Survey of Astronomy

Astr 1010, Section 03
Announcements

- Brooks Observatory 1010 viewing starts this week.
- 9pm–10:15pm, Monday-Thursday.
- Bring blue tickets.
- Clear weather only (check website).
- Take elevator to 5th floor of this building!
- Dress warmly (it’s an open dome!).
- Don’t forget to record your impressions on the M.A. assignment.
Announcements

- **First MIDTERM Exam:** Mon, Sep. 22, covering chapters 1–3 + tutorials.

- **Homework #1:** First (practice) problem is ungraded. I’ll usually assign a practice problem which is never graded. It may be emphasized on the exams!

- **10% penalty/day remains in effect; if you haven’t finished, still worth it**

- Impression of your planetarium visit.
**Last Time**

- **Earth’s axis** “precesses” slowly like a top. Polaris won’t always be the “north star”!

- **Phases of the moon:** not due to shadow of earth on moon, but geometry of earth-moon-sun. Half the moon is always illuminated (except during eclipses).

- **Moon “slips”** on the celestial sphere, like the sun, but much faster, moving 1/2° per hour! Rises ~52min earlier each day.
Eclipses occur when moon falls in earth’s shadow (lunar) or earth falls in moon’s shadow (solar).

Eclipses are rare because the moon’s orbit around the earth is tipped 5° relative to the earth’s orbit around the sun.

Both occur at the same frequency, but lunar seen by half the earth, solar only a small region on the earth’s surface.
What is Science

**Scientia:** “knowledge”.

Not all knowledge comes from science.
Science is a Human endeavor

**Perceptions:**
sight, touch, etc.
The sky looks blue.

**Curiosity:** A question regarding your perception.
Why is the sky blue?

**Imagination:** Come up with a possible explanation (hypothesis).
The sky reflects the blue oceans.

**Skepticism:** Test the hypothesis playing devil's advocate.
Wrong. No oceans in Arizona.
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What is science?

There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.

— Mark Twain

Not a perfect enterprise.
Hallmarks of Science

Natural Causes: Scientific models invoke only natural causes.

Occam’s razor: Simplest possible model is (usually) the best.

Verifiability: Others must be able to verify findings.

Falsifiability: Scientific models or theories must make predictions. If they don’t agree, the model will be abandoned.
That’s just like your “theory”, dude.

A scientific “theory” is different from a hypothesis. It must:

1. Explain a wide variety of observations with a few simple principles, **AND**

2. Be supported by a large, compelling body of evidence, **AND**

3. Not have failed any crucial tests of validity.
Can Theories be wrong?

- Yes! (remember falsifiability?)

- Newton's law of gravity stood for 200 years.

- Einstein showed that Newton's law only works in certain situations (like those we encounter on earth).
Examples of non-science

- **UFO’s**: no one can verify an individual UFO account.

- **Astrology (which is not astronomy)**: predictions no better than random chance.

- **Plenty of useful fields of knowledge are “non-science” — it’s not an insult. Example: Learning to sing.**
Planets Known in Ancient Times

- **Mercury:**
  - Difficult to see,
  - Always close to the Sun

- **Venus:**
  - Bright,
  - Morning or evening “star”

- **Mars:**
  - Red

- **Jupiter:**
  - Very bright

- **Saturn:**
  - Moderately bright
Venus, Mercury, Mars from Perth, Australia

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APOD/2008–09–12
The Planet’s Motion

Planets “wander” on the celestial sphere, slipping day by day, like the sun and the moon, but less uniform in motion.

Diurnal motion like fixed stars

- Rise in “east”
- Transit “high/low in south”
- Set in “west”

Usually moving W to E, but varying in speed and brightness.
How did the Greeks explain planetary motion?

The underpinnings of the Greek "geocentric" model were laid by Aristotle:

- The Earth is at the center of the Universe
- Heavens are "perfect": objects move on perfect circles or spheres.
But how do you explain this?

Mars (and to lesser extent, Jupiter and Saturn) seems to stop, turn around!, and then continue across the sky throughout the year.
WHERE WOULD YOU LOOK TO SEE A PLANET RISE WHEN IT IS IN RETROGRADE MOTION?

A) NEAR THE EASTERN HORIZON

B) NEAR THE WESTERN HORIZON
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WORKBOOK

- FORM GROUPS OF 2-3.

- LET’S DO “OBSERVING RETROGRADE MOTION” ON PAGE 97.
Retrograde Motion?

Naturally explained by the Earth catching up to and “lapping” the other planet in their mutual orbits around the Sun.

Interactive Fig. 2.27.
You observe Mars and find that it is undergoing retrograde motion. What time does it transit?

A) about 6am
B) Noon
C) about 6pm
D) Midnight
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- **A) about 6am**
- **B) Noon**
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- **D) Midnight**

Being “lapped” at “opposition”!

Where is the sun?
A planet is moving in retrograde motion. Over the course of several nights, how will the planet appear to move relative to the background stars?

A) east to west

B) west to east

C) It will not move at all, as planets do not move with the stars.

D) It will move randomly, as planets move differently than the stars.
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Ancient Astronomy

Earliest recorded astronomy:
- Babylonian/Egyptian.
- Chinese.
- Mayan.

Early religion and astronomy:
- Association of objects in the sky with gods.
- Planets=lesser gods.
# Planets and Gods of Mythology

<table>
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<th>Babylonian</th>
<th>Greek</th>
<th>Roman</th>
<th>German/Norse</th>
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<tr>
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<td>Shamash</td>
<td>Helios</td>
<td>Sól</td>
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<tr>
<td>Moon</td>
<td>Sin</td>
<td>Selenē</td>
<td>Luna</td>
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<td>Nabû</td>
<td>Hermes</td>
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<td>Thor</td>
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<tr>
<td>Saturn</td>
<td>Ninurta</td>
<td>Kronos</td>
<td>Saturnus</td>
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</table>
Features of Ancient Astronomy

- **Time of day/time of year/seasons.**

- **Other calendars:** e.g. the Lunar calendar (as opposed to our solar calendars), still in use in the Muslim religion.

- **Some (e.g. Jewish calendar) synchronized lunar and solar.**
An Egyptian obelisk was used to tell time.
Stonehenge (completed around 1550 B.C.)
Yucatan, Mexico: Mayan Observatory
The Greeks: Developers of modern science

- Greeks made models of nature.
- Observe ➤ Think ➤ Hypothesize
- Explained observations without resorting to mythical or supernatural powers.
- Openly debated such models, developing the scientific method.
Earth is Round

- Pythagoras/Aristotle (500BC/350BC)

- Observers farther N or S see different stars

- Altitude of pole star (= latitude)

- Shape of earth’s shadow (seen during lunar eclipse) always round
Earth is round

Ships sailing over horizon

Hull disappears first

Mast disappears last
Size of Earth

- Eratosthenes
- Sun far away
- All observers point same direction to sun
Size of Earth

- **Eratosthenes**

- **Altitude of sun at noon on summer solstice**
  - At zenith in Syene
  - 7° south in Alexandria
    - $7°/360° = 1/50$ circle

- **Distance between cities**
  - 5000 “stadia” (a unit)

- **Circumference of Earth**
  - $50 \times 5000 = 250,000$ stadia
    - (about 40,000 km)
**Size of Earth**

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  (about 40,000 km)  \[\text{Actual value} = 40,076 \text{ km!}\]
HYPOTHESIS

- Greek believed the “celestial sphere” was a real, fixed sphere with the earth at its center, and where the stars were fixed.

- Sun, moon, and the “wandering” planets each got their own sphere (nested).

- Rejected sun-centere (heliocentric) models, since the stars suffered no parallax.
Parallax

- Apparent movement of foreground sources due to changing position of observation.

- Try it with your finger!
If earth orbits the sun, stars should show parallax through the year. Not observed by the greeks.

Two possibilities:

A) Earth orbits the sun, but stars are so far away, parallax is not detectable.

B) Earth is stationary at the center of universe: no parallax.

Greek rejected A, the correct answer.
Claudius Ptolemy (C. A.D. 100-170)

Movement of small circles upon larger circles explained retrograde motion.
Ptolemaic Model

- Fairly complex (e.g. large circles offset from center).
- This “Ptolemaic model” could predict the location of the planets to within a few degrees.
- Lasted for 1,500 years!
- Arabic translation of Ptolemy’s work named Almagest (“the greatest compilation”)

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Ptolemaic System
Reminders

- Finish reading Chapter 3.
- 1st round of observing @ Brooks Observatory: this week.
- Exam Review on Wed.