Astro 210

Lecture 4

Jan 26, 2011

Announcements

- HW1 posted; due at *start* of class Friday
  note juicy 10-point bonus (requires planning & digital camera)
- Office hours: Instructor 2-3pm Wed; TA 10:30-11:30am Thurs
- **register** your iClicker; link on course webpage
- first Planetarium show one week from today
  info online: **reservations**, schedules, directions, report form
- if this is your first class: see me afterward!

Phases of the Moon

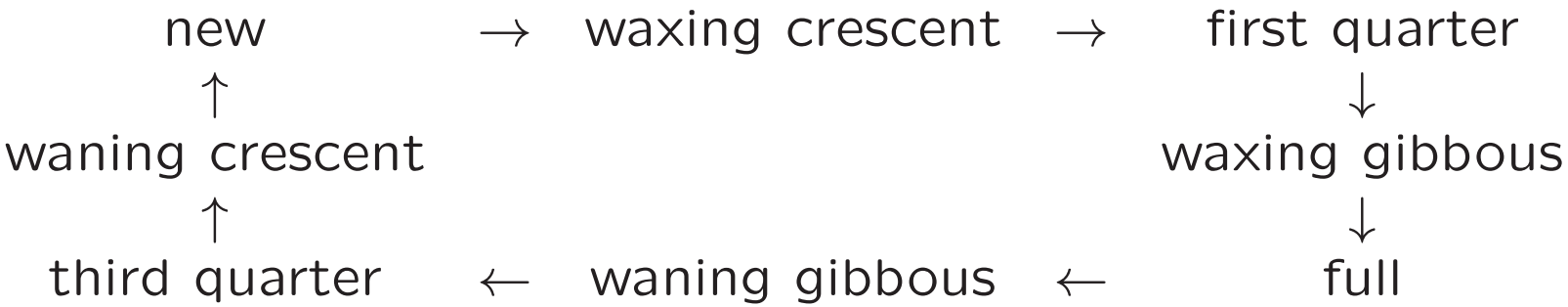

diagram: phases as seen on sky

Q: what is basic physical origin of phases? Why do we sometimes see only part of the Moon illuminated?

phases simple but beautiful

basic effect: **see illuminated moon from different angles**

phases **not** due to Earth blocking sunlight

i.e., phases are not eclipses!

diagram: top view, sky views

excellent exercise in translating situation in 3-D space

to 2-D projection on sky

for each Sun-Earth-Moon position, ask:

Q: how much of Moon's surface is illuminated by the Sun?

Q: how much of the illuminated portion can we see from Earth?

Q: what does this look like in the sky?

iClicker Poll: Moon Phase and Rise Time

Note: each phase rises and sets at a specific time of day

When does the 1st Quarter moon rise?

A noon

B 3pm

C dusk

D midnight

E 3am

Phases and Latitude

Note: lunar phase pattern depends on observer latitude
i.e., which from hemisphere you look

all of the above discussion was for *northern* observers

Q: what aspects of the situation change for southern observers?
Q: what aspects do not change

southern observers: "upside-down" relative to north
(and vice versa)
$\rightarrow$ moon image same (illuminated vs dark portion identical)
but "upside-down"

unchanged:
- waxing or waning nature of phase
(i.e., increasing or decreasing illumination)
- type of phase (crescent, gibbous, etc)

different:
- southern observers see reversed moon right $\leftrightarrow$ left
relative to northern observers
- e.g., waxing crescent illuminated on *left* side
waning gibbous illuminated on *right* side

For all homework, exam problems: assume *northern* observers on earth (and on the Moon!)

my suggestion: practice!
do the experiment in real life!
when moon up: point to moon, then sun, look at angle!

complete cycle of lunar phases in 29.5 days
$\Rightarrow$ 3rd fundamental measure of time: **month of phases**

Any questions?

Eclipses

Lunar Eclipse: moon in earth's shadow

diagram: Sun, Earth, Moon

`www: lunar eclipses`

note: can still see Moon even when totally in Earth's shadow!
appears much dimmer, and red

Q: what's going on? why the red color?

note that *direct* sunlight is totally blocked
so light must be indirect, in fact:
scattered light from earth's atm.
red b/c blue is scattered more strongly, so only red is left
in other words:
  glow is from all the sunrises and sunsets on Earth!

solar eclipse: observer in moon's shadow
Note: Earth larger than Moon
Q: what does this immediately imply for solar eclipses?

since Moon smaller than earth, whole earth cannot be in shadow
in fact, only a small region, $\sim$ 100 mi, at a given time
"eclipse path"

interesting coincidence: Moon and Sun have
almost identical angular size
and what's more: Moon's distance changes (not circular orbit)
`www: moon perigee/apogee comparison`

together this means: two kinds of solar eclipses
`www: annular eclipse`
`www: total eclipse`
`www: looking back on Earth's shadow`

Note: there is *not* a solar or lunar eclipse every month!

if Moon's orbit plane around Earth
were same as Earth's around the Sun (i.e., the ecliptic)
then *would* have eclipses monthly

the fact that we *don't* means that
the two orbits are *not* coplanar!

⋆ moon's orbit plane slightly tilted w.r.t. ecliptic
so moon is typically below or above ecliptic

`www: eclipse diagram`

only eclipse when Moon orbit crosses ecliptic plane
happens *twice* a year $\rightarrow$ "season of eclipses"

geometrically: intersection of planes is a *line*
and intersection of line with closed orbits is 2 points

Note: eclipse "season" last about ~ 1 month
i.e., time window of alignment about equal to Moon orbit period
$\rightarrow$ can sometimes have two or three eclipses in same season

Next eclipses: partial solar June 1 and July 1, lunar June 15
watch over summer, impress someone with your ASTR210 skills!

Any questions?

Planets

Known since ancient times:
Mercury, Venus, Mars, Jupiter, Saturn

Discovered later, with telescopes:
Uranus, Neptune, Pluto

daily motion: westward w.r.t. horizon
i.e., .rise in east, set in west

w.r.t. fixed stars:
always stay close to ecliptic
usually move eastward
`www: SOHO LASCO planet movie`
but sometimes westward: "retrograde motion"
`www: retrograde motion of Mars`
so motion not uniform in angular speed
in fact, not uniform even when in "direct" (non-retro) motion

retrograde motion not random in occurrence!
key patterns observed:

- for each planet, retrograde onset is *periodic*
  with different periods for different planets
- retrograde occurence *correlated* with position relative to Sun:

Mercury, Venus	Mars, Jupiter, Saturn (& others)
always stay close to sun on sky *never* seen opposite Sun	can move freely along ecliptic can be opposite sun
retro when in **conjunction** (i.e., when closest to Sun on sky)	retro when in **opposition** (i.e., opposite Sun on sky)

These Patterns Cry Out For Explanation

you may have noticed–I've heaped a lot of facts on you.
Do you have to memorize them? Do *I* have them memorized?
No! There's a simpler way of remembering.
→ build a **model** of the solar system's geometry and dynamics
organize, explain all of this data!

> Science is built up with facts, as a house is with stones.
> But a collection of facts is no more a science
> than a heap of stones is a house.
> —Henri Poincaré

Crucial point:
when making model for motions of planets
have to explain *all* observed features;
turns out the retrograde motion, in all its detail,
gave people the hardest time...

Building a Scientific Model

Scientific Models must:

- explain observations
- predict future observations

> The principle of science, the definition, almost, is the following: *The test of all knowledge is observation.* Experiment is the *sole judge* of scientific "truth."
>
> The first principle is that you must not fool yourself–and you are the easiest person to fool.
>
> —Richard Feynman