# Astronomy 2310
# General Astronomy

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  - **Course Webpage: http://physics.uwyo.edu/~mpierce/A2310**
  - **Office Hour**
    - **Tues. & Thurs: 1:00pm – 3:00pm**
    - **Also by Appointment**
- **Lab Instructor**
  - **Earl Wood**

# Astr 2310 Tues. Jan. 26, 2016
# Today's Topics

- **Class Overview**
  - **How to do well in this class**
  - **Syllabus**
  - **Schedule**
- **Introductions**
  - **Who are you?**
  - **Who am I?**
- **Course Prologue**
  - **Astronomy & Astrophysics as a science**
  - **Tour of the Universe**

# Today's Topics Continued

- Celestial Sphere
  - Concepts and Nomenclature
  - Rising and Setting of Celestial Objects
  - Effects of Latitude
- Preview of Lab this Week
- Homework (none this week)

- Reading for Next Time

# How to Do Well in this Class

- **Come to class**
- **Read textbook chapters before class**
- **Print-out and read on-line notes (add to them)**
- **Ask questions in class**
- **Turn in homework on time**
- **Turn in labs on time**

# Highlights of the Syllabus

- **Course Content: a quantitative survey of Astronomy**
  - **Prerequisites: Trig., Calculus-I and Physics-I**
- **Lectures: Reading done in advance, notes on the web**
  - **A chapter covered each week!**
- **Laboratory: Starts THIS week, Attendance Required!**
- **Homework: Typically Assigned/Due on Tuesdays**
- **Exams: 2 exams + final, both in-class and take-home parts**
- **Grading: Exams – 50%, Homework + Labs - 50%**

# Who are You?

- **Introductions**
- **Please fill out the questionaire**
  - **I can make adjustments depending on math background**
  - **Why are you taking the class?**
  - **What do you want to learn from it?**

# Who am I?

- **Background**
  - **PhD University of Hawaii**
    - **Measured expansion of the Universe**
    - **Inferred Existence of Dark Energy**
  - **Plaskett Fellow, Herzberg Institute for Astrophysics (Victoria, BC)**
  - **Research Fellow, Kitt Peak National Obs. (Tucson, AZ)**
  - **Indiana University**
  - **University of Wyoming**
- **Research Interests**
  - **Evolution of Galaxies**
  - **Cosmology**
  - **Astronomical Instrumentation**
  - **Come by and talk if you want to hear more**

# Prologue & a Tour of the Universe

- **Astronomy: the study of the Universe**
  - **Discovery & application of physical laws to understand how the universe works and came to be.**
  - **Study of the solar system: understand the Earth as a planet and its context.**
  - **Study of larger-scale properties: understand the origin of the Sun, other stars and the Universe**

# The Scale of the Cosmos

**"Space is big. Really big. You just won't believe how vastly, hugely, mind-bogglingly big it is. I mean, you may think it's a long way down the road to the chemist, but that's just peanuts to space."**

**-- Douglas Adams,**
***The Hitchhiker's Guide to the Galaxy, 1979***

**Size-scales vary by > 40 orders of magnitude: $10^{40}$**

# Space is REALLY Transparent!

- **We can see very far only because space is incredibly transparent.**
  - **We can see 10 Billion Light Years!**
- **Earth's atmosphere seems pretty transparent.**
- **How far could we see if space were only as transparent as the Earth's atmosphere?**

# The Age of the Universe is Finite

- **The Universe is very old, but not infinitely old (about 15 Billion years old).**
- **The speed of light is very large but not infinite =186,000 miles/sec, 300000 km/sec.**
- **So, as we look over increasingly larger distances we look back into the past!**
  - **We can study the history of the Universe!**
- **The "look-back time" = light travel time.**
- **What if the Universe were infinitely old?**

# Scientific Method

- Assume that the natural world has order and not designed to trick us (chaos doesn't rule).
- Expect that science produces change. Revision is expected
- Math provides a high-precision language and cuts down on the BS (hard to fake).
- Procedure is formalized to make it efficient. Hypothesis Experiment Model/Theory

# Scientific Method Continued

- **We don't waste time on mundane ideas**
  - **The Sun rises everyday, why test it?**
  - **Instead study the "cutting-edge" of science.**
- **Search for Universal Ideas/Laws**
  - **Universal Law of Gravity**
  - **Conservation Laws in Physics**
    - **Assume laboratory physics is same as space physics**
- **Astronomy is a Passive Science**
  - **Few real experiments, observations instead**
- **Science isn't Perfect but Highly Successful**

# Brief Tour of the Universe

**Earth:** 13,000 km in diameter ($D_{earth}$)

**Moon:** distance ($d_{moon}$) 30 x $D_{earth}$ (1.3 light seconds)

$D_{moon} \sim \frac{1}{4} D_{earth}$

**Sun:** $d_{sun} \sim 400\ d_{moon}$ (1 A.U., $150 \times 10^6$ km, 8 light min.)

**Jupiter:** $d_J \sim 7.8 \times 10^8$ km, 5.2 AU (33.6 light min.)

$D_J = 143{,}000$ km, $\sim 11\ D_{earth}$

**Pluto:** $d_P \sim 5.9 \times 10^9$ km, 40 AU (5.2 light hrs.)

**Nearest Star (α Centauri):** $12 \times 10^{12}$ km, 300,000 AU, 4.3 light years

# Tour Continued

**Milky Way Galaxy:** 100,000 ly across,
center ~ 25,000 ly from Earth
contains ~ $10^{10}$ stars

**Andromeda Galaxy:** 2 x $10^6$ ly away

**Virgo Cluster:** cluster of ~ 1000 galaxies, 50 x $10^6$ ly away

**Most Distant Galaxies:** $10^{10}$ ly away

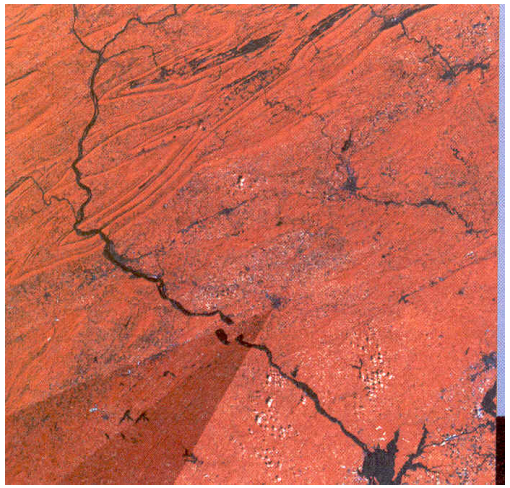
**Edge of Visible Universe:** 14 x $10^9$ ly away

# The Scale of the Cosmos

**Zoom outward in steps of 100**

**52 feet across**

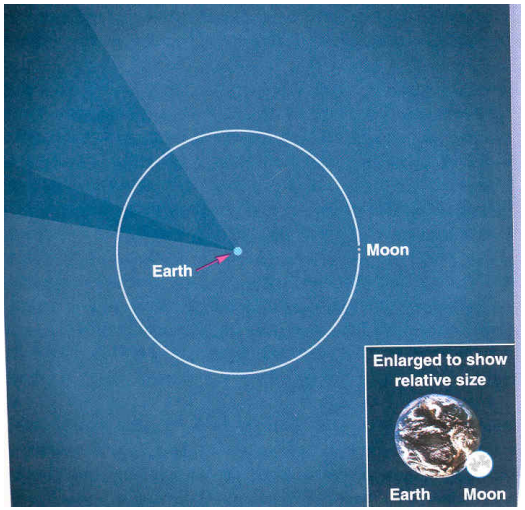
**5200 ft = 1 mile = 1.6 km**



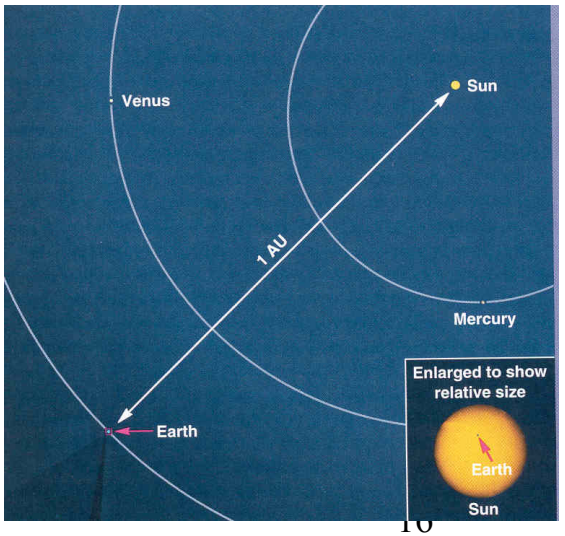
**160 km**

**16,000 km**

(From our Text: Horizons by Seeds)



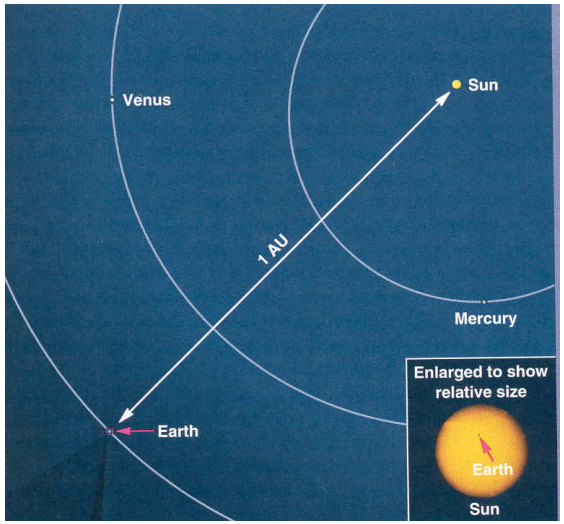

**1,600,000 km**



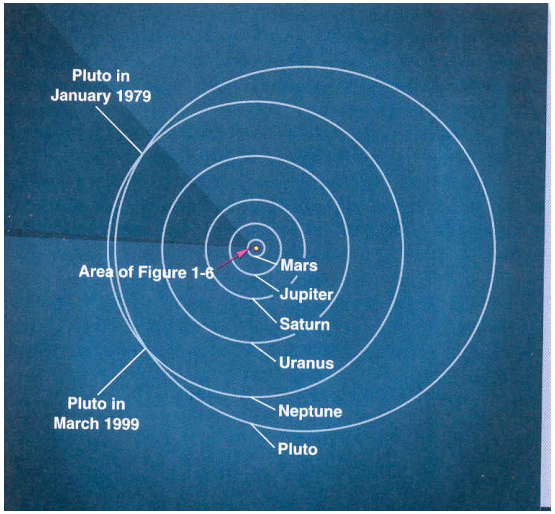

**160,000,000 km**

# The Scale of the Cosmos

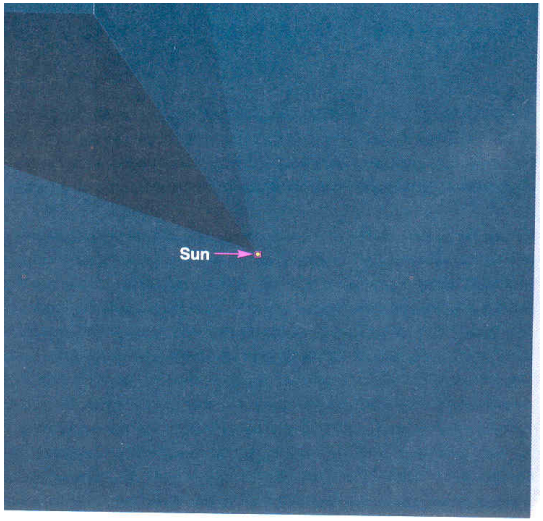
**Zoom outward in steps of 100**



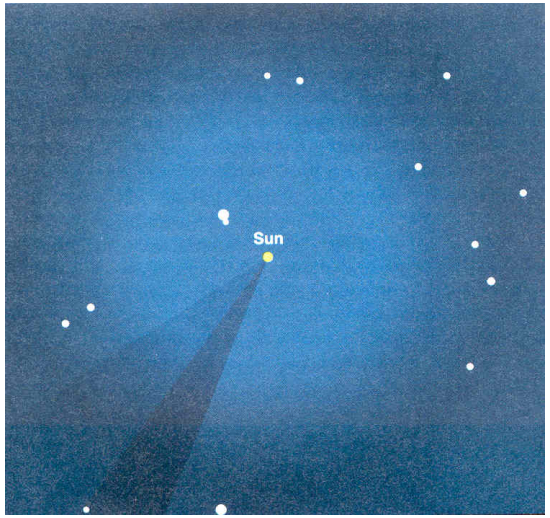

**160,000,000 km = 1.1 astronomical units**



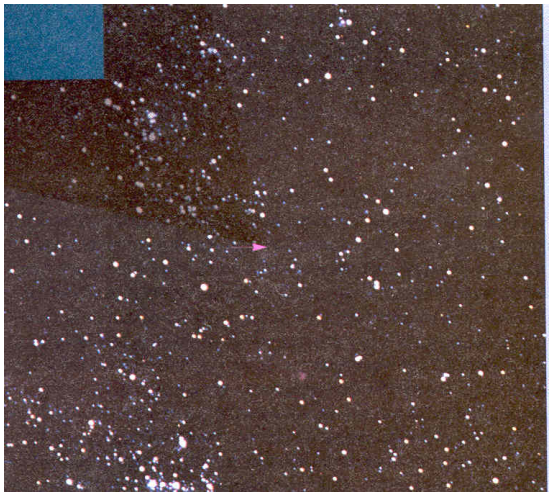

**110 AU**




**11,000 AU**




**1,100,000 AU = 17 light-years**



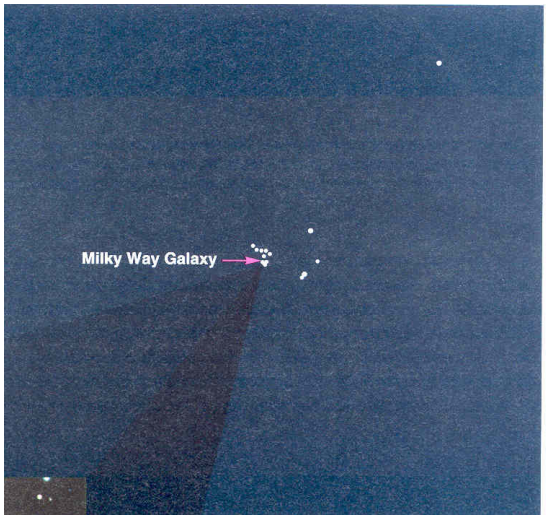
**1,700 ly**

**17,0000 ly**

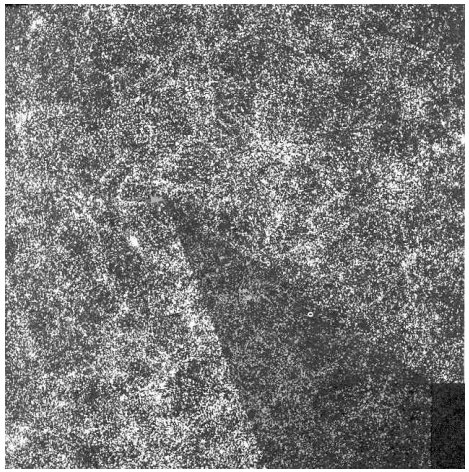
# The Scale of the Cosmos

**Zoom outward in steps of 100**

**17,000 ly**




**1,700,000 ly**



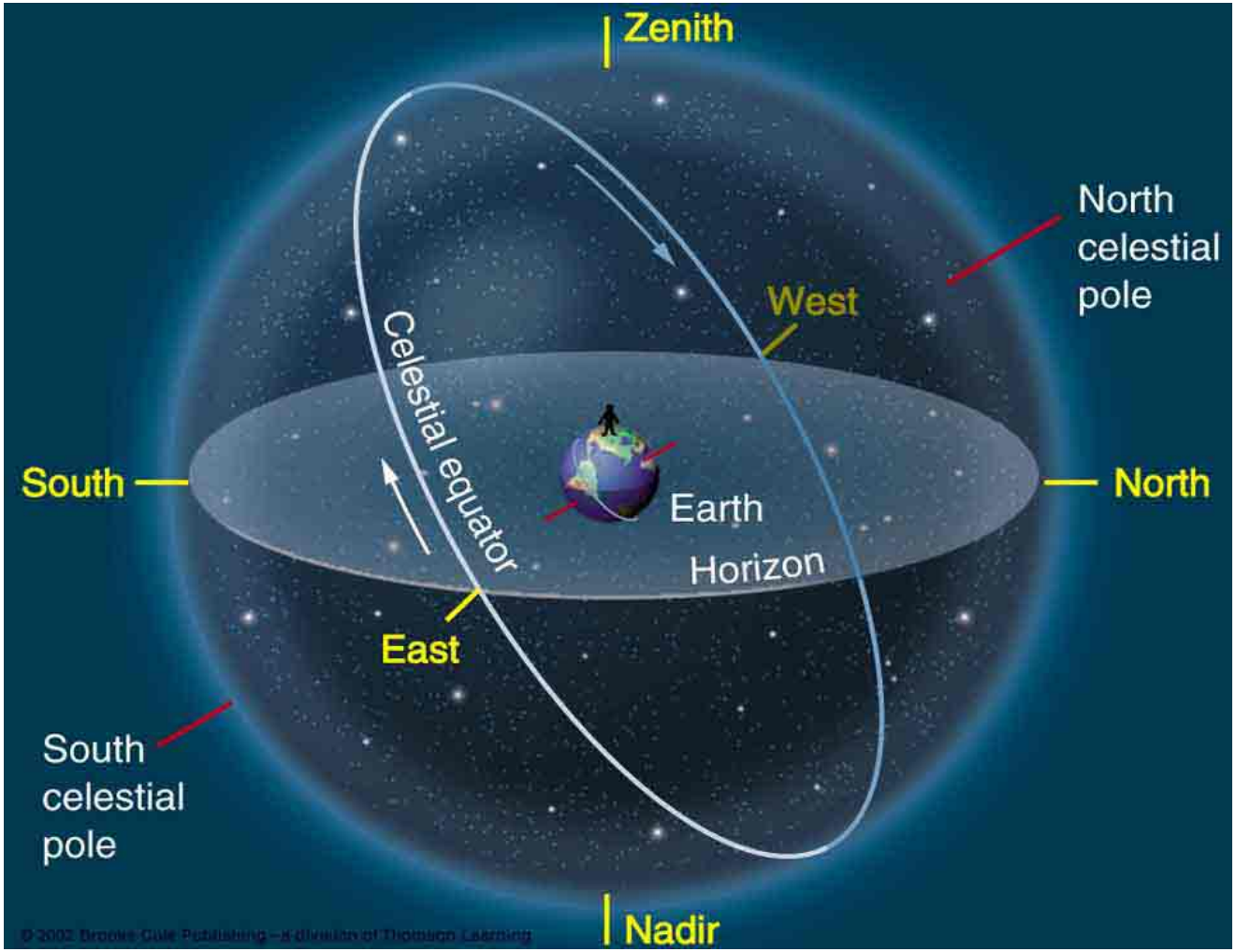
**170,000,000 ly**

- **It has taken twelve steps of 100 to go from human scale to the scale of the cosmos**
  - **How do we quantify this?**
- **Appropriate units**
  - **In ordinary life we use inches for small things, miles for large**
  - **Astronomers use meters for small things, "AU" for planets, light-years for stars**
- **Use scientific notation: $10 = 10^1$ $100 = 10^2$ $1000 = 10^3$ $0.1 = 10^{-1}$ $0.01 = 10^{-2}$**
  - **It makes it possible to easily express large and small numbers**
  - **It also makes dividing and multiplying them easier.**

# Powers of Ten Movie

- **Original "Powers of Ten" Movie (imitated but never duplicated!)**
- **"Cosmic Voyages" video, narrated by Morgan Freeman (Imax version at Smithsonian Institute)**
- **First five minutes of the 1997 film *Contact***
- **Movie Time!**

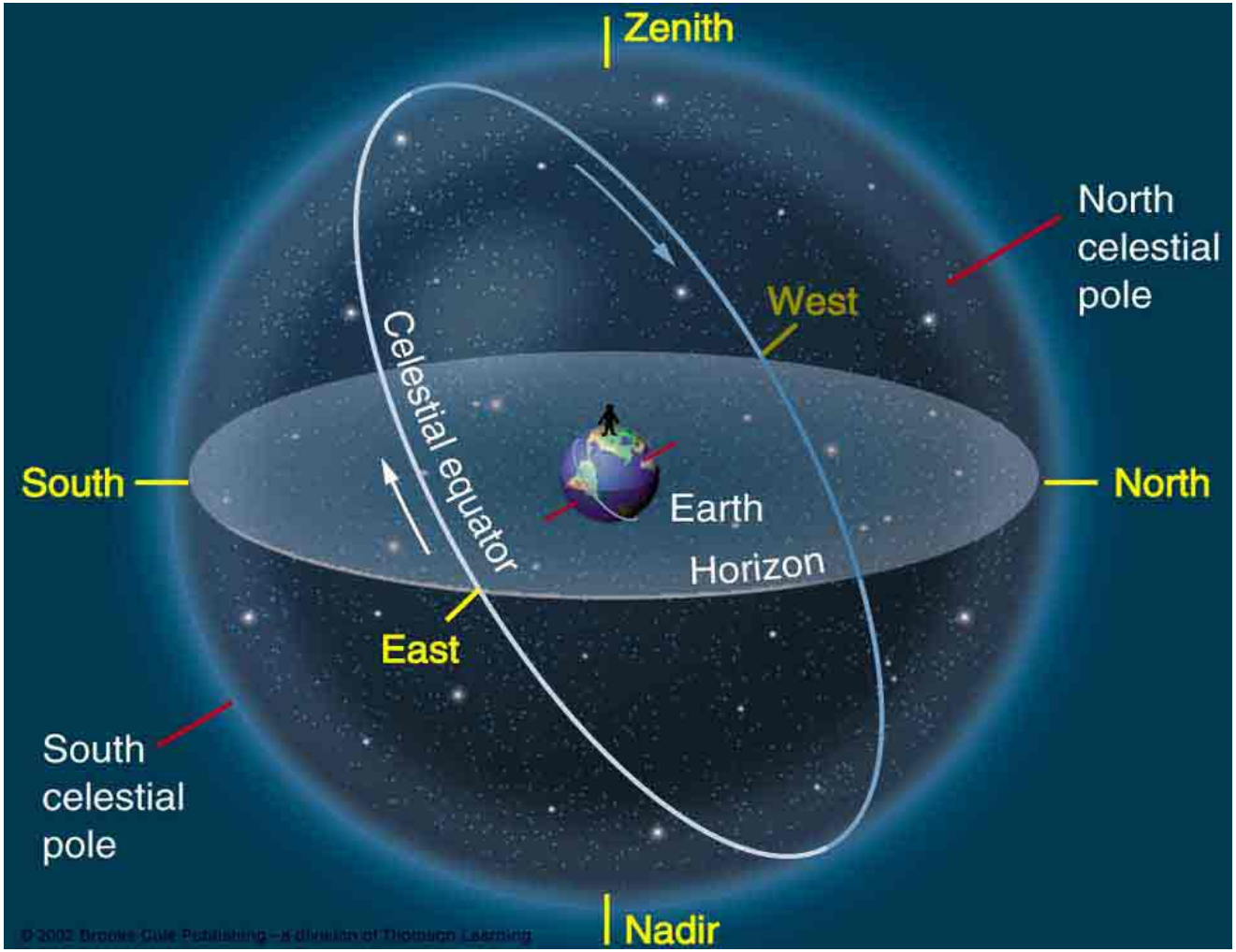
# Celestial Sphere



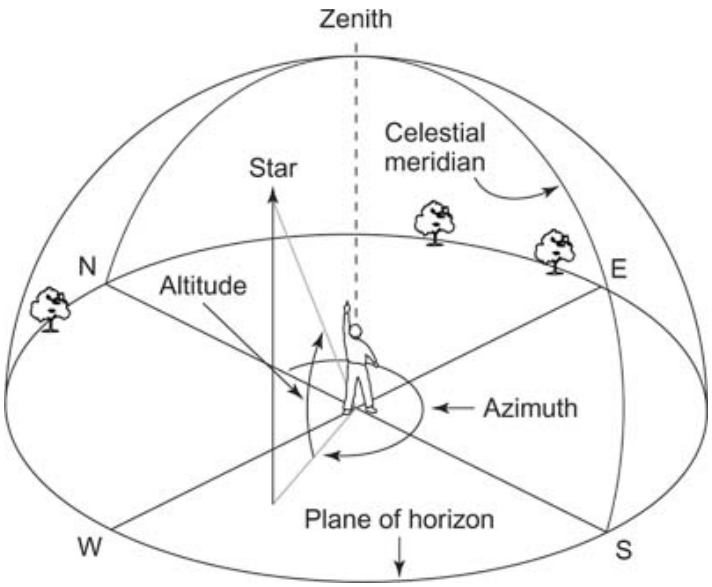
# Celestial Sphere Concepts

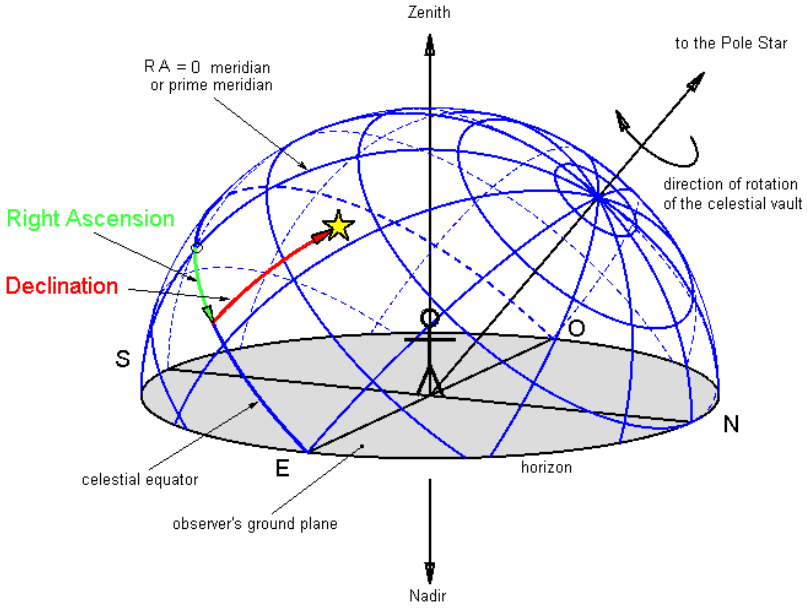
- **Reference points**
  - **Horizon, Zenith & Meridian**
  - **North and South Celestial Poles, Celestial Equator**
- **Effects of Latitude**
  - **Height of Celestial Pole**
  - **Circumpolar Stars**
- **Effects of Earth's Rotation**
  - **Rising and Setting of Celestial Obects**
  - **Time and Time Zones**
  - **Ecliptic**

# Celestial Sphere



# Celestial Sphere




- **Geocentric coordinates: Altitude & Azimuth**
- **Celestial coordinates: Right Ascension & Declination (plus Hour Angle)**
- **Transformation between them requires spherical trigonometry**

# Nomenclature

- **HORIZON:** **The horizontal circle which separates the part of the sky visible to you and the part of the sky hidden by the earth. Half the Celestial Sphere is visible at any given time but the visible portion depends on latitude and time of day and year.**

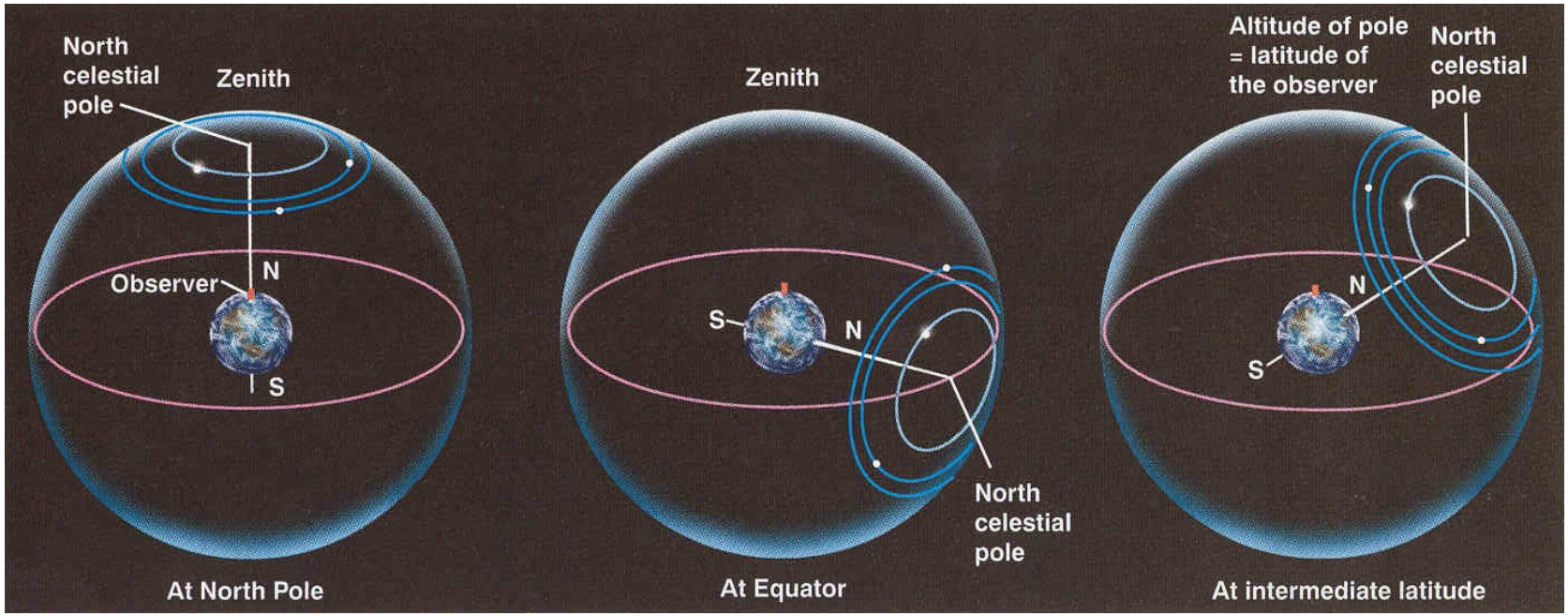
- **ZENITH:** **The point on the sky directly overhead.**

- **MERIDIAN:** **The circle which starts on the northern horizon, runs through the zenith, continuing on to the southern horizon. It separates the eastern half of the sky from the western half.**

- **CELESTIAL POLES:** **The points where the extension of the rotation axis of the earth would intersect the celestial sphere. The NCP is the North Celestial Pole and the SCP is the South Celestial Pole.**

- **CELESTIAL EQUATOR:** **The circle around the sky corresponding to the projection of the earth's equator. The Celestial Equator divides the Northern Sky from the Southern Sky.**

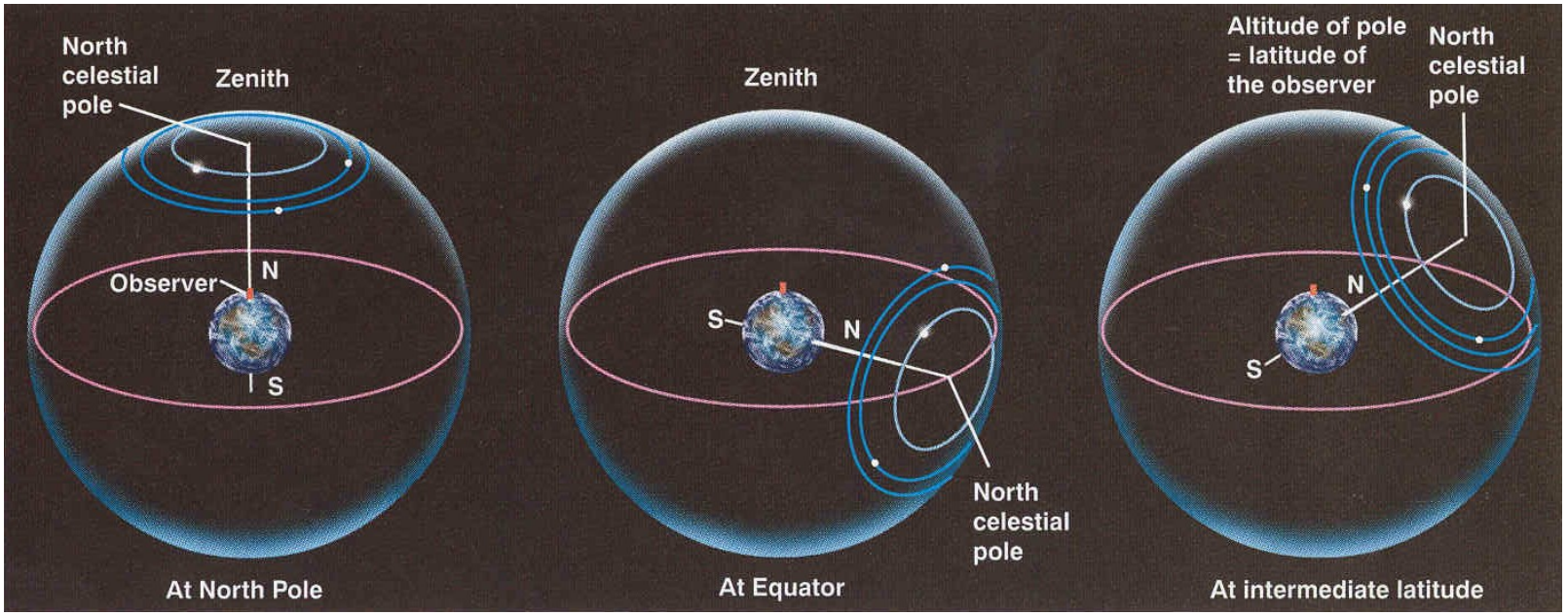
# Effects of Latitude




From Voyages through the Universe, by Fraknoi et al.

- **At the Earth's north pole, looking overhead all stars appear to circle around the north celestial pole.**
- **At the equator:**
  - **Stars on the celestial equator rise in the east, move overhead, then set in the west**
  - **The N and S celestial poles are just on your N and S horizons, and stars near those points still circle around them. But those stars are only visible for the upper half of their circles.**

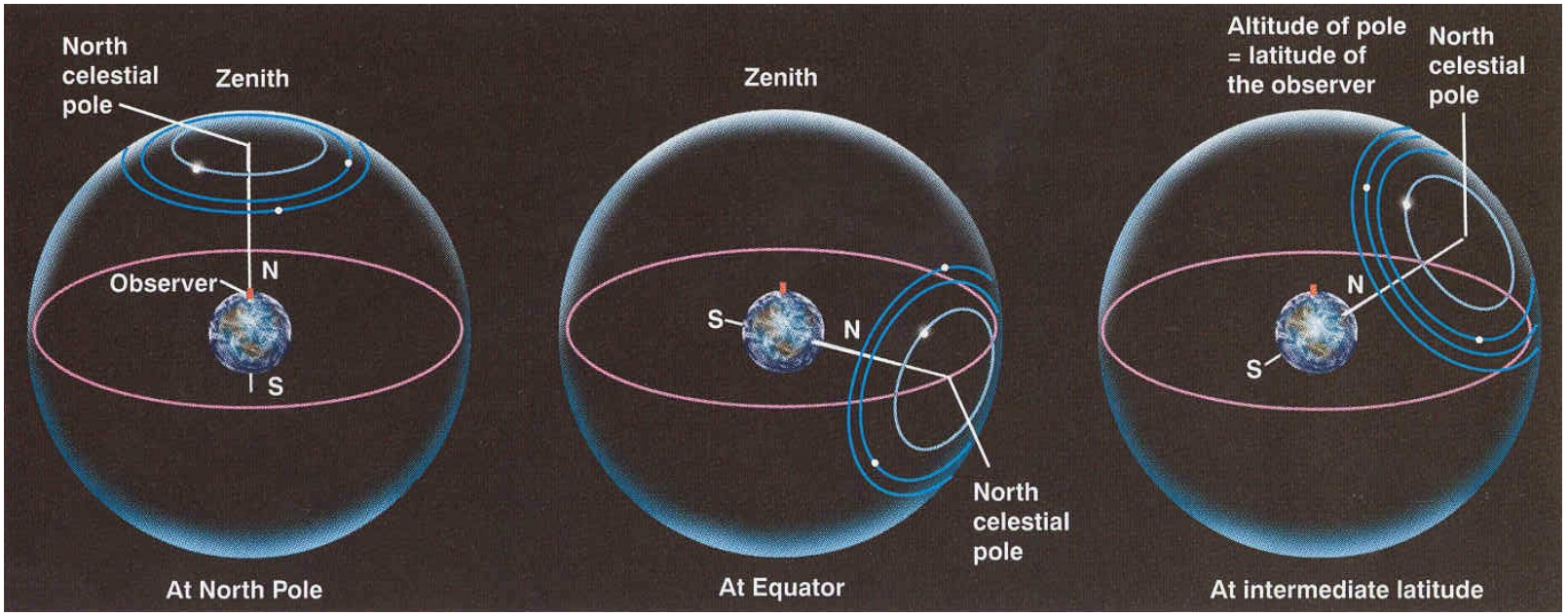
# Intermediate cases like Laramie




From Voyages through the Universe, by Fraknoi et al.

- **Height of the Celestial Pole is your latitude. Stars close enough to the north celestial pole are always above the horizon, and just circle the pole star. (CIRCUMPOLAR STARS)**
- **Stars on the celestial equator rise in the east, move higher along a slanted path which crosses the "meridian" to the south of the zenith, then descend and set due west.**
- **Stars far enough to the south never make it above the horizon.**

# Intermediate cases like Laramie

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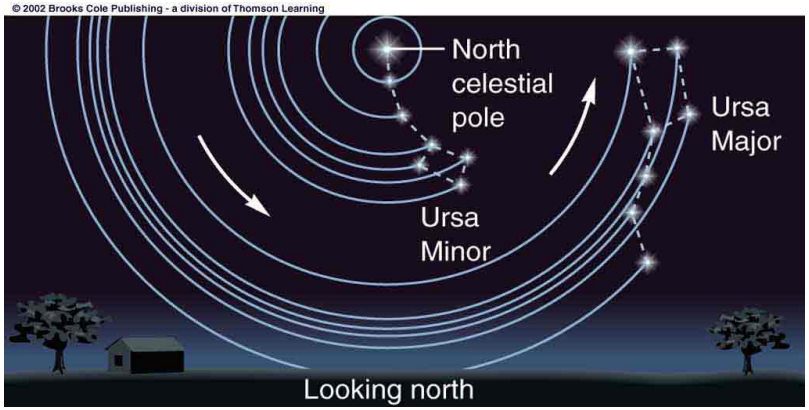
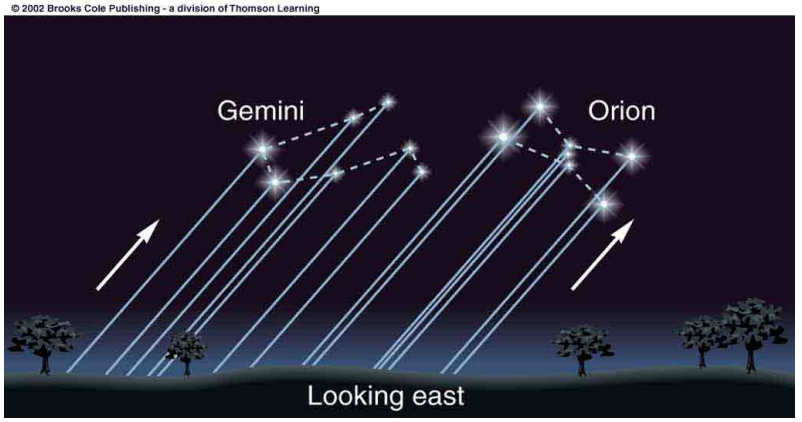
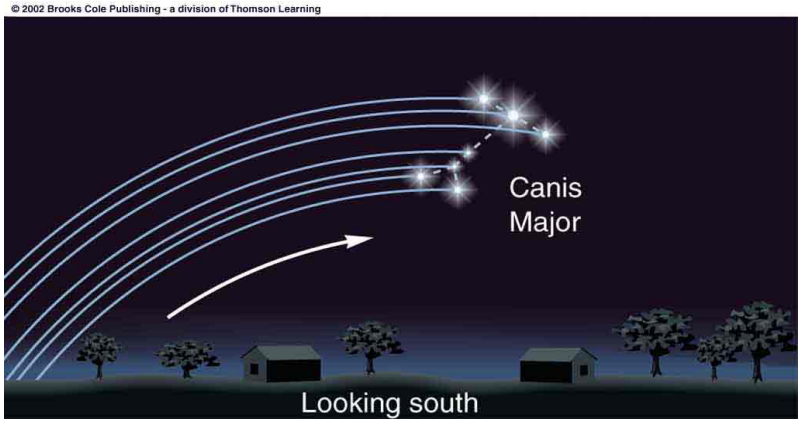
- **Stars far enough to the south never make it above the horizon.**

# Effects of the Earth's Rotation: Stellar Motion from the Northern Hemisphere

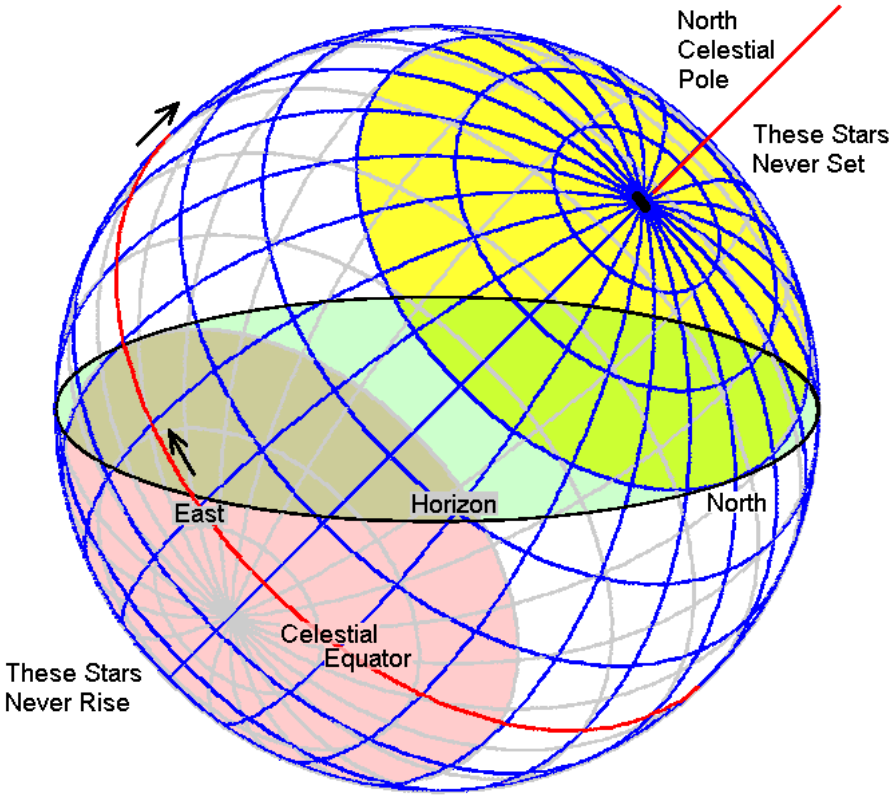


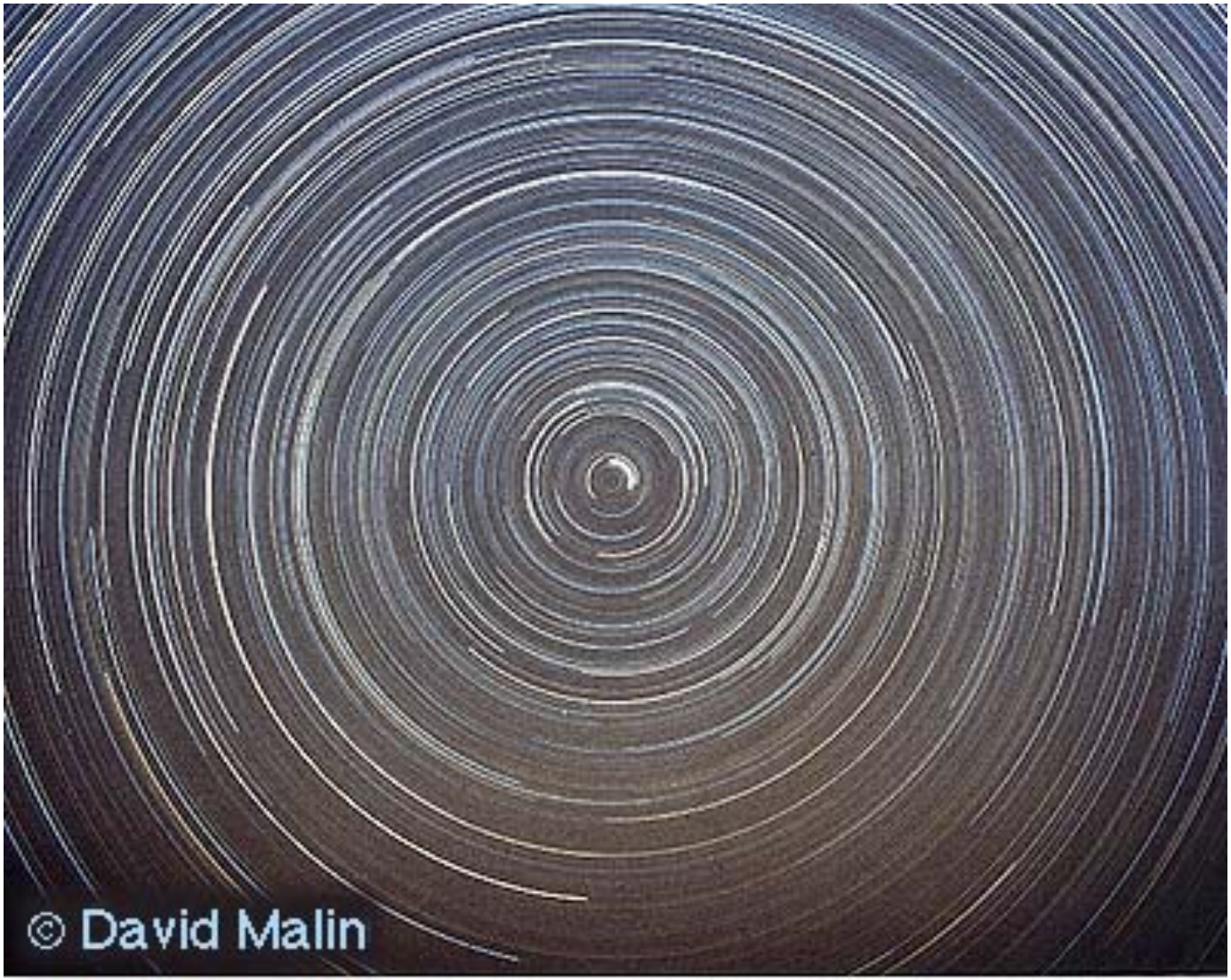



# Circumpolar Stars

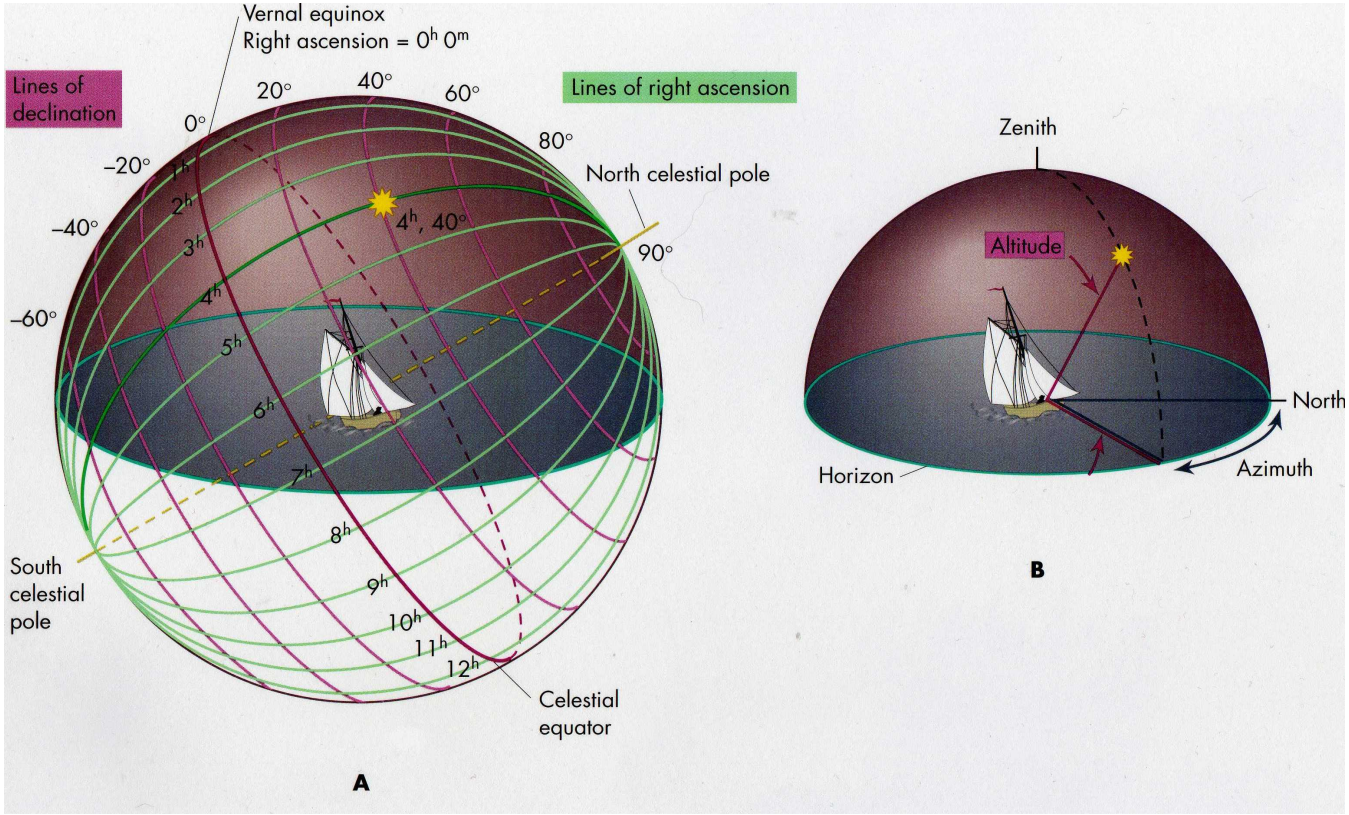
- **Northern Hemisphere**
  - **Stars near NCP (within observers latitude) don't set**
  - **Stars near SCP (within observers latitude) don't rise**
  - **Where is the Zenith?**
  - **Where is the Celestial Equator?**



# Circumpolar Star Trails



# Astronomical Coordinates




**The location of an astronomical object can be specified via Right Ascension (RA) and Declination (Dec.) (left) or in real-time via Altitude (Alt) and Azimuth (AZ) (right). Define the zero point as the location of Sun at Vernal Equinox (~ March 21-st).**

# Lab this Week

- **Celestial Sphere & Planetarium Visit**
  - **Understand the geocentric perspective**
    - **Horizon, Zenith & Meridian**
    - **Celestial Pole, Celestial Equator**
      - **Effect of Latitude**
      - **Circumpolar Stars**
    - **Rotation of the Earth**
      - **Time and Time Zones**
      - **Rising and Setting of Celestial Objects**
  - **Understand Seasonal Motions**
    - **Origin of Seasons**
    - **Annual Drift of Stars**

# Key Concepts of Chapter 1

- **Celestial Sphere**
  - **The geocentric perspective**
  - **Coordinate Systems**
  - **Celestial Motions**
  - **Solar & Sidereal Time (lecture 2)**
  - **Calendars (lecture 2)**

# Key Concepts of Chapter 1

- **Celestial Sphere**
  - **The geocentric perspective**
  - **Coordinate Systems**
  - **Celestial Motions**
  - **Solar & Sidereal Time**
  - **Calendars**

# Homework this Week

**No Homework this week**

# Reading this Week

**By Next Thursday:**

**Review Math**

- **Review Celestial Sphere, Celestial Motions**
- **http://en.wikipedia.org/wiki/Celestial_sphere**

**By Next Tuesday:**

- **Finish Chapter 1 & Begin Chapter 2**