Astro 210
Lecture 3
Aug 27, 2010

Announcements

- iClickers *required* starting today
- **register** your iClicker; link on course webpage
- HW1 available; due in class next Friday

Last time: Began gathering data $\Rightarrow$ the naked-eye sky

- without distance info, 3-D universe flattened $\rightarrow$ 2-D sky
- full sky: celestial sphere

Q: what is it? How is is "celestial"? Why is it a sphere?

Q: what is the motion of stars relative to each other? relative to the horizon?

Today: Motions of Sun, planets

Sun Motion

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

when at highest point: noon

fundamental measure of time: **solar day**

$\Rightarrow$ interval from one noon to next (spin period)

maximum angular elevation varies with seasons

in Chambana:

$\sim$ June 21, summer solstice: $73.5°$

$\sim$ March 20, Sept 23, equinoxes: $50°$

$\sim$ Dec 22, winter solstice: $26.5°$

$\rightarrow$ variation has same period as seasons

yearly movement sun moves east w.r.t. fixed stars
- along a specific path: the **ecliptic**
  a *great circle* (*Q: what's that?*) on celestial sphere
  passes through 12 constellations: zodiac

Q: how can we figure out observationally where sun is if can't see surrounding stars during the day?

Q: what does Sun's path on 2-D sky imply for 3-D nature of Earth-Sun motion?

Solar Motion on the Sky, and in Space

Zodiac known to ancients:

note changing pattern of constellations you can see at night

and around sunrise/set; can work out where Sun is

More modern techniques now exist:

`www:` `SOHO LASCO movie`

ecliptic on *sky* is a great circle

i.e., intersection of sphere and plane

   which goes through sphere center

in 3-D *space*, earth-sun motion lies in a plane

$\Rightarrow$ the ecliptic plane

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The Tilt

- Earth-Sun orbit axis $\neq$ Earth spin axis

- ecliptic plane tilted w.r.t. celestial equator by 23.5°
  www: ecliptic animation
  Demo: with pen

- cel sphere axes fixed w.r.t. stars:
  polaris always $\sim$NCP

- 2nd fundamental measure of time:
  year of seasons: Earth-Sun orbit period

Q: how about the Moon–motion? effects to be explained?

Moon Motions

daily: rises in east, sets in west

also: *east*ward motion w.r.t. fixed stars; through zodiac
(close to ecliptic, but not exactly)
completes one orbit in ~ 27 days
(rises about 49 min later each day)

Lunar phenomena:
• phases
• eclipses

to understand, helps to appreciate relative scales

iClicker Poll: Earth vs Moon Sizes

Vote your conscience–all get credit!

If the Earth were the size of the globe, then
which represents the proportional size of the Moon?

A   softball

B   baseball

C   golf ball

D   marble

iClicker Poll: Earth vs Moon Distance

If the Earth were the size of the globe, then

how far from the Earth should the Moon ball be?

Hint: the Moon's angular diameter is $0.5°$

A   arm's length

B   front row

C   middle row

D   back row

E   Expresso Royale at Illini Union

Earth vs Moon: Scales

size: radii in ratio

$$\frac{R_{\mathsf{Moon}}}{R_{\mathsf{Earth}}} \approx \frac{1}{4} \tag{1}$$

orbit distance:

we observe angular diameter $\theta = 0.5°$: small angle

set by Moon diameter $D_{\mathsf{Moon}} = 2R_{\mathsf{Moon}}$ and distance r_{Moon}:

$$\theta|_{\mathsf{radians}} \approx \frac{D_{\mathsf{Moon}}}{r_{\mathsf{Moon}}} = 2\frac{R_{\mathsf{Moon}}}{r_{\mathsf{Moon}}} \tag{2}$$

$$= 2\pi\frac{0.5°}{360°} \text{ radians} \approx 0.009 \tag{3}$$

and so $r_{\mathsf{Moon}} \approx 220 R_{\mathsf{Moon}} \approx 60 R_{\mathsf{Earth}}$

if $R_{\mathsf{globe}} = 10$ cm, then $r_{\mathsf{ball}} \approx 600$ cm $= 6$ m $= 18$ feet

Lesson: Moon is small, far away!

$\rightarrow$ shadow easy to miss!

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Phases of the Moon

new   →   waxing crescent   →   first quarter

↑   ↓

waning crescent   waxing gibbous

↑   ↓

third quarter   ←   waning gibbous   ←   full
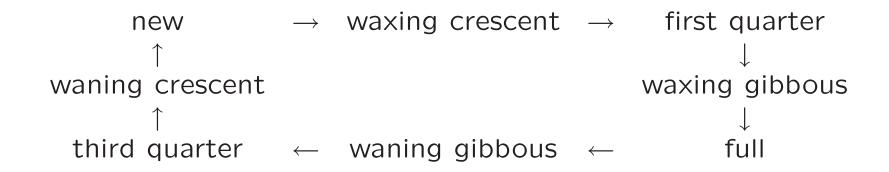
diagram: phases as seen on sky

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

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?