Astronomy 114

Lecture 3: Motions and Seasons

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UMass/Astronomy Department
Announcements

- Problem Set #1 due on **Wednesday**
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- Don’t forget reading (see bottom of page!)
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From the coordinate system attached to the Earth, motions of the heavenly bodies across the sky may seem perplexing . . .
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- Today’s topic: astronomical motions and everyday life
- From the coordinate system attached to the Earth, motions of the heavenly bodies across the sky may seem perplexing . . .
- Example of coordinate system relativity and the importance of frames of reference
Celestial sphere (1/2)

The solar system orbits Galaxy in 200 million years
Celestial sphere (1/2)

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The random but unique patterns of the nearby stars projected on the celestial sphere are called constellations and have historical names.
By international agreement, the celestial sphere has been divided into 88 regions named by the enclosed constellation.
Celestial sphere (2/2)

- Camera with open shutter
- Stars appear to move counter-clockwise (in North)
- Polaris (the North Star) nearly stationary

Northward view at Kitt Peak National Observatory, Tuscon, AZ
Diurnal Motion of the Night Sky

- Stars in the night sky rise in the East and set in the West
- Due to Earth’s rotation

![Diagram of Earth with stars and time zones](image)

- a  Earth as seen from above the North Pole
- b  4 hours later
Annual Change in the Night Sky

As Earth orbits about Sun, different constellations are overhead at midnight.

Circumpolar constellations remain unchanged.
Celestial coordinates (1/3)

- Celestial equator is the projection of Earth’s equator on Celestial Sphere
- The North/South Celestial Poles (NCP/SCP) are projections of the polar axes
Celestial coordinates (1/3)

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- Projected longitude called *Right Ascension*
- Projected latitude is called *Declination*
Celestial coordinates (2/3)

- **Celestial sphere** appears to spin around the Earth
- **Zenith**: point directly over head
- **Horizon**: curve where plane of the ground meets the celestial sphere
Celestial coordinates (2/3)

- Celestial sphere appears to spin around the Earth
- **Zenith**: point directly over head
- **Horizon**: curve where plane of the ground meets the celestial sphere

An observer at $35^\circ$ N latitude, the NCP has an altitude of $35^\circ$ above the horizon
Celestial coordinates (3/3)

The **ecliptic** is the Sun’s path in the celestial sphere over a year.
Rotating Earth acts as a *Gyroscope*

Over many years, axis points in the same direction
Rotating Earth acts as a Gyroscope

Over many years, axis points in the same direction

- In Winter (in North),
  Sun’s rays are overhead in the Southern Hemisphere
- Sun appears low in sky
- Moon appears high in sky
In Summer (in North),
Sun’s rays are overhead in the Northern Hemisphere
Sun appears high in sky
Moon appears low in sky
In Summer (in North), Sun's rays are overhead in the Northern Hemisphere.

- Sun appears high in sky
- Moon appears low in sky

Special latitudes:
- Tropics of Cancer and Capricorn
- Arctic and Antarctic Circles
The Moon and the Sun together tries to *tip* the Earth

The Earth responds by twisting its axis in space

Like leaning into a turn on a bicycle
Currently Polaris, the current North Star, is close to axis of rotation on the celestial sphere overhead at midnight.

In thousands of years, other stars with be the North Star.
The Celestial Coordinate System is defined where the equator crosses the ecliptic plane in the Spring

“First Point of Aries”

Now in constellation Pieces. In 600 years, constellation Aquarius.
Solar time

One *solar* day: noon to noon (or midnight to midnight)
Solar time

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- Our Sun takes 365.24220 days to move around the celestial sphere once (one year).
Time keeping (1/2)

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- 0.24220 fractional days is 5 hours, 48 minutes, and 46 seconds
- 0.24220 is close to 0.25. By adding one day to the calendar every four years, shy of the perfect year by $1 - 4 \times 0.24220 \text{ days} = 45 \text{ minutes}$; or 1 day in 128 years.
Celestial time

One *sidereal* day: time required for the same point on the celestial sphere to be overhead.
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Celestial time

- **One sidereal day**: time required for the same point on the celestial sphere to be overhead.
- Earth moves in its orbit approximately one degree per day.
- The sidereal day is \(24 \times 60\) minutes/365.24220 = 4 minutes shorter than a solar day.