

# AY 1

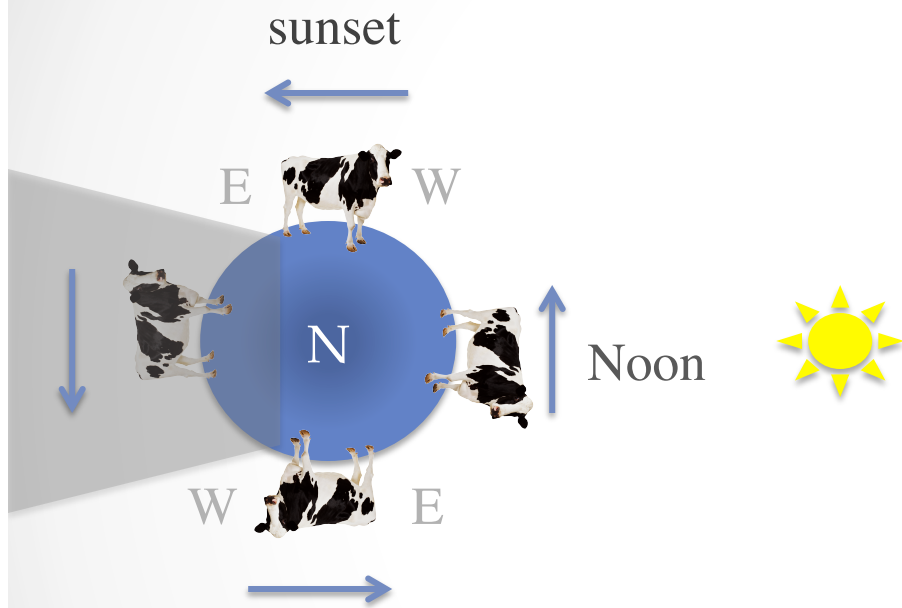
- <https://astro1.sites.ucsc.edu>

# Motions of the Earth



- Stuff everyone should know

# Earth Motions

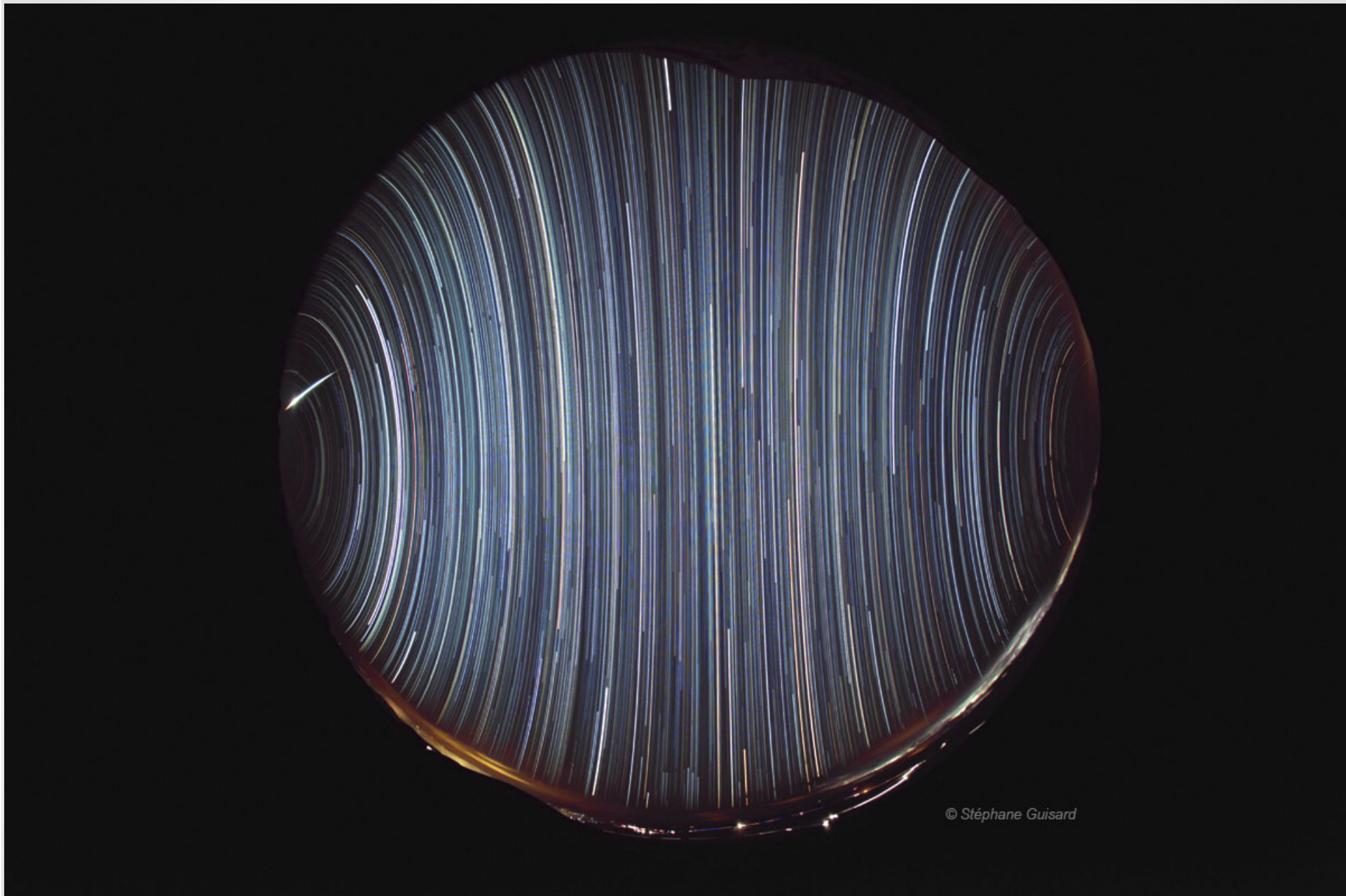


- Why is there day and night?  
OR
- Why do the Sun and stars appear to move through the sky?

Because the Earth rotates around its N-S axis once every 24 hrs



Star trails that include the north celestial pole



• Star trails at the equator •



- How fast is a gaucho napping at the equator moving due to the Earth's rotation (english units)?

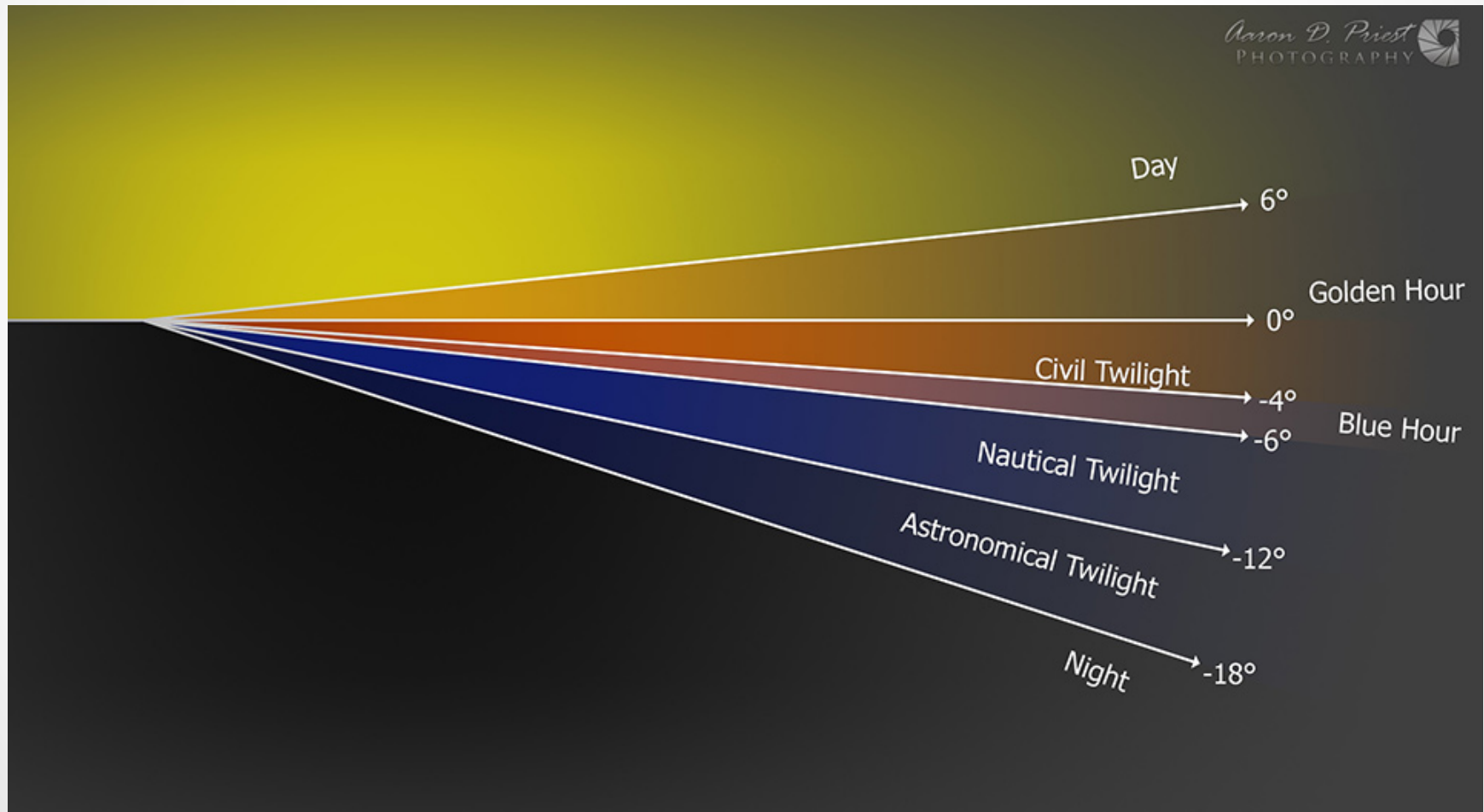
Speed = Distance/time (units like miles/hr)

Distance =  $2 \times 3.14 \times 3820 = 24,000$  miles

$S = 24000 \text{ miles} / 24 \text{ hours}$

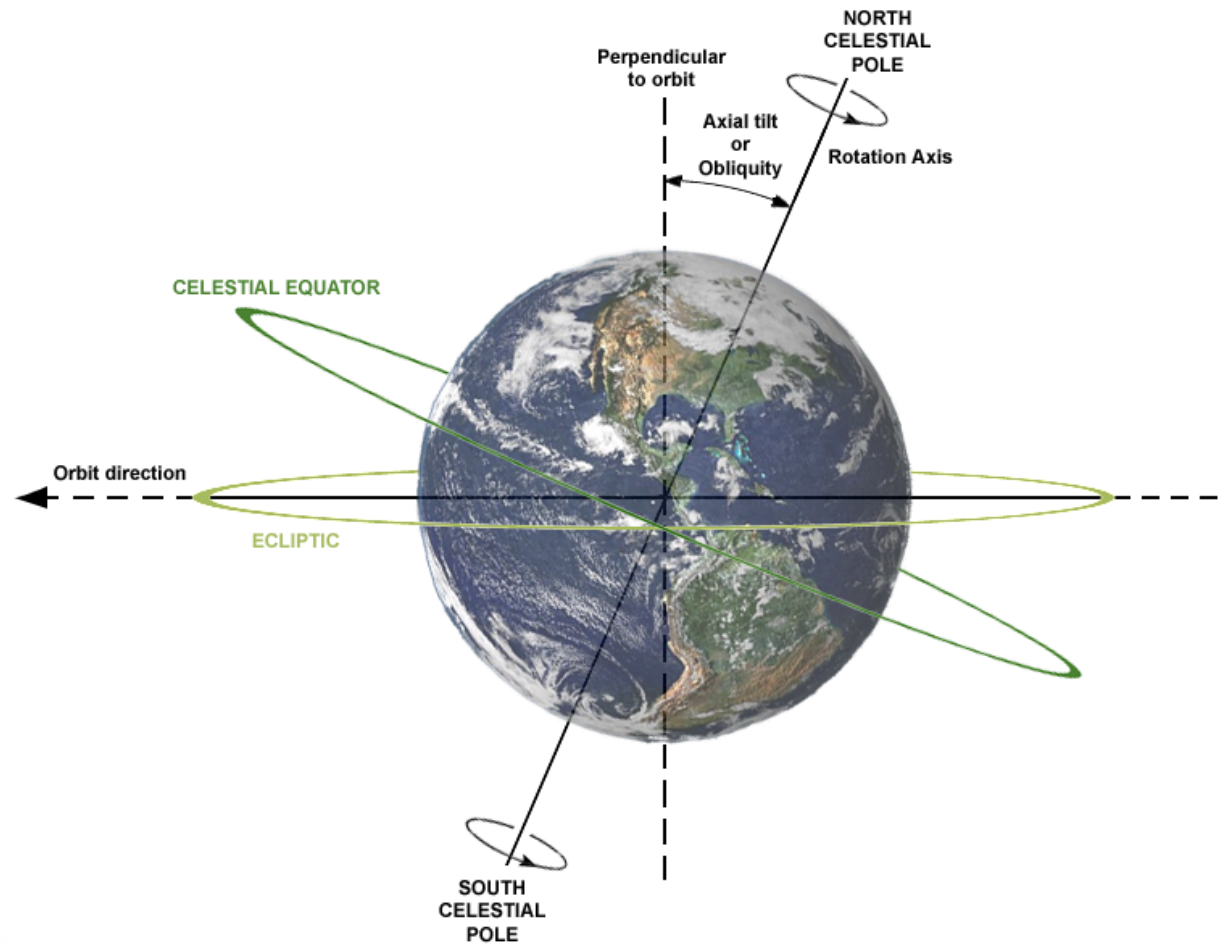
$S = 1000 \text{ miles/hour}$

# Twilight

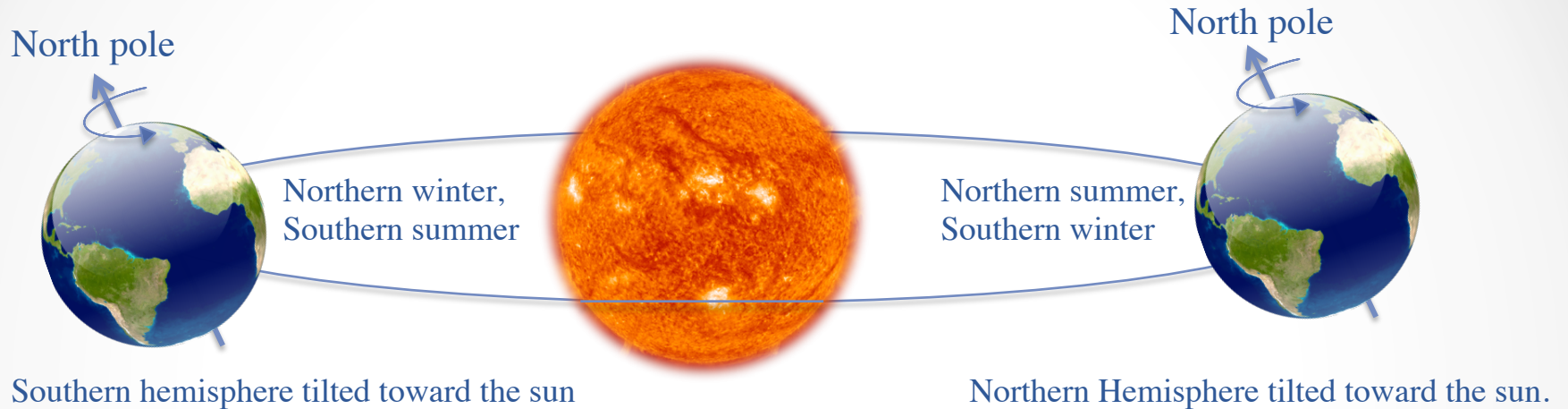




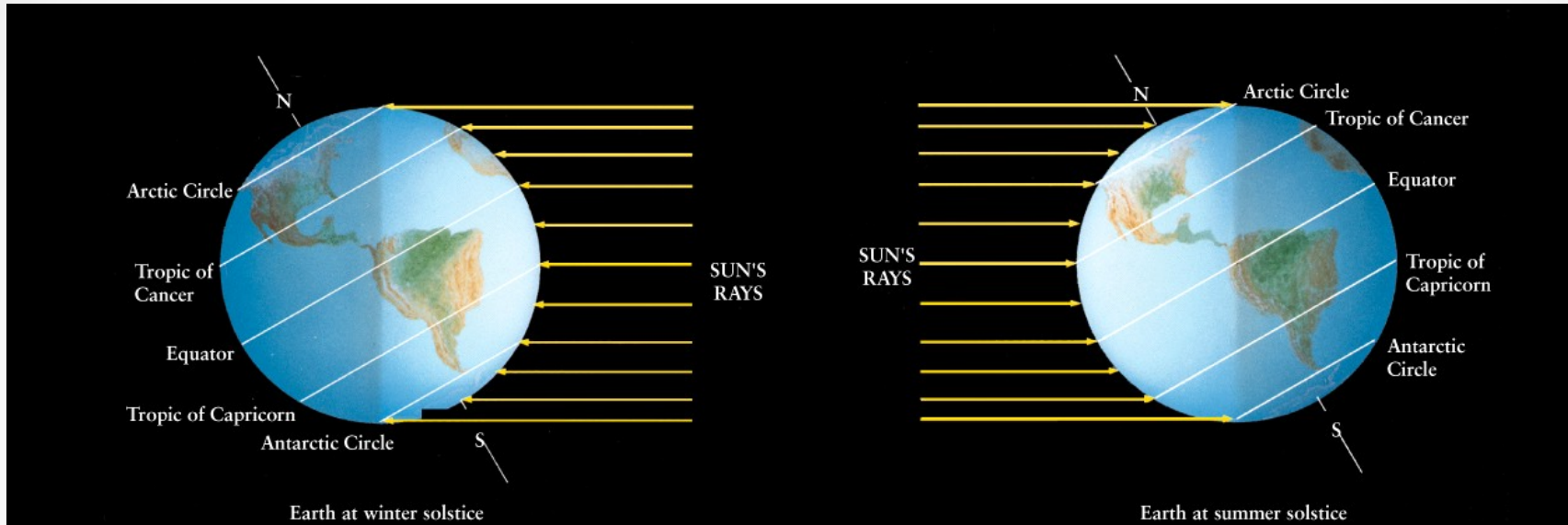
# Seasons: Getting Oriented



# The Reason for Seasons



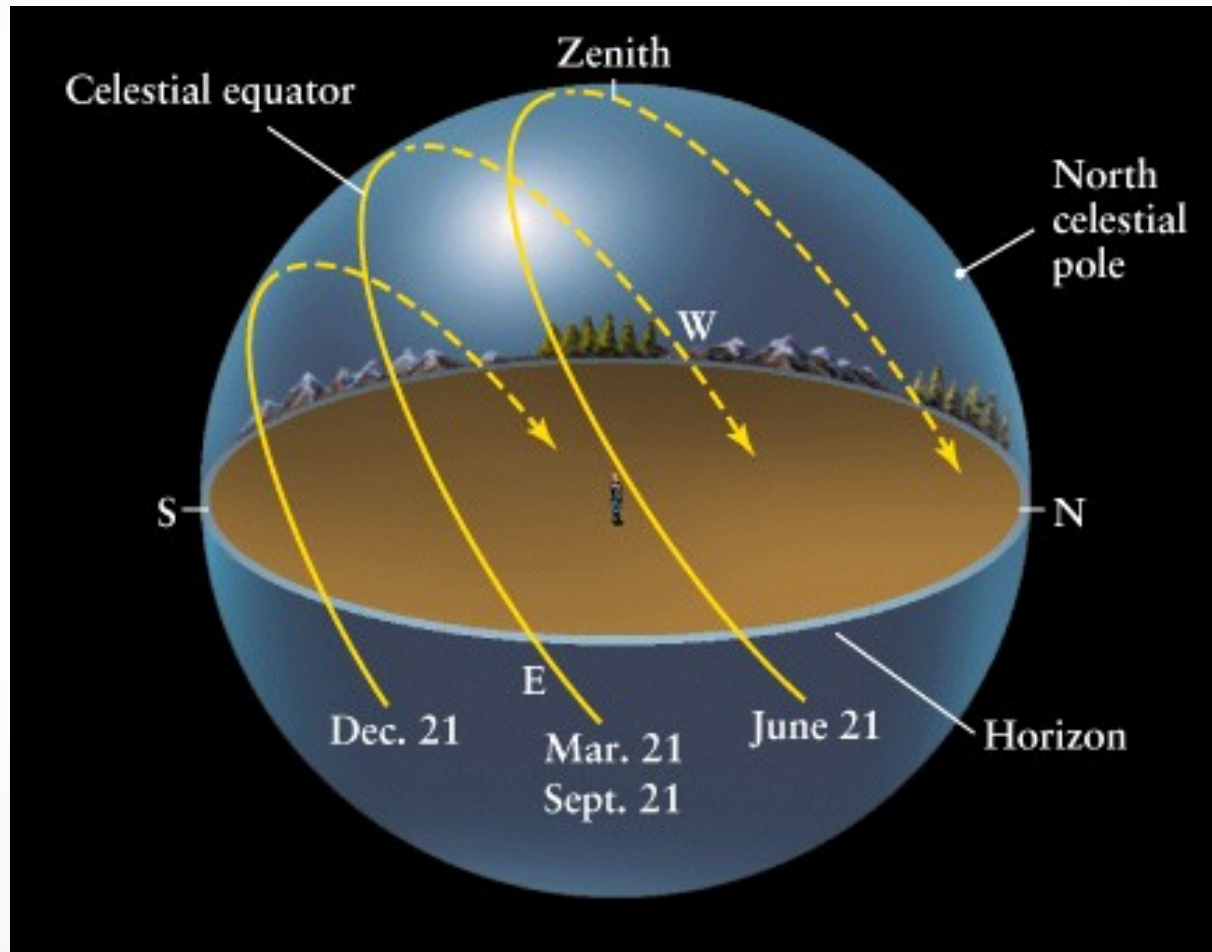
- The Earth is in a slightly elliptical orbit around the Sun - we are ***furthest*** from the Sun during the Northern Hemisphere summer.
- It is the ***tilt*** of the Earth's axis with respect to orbit plane that is the cause of the seasons.



Dec 21 Southern hemisphere summer, Sun is directly above the Tropic of Capricorn

June 21 Northern hemisphere summer, Sun is directly above the Tropic of Cancer

# Sun's Path Through the Year



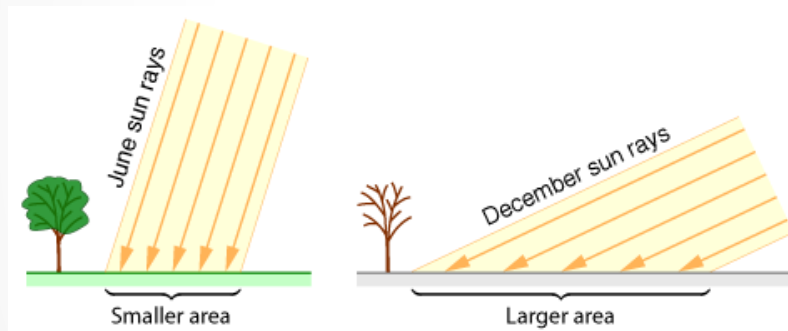
# Reason for Seasons cont.

The tilt has two main effects.

- 1) The path the Sun takes through the sky changes during the year (look to the South to see the Sun in the winter, over head in the summer). Fewer daylight hours in the Winter.
- 2) The intensity of sunlight decreases in the winter (the Sun is at a larger angle from the zenith).

Therefore: it is cold in the winter.





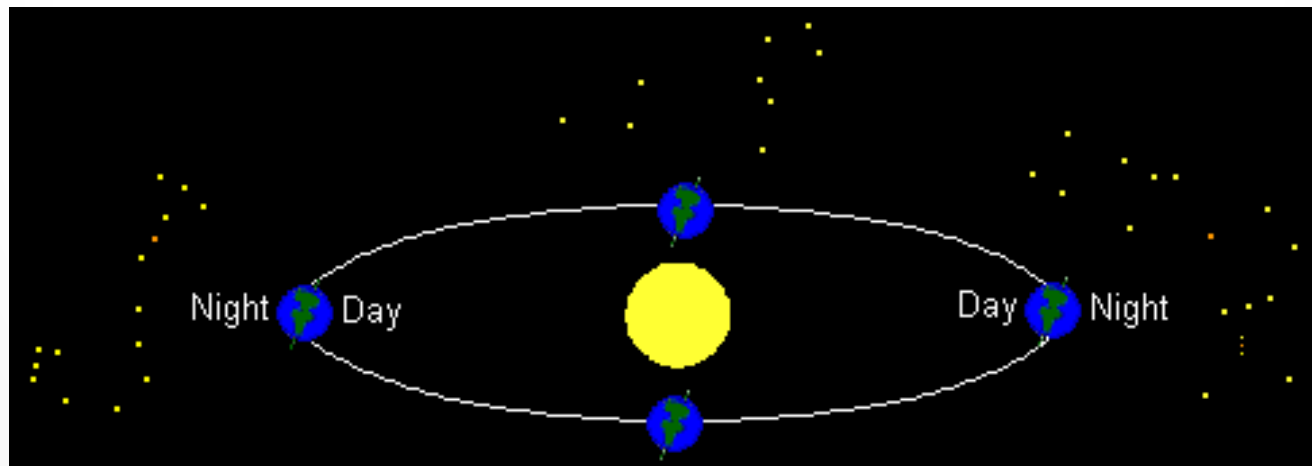
- The solar energy per unit area decreases as the Sun moves lower in the sky. This is the reason it is cooler in the winter and in the morning

# iclicker quiz

- The spin axis of Venus is aligned with the orbital axis. For Venus which of the following is true?
  - A. The length of a day is the same as the length of a year on Venus
  - B. "Star trails" on Venus would make straight lines in the sky
  - C. There would be no day and night on Venus
  - D. There would be no changing seasons (that is change in the number of daylight hours or change in the average temperature) over the Venus year

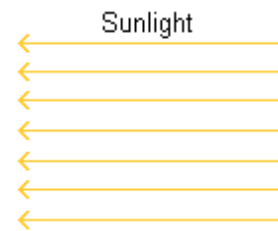
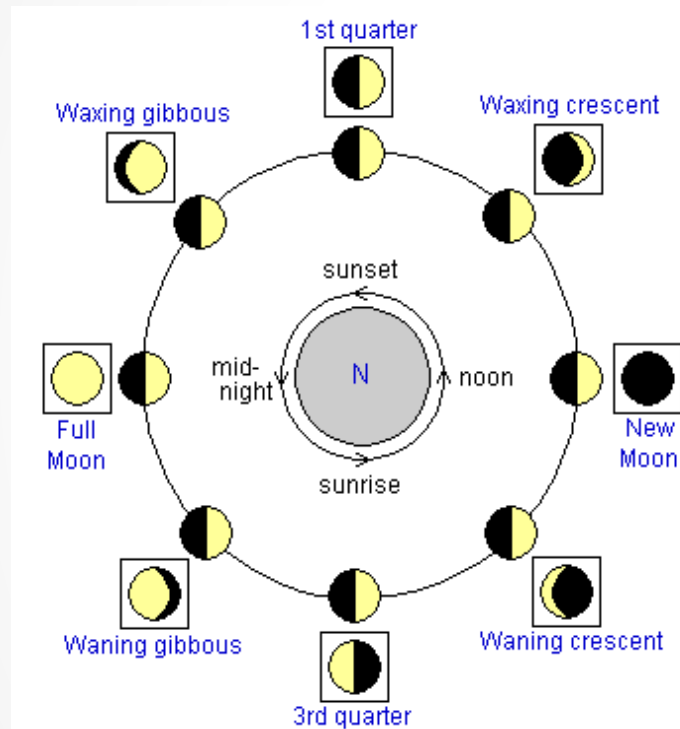
# The Night Sky at Different Seasons

We see different stars at different times of the year. The stars are always there, but can only be seen against the dark night sky.





# Moon phases



The moon phases are due to the relative positions of the Sun and moon. One half of the moon is always illuminated, it is only a question of what fraction of the illuminated face we can see from the Earth.

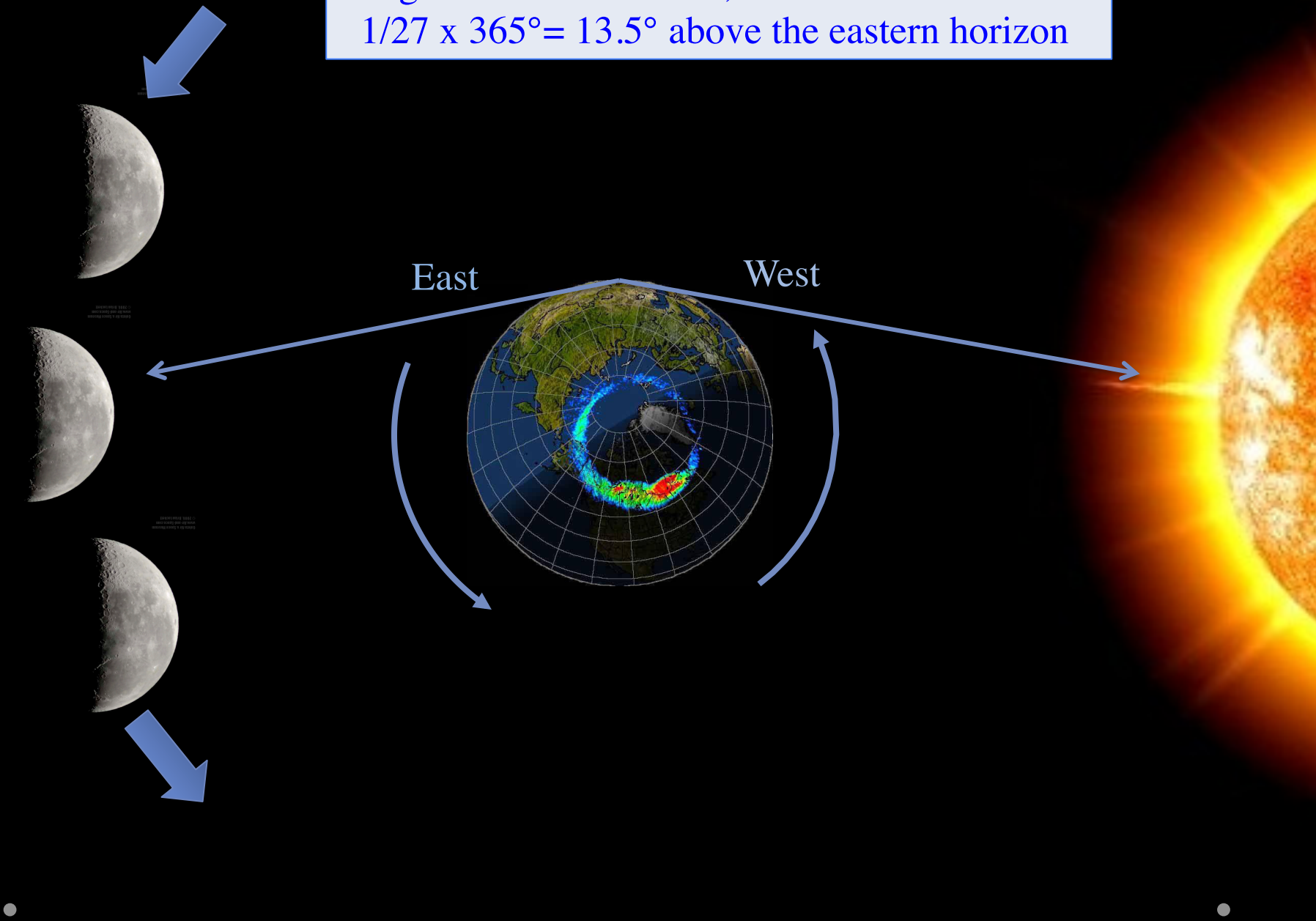
# Clickr quiz

Q. What time does the full moon rise?

- a) At midnight
- b) At sunrise
- c) At sunset
- d) Any old time, this is a trick question.

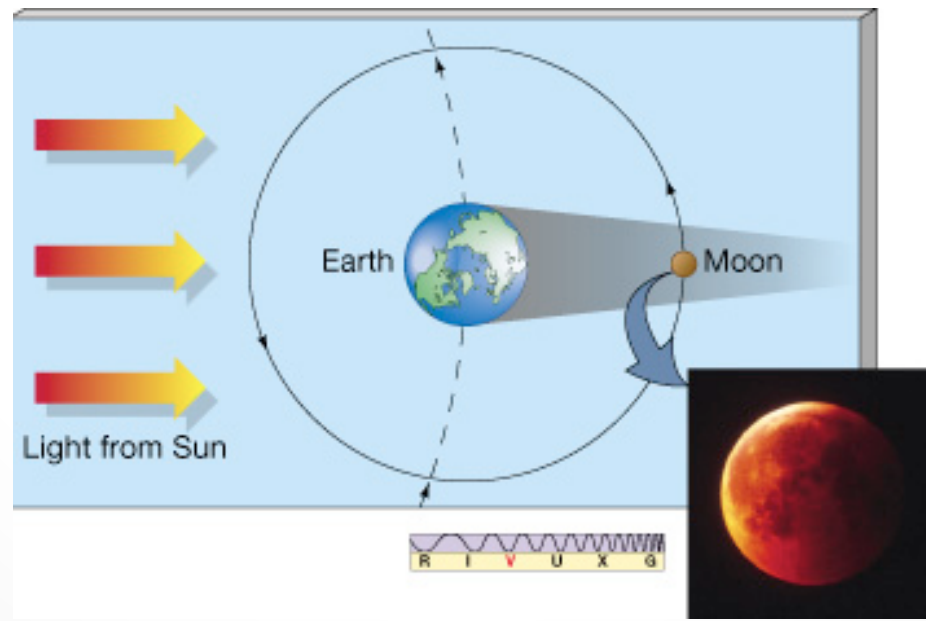


Night before full moon, at sunset the moon is  $1/27 \times 365^\circ = 13.5^\circ$  above the eastern horizon

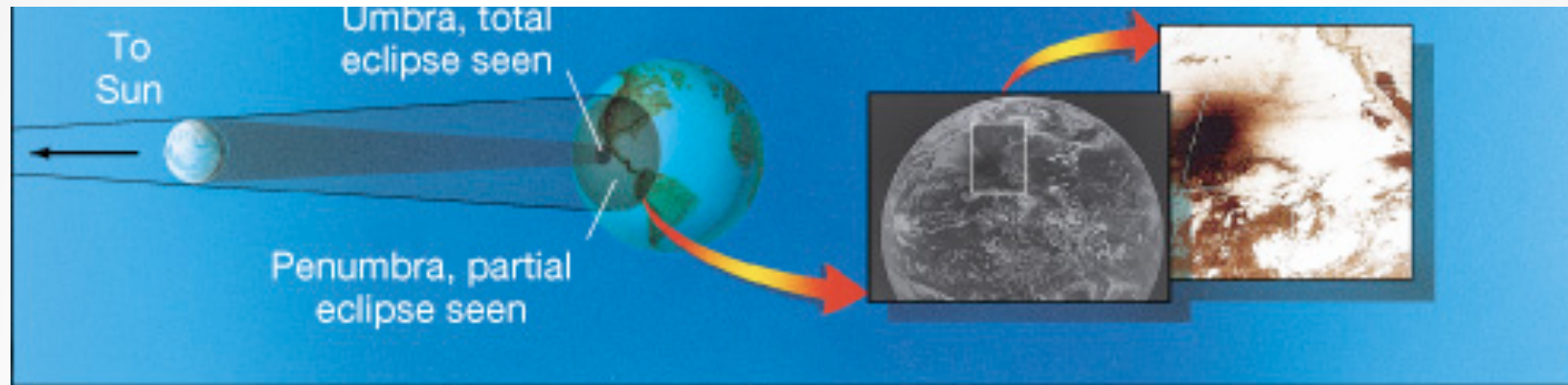


# Lunar Eclipse

For a full moon, the Sun, Earth and Moon are all aligned. The Moon can fall into the shadow of the Earth. This is called a lunar eclipse.



# Solar Eclipse



A similar thing can happen during the new moon. The Moon can cast a shadow on the Earth when it passes in front of the Sun.



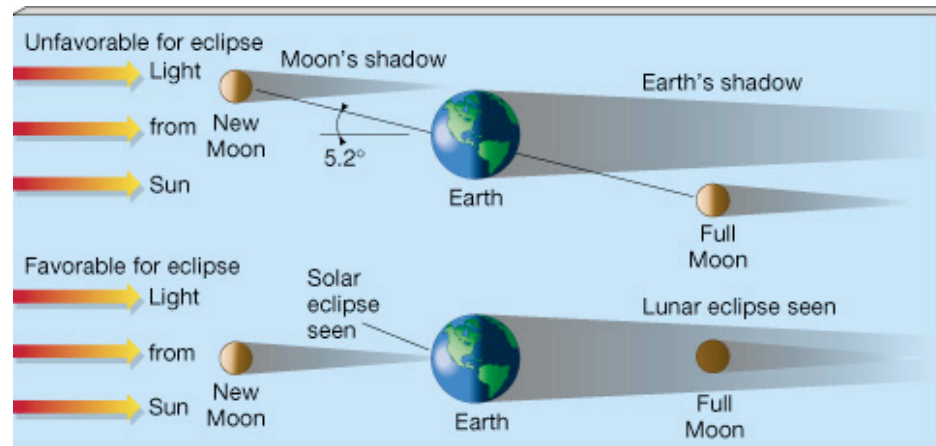




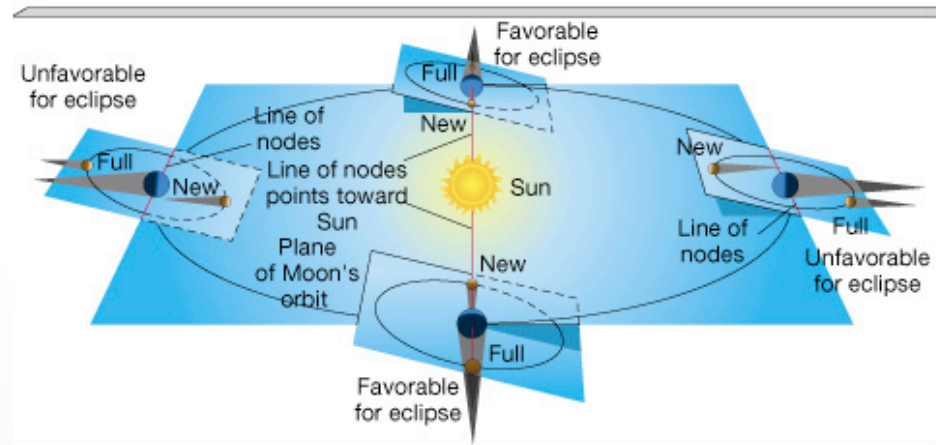




# Why don't we have an eclipse every month?



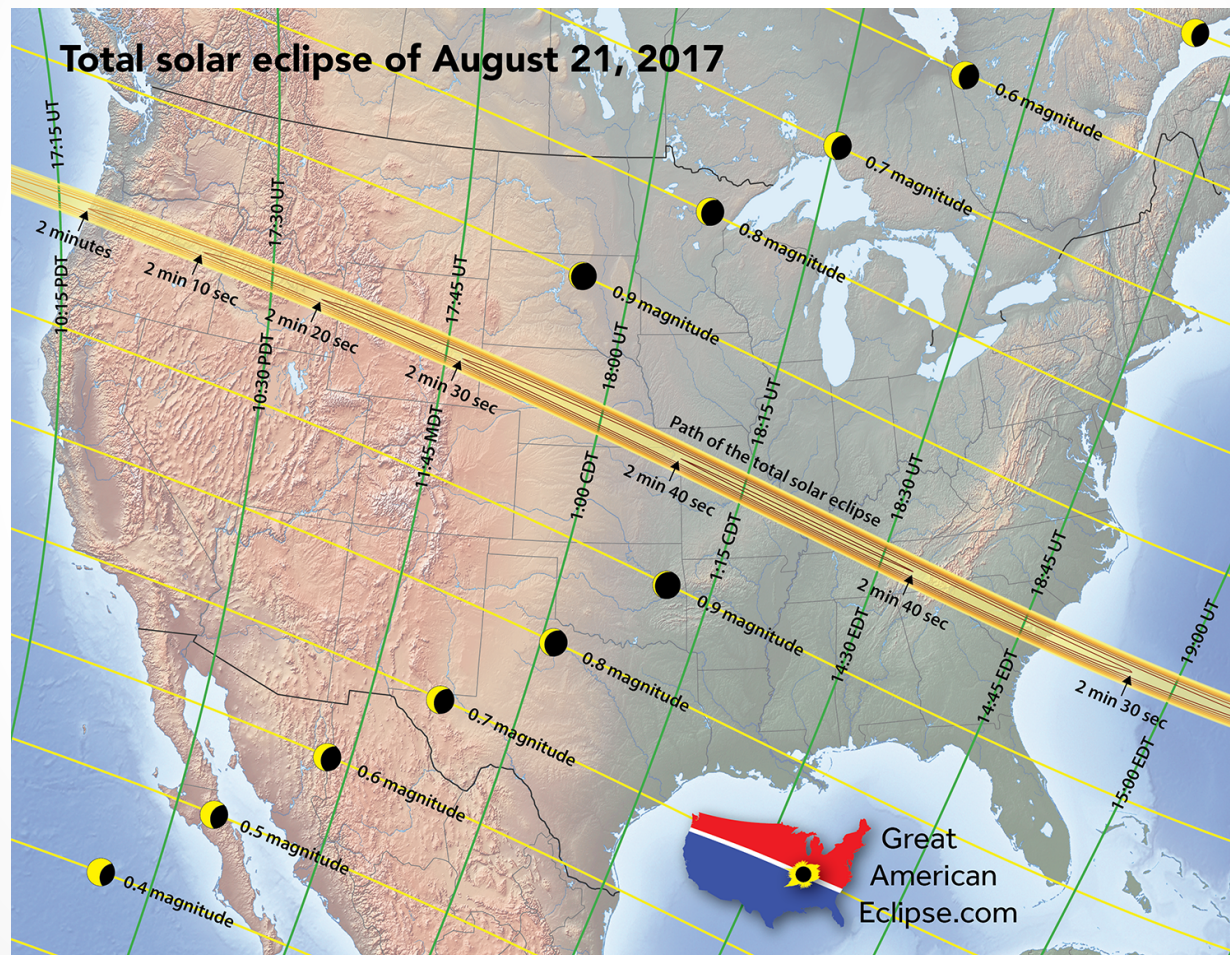
(a)



(b)



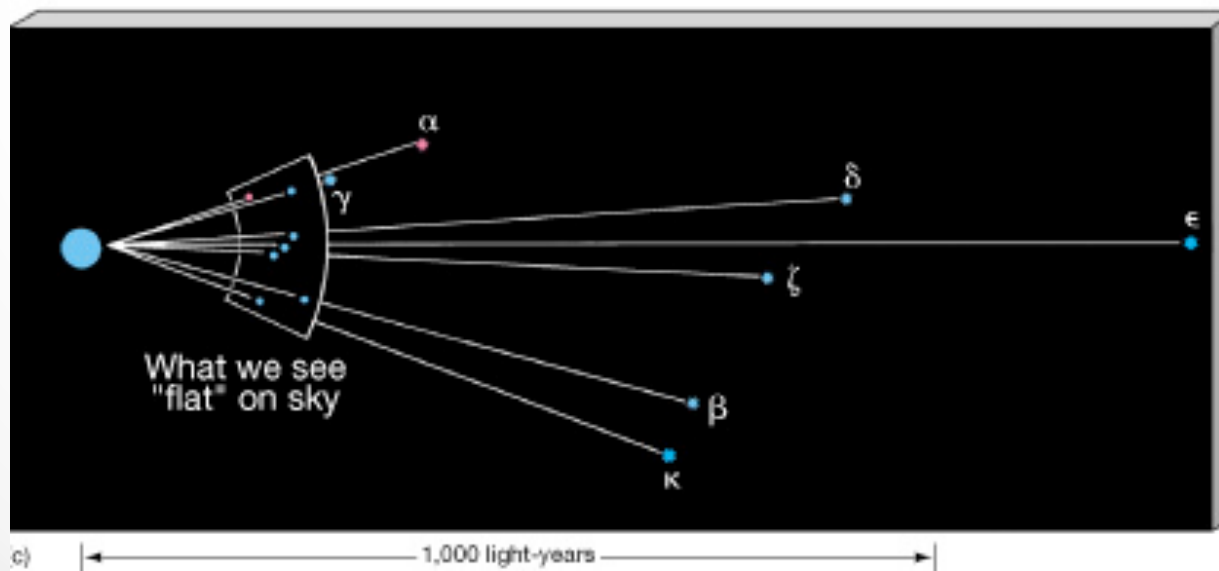
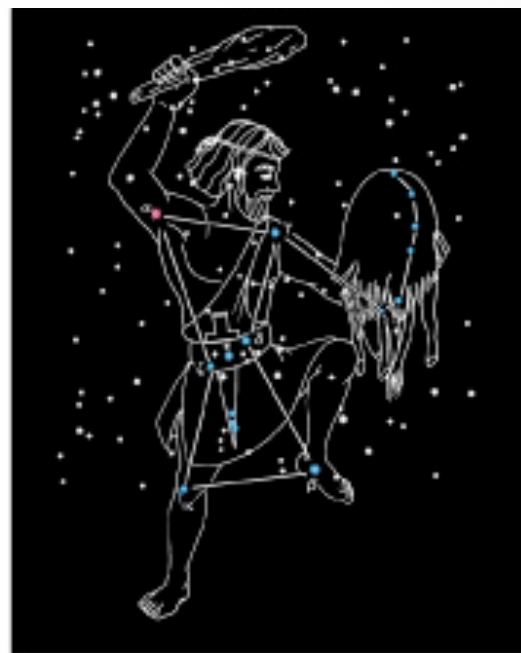
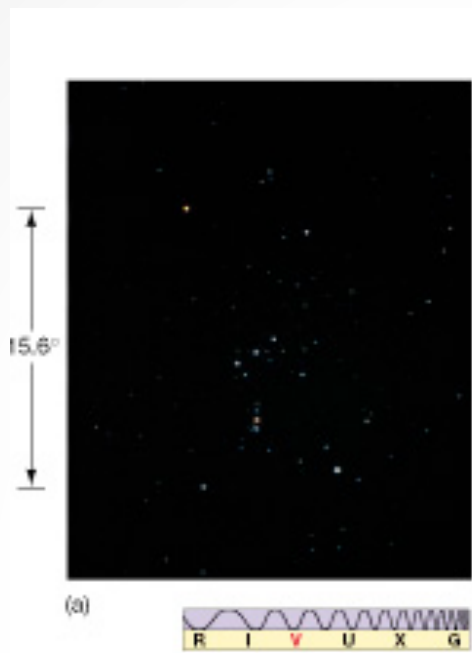
# The Great American Eclipse of 2017



# Sky at night: constellations



- Stars are essentially fixed in the sky
- *Apparent* groupings of bright stars were connected by various cultures and given names
- Astrology has zero basis in science

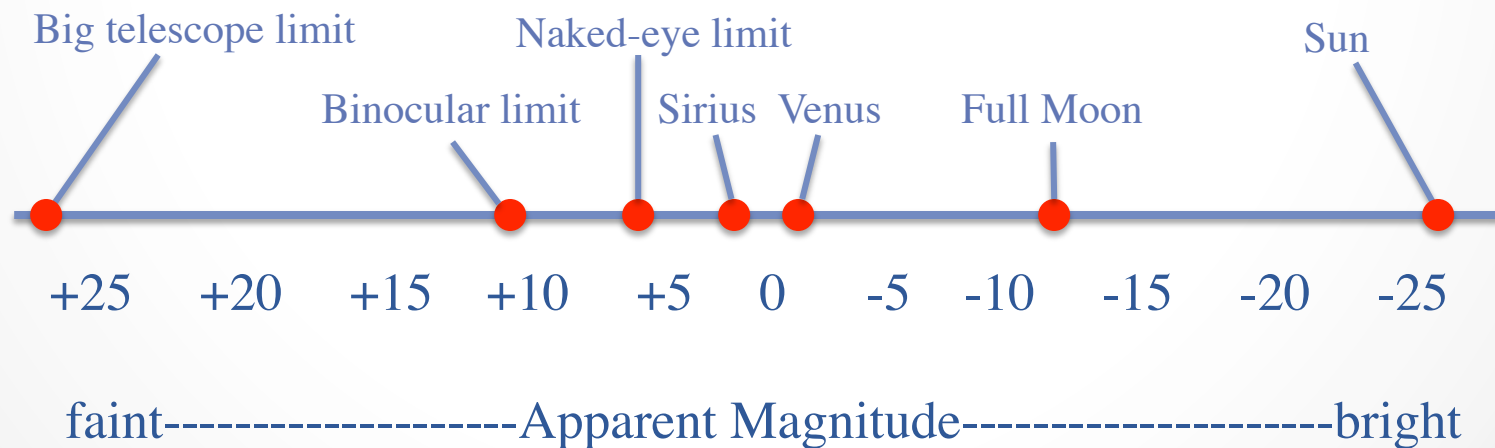


# What about Star Names?

- The brightest stars have lots of names, none official. There are some widely-used catalogues.
- A convention often used in astronomy is to use the Greek alphabet to identify the brightest stars in the constellations.
  - Sirius =  $\alpha$  Canis Majoris is the brightest star in the constellation Canis Major.
  - $\beta$  Canis Majoris is the second brightest etc.

# Stellar Brightness

- Will use brightness to be *apparent* brightness.
- This is not an INTRINSIC property of a star, but rather a combination of its Luminosity, distance and amount of dust along the line of sight.





# Naked-Eye Observations

- There are about 6000 stars you can see with your unaided eye at a dark site
- Limited by:
  - size of the human eye: 5 – 7 mm pupil
  - the eye's "integration time" of ~0.1seconds
  - resolution of ~ 1 arcmin



# Planets



Mars retrograde motion

- Planet means “wanderer” and it was realized long ago that some “stars” moved against the fixed stars
- They are seen along the ecliptic. Mercury, Venus, Mars, Jupiter and Saturn are all naked-eye objects

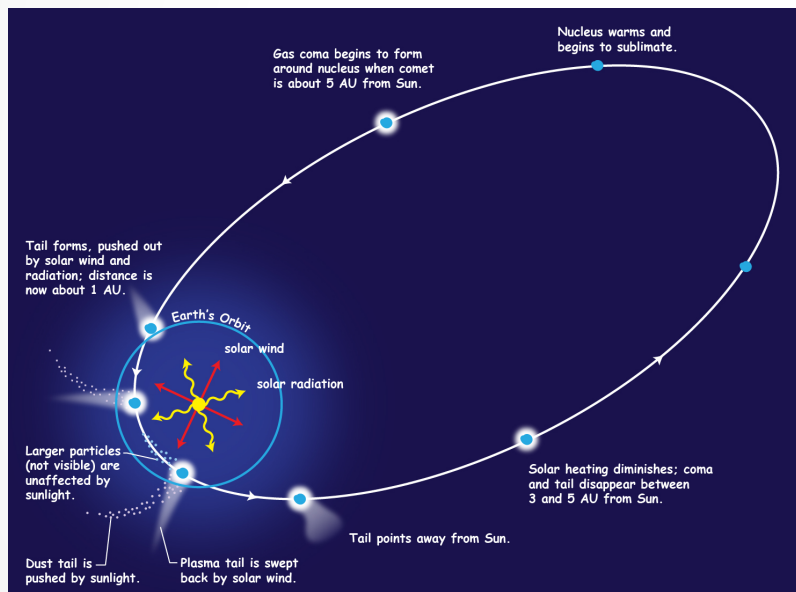
# Other stuff in the sky



Perseid shower

- The Solar System is full of rocks and dust/ice balls
  - Comets
  - Asteroids
  - Meteoroid
  - Dust
- When small bits intersect with the Earth, (“crossing orbits”) they burn up as “shooting stars”
- Larger objects can survive and hit the ground (meteorite)

# Comets



- In the outer solar systems are small icy bodies that sometimes have their orbits perturbed by one of the giant planets
- If their orbits take them close to the Sun, the solar wind and radiation pressure boils off material and results in a coma and tail

# Comets II



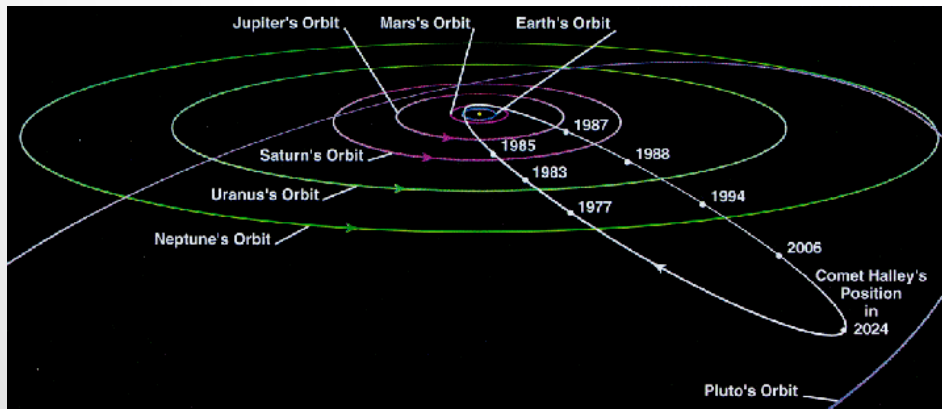
- Most comets are not bright enough to be seen with the unaided eye
- Some are spectacular and large
- About 1/3 of the comets discovered to date are periodic with periods  $< 200$  years



# Comets III



- Halley's comet with a 75-year orbit was first recorded in 240 BC
- Halley in 1701 identified a bright comet and put together the long history
- Provided a test of Newton's theory of gravity
- Some orbits it comes closer to Earth



# Meteors



- The larger debris left behind a comet passage through the inner Solar System causes meteor showers at predictable times
- Showers are named after constellations, but each has a particular comet passage that is responsible for the shower

## Major Meteor Showers in 2017

Shower	Radiant and direction	Morning of maximum	Best hourly rate	Parent
<b>Quadrantid</b>	Draco (NE)	Jan. 3	60-100	2003 EH <sub>1</sub>
<b>Lyrid</b>	Lyra (E)	April 22	10-20	Thatcher (1861 I)
<b>Eta Aquariid*</b>	Aquarius (E)	May 6	20-60	1P/Halley
<b>Delta Aquariid</b>	Aquarius (S)	July 30	20	96P/Machholz
<b>Perseid*</b>	Perseus (NE)	Aug. 12	90	109P/Swift-Tuttle
<b>Orionid</b>	Orion (SE)	Oct. 21	10-20	1P/Halley
<b>Southern Taurid*</b>	Taurus (S)	Nov. 5	10-20	2P/Encke
<b>Leonid</b>	Leo (E)	Nov. 17	10-20	55P/Tempel-Tuttle
<b>Geminid</b>	Gemini (S)	Dec. 14	100-120	3200 Phaethon



# Meteor Storms



- Every now and then the Earth's orbit goes right through the densest part of a debris tail
- Great Leonid Meteor Storm of 1833 had an estimated 200,000 meteors per hour (50 is more typical)

# Meteorites: meteor that reaches the ground



- Approximately 5 tons of material lands on Earth each day. Mostly in dust-sized material.
- Chances of your house being hit by meteorite in your lifetime:  
1 in 4 trillion

# Chelyabinsk superbolide

- 20-meter diameter entered atmosphere 15 Feb 2013 at 19 km/sec (42,000 mph)
- Shallow entry angle and it exploded at 30km above ground
- Released the equivalent of a 500kilo ton nuclear bomb (30x Hiroshima)
- Blast wave caused all the damage: 1500 people required medical attention
- <https://www.youtube.com/watch?v=Tu1vhfnCd3o>

# Tunguska 1908 event



- Fireball and explosion heard 1200 km away
- Very remote site. On investigation, 2000 square km of forest (80 million trees) was flattened and thousands of reindeer carcasses were found
- 40-meter bolide, air detonation

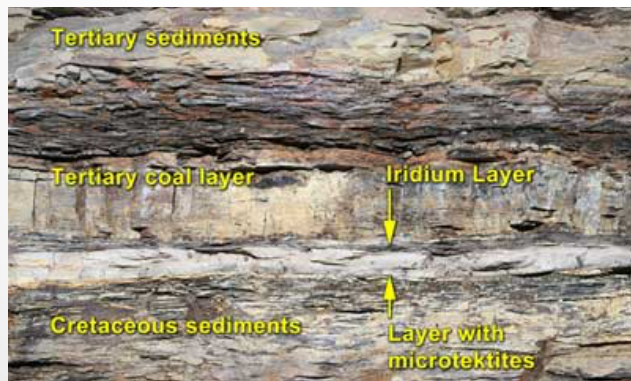
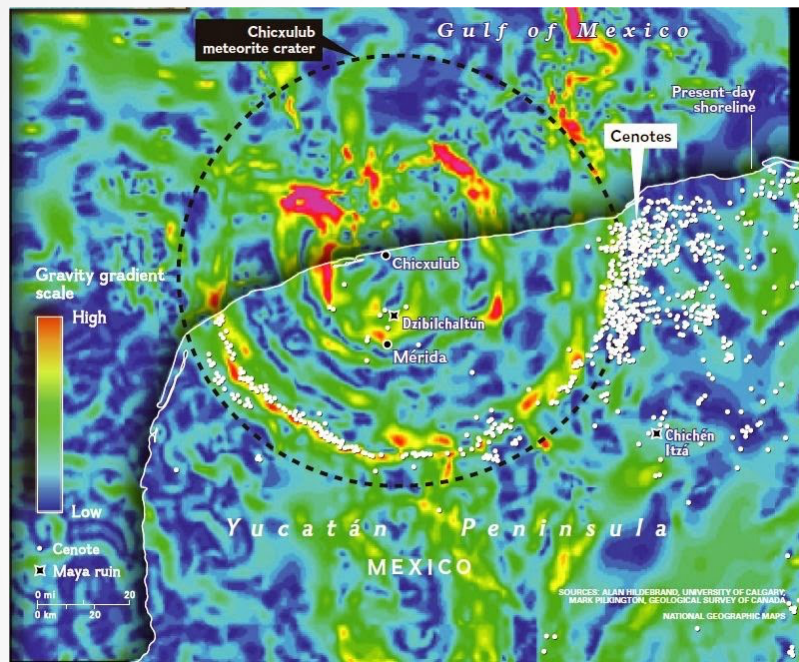
# Large Meteorites



- Objects  $> 50\text{m}$  in diameter make quite an impact (1 per 100 years)
- At  $2\text{km}$  and above, has global consequences (once per 250,000 years)



# K-T Boundary: 65 Million years ago



- Cretaceous-Tertiary Mass Extinction event
- high levels of iridium in the K-T boundary clay worldwide. Iridium abundance is very low in the Earth's crust, high in chondritic meteors
- K-T clay also contains soot and “shocked” quartz
- 50km impactor

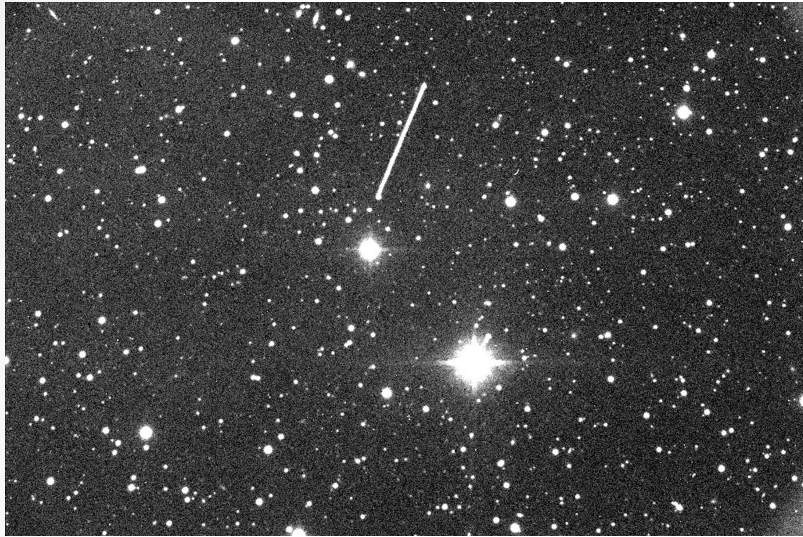
Meteor/Asteroid Size	Frequency	Damage
$10^{-6}$ meters	300,000 per second	Burns up in atmosphere
$10^{-3}$ meters	Every 30 seconds	Burns up in atmosphere
1 meter	Every year	Fireball, minor airburst
10 meters	Every 10 years	Airburst, sonic boom, fragments hit Earth. Russia Feb 2013
100 meters	Every 1000 years	Huge airburst, many fragments, ~hydrogen bomb in released energy
$10^3$ meters	Every 100 million years	Planet-wide destruction

# Lifetime odds of cause of death

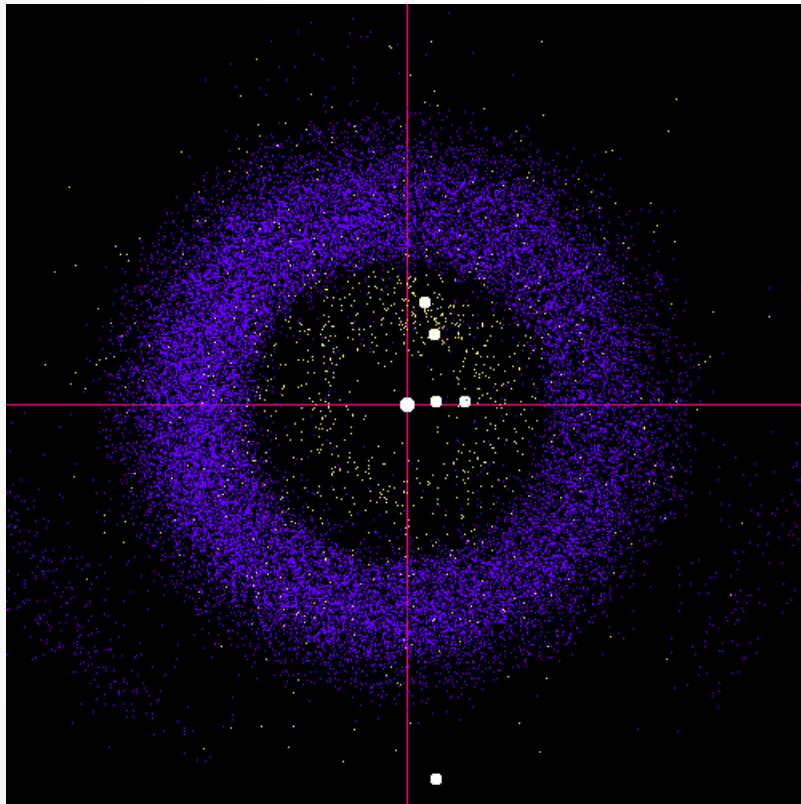
Cause of Death	Chances
Heart disease	1 in 5
Cancer	1 in 7
Car accident	1 in 100
Homicide	1 in 300
Firearms accident	1 in 800
Electrocution	1 in 5000
Airline crash	1 in 20,000
Tornado	1 in 60,000
Lightning	1 in 84,000
Asteroid impact	1 in 200,000
Shark attack	1 in 300,000



# Early Warning



- Asteroids are easily detected when they are close to Earth (for sizes  $> 300$  meters)
- All-sky imaging systems are in place to monitor the entire sky a few times per week
- Lots of “collision avoidance” schemes under discussion



- White dots are Sun, Mercury, Venus, Earth, Mars and Jupiter
- Blue dots are asteroids that don't cross the Earth's orbit
- Yellow dots are asteroids with Earth-crossing orbits

(courtesy of N. Kaiser, U Hawaii)



- Where is the North Star?

# Next topic: Light

- Quiz 1: April 18

