Astro 210

Lecture 21

March 9, 2011

Announcements

- Friday only: class moved for Engineering Open House
  meet in Ceramics Bldg room 218
- HW6 due at start of class next time
  typos discovered, erratum & corrected questions posted
- Night Observing: **last chance** this week!
  first clear night today-Thursday will be *last* session
  report forms, info online

Last time: terrestrial planets

Life on Mars?

Water $\rightarrow$ maybe life?
No clear evidence

But: ancient Mars meteorite (discovered on Earth)
Q: how did it get here? how know it's Martian?
claimed to have fossil bacteria
`www: microscopic image--bacteria-like figures?`
$\rightarrow$ perhaps life long ago?

Q: even if Mars had bacterial life–why is this a Big Deal?

Jupiter

prototype for Jovian planets

mass: $M = 1.9 \times 10^{27}$ kg $= 0.1\% M_{\odot} \simeq$ sum of rest of planets

radius: about 10 R_{Earth}

$\rho_{\text{avg}} \simeq 1,300\ \text{kg/m}^3 \ll \rho_{\text{rock}}$ for sure isn't rocky!

composition: H 79%, He 20%, 1% other $\rightarrow$ very similar to sun

color: ammonia clouds

spin: rapid, 9hr 50min $\rightarrow$ oblate ("M&M shape") $\rightarrow$ atmospheric circulation!

`www: Jupiter`

high pressure regions: zones

low pressure regions: belts

Great Red Spot: long-lived storm

`www: Red Spot`

`www: red spot animation`

Jupiter Interior

`www: Giant planet interiors`
no solid surface!

gaseous atmosphere becomes increasingly dense
until compressed liquid H_2 (hi pressure)
then liquid H metal, probably rocky core
(differentiation of heavy elements)

Saturn

Rings

not solid! many small icy rocks, dust
each has individual circular Keplerian orbit
$\rightarrow$ rings have different periods, speeds depending on distance
$\sim$ few $\times$ 100 m thick: razor-thin!
aligned with equator

Cassini-Huygens: ongoing mission
spectacular views of rings
detailed data on ring structure, interaction with moons
`www: Cassini images, movies`

iClicker Poll: Saturn's Rings

Saturn's rings made of orbiting particles

What is pattern of orbit periods, from innermost to outermost?

A $P_{\text{inner}} < P_{\text{mid}} < P_{\text{outer}}$

B $P_{\text{inner}} = P_{\text{mid}} = P_{\text{outer}}$

C $P_{\text{inner}} > P_{\text{mid}} > P_{\text{outer}}$

So: why does Saturn have rings?
what gives them their structure?

Tidal Forces: Roche Limit

consider object held together **by gravity alone**

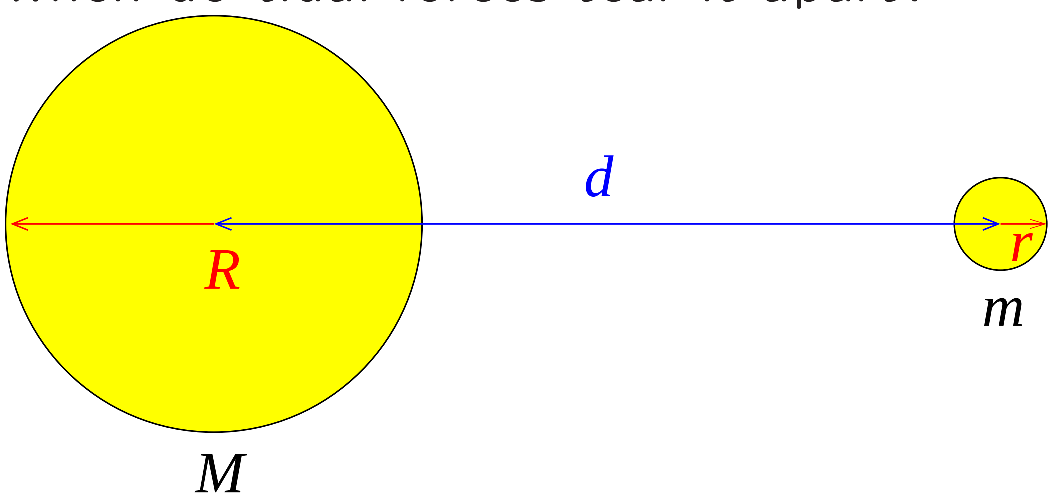
"self-gravitating" mass m, size r

think: "rubble pile" held together by its own gravity

put in gravitational field of larger object M

tidal forces of M in competition with self-gravity *Q: why?*

when do tidal forces tear it apart?



how close is too close?

competition: *inward self-gravity* vs. *outward tides*

•grav. force on test particle at surface is $F_{\mathrm{g}} = Gmm_{\mathrm{test}}/r^2$

•large body of mass $\mathcal{M}$ at d exerts tidal force
$F_{\mathrm{t}} = 2G\mathcal{M}m_{\mathrm{test}}r/d^3$

tides and gravity equal when $Gmm_{\mathrm{test}}/r^2 = 2G\mathcal{M}m_{\mathrm{test}}r/d^3$, or

$$d^3 = 2\frac{\mathcal{M}}{m}r^3 \tag{1}$$

if densities of similar

$$\frac{\mathcal{M}}{R^3} \approx \frac{m}{r^3} \tag{2}$$

and so

$$d^3 = 2R^3 \;\; \Rightarrow \quad d = 2^{1/3}R = 1.3R \tag{3}$$

∞

more detailed analysis: $d = 2.4R$
this is "Roche limit"; closer → torn apart

Saturn: rings inside Roche limit, moons outside
$\rightarrow$ rings are "protomoon" that never coalesced
$\rightarrow$ more likely: captured moon

note: **all** Jovian planets have rings!
`www: Jupiter rings (Voyager, IR)`

note: we are inside the Roche limit for Earth!
Q: why don't we get ripped apart?

Debris

in addition to planets

Solar system contains large amount of smaller junk

- rocky debris: asteroids
- icy debris: comets

Debris I: Asteroids

Properties

"minor planets" number $\sim 10^5 - 10^6$

masses: total $\sim 10^{-5} M_{\text{Earth}}$

sizes: poorly known, but go up to ~ 300 km

composition: solid (no gasses, ices)

- 5/6 are "C-type" carbon rich
- 1/6 rea "S-type" iron rich

Q: how do we know this?