Reading: Ch. 2, Sec.3 w/ **web reading;** Ch. 15, Sec. 1-3
Homework 9 - NASA Budget Debate - **hand in tomorrow/Monday,** 2nd part in-class
Exam 2 - Grades available soon
Last Exam - Wednesday, December 18, 4:30-6:30PM

Last time: **Collisions: Past, Present and Future**

- Collisions in the past
  - Cratering rates then and "now"
- Impact Energetics & Frequencies
- Recent Examples
- The K-T Impact –> Death to all Dinosaurs?
  - evidence and consequences
- The Threat Today

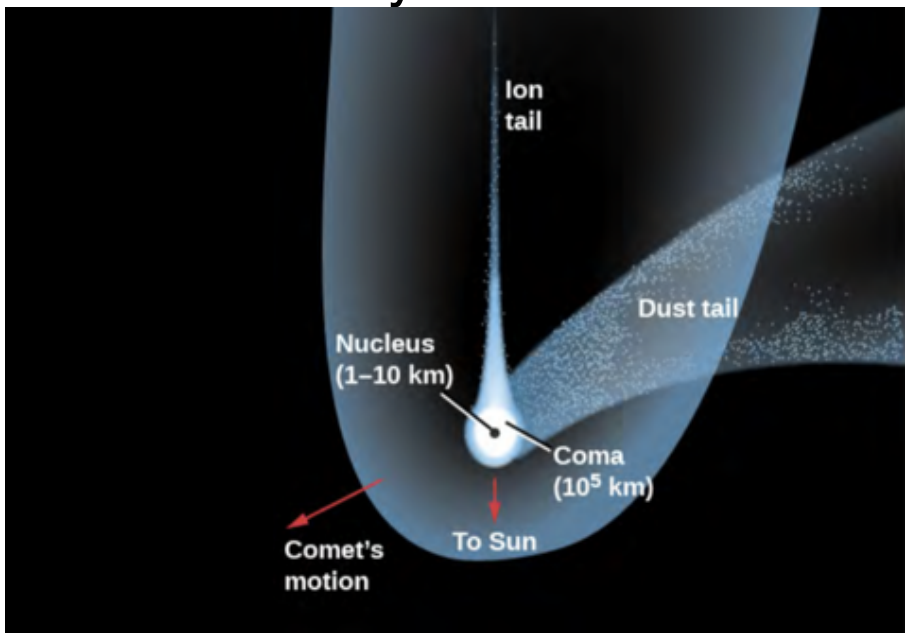
Today: **Comets**

- Comet anatomy: nucleus, coma, and tail(s)
- Comet Origins and Fates
  - Oort cloud and Kuiper belt
- The importance of comets

Comets - "Hairy Stars"

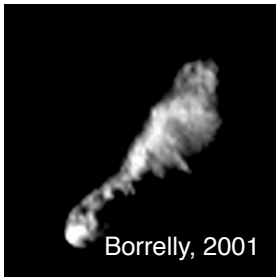
- Comet anatomy
  - at the heart - tiny, dark nucleus
  - bright 'head' = coma
  - near Sun - tenuous, long tail(s)
- Comet Origins and Fates
  - Two regions of origin - Oort cloud and Kuiper belt
  - accidental encounters - fall into inner solar system
- The importance of comets
  - pristine material from S.S. formation
  - primary vehicle for restoration of water on Earth?

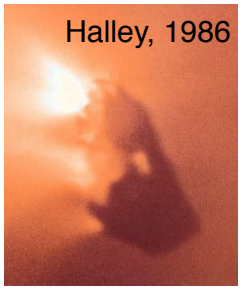
Anatomy of a Comet



Anatomy of a Comet - **the Nucleus**

- a comet's Nucleus
  - very small (< 20 km) - dark, lumpy
  - icy composition with dark crustal material (carbon-rich): H_2O, CO_2, NH_3, CH_4
  - loosely packed
  - a dirty snowball
- for most of time, the Nucleus is all there is!



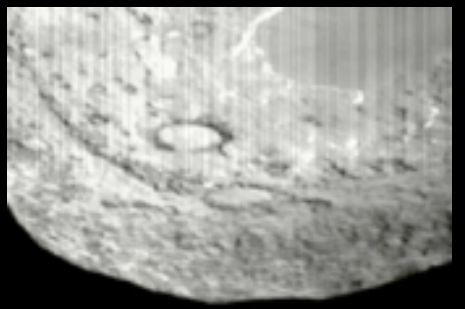


comet nucleus "color"

- comet nucleus - dirty ice with a dark crust
- reflects << 10% of light - similar to charcoal
- still, looks bright in isolation

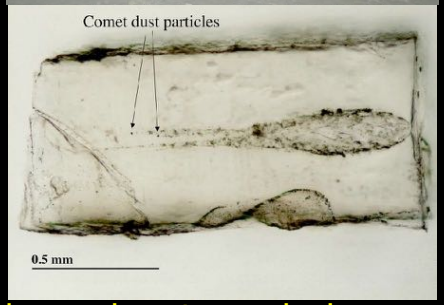
http://www.universetoday.com/114034/what-comets-parking-lots-and-charcoal-have-in-common/

Close encounters with comets



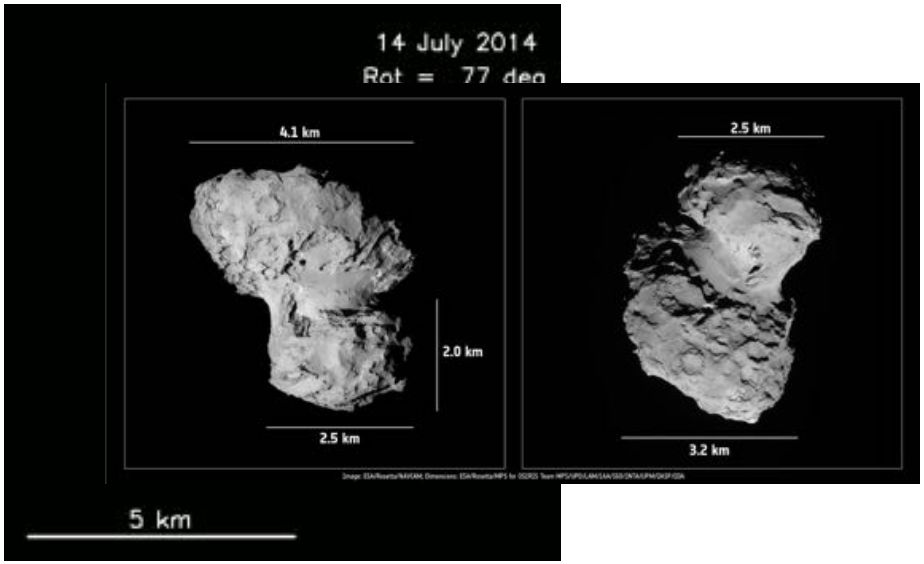
Deep Impact at Temple I
July 4, 2005

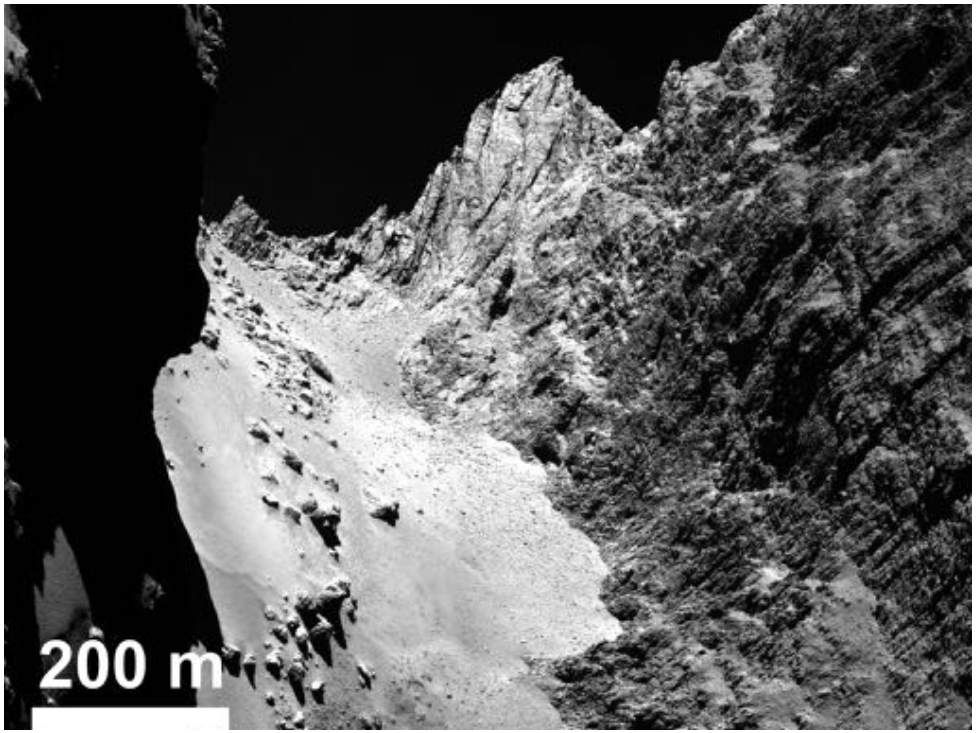
Close encounters with comets



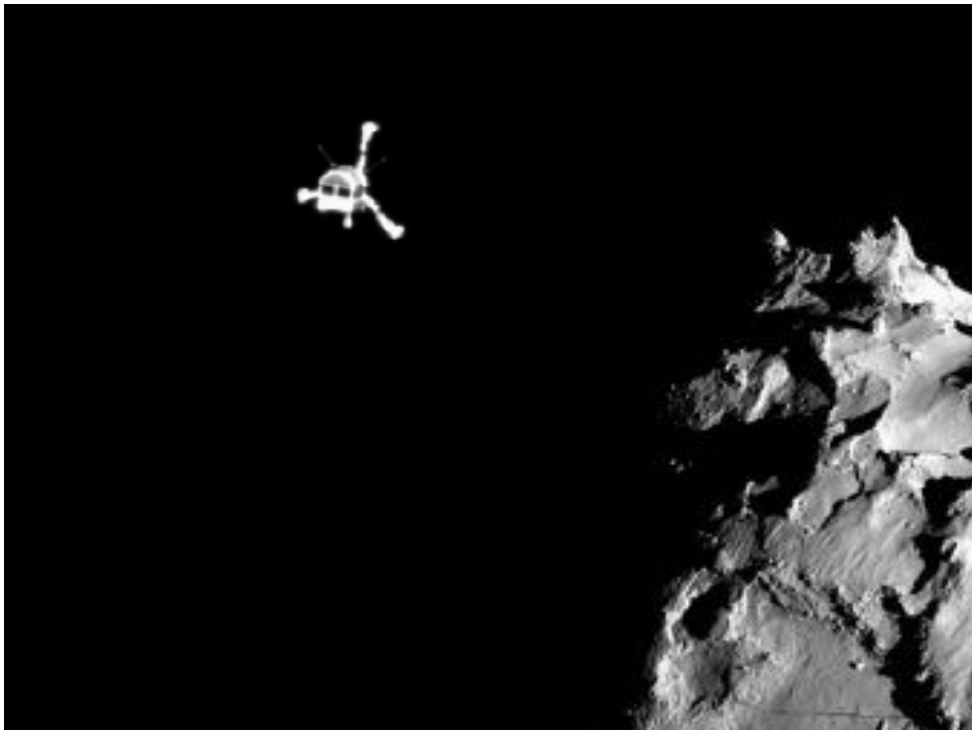
Stardust - Comet Wild sample return mission - 1999-2004-2006

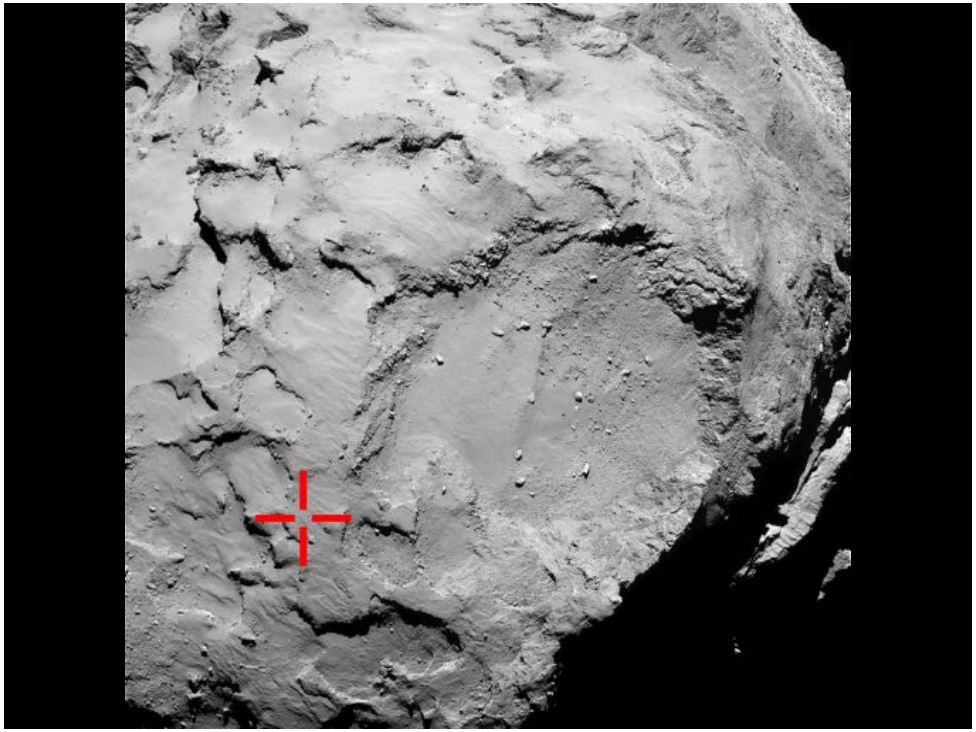
November 12, 2014 - Rosetta & Philae at Comet 67P/Churyumov-Gerasimenko





November 2014 - Rosetta & Philae



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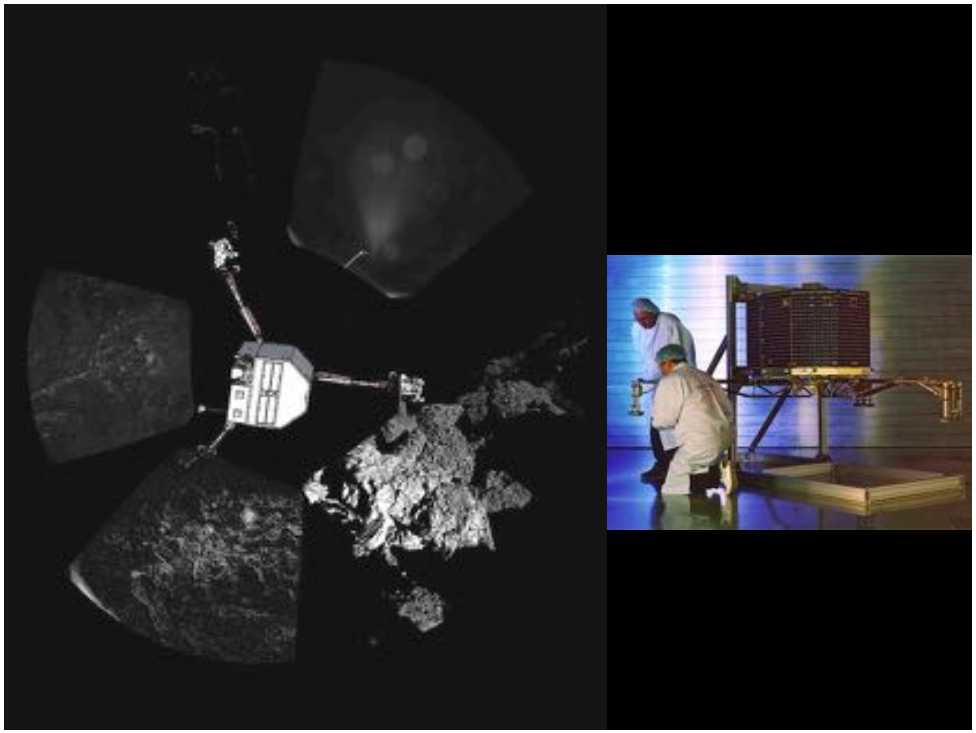
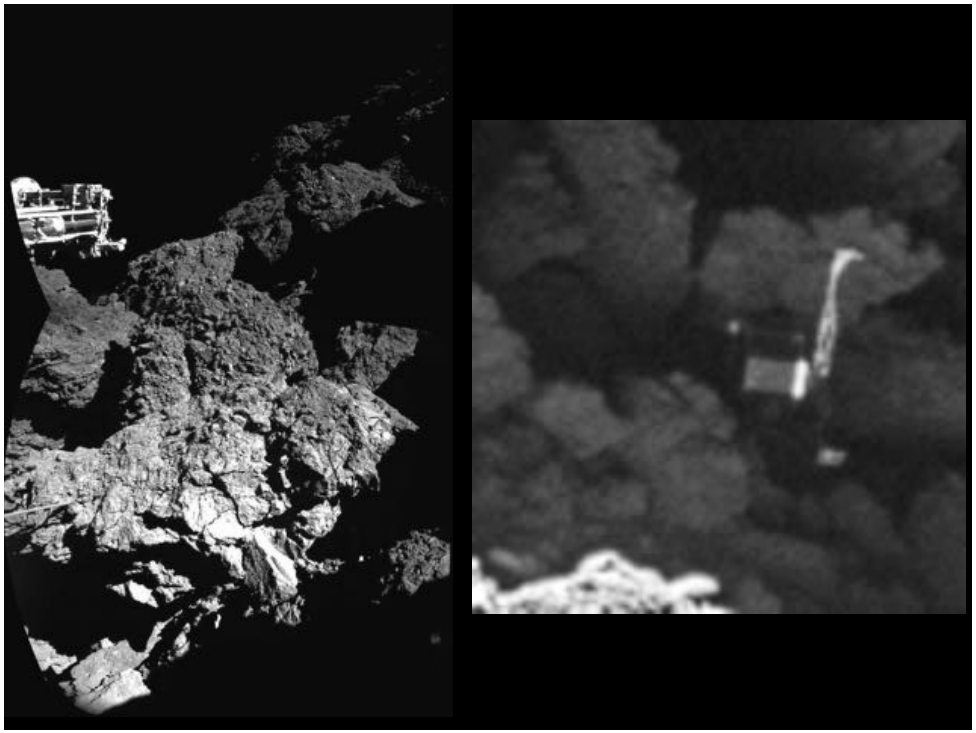
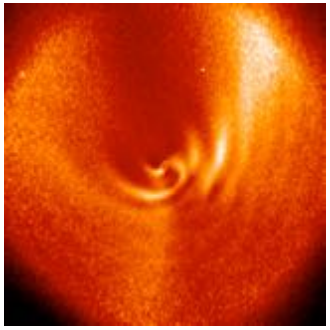
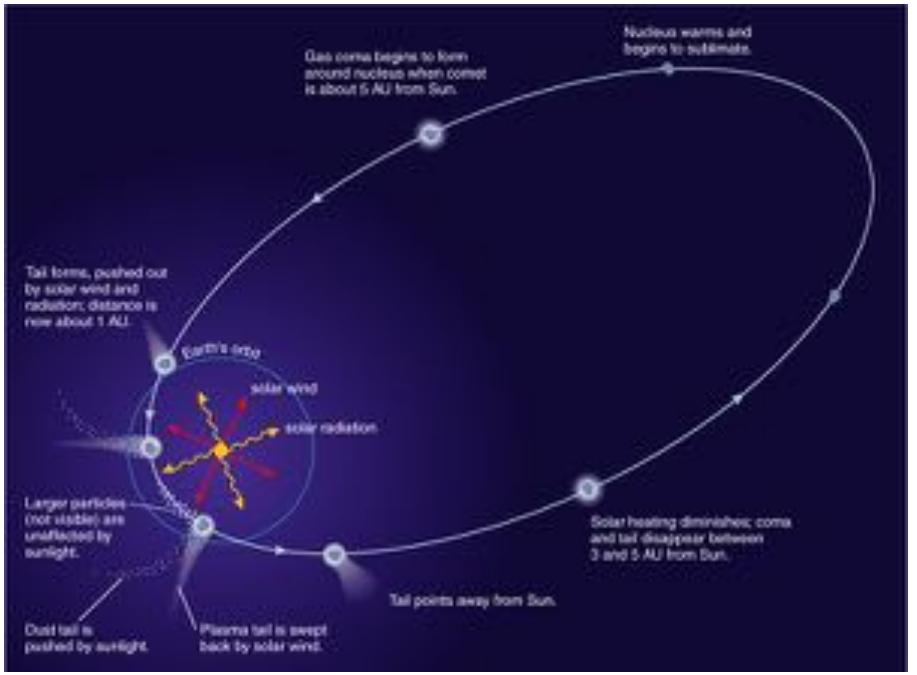




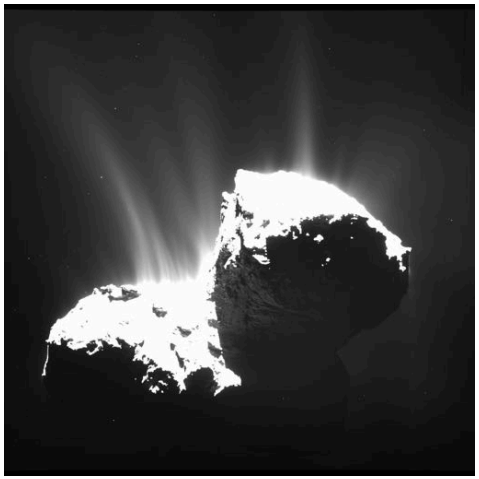
Anatomy of a Comet - **the Coma**

- within 5AU of the Sun... sublimation from nucleus
- released dust and gas form the **coma**
- growth in size on approach to Sun
  - thousands of km across - and bigger
- rotation/lumpiness of nucleus produces structure

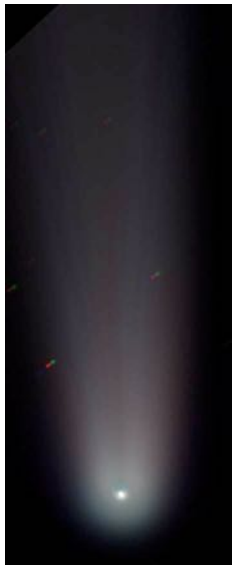




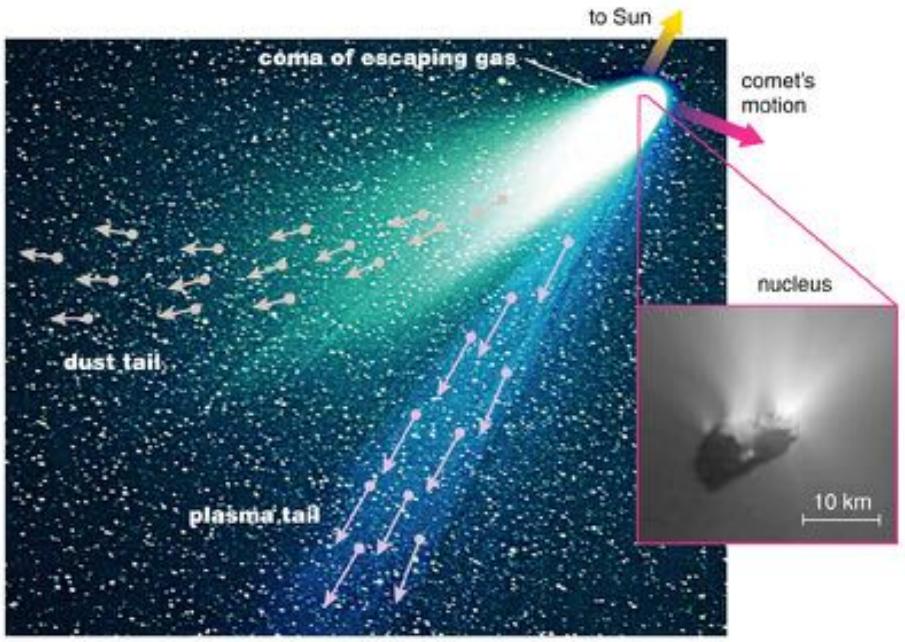
June, 2015 - Rosetta at Comet 67P/Churyumov-Gerasimenko



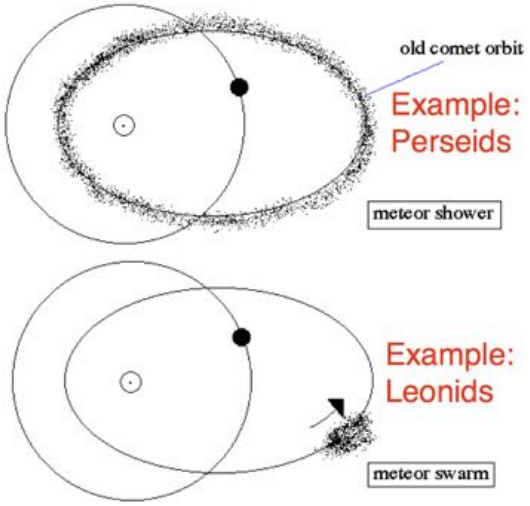
Anatomy of a Comet - **the Tail(s)**

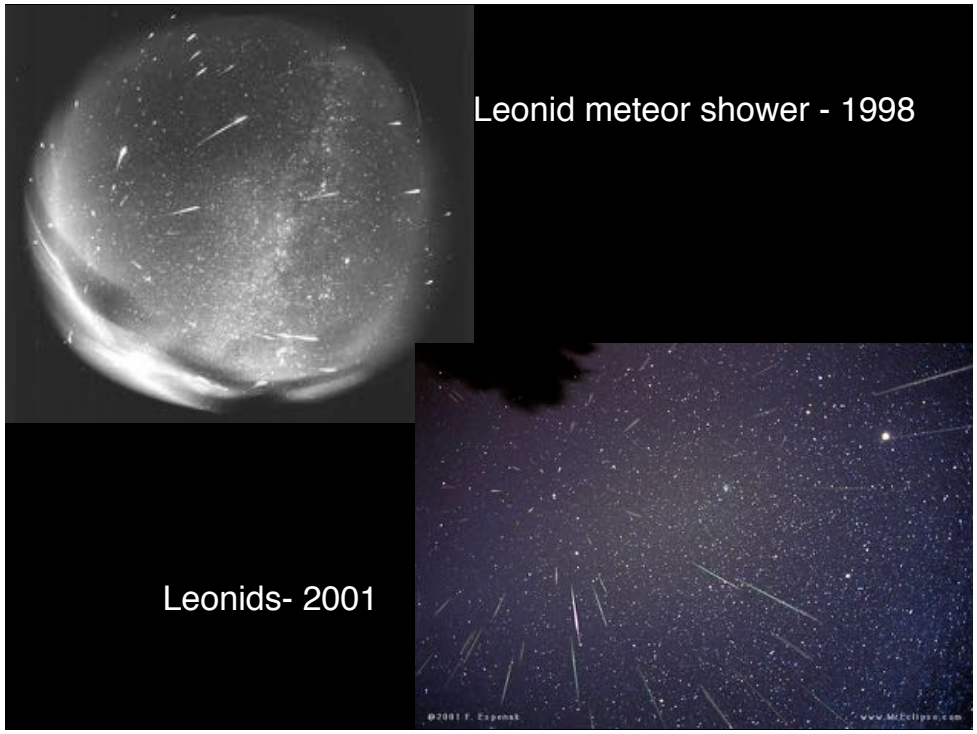


- Material streaming away from Coma
  - appear only when comet is close to Sun
- always point away from the Sun
- Dust tail
  - dust released from nucleus
  - dust particles orbit Sun independently
  - white in color (reflected sunlight
- Ion (plasma) tail
  - gas escapes, gets ionized
  - pushed “straight” back by solar wind
  - bluish in color
- Tails can extend millions of km in length



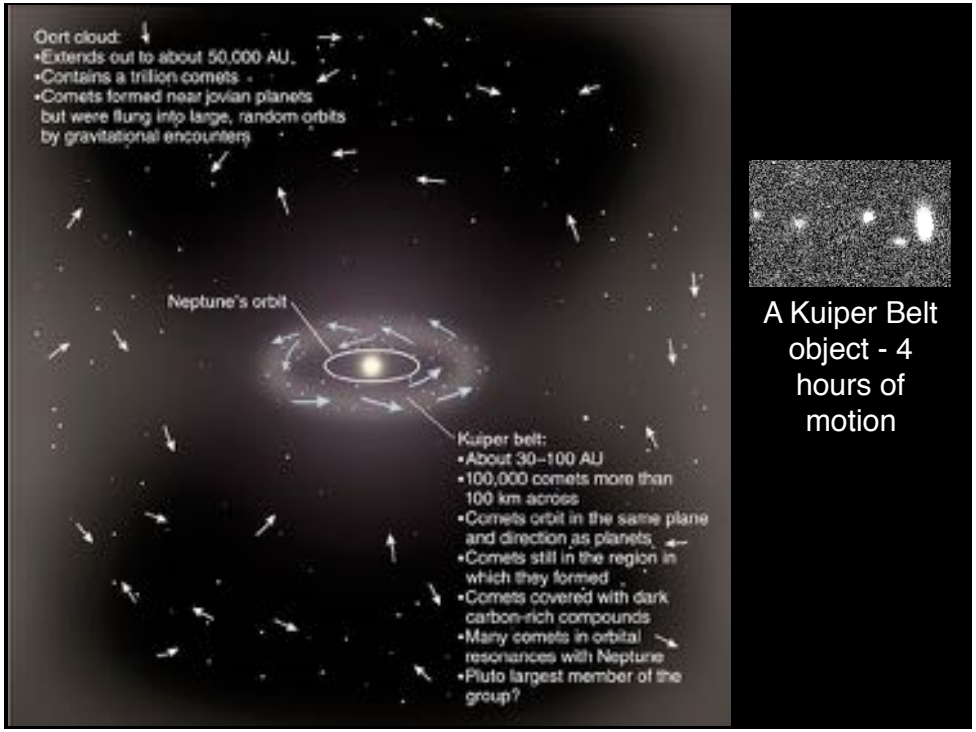
Comets and Meteor Showers





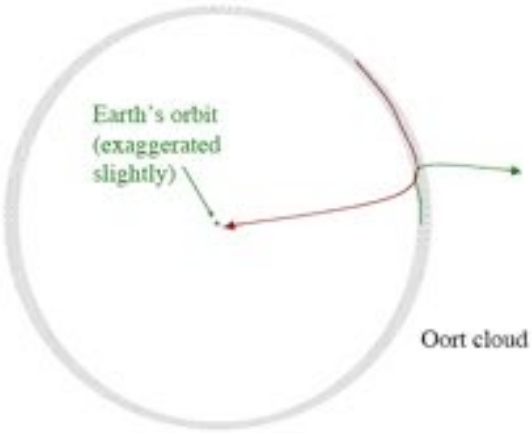
Comet Origins and Fates

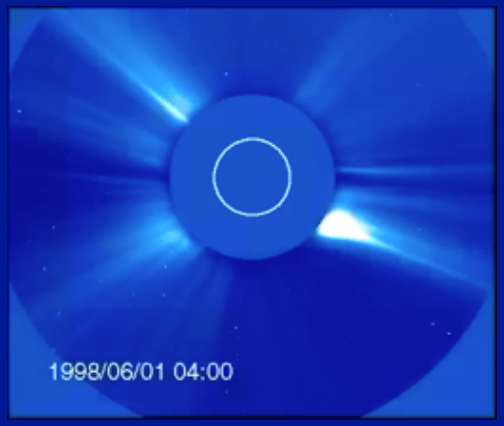
- Origins
  - The Oort cloud (out to 50,000 a.u.)
    - trillions of comets
    - orbital periods of millions of years
  - The Kuiper belt (30-100 a.u.)
- How do they stray to inner solar system?
  - accidental encounters at “home”
  - Bull’s eye sends them to inner Solar System
- Periodic comets
  - capture by encounter with planets (Jupiter...)
  - New orbit within inner solar system
  - example: Halley’s Comet (76 year period)



A Kuiper Belt object - 4 hours of motion

Bull's-Eye gets us a comet!





Comet ISON perihelion November 28, 2013