

Astro 210
Lecture 22
March 11, 2011

Announcements

- HW6 due
- Night Observing: arrgh! this week a bust
last chance next week!
first clear night Mon, Tue, or Wed will be *last* session
report forms, info online
- Hour Exam 1: mea culpa! scores available by Sun nite
exams handed out Monday

Last time: Jovian planets

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Today: solar system debris, and Pluto

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 are “S-type” iron rich

Q: how do we know this?

Asteroid Orbits

asteroids orbit Sun → must follow Kepler's laws (of course!)

wide variation in a , e

but average $a \simeq 2.8$ AU

→ between Mars & Jupiter

average eccentricity $e < 0.1$: nearly circular

most orbit planes close to ecliptic

www: Inner Solar System in real time

www: Near-Earth objects

if cross Earth's orbit, enter atmosphere: meteorite

www: Leonids

www: fireball

Note: meteorites on view in Geology—extraterrestrial matter!

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LSSST: will identify $> 90\%$ of near-Earth asteroids > 140 m

what do asteroids look like? From ground, see only largest
but now have visited some (on the way to outer SS)

www: Gaspara

www: Ida & Dactly

Near Earth Asteroid Rendezvous

intercept near-earth asteroid 433 Eros

S-type: stony-iron

large: 35 km long, 14 km wide—Chicago

“potato shaped”

www: NEAR image of 433 Eros

www: NEAR movie

↳ hints of stratification—broken from (much) larger object?

Debris II: Comets

www: Hale-Bopp, Hyakutake, Ikeya-Seki

last year: brightest comet in decades! www: McNaught

Comet Structure: “dirty snowball” **nucleus:** ~ 10 km
solid: ices (H_2O , CO_2 , CH_4), embedded dust grains

very elliptical orbits: changing $r \rightarrow$ changing T

far from Sun: completely frozen

as approach: ice \rightarrow vapor (sublimation)

dust, gas released $\rightarrow 10^6$ km **coma**

www: HST Hale-Bopp: coma & jets, nucleus unresolved

pressure from sunlight & solar “wind” of particles

\rightarrow **tails:** Ion, dust

ion tail: small, low-momentum particles

→ carried by solar wind

→ points away from Sun

dust tail: larger, higher-momentum particles

→ retain \vec{v} component in comet direction

→ non-radial arc tracing comet path

NASA Mission: Stardust

at 1.86 AU from Sun (2.6 AU from earth)

fly by comet P/Wild 2, collect samples of dust, gas

returned to earth last year: parachute, caught by airplane

“fresh” comet, hasn’t lost all of its original material

→ learn about interstellar dust grains

○ → output of stars and building blocks of planets

Comet Orbits

“Long Period”: $P > 10^5$ yr

→ $a > 2000$ AU!

all orientations → not just ecliptic

Oort Cloud

spherical comet “reservoir” at 3000–100,000 AU

not observed directly!

probably did not form there....

ejected by Jovian planets in early SS?

“Short Period”: $P < 200$ yr

lie in ecliptic

→ not from Oort cloud → **Kuiper Belt**

∨ $a = 30 - 100$ AU

www: Outer solar system sketch

first Kuiper belt object detected in 1992
a.k.a., *Trans-Neptunian* objects; today, tally is hundreds
typically \sim few% – 10% size of Pluto
probably formed where they are now
estimates: 70,000 KBO's
total mass $\sim 0.1M_{\text{Earth}}$

also: some comets strongly deflected,
have orbits with very small perihelion
(i.e., *very* close to Sun).

www: sun-grazing comets

Pluto

Orbit

$a = 39.5$ AU, $P = 285$ yr, $e = 0.25$ – largest for planet

Properties

$\rho_{\text{avg}} \simeq 2000$ kg/m³ → ice, rock surface: N₂ ice
atm: very thin, $P = 10^{-5}$ earth

www: HST image

Pluto's Moon: Charon – together a “double planet” system

Mass $M_P + M_C = 0.0024M_{\text{Earth}}$; $M_C \simeq 0.12M_P$

$R_P = 720$ km, $R_C = 395$ km

both spins, orbit have same period:

- system tidally locked into co-rotation
- each keeps same face to other

similar to comet nucleus, Kuiper Belt object

Pluto: smallest planet or largest KBO?

Pluto: History and Status

Clyde Tombaugh (1930): Pluto discovered in sky scan totally unlike its outer planet neighbors

1930's-1950's: Kuiper belt idea proposed

1990's: Kuiper belt objects discovered

2002–present: more large outer solar system objects

- Quaoar (“Kwawar”): \approx 60% Pluto size
- Sedna: \approx 70% Pluto size
- “Xena” → Eris: **larger** than Pluto!!

preliminary (Nov 2010) data: maybe not! but for sure more massive

all these are spherical rocky iceballs

largest of huge population of object beyond Neptune

orbits more elliptical than planets, but still \approx in ecliptic

→ “transneptunian objects” or Kuiper belt objects

smaller Kuiper belt members sometimes scatterer → comets

To Be Or Not To Be

2006: International Astronomical Union redefines “planet”
Pluto demoted to “dwarf planet”
along with Ceres (asteroid belt), and KBO’s Eris + 2 others

Revise your vote—or not: Is Pluto a full-fledged, non-dwarf planet?

- A** No way! Good riddance!
And I’ve got my eye on you, Neptune!
- B** Umm, probably not?
- C** Umm, probably so?
- D** Yes way! Pluto was robbed! Long live Pluto!