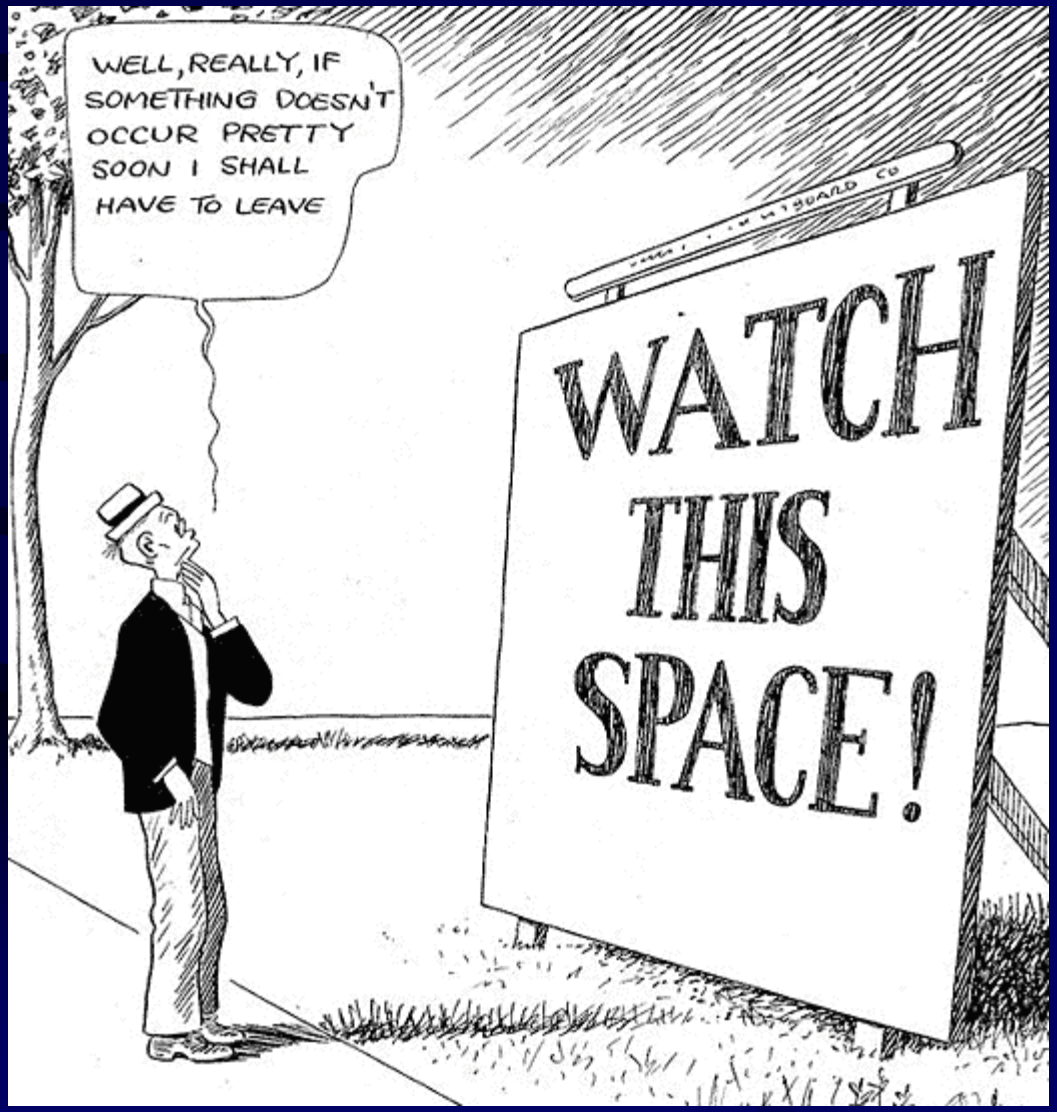
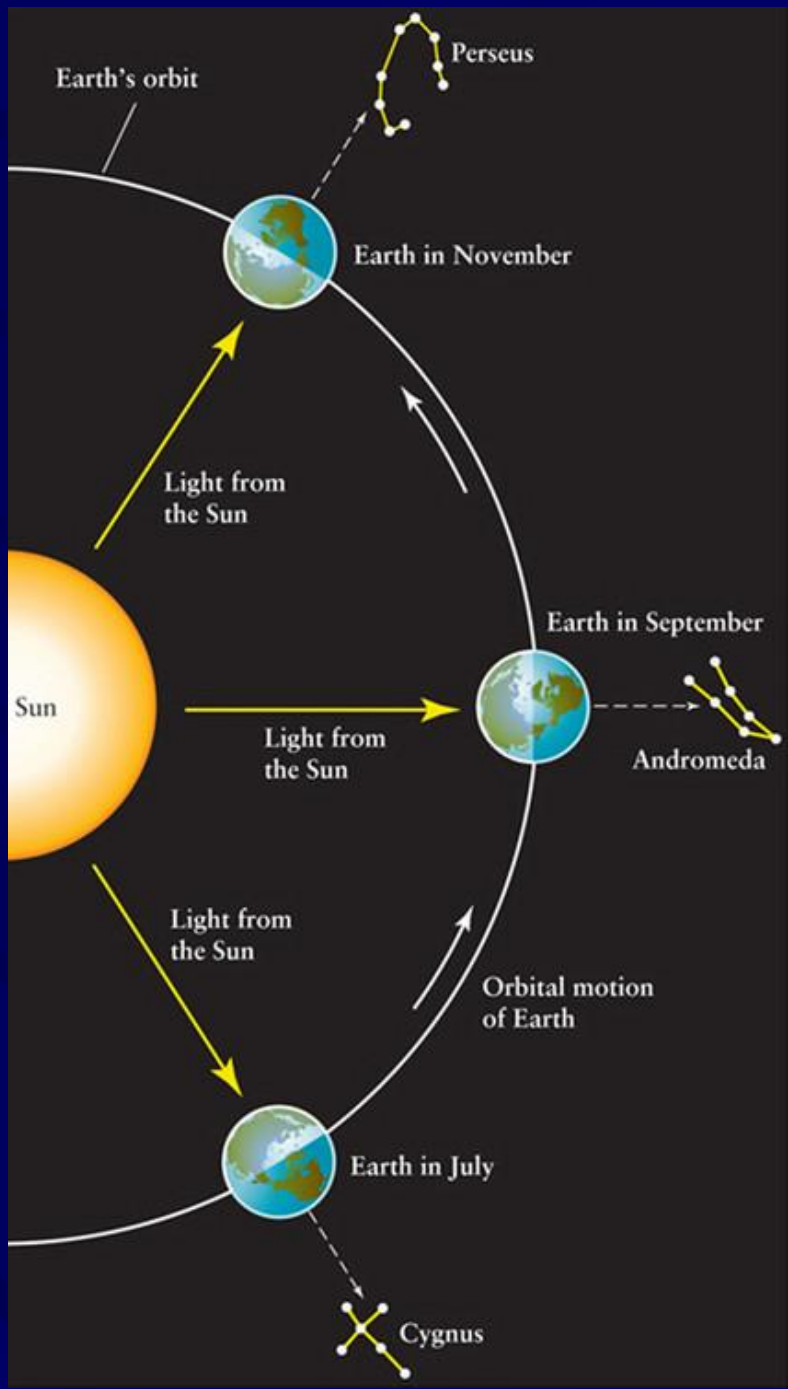
Seasonal Motion



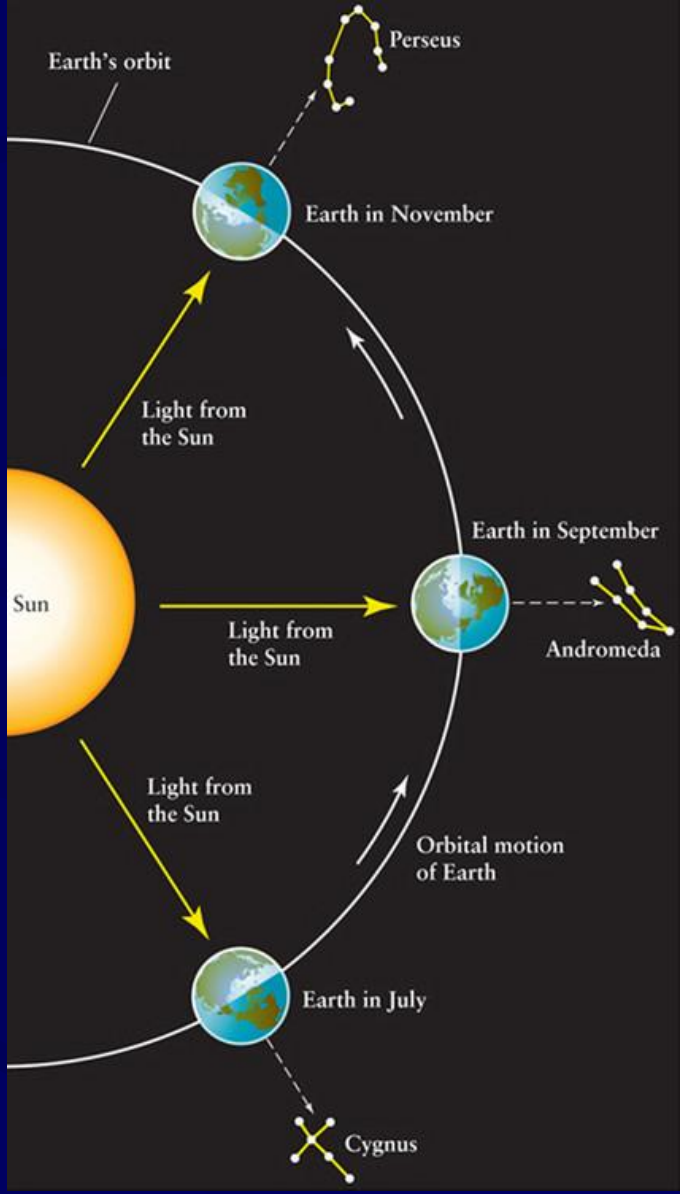
Reminder: Seasonal Motion

- If you observe the sky at the same time, say midnight, but on a different date, you find that the celestial sphere has turned: different constellations are high in the sky



Equivalent Skies

- Celestial Sphere turns 15º per hour due to daily motion, and 1º per day due to seasonal motion.
- So fifteen days are equivalent to one hour!
- Meaning: Stars look the same if you observe 15 days later (date) but 1 hour earlier (time)
  - Example: Same view on Sep 1 10pm and Sep 15 9pm and Sep 30 8pm



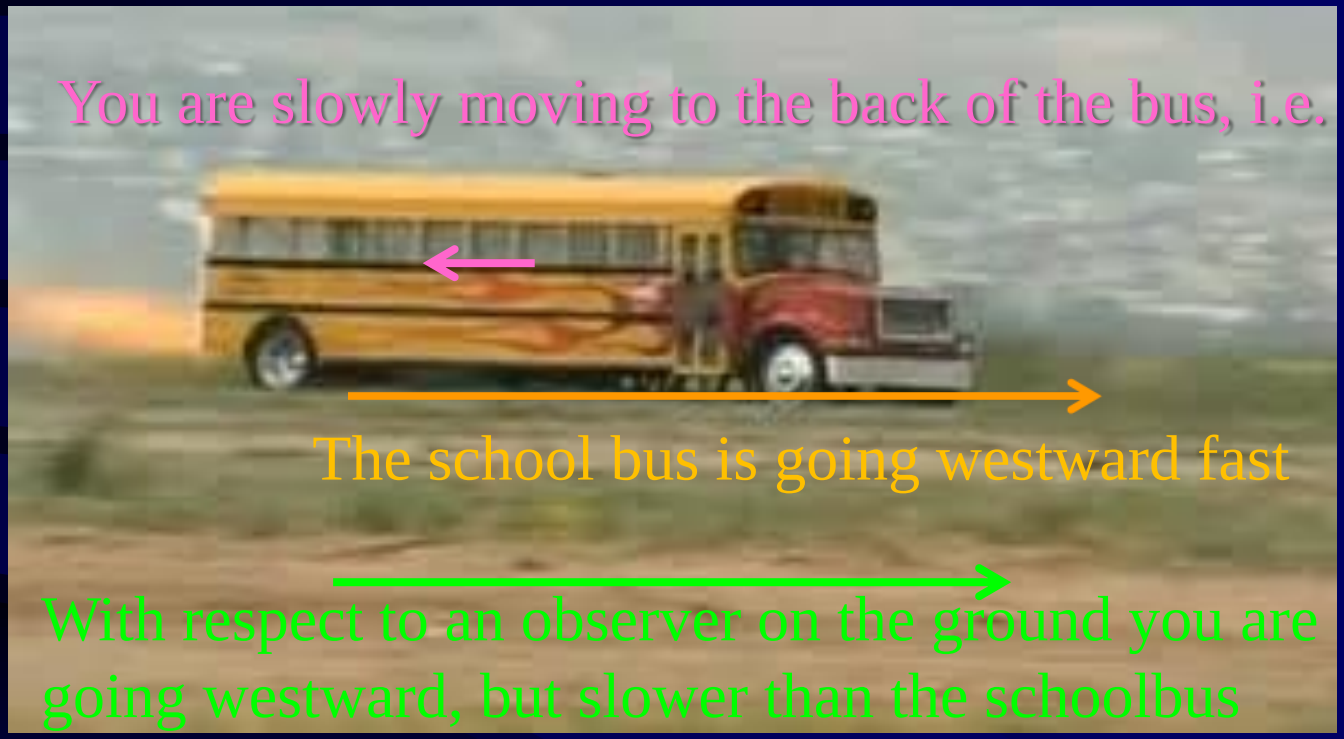
Cross-Checks

- In one month the stars rise earlier 2 hours compared to the sun
  - Makes sense, since 4 min/day x 30 days = 120 min = 2 hours
- After 6 month we have to observe 6 x 2 hours =12 hours earlier
  - The stars visible at midnight half a year earlier are now “visisble” at noon
  - Makes sense, since earth has traveled to the other “side” of its orbit

Fast and slow motion of the sun added together: Sun is slower than the stars, but still pretty fast

- The sun moves from east to west daily, i.e. fast
- Additionally, it moves with respect to the stars slowly from west to east – this is the seasonal motion
- Added together the sun moves west, but slower than the stars, cf. moving backwards on a schoolbus

School Bus Analogy



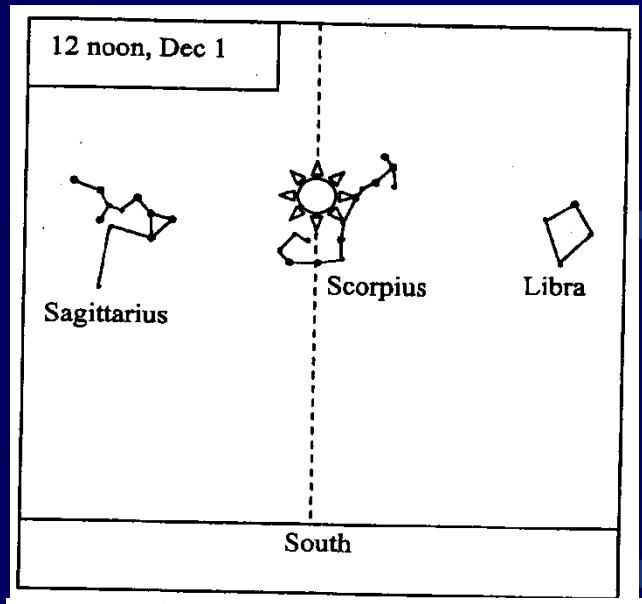
East

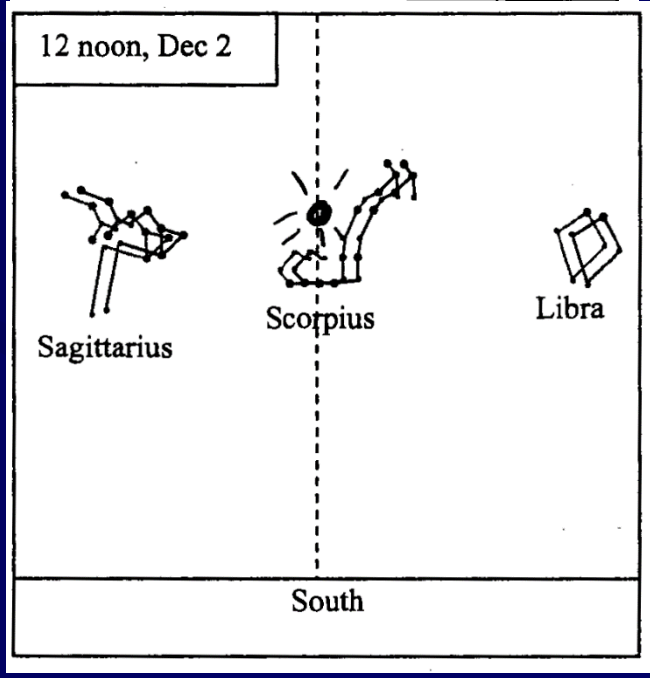
West

You = the sun, school bus = the celestial spehere, i.e. stars,
Observer on the ground = Observer on earth

How do we "see" that the Earth is moving around the Sun or v.v.?

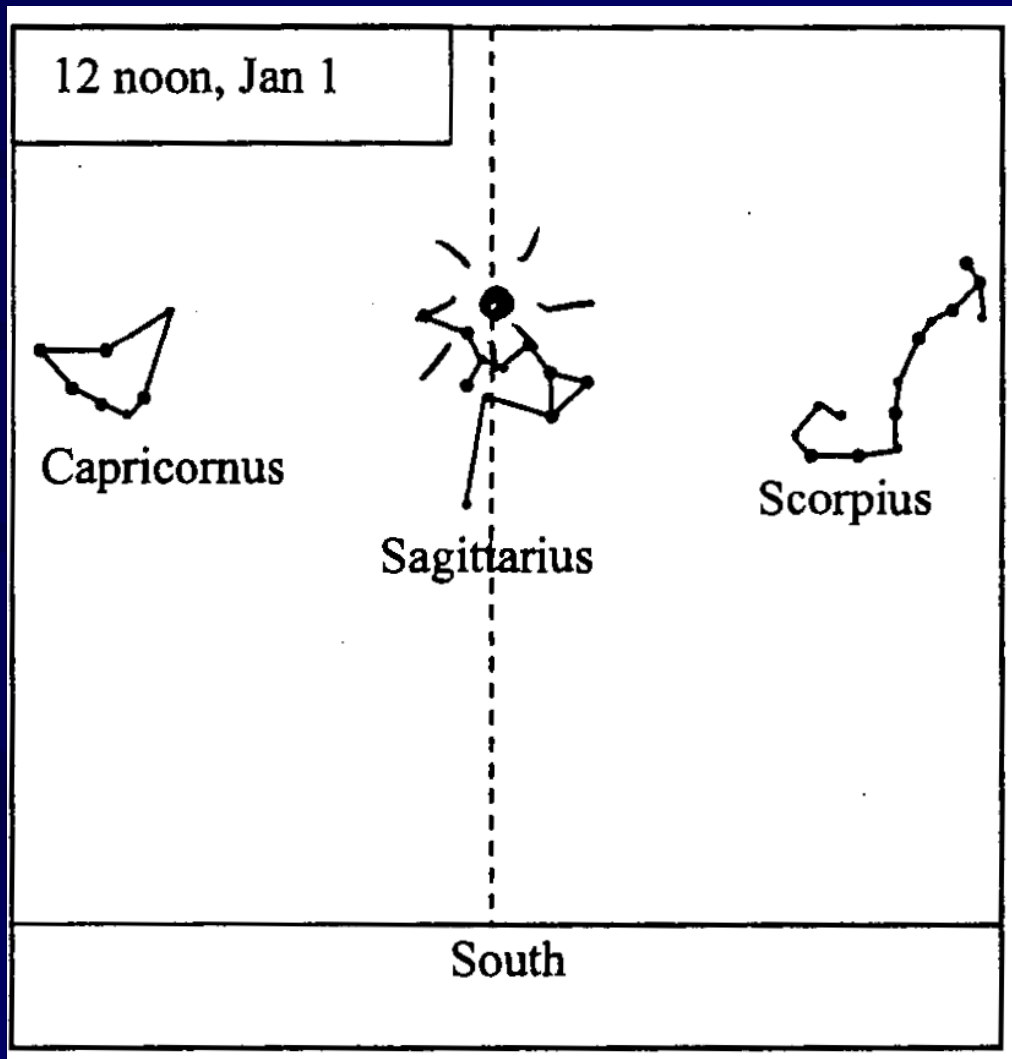
- Small discrepancy between sun's motion and motion of stars
- Sidereal vs solar day
- At noon, say, the sun is not exactly in front of the same stars on the next day.
  - It is exactly in the south
  - The stars are faster, so a little west of south





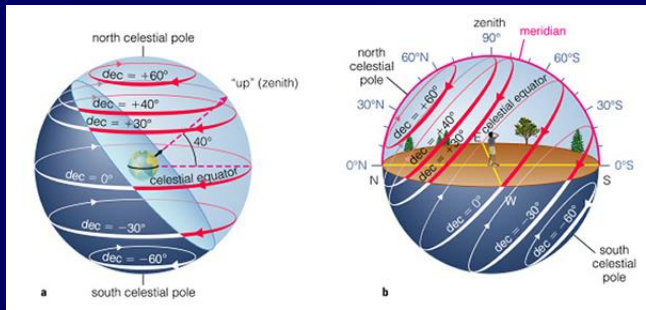
Eventually, the sun drifts slowly into the next zodiac constellation

- 4 min/day = 2 hr/mo = 12 hr/ ½ year
- Also: 2 hr = 30 deg, and 30 degrees = one constellation
- So: 12 constellations per year, 1 for each month



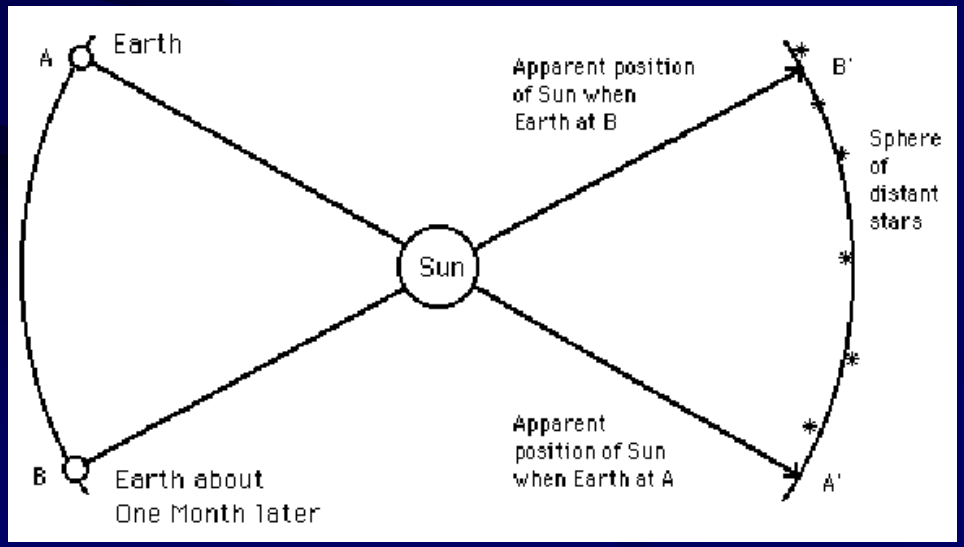
Two simple rotations around different axes and an observer oriented in a third direction

- This explains a lot of features of the universe as observed in the sky!
  - Daily rising and setting
  - Different lengths of days (sun moving wrt cel.eq.)
  - Different altitude of sun at noon at different dates
  - Different altitude of sun at noon at different latitudes
  - Solar/sidereal day are different



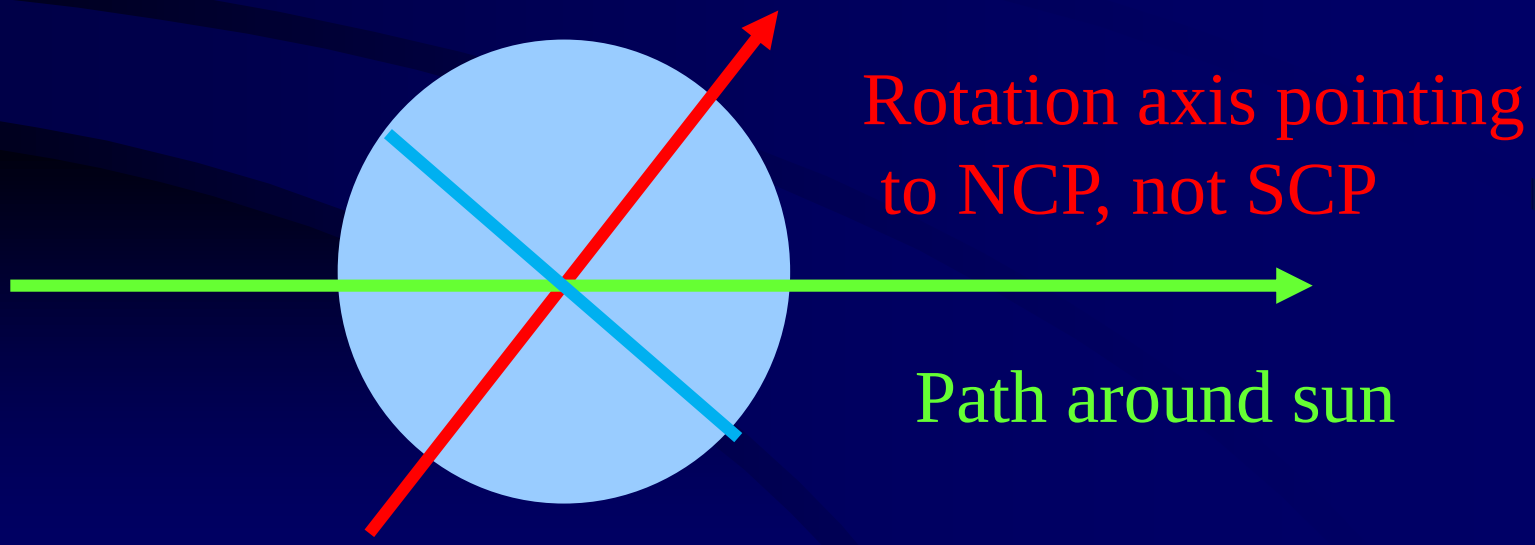
The Path of the Sun

- Which path does the sun trace out with respect to the stars?
  - The earth goes around the sun in the plane of the ecliptic, so expect celestial equator, but this is wrong due to Earth's axis tilt
  - See Skygazer: path of the sun



Axis Tilt → Ecliptic

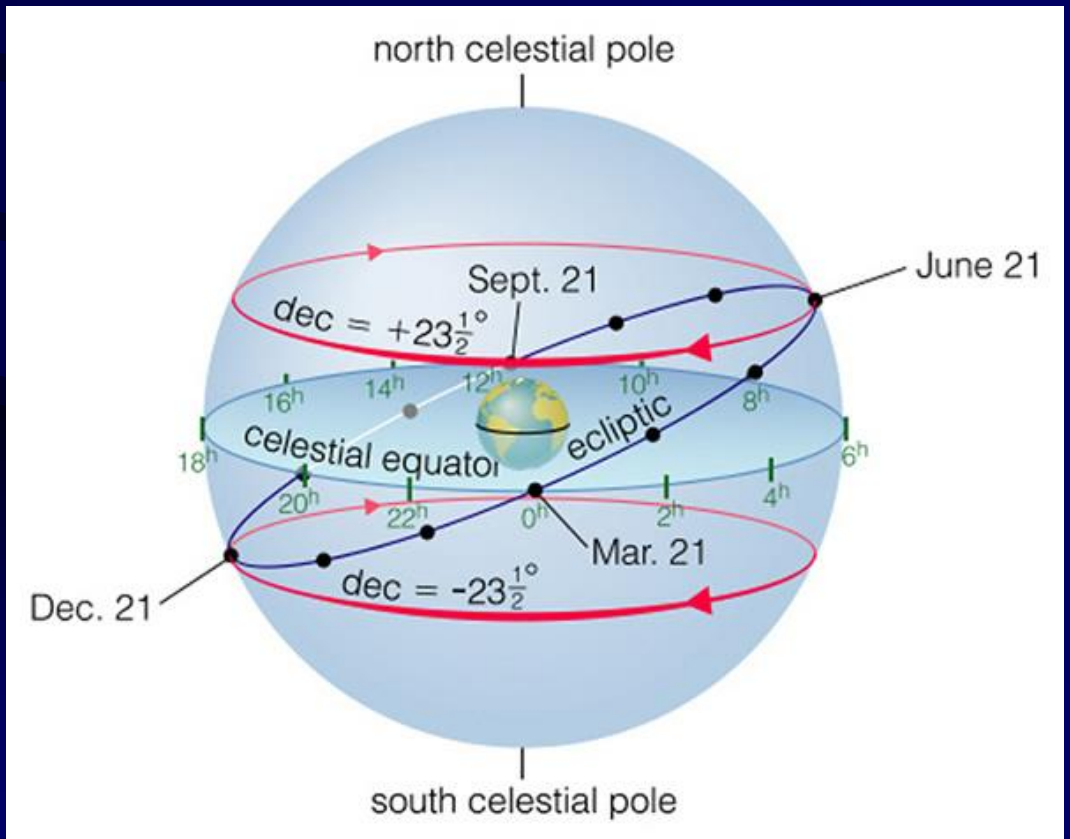
- The Earth's rotation axis is tilted 23½° with respect to the plane of its orbit around the sun
- This means the path of the sun among the stars (called ecliptic) is a circle tilted 23½° wrt the celestial equator



Position of Ecliptic on the Celestial Sphere

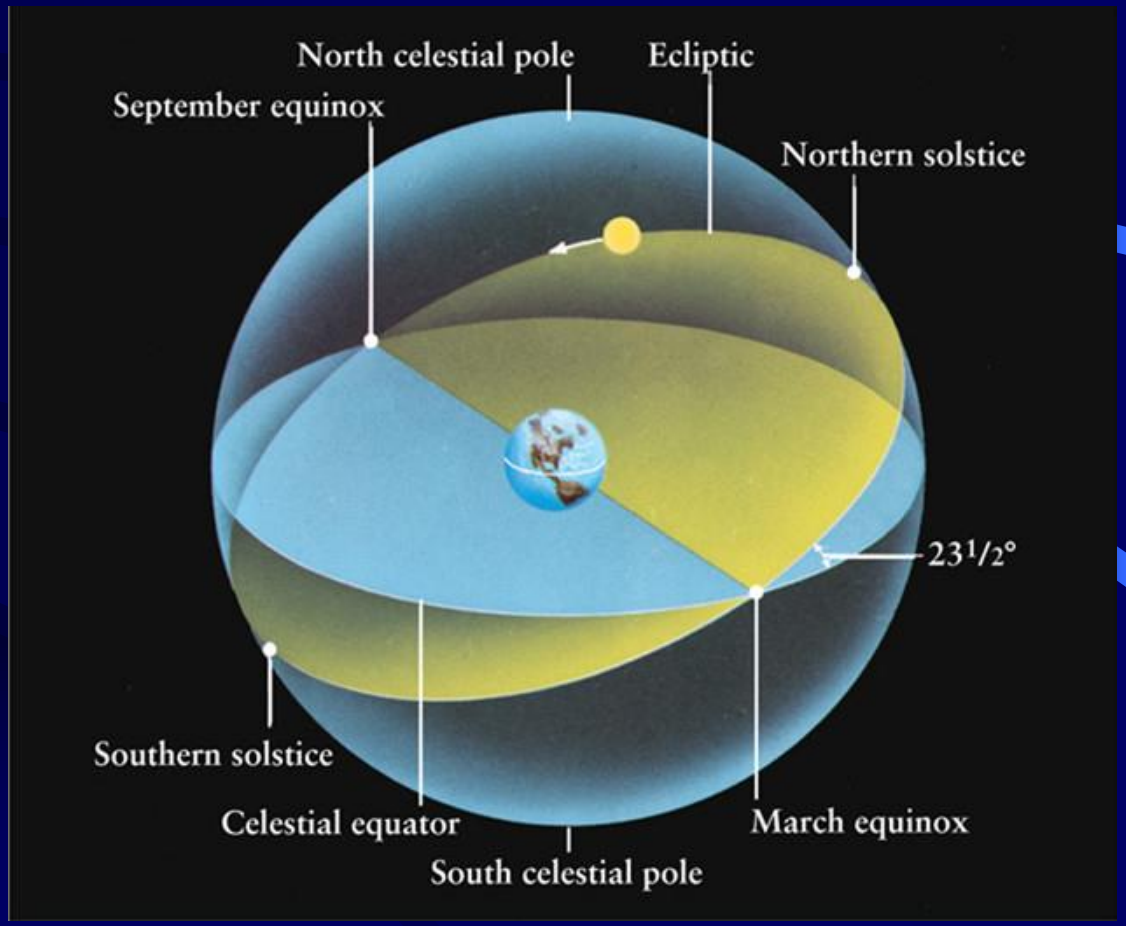
Earth's equator is tilted w.r.t. ecliptic by 23 ½ degrees

➔ Sun appears to be sometime above (e.g. summer solstice), sometimes below, and sometimes on the celestial equator



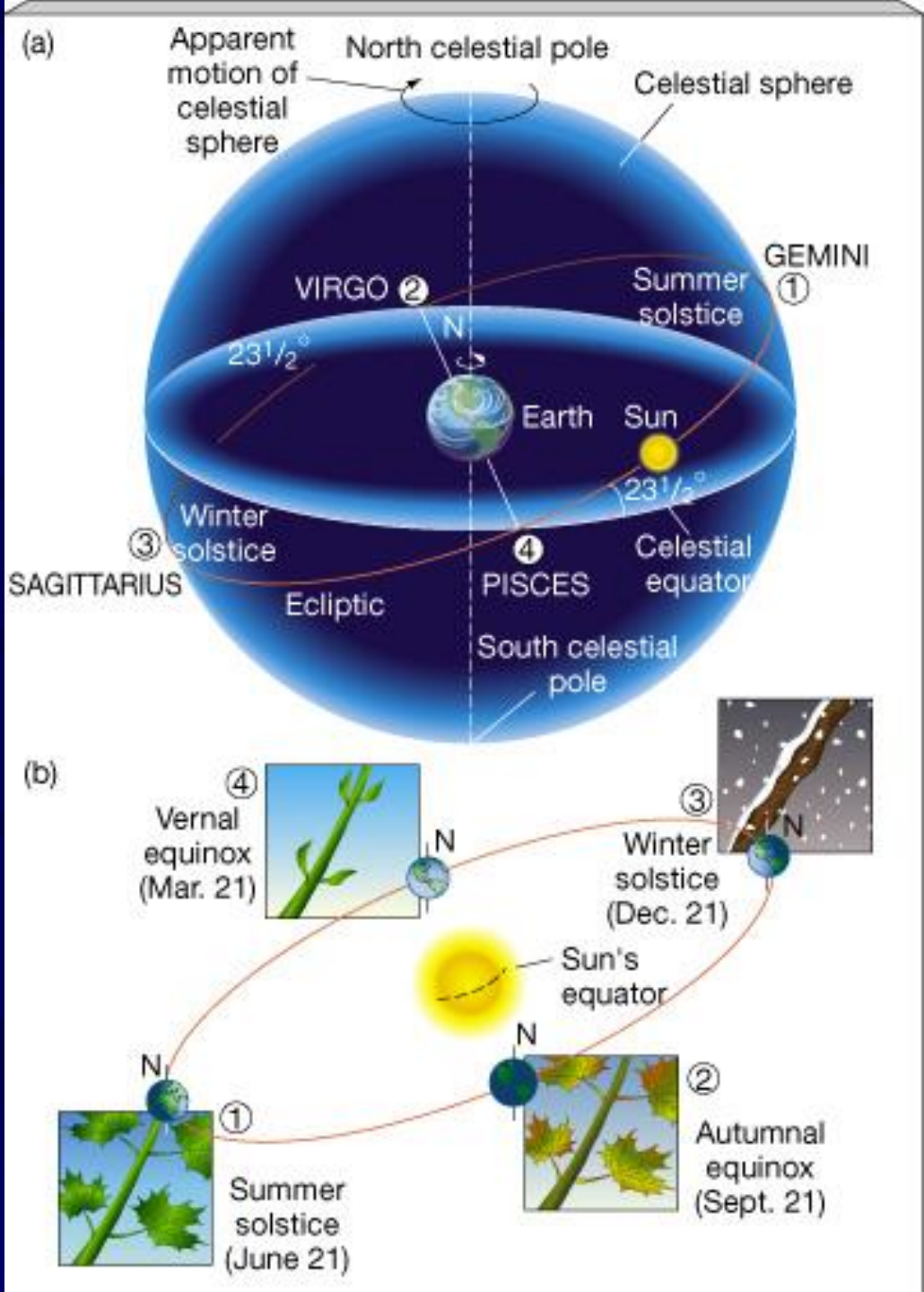
The Sun appears sometimes among the stars above the Celestial Equator, and sometimes amongst the southern stars

- March 21 – March (vernal) equinox
- June 21 – northern Solstice
- September 23 – September (autumnal) equinox
- December 21 – southern Solstice



The Seasons

- Change of seasons is a result of the *tilt* of the Earth's rotation axis with respect to the plane of the ecliptic
- Sun, moon, planets run along the ecliptic



Is the sun rising in the East?

- Typically NOT, only Mar 21/Sep23! See for yourself!
  - Study variation of the rising/setting points of the sun over time
  - Need at least 10 sunrises or sunsets; more is better
  - Measure time and azimuth (angle relative to North)
  - Note position of sunrise/sunset on horizon
  - Measure angle to that position relative to some fixed landmark (mountain, etc.)