ASTR1070 – Lecture 6
The Night Sky II: Moon Phases and Eclipses

Lecturer: Patrick Wilcox
6/21/2016
Last time...

• Revolution vs. Rotation
  – Right hand rule of rotation and revolution
• Synodic vs. Sidereal
• Seasons are caused by the Sun's light approaching different parts of the surface of the earth at varying angles
• “Start” day of seasons are special locations in Earth's orbit around the Sun
Review: Seasonal Landmarks

Summer Solstice

Earth Axis
- Arctic Circle
- Tropic of Cancer
- Equator
- Tropic of Capricorn
- Antarctic Circle

Image credit: NASA/JPL
This Time...

- Specific Terminology (again)
- Eclipses
- Tides
- Moon Phases
Specific Terminology

- **Terminator** – the boundary between illuminated and dark regions

A view of Earth from the Apollo 11 spacecraft

Image Credit: NASA
Specific Terminology (cont.)

- **Orbital Inclination** – the relative angle at which one body orbits compared to others
Nightly Moon Motion

Q: Regular motion in the night sky appears to be [______] and the Moon appears to move [______] than the background stars.

1. East to West; Slower
2. West to East; Slower
3. East to West; Faster
4. West to East; Faster
Nightly Moon Motion (cont.)

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Nightly Moon Motion (cont.)

Q: If I see a Full Moon here in Iowa City, what is the moon phase that same night in London (about \(\frac{1}{4}\) of the way across the globe to the East)?

1. First Quarter
2. Last Quarter
3. Full Moon
4. New Moon
Q: If I see a Full Moon here in Iowa City, what is the moon phase that same night in London (about ¼ across the globe to the East)?

1. First Quarter
2. Last Quarter
3. Full Moon
4. New Moon
Eclipses

- **Lunar eclipse** – Earth's shadow is cast over the Moon
  - Occurs during a Full Moon
  - Visible to most of Earth

- **Solar eclipse** – the Moon's shadow is cast over part of Earth
  - Occurs during a New Moon
  - Only visible by a portion of Earth
Eclipses (cont.)

• **Q:** Why don't eclipses happen every moon cycle?

**A:** Orbit of the moon is inclined compared to plane of the solar system.

Not to scale.
Eclipses (cont.)

- The moon's inclination is pretty well fixed.
- Points where the Moon crosses the ecliptic (every 2 weeks) are called *nodes*.
- When the nodes line up with a New or Full moon, an eclipse is possible.
- The direction of the inclination changes over time (18.5 yr cycle).
Lunar Eclipse

Anatomy of a Lunar Eclipse
(Not to scale)

- Sun
- Earth
- Moon (Eclipsed)
- Umbra (full shadow)
- Penumbra (partial shadow)

Moon’s Orbit

Image credit: astronomy.starrynight.com
Lunar Eclipse (cont.)

- Two types of shadows cast
  - Umbra – area with total shadow
  - Penumbra – area with partial shadow
- A total eclipse will present penumbral shadows before the umbral shadow
- Some eclipses are partial – the moon only goes through the penumbra and never is totally shadowed
Lunar Eclipse (cont.)
Lunar Eclipse (cont.)

- Visible to entire side of Earth at once so they tend to seem more frequent
- An eclipsed Moon often appears red due to some light getting bent through Earth's atmosphere
- Next Lunar Eclipses visible to us:
  - Penumbral (partial) Lunar eclipse – Feb 10, 2017
  - Total Lunar eclipse – Jan 20, 2019
  - During this same timeframe: there are 2 partial and 2 total eclipses visible to Europe and Asia
Lunar Eclipse (cont.)

• Suppose this: what would a lunar eclipse look like from the surface of the moon?
Solar Eclipse

Anatomy of a Solar Eclipse
(Not to scale)

- Sun
- Moon
- Earth
- Penumbra (partial shadow)
- Umbra (full shadow)
- Moon’s Orbit

Image credit: astronomy.starrynight.com
Solar Eclipse (cont.)

• Only a small part of the world will ever see a total Solar Eclipse at any time

• Three types:
  − Total Solar Eclipse
  − Annular Solar Eclipse ("ring of fire")
  − Partial Solar Eclipse

• Next Total Solar Eclipse Near Us:
  Aug. 21, 2017!!!
Solar Eclipse (cont.)

Image credit and more info: http://www.timeanddate.com/eclipse/solar/2017-august-21
Tides

- Sun and Moon both have gravitational pull on Earth
- Earth's oceans mold to this gravitational pull
- Sun-Moon-Earth aligned = spring tides
  - Large high-low tide difference
  - Happens just after both New and Full Moon alignments
- Sun-Earth-Moon anti-aligned = neap tides
  - Smaller tidal difference
  - Happens just after First/Last Quarter alignments
Moon Phases

- Illumination of the Moon varies by the relative location of the Moon and Sun
- There are two primary phases and six intermediate phases

Image: NASA
Moon Phases (cont.)

- The same phase is visible at all points on Earth (that can see the Moon at that time)
- The phase cycle is about 29 days (Moon-th)
Moon Phases (cont.)

- Idealized local time:
  - We ignore tilt of Earth and the Sun is visible from 6am-6pm every day
  - We presume that you have “perfect” local time according to the Sun
Moon Phases (cont.)

- Idealized local time is based on the position of the Sun
- Local time issues
  - Daylight savings time
  - Time zones
  - Days aren't really exactly 12 hours long all the time
Moon Phases (cont.)

First, some new vocabulary:

- **Culmination** – the highest elevation that a particular object reaches each night
- **Meridian** – the imaginary line that runs North-South and directly overhead

*Objects always are on the meridian when they culminate.*

star trails video: https://www.youtube.com/watch?v=udKPl75xg8c
Moon Phases (cont.)

- Demonstration of Moon Phases
- Note that the phase doesn't change based on location of the observer
- Knowing the phase and location of the moon in the sky – one can tell the time
  - Full moon culminates at Midnight
  - New moon culminates at Noon
  - What about First Quarter?
Moon Phases (cont.)

Idealized local times for the rise and set of the moon.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Rise</th>
<th>Set</th>
<th>Culmination</th>
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<tr>
<td>New</td>
<td>6am</td>
<td>6pm</td>
<td>noon</td>
</tr>
<tr>
<td>Waxing Crescent</td>
<td>9am</td>
<td>9pm</td>
<td>3pm</td>
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<tr>
<td>First Quarter</td>
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<td>midnight</td>
<td>6pm</td>
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<tr>
<td>Waxing Gibbous</td>
<td>3pm</td>
<td>3am</td>
<td>9pm</td>
</tr>
<tr>
<td>Full</td>
<td>6pm</td>
<td>6am</td>
<td>midnight</td>
</tr>
<tr>
<td>Waning Gibbous</td>
<td>9pm</td>
<td>9am</td>
<td>3am</td>
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<tr>
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<td>9am</td>
</tr>
</tbody>
</table>
Moon Phases (cont.)

- Try it: what time is it?
  - Full moon on Eastern Horizon
    - Hint: is the moon rising or setting?
  - New moon on the Meridian
  - First Quarter on the Western Horizon
  - This image taken from the Eastern Horizon:

Image source:
http://stars.astro.illinois.edu/
Summary

- Eclipses happen when Earth, Moon and Sun are aligned perfectly.
- Tides are the gravitational influence of the Moon and Sun relative to Earth.
- Moon phases are a predictable, regular, cycle of the Moon casting a shadow on itself.