

Astronomy 122

Section 1– TR 1300-1350

1320 Digital Computer Laboratory



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Office Hours:
T 10:30-11:30 a.m. or
by appointment

This Class (Lecture 3):

The Glorious Dance

Next Class:

The Earth-Moon System

Homework #1 due Fri!

<http://eevore.astro.uiuc.edu/~lwl/classes/astro122/spring06/>

Music: *Space Oddity* – David Bowie

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Outline



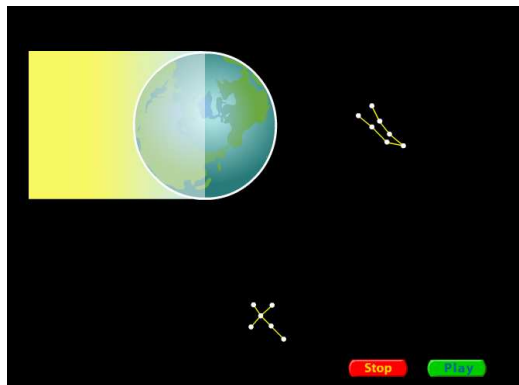
- The Celestial Sphere
- Motions of the Sky
- Seasons



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The Earth is Rotating



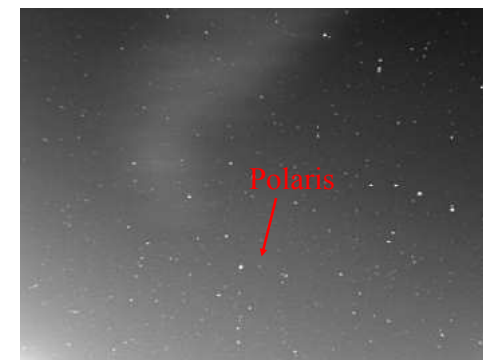
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Question



If we took a time-lapse photo of the starry night sky toward Polaris, what would it look like? Hint: The Earth is rotating (eastward).



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Daily Paths



- Earth's rotation creates daily (diurnal) motion of the stars, Sun, Moon, & planets
- Earth spins eastward, so stars appear to move westward – **daily paths**

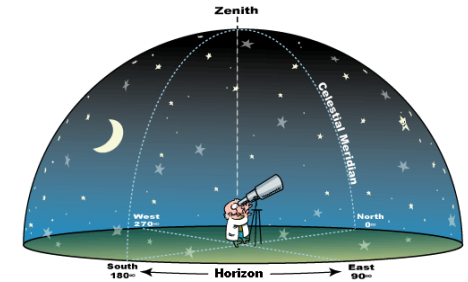
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Your View of the Sky



- **Zenith** – point directly overhead
- **Horizon** – marks the intersection of Earth and sky
- **Meridian** – from North to South through the zenith



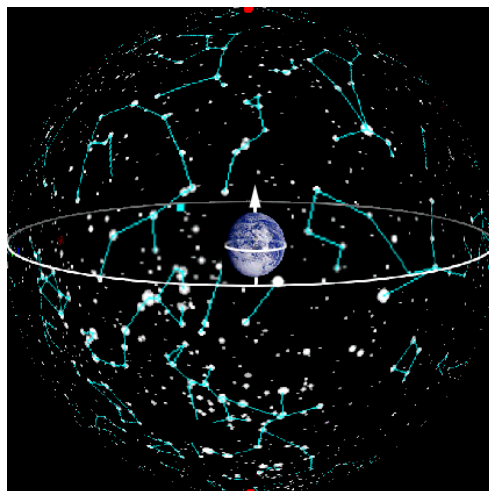
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The Celestial Sphere



Imagine the Sun, Moon, & stars glued on a transparent globe around the Earth



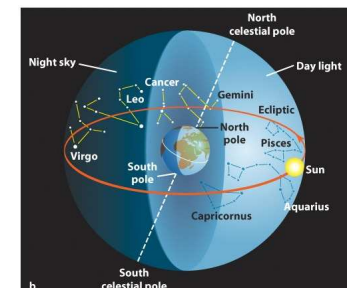
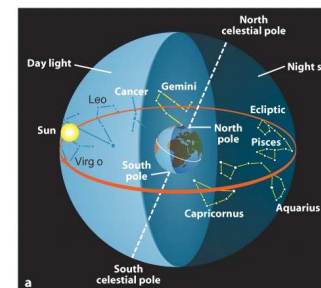
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Seasonal Motion



- As the Earth orbits the Sun, the stars visible at night change– The constellations are different in every season.
- A star crosses the meridian one hour earlier every two weeks.



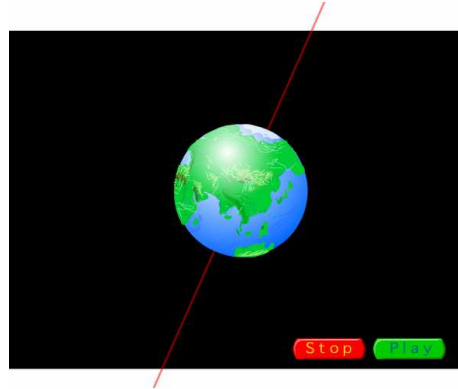
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Celestial Poles and Equator



- **Celestial poles** – extensions of the Earth's axis onto the celestial sphere
- **Celestial equator** – project the Earth's equator onto the celestial sphere



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Celestial Coordinates



- Measuring North-South
 - **Earth:** Latitude, measures from the equator
 - **Sky:** Declination, measures from the celestial equator
- Measuring East-West
 - **Earth:** Longitude, measured from Greenwich, England
 - **Sky:** Right Ascension, measured from the Vernal Equinox (position of the Sun on first day of Spring)

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How do the Stars Move?

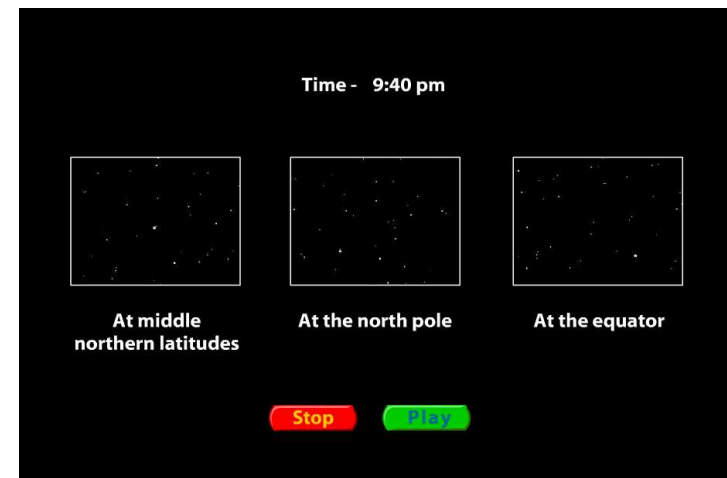


- Compare the motion of the stars at the North Pole, the Equator, and Urbana.

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Stars motion depend on your Latitude!



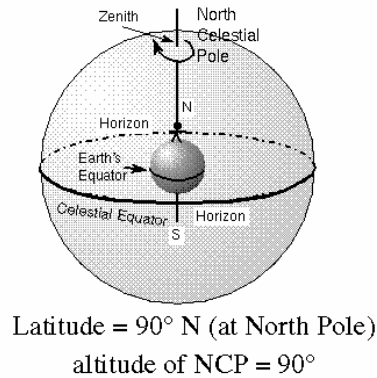
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Changes with Latitude



- The positions of the celestial poles and celestial equator on the sky depend on your latitude (GPS anyone?)
- Note: The celestial equator always crosses the horizon at due east and due west



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At the North Pole



- Polaris is directly overhead
- The sky appears to spin around it
- Stars don't rise or set (circumpolar), they just go around
- All stars are circumpolar at the pole!



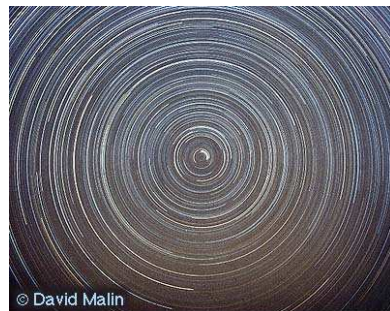
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Circumpolar Stars



- The sky appears to spin around Polaris.
- Earth's rotation is counter clockwise, if you were to look down on the North Pole
- Most stars' daily paths rise in the east and set in the west
- But, some are so close to Polaris, they can't reach the horizon!
- Called *circumpolar stars*



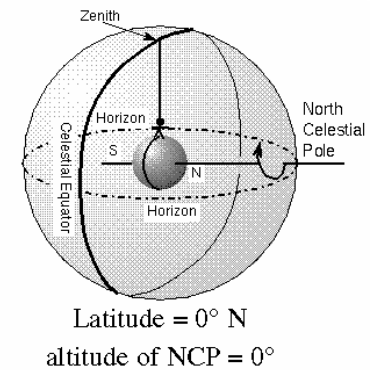
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Changes with Latitude



- The positions of the celestial poles and celestial equator on the sky depend on your latitude (GPS anyone?)
- Note: The celestial equator always crosses the horizon at due east and due west



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At the Equator



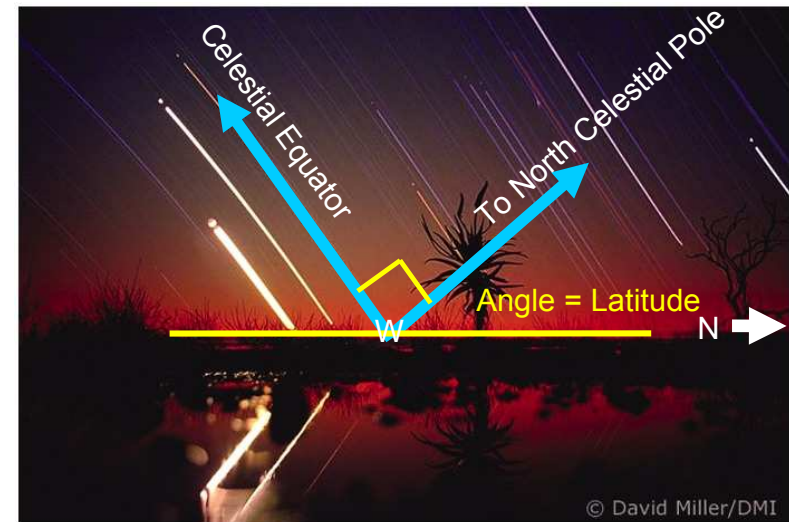
- Polaris is right on the horizon
- Stars rise straight up from the eastern horizon and set straight down on the western horizon
- No stars are circumpolar at the equator!



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Motions in the Sky



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Question



You observe a star rising directly to the East from Urbana. When this star reaches its highest position above the horizon, where will it be?

- High in the northern sky
- High in the eastern sky
- High in the southern sky
- High in the western sky
- Directly overhead

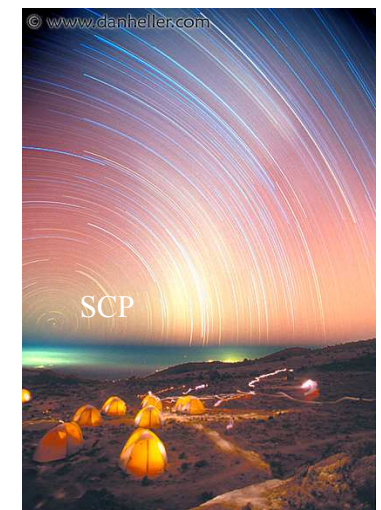
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South of the Equator



- South of the equator, you can't see Polaris
- You do see the South Celestial Pole
- But nothing is there.



<http://antwrp.gsfc.nasa.gov/apod/ap040911.html>

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Earth's Orbit



- The Earth's rotation explains the motions of the stars over a day, but why does the sky change over many nights? (i.e. Why can you see Orion only from Dec-March?)



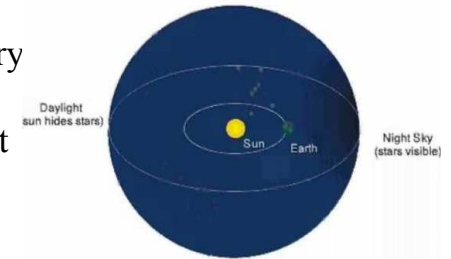
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Free Trip Around the Sun

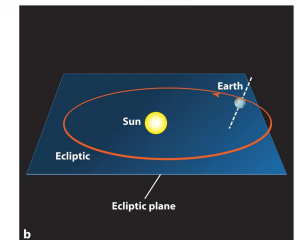


- The Earth orbits the Sun every 365 days
- The plane of the Earth's orbit is called the **ecliptic**



"Living on Earth may be expensive, but it includes an annual free trip around the sun."

-Asleigh Brilliant



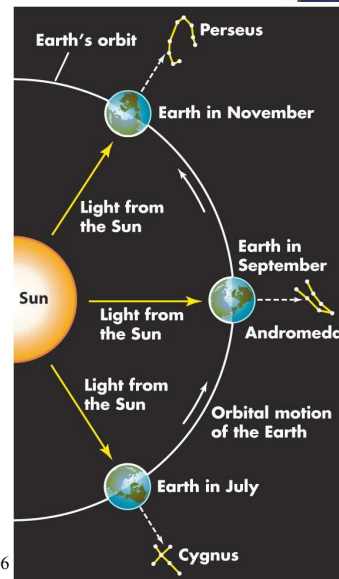
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Orbiting for Fun



- The Earth moves around the Sun.
- And the stars are far away.
- This makes the stars appear to move slightly every day.
- A star will rise about 4 mins early every day or about 2 hours earlier every month (24 hours/12 months).



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The Gregorian Calendar



- Actually, the revolution period is 365.2422... days long
- A regular calendar year is 365 days long
- Accounting for difference
 - Leap years: 1 extra day every 4 years = 365.25 days
 - No leap years every 100 years = 365.24 days
 - Add leap year every 400 years = 365.2425 days



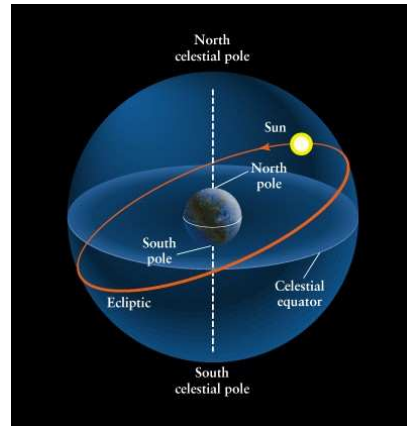
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The Ecliptic on the Celestial Sphere



- Similarly, from our point of view, the Sun moves a little each day with respect to the stars.
- This path (the ecliptic) can also be drawn on the celestial sphere
- Note, the ecliptic and the celestial equator are not the same circles
- What would cause that?



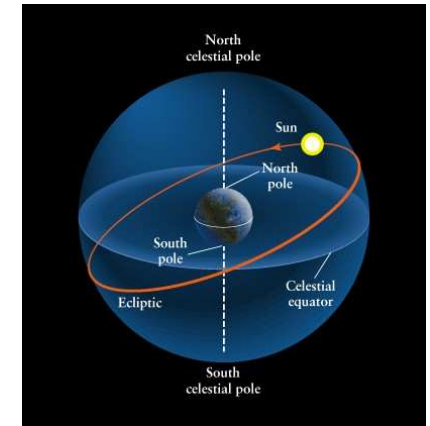
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The Ecliptic on the Celestial Sphere



- You're tilted.
- You're whole freakin' world is tilted.
- The Earth's axis is tilted to the ecliptic plane by 23.5°



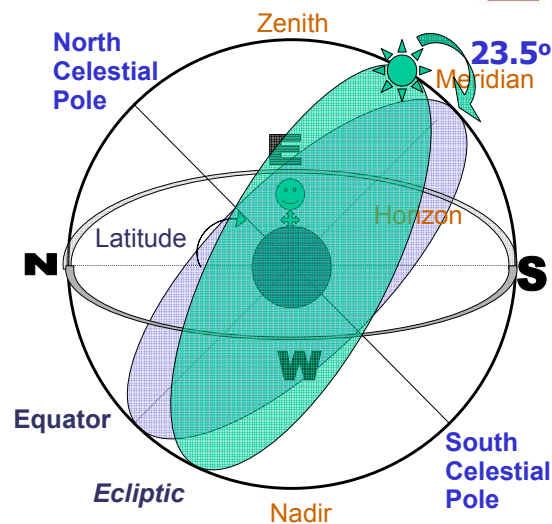
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Building A Celestial Sphere



- NCP is up from horizon at an angle equal to your latitude
- Equator is 90° from NCP
- Ecliptic is 23.5° tilted from equator



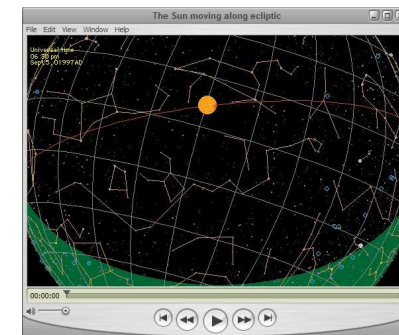
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The Sun Moves in the Sky



http://planck.phys.uwosh.edu/mike/exercises/anim/ecliptic_movie.mov



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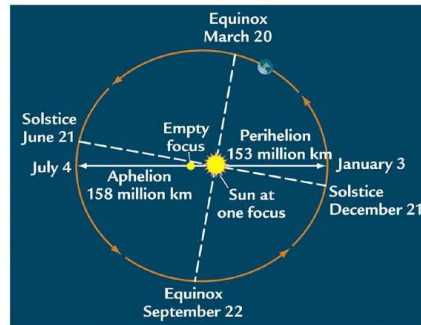
What Causes the Seasons?



The Earth is closer to the Sun in the summer?

No!

- While the Earth's orbit is not perfectly circular, it is actually closest to the Sun in *January*
- Also, summer in Northern Hemisphere is winter in Southern and vice versa



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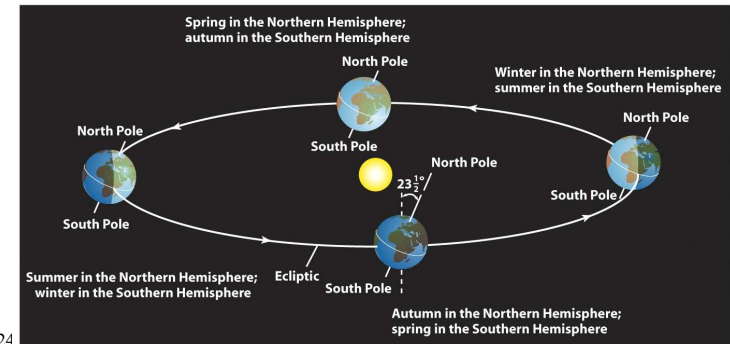
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What Causes the Seasons?



So what does cause the seasons?

- It's the tilt of the Earth's spin axis
 - Affects the length of day **and** intensity of sunlight

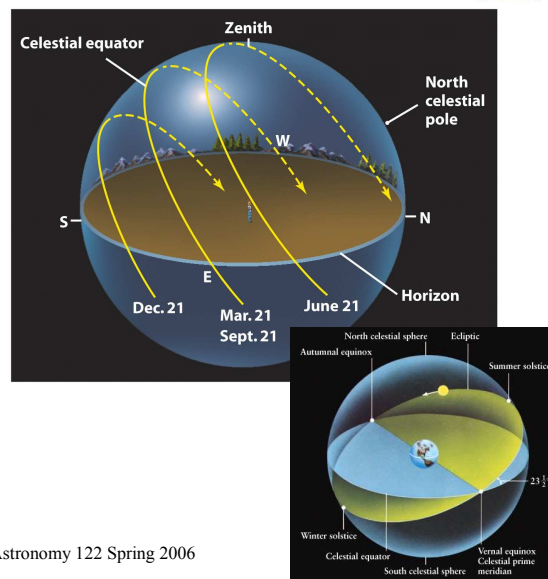


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Sun's Daily Paths



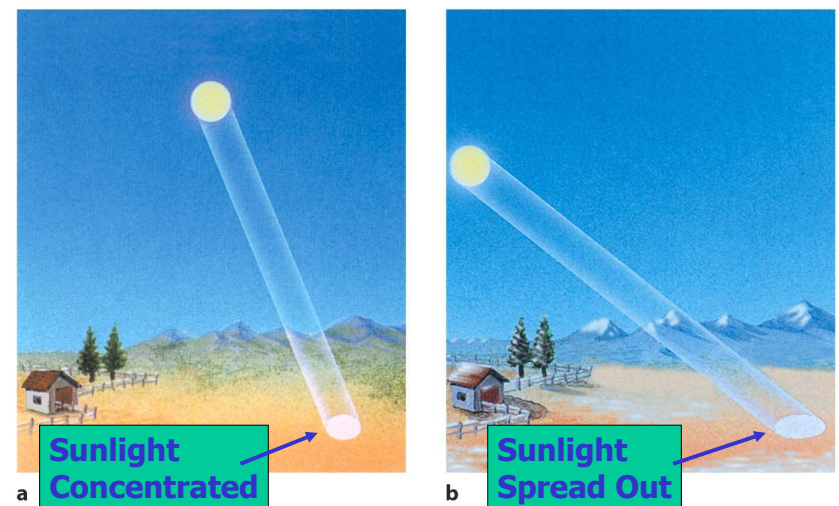
- In the summer, the Sun is north of the celestial equator
 - Long days
 - High in the sky
 - Direct sunlight
- In the winter, it is south of the celestial equator
 - Short days
 - Low in the sky
 - Indirect sunlight



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Summer vs. Winter



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Seasons Around the World



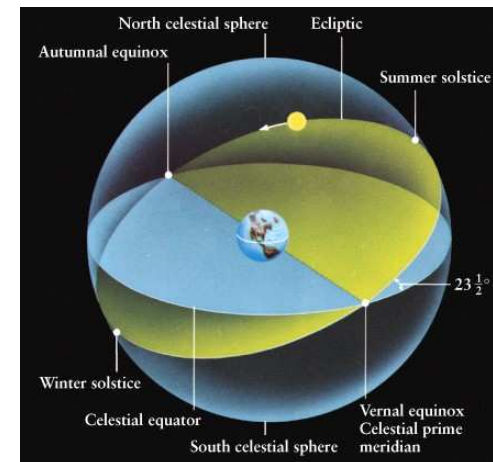
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Solstices and Equinoxes



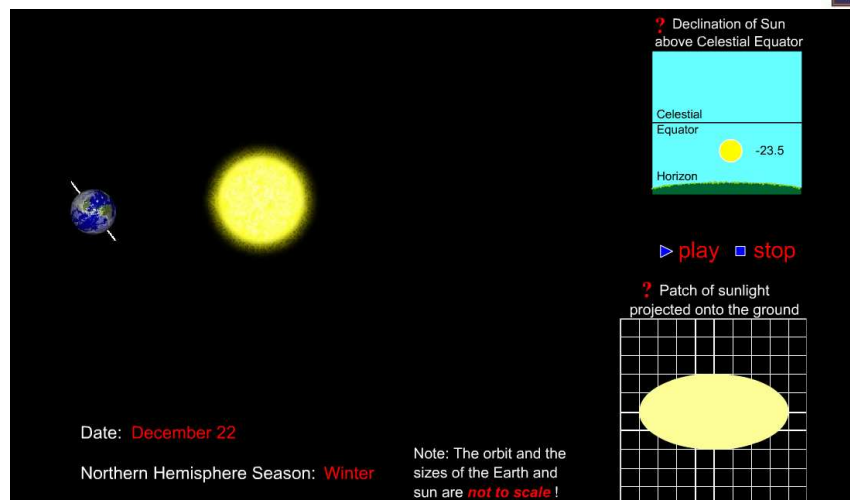
- *Solstices*
 - Most northern and southern points on the ecliptic
 - Longest and shortest amounts of daylight
- *Equinoxes*
 - When the ecliptic crosses the celestial equator
 - Daytime and nighttime equal



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Seasons Animation



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Solstices and Equinoxes



- Winter Solstice – December 21
 - 9 hours of daylight, 15 hours of night
- Spring (“Vernal”) Equinox – March 21
 - 12 hours of daylight, 12 hours of night
- Summer Solstice – June 21
 - 15 hours of daylight, 9 hours of night
- Fall (“Autumnal”) Equinox – Sept 21
 - 12 hours of daylight, 12 hours of night

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The Tropics



- Over the year, the Sun varies from 23.5° north to 23.5° south of the celestial equator
 - If you live between 23.5° N and 23.5° S latitude, the Sun can reach the zenith – directly overhead
 - Sun never gets directly overhead in Urbana, 40° N
- Between 23.5° N and 23.5° S latitude is called the tropics
 - 23.5° N – Tropic of Cancer
 - 23.5° S – Tropic of Capricorn

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The Arctic and Antarctic



- Above 66.5° N and below 66.5° S latitudes (90 – 23.5 = 66.5), the Sun can be *circumpolar*!
- North of 66.5° N
 - The Arctic
- South of 66.5° S
 - The Antarctic

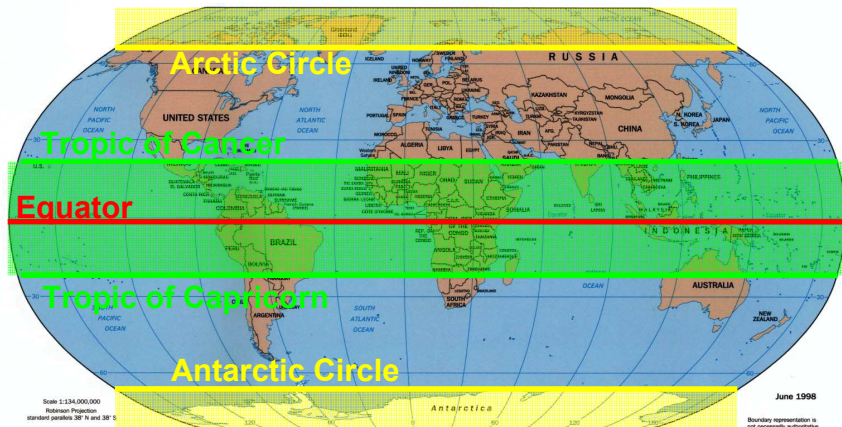


Midnight Sun in Barrow, Alaska

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Tropics and Arctics



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