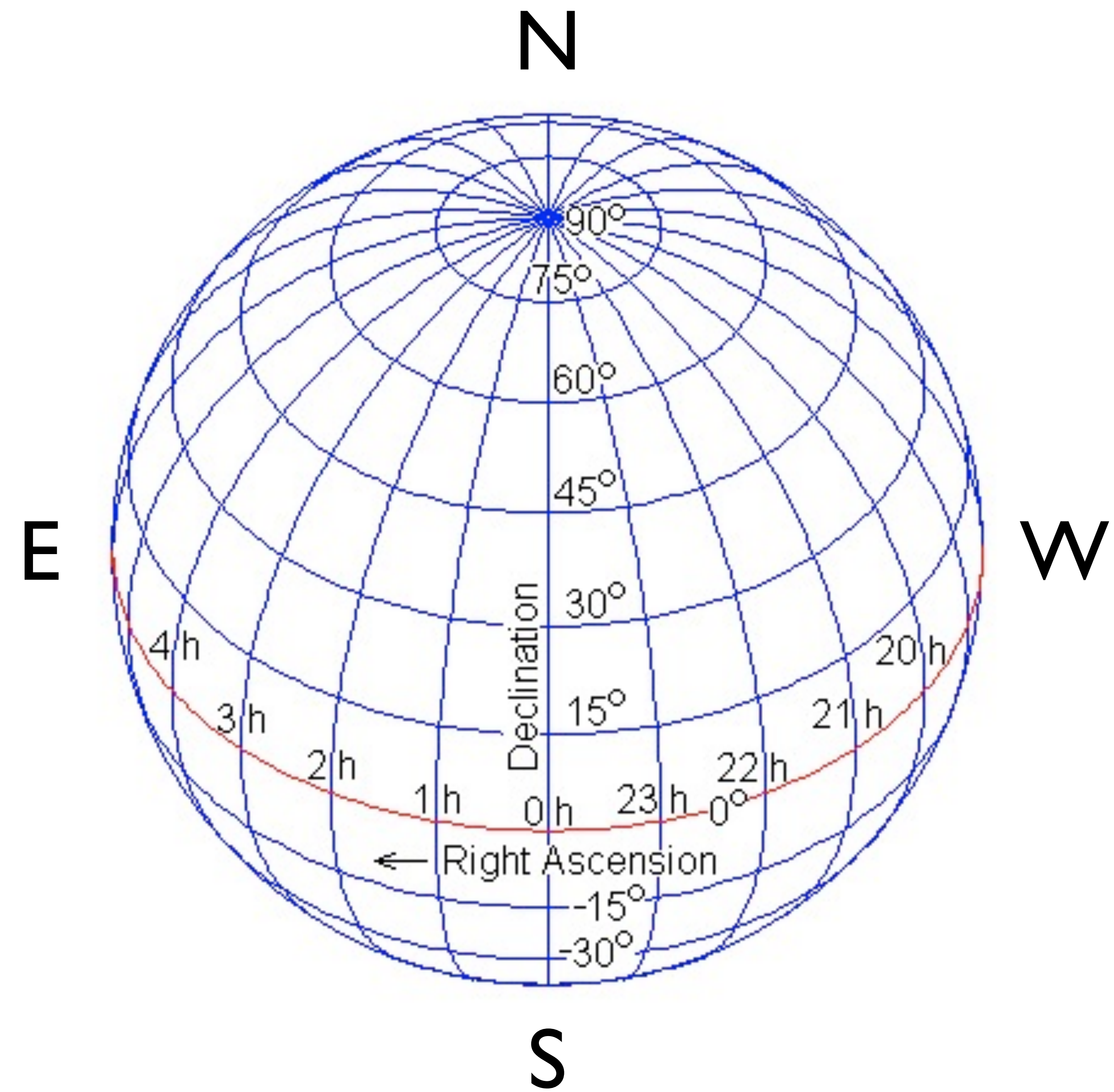
e.g.: reference point (0h) culminates (passes meridian) at midnight; all points that culminate 4 (star)-hours later have α = 4h

Right ascension (RA) + Local Sidereal Time (LST)

sky rotates East to West;
East is “left”

R.A. runs from right to left
in astronomical maps!

local sidereal time (LST): RA
of the objects currently
culminating (on meridian)



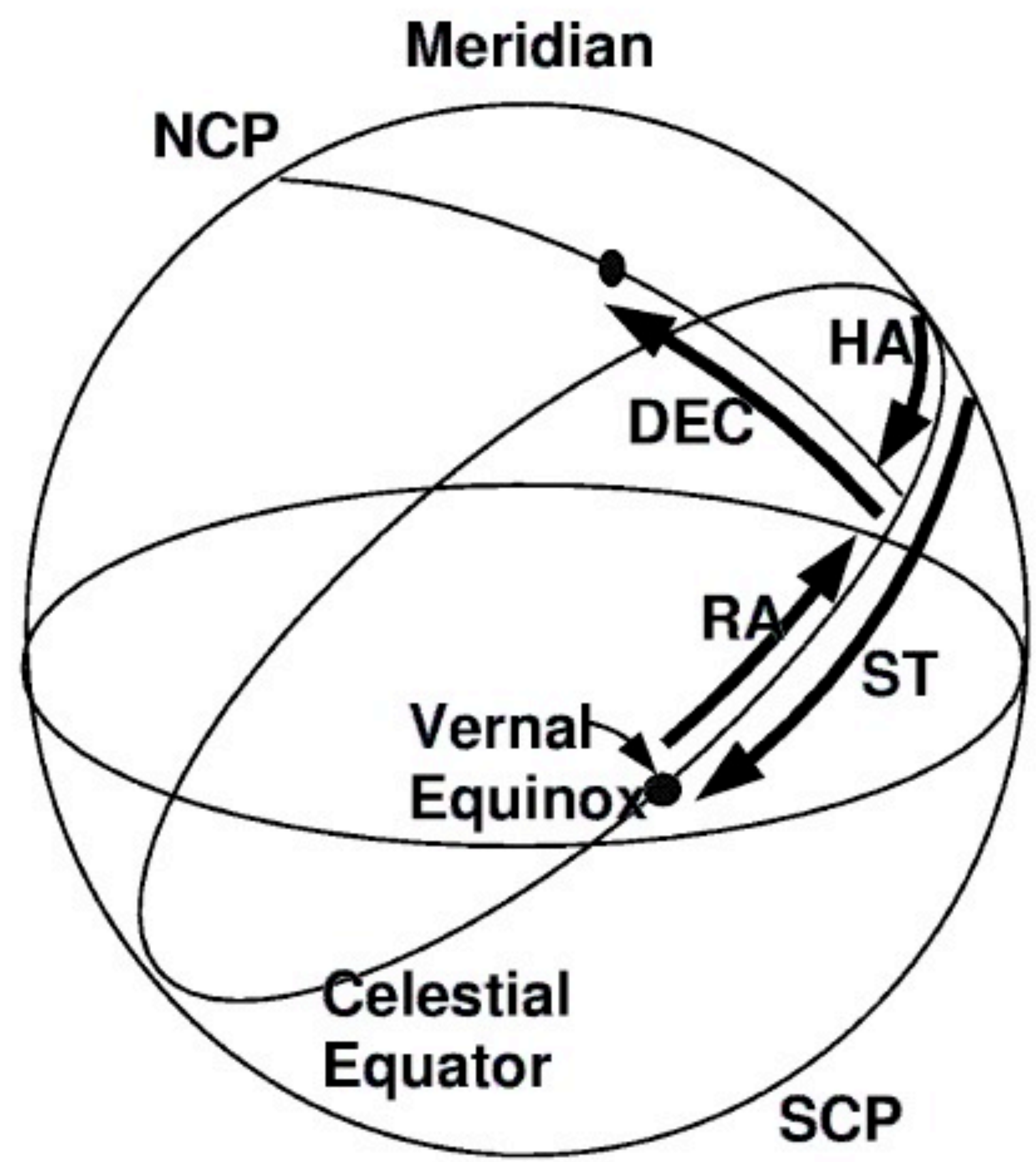
RA, LST, and Hour Angle

hour angle (HA): time that has passed since object culminated

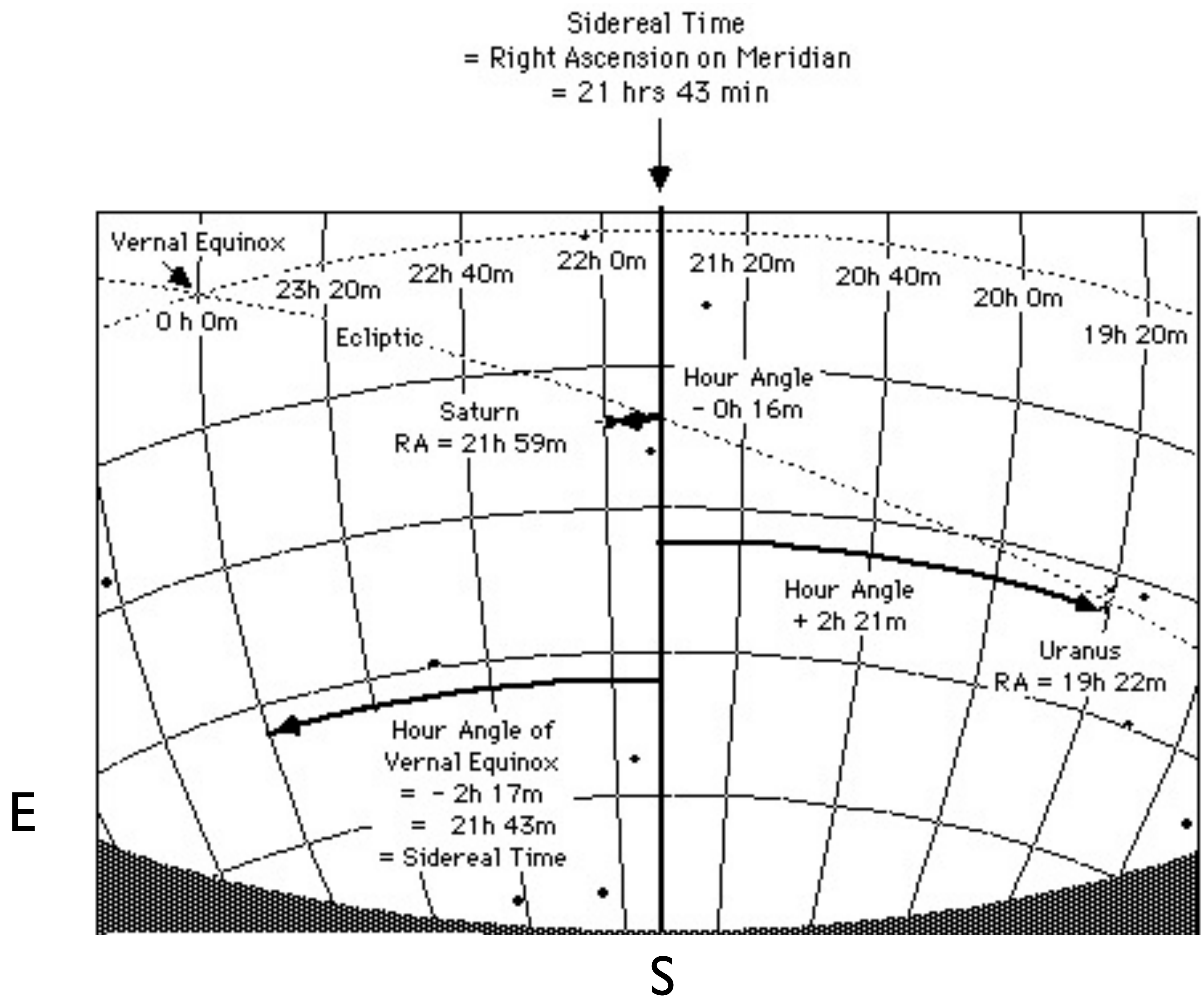
$HA = LST - \alpha_{object}$

HA > 0h: object has already culminated, it is “setting” and in the western half of the sky

HA < 0h: object is rising, is in the eastern half of the sky, will culminate in |HA| hours



Example



Sidereal Time =
Right Ascension +
Hour Angle

Saturn:
21h 59m RA +
(- 0h 16m) HA
= 21h 43m ST

Uranus:
19h 22m RA +
2h 21m HA
= 21h 43m ST