Age & Comets–February 25

- Test 2
  - Mon, Feb 28
  - Covers
    - 6 questions from Test 1. Added to score of Test 1
    - Telescopes
    - Solar system
  - Format similar to Test 1
- Homework 3 closes 3am Mon
- Age of solar system determined with meteorites
- Comets
- Missouri Club

Meteors (often pieces of comets)

- Small particles burning up in Earth's atmosphere.
  - Typical meteor = 1 gram (size of a pea)
  - Bright fireballs = golf-ball sized particle.
  - Bowling balls would make it to Earth's surface.

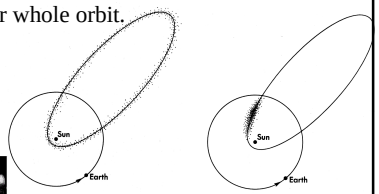
Meteorites (always pieces of asteroids)

- The particles that make it to the Earth's surface.
  - Allende meteorite (Mexico): 2 tons of fragments recovered after airburst.

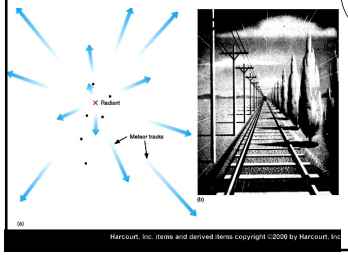
Peekskill, NY early '90s

Meteor showers

- Result of Earth passing through trail of debris from an old comet.
  - Some trails spread out over whole orbit.
  - Others are clumped up.



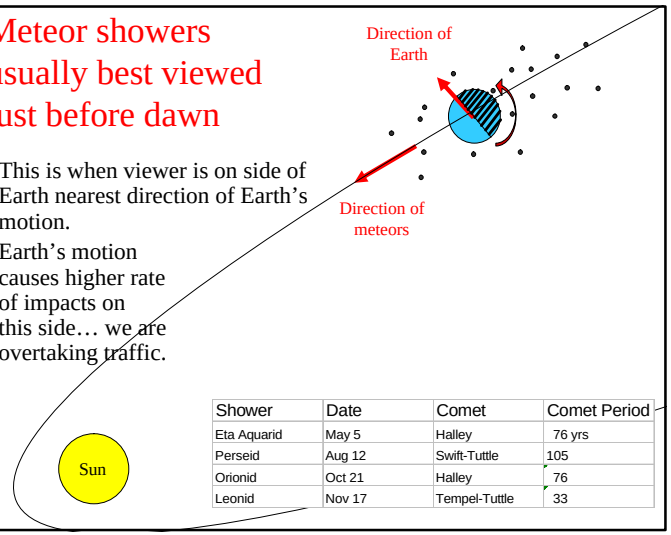
See [Fig. 9.9]



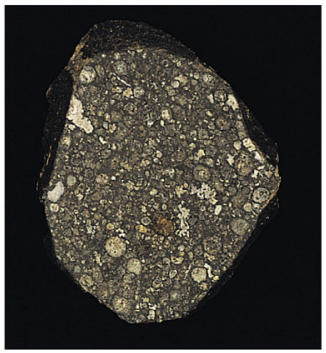
Radiant
- The direction from which the meteors appear to come.
- Determined by combination of motion of meteors and motion of Earth.

Meteor showers usually best viewed just before dawn

- This is when viewer is on side of Earth nearest direction of Earth's motion.
- Earth's motion causes higher rate of impacts on this side… we are overtaking traffic.



Shower	Date	Comet	Comet Period
Eta Aquarid	May 5	Halley	76 yrs
Perseid	Aug 12	Swift-Tuttle	105
Orionid	Oct 21	Halley	76
Leonid	Nov 17	Tempel-Tuttle	33

- Primitive meteorites (not melted)
  - Stony (left). Formed in inner asteroid belt
  - Carbon-rich (right). Formed in outer asteroid belt


- Processed meteorites (melted)
  - Iron (left). Large iron crystals => cooled very slowly =>part of a large object
  - Stony (right).

Age of rocks

[pg. 159]

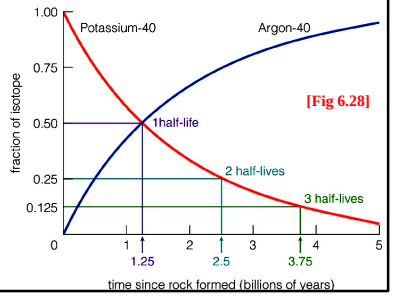
- Radioactive decay
  - unstable atomic nucleus decays into stable nucleus (different element)
    - Examples:

      Uranium-238 ➔ Lead-206 + 8 x Helium-4 (4.5Billion years)

      Potassium-40 ➔ Argon-40 + e^+ (1.25 Billion years)

      ($19p^+$, 21n) **($18p^+$, 22n)**

- *Half-life*
  - Time for 1/2 of radioactive nuclei to decay
- Minerals form with radioactive elements
  - ➔ "daughter" nuclei that shouldn't be in pure mineral.
  - Ratio of daughter/parent nuclei ➔ age since mineral formed.



K-40 ➔ Ar-40 + e^+ (1.25 Billion years)

- Q A meteorite is found with K40 and Ar40 in the ratio 2:1. Its age is ___ 1.25 Byrs.
  a. Older than
  b. Close to
  c. Younger than

- Q The nuclear chemist is concerned about heating during its passage through the earth's atmosphere. The surface of the meteorite would appear be ___ than the center if heating is significant.
  a. Younger
  b. older

Isotopes in primitive meteorites ➔ date of formation of solar system.

- Primitive meteorites have very narrow range of ages
  - 4.48-4.56 billion yrs. Average = **4.54 billion yrs**.
- Primitive meteorites contain Xenon-129
  - Iodine-129 is made in supernovae (exploding stars)
  - Iodine-129 ? Xenon-129 (17 Million years)
  - Xenon-129 is a gas even at low temperatures

  ⇒Meteorite form a few tens of millions of years after a supernova

  ⇒**A supernova triggered collapse of cloud that became solar system**

Comets [9.2]

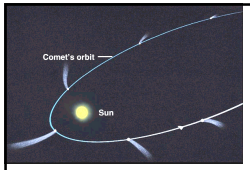
- Small icy nucleus.
- "Dirty snowball" model
  - mostly water ice
  - + other ices
  - mixed with silicate grains and dust
- Outer layers of nucleus vaporize when comet approaches sun.
  - Little geysers and eruptions observed.
  - Comet's head (Coma) often as large as Jupiter
    - up to 250,000 km diameter.
    - Primarily H_2O gas.
    - + few percent CO, CO_2 and hydrocarbons.
  - Huge hydrogen clouds around head can get bigger than sun.

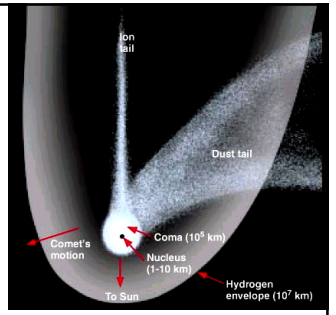
Hale-Bopp (1997)

Comet Hale-Bopp February 7, 2000
This fading super comet continues to be visible in small telescopes almost 5 years after it was discovered. Despite now being out beyond the orbit of Saturn, the comet continues to display a strong coma.
The image is a combination of 3, 3-minute exposures using a 416xt CCD and a 12" f/6 newtonian telescope at prime focus. Taken by Maurice Clark

Comet Hale Bopp (1995 o1)
april 9, 1997

Tails



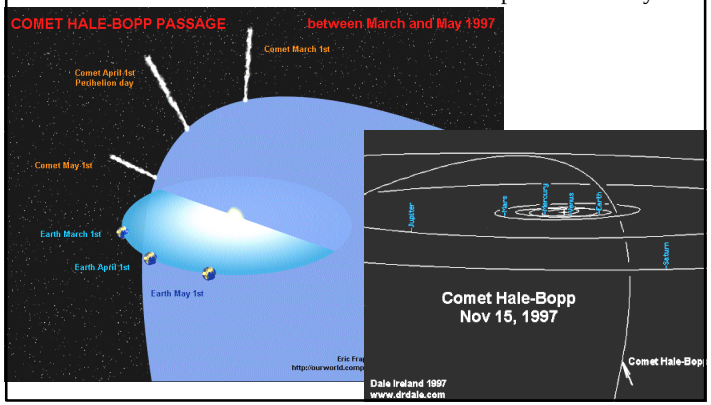


- dust tail
  - up to 10 million km long
  - smoke-sized dust particles
  - driven off nucleus by escaping gases
  - pushed outwards by Sun's radiation
  - competing force of Sun's gravity ➔ curve in tail.
- ion tail
  - Up to 100's of millions km long
  - small charged particles, pushed out by charged particles from Sun (solar wind).

45 minute animation

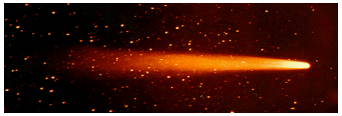
Hale-Bopp's orbit

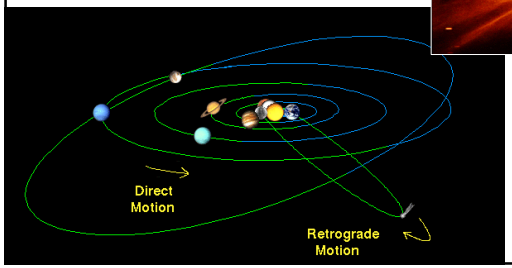
- 4200 yrs since last appearance
- 2400 yrs to next passage
- perihelion: 0.914 au
- inclined 90º to plane of solar system



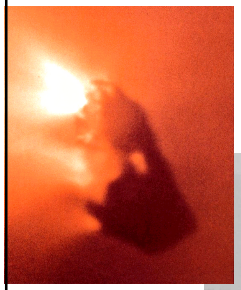
Halley's Comet

- first observed 239 BC
- 76 year average period
- most recent visit 1986
- fizzled out last time around



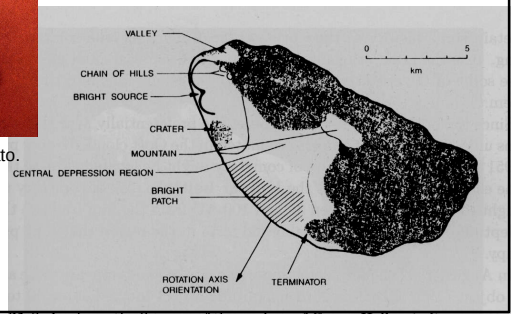


Halley's nucleus.



Picture taken by Giotto.
Sun is at lower left.

- Nucleus is 10×15 km (6×10 mi)
- Nucleus is irregular in shape
- Nucleus is jet black
- Evaporation is confined to small regions



Oort Cloud & Kuiper Belt

- No comets have orbits coming from interstellar space.
- Strong tendency for aphelia at ~ 50,000 AU
- No preferential direction from which comets come

- Best current model: The Oort Comet Cloud
  - 10^{11} - 10^{12} comets in loosely bound solar orbits at 50,000AU
  - Ejected by Jupiter into random directions
  - Gravitational perturbations occasionally deflect one in.
  - Guesstimate: 1 trillion (10^{12}) comets total
    x 10^{-10} earth-masses/comet = 10^{2} earth masses total.

Second source of comets: Kuiper Belt

- At 30-50 AU,
  - just beyond Pluto.
- 60 faint objects spotted so far.
- 40% have 2:3 orbital resonances with Neptune, similar to Pluto's.
- Pluto and its moon Charon probably in this class.

applet