

Solar System: Other Objects



Asteroids

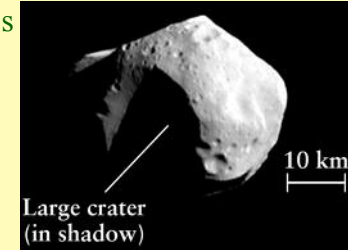
- rocky/metallic objects *in orbit around the Sun*
- ~ 75% *carbonaceous*, 17% *stony*, 8% *iron*

- typically *irregular* shapes
(eg) 253 Matilde (NEAR)

- “*minor planets*”

- ~ 10^6 asteroids
- ~ 10^5 have known orbits

- *total mass equivalent ~2000 km diameter object*



History

- 1700 & 1800's - discovery of *Uranus*, *Neptune*
- *Bode's Law* predicted a planet: *Mars* ↔ *Jupiter*
- 1 *Ceres* discovered by *Giuseppe Piazzi* (1801)
- 2 *Pallas* discovered by *H. Olbers* (1802)
- *Ceres* is the largest asteroid; ~ 900 km diameter
- ~ 200+ are greater than 100 km diameter
- took 50 years to find *first 10* asteroids
- discovery of 1000's of asteroids: *photography*

Vesta and Ceres Size in Context



Dawn

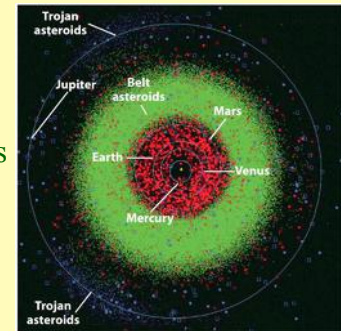
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Phobos (Mars EXPRESS)



Location

- *most* in **asteroid belt** between *Mars & Jupiter*
- **NOT** like “*SW: ESB*”
- $\sim 10^6$ km between asteroids (2x Earth-Moon distance)
- *some* asteroid groups *cross* Earth's orbit:
Apollos, Amors, Atens



- *most* are *small & dark* **Q:** How do we find them?

Finding asteroids



CLICKER: Asteroids in the asteroid belt...



- are typically beyond the Frost Line
- take hundreds of years to orbit the Sun
- orbit mostly between Jupiter & Saturn
- rarely intersect the orbits of the planets

Meteors & Meteorites

- **meteoroids**: small rocks in space
- **meteors**: material that enters Earth's atmosphere



- **meteorites**: meteors which *hit the surface*

Meteor (*Australia: Oct 03*)

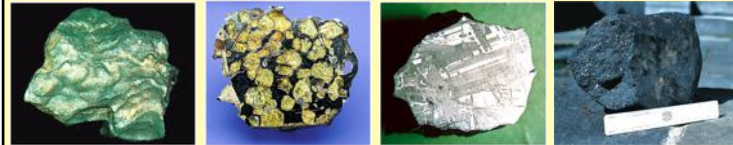


Meteor (*Russia: Feb13*)

Composition

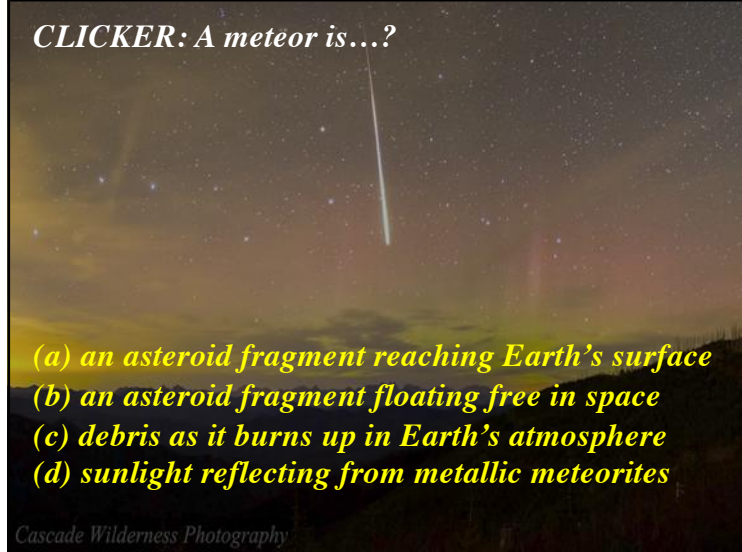
Q: Why are meteorites so interesting?

- **meteorites** are **primitive solar system material**



- **stony** (87%), **stony-iron** (2%), **iron** (6%)
- **carbonaceous chondrites** (5%)
- **CC** contain **C**, **amino acids** (organic compounds)
- **undifferentiated** so **unmelted**; orig solar nebula?

CLICKER: A meteor is...?



(a) an asteroid fragment reaching Earth's surface
 (b) an asteroid fragment floating free in space
 (c) debris as it burns up in Earth's atmosphere
 (d) sunlight reflecting from metallic meteorites

Cascade Wilderness Photography

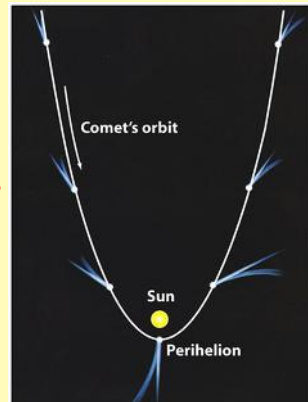
Comets

- "dirty snowballs" (ice & dust) in orbit around Sun

- 3 main parts:
 - nucleus
 - coma ("halo")
 - tail(s) (ion & dust)



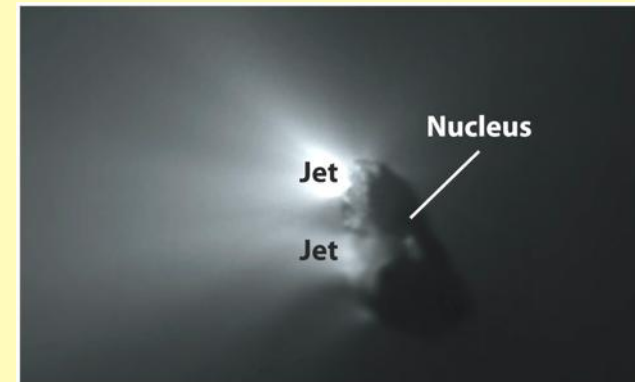
- comets *lose* mass (~ 0.1%) near the Sun *Q: why?*
- *coma* grows & brightens
- ~ size of *Jupiter!*
- *tail* can be *millions km* long
- *ion tail* points *directly away* from Sun (solar wind)
- *dust tail* has curved shape
- *comet debris* along orbit causes *meteor showers*



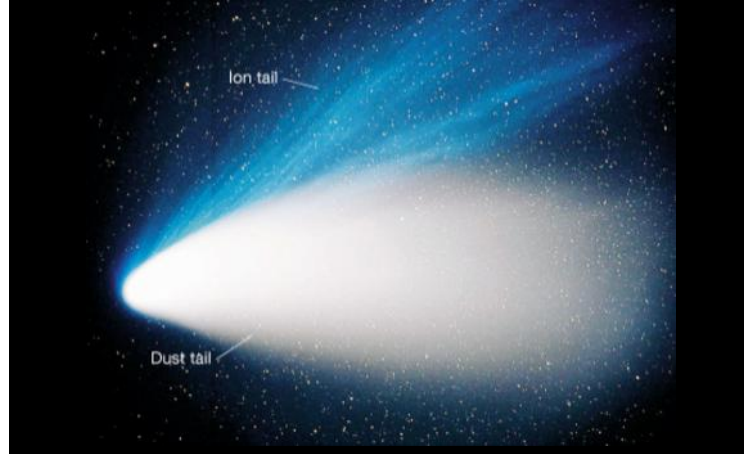
Q: Do comets last forever?

Nuclei

- *Giotto* flyby of *Halley* (1986); 15x8 km nucleus



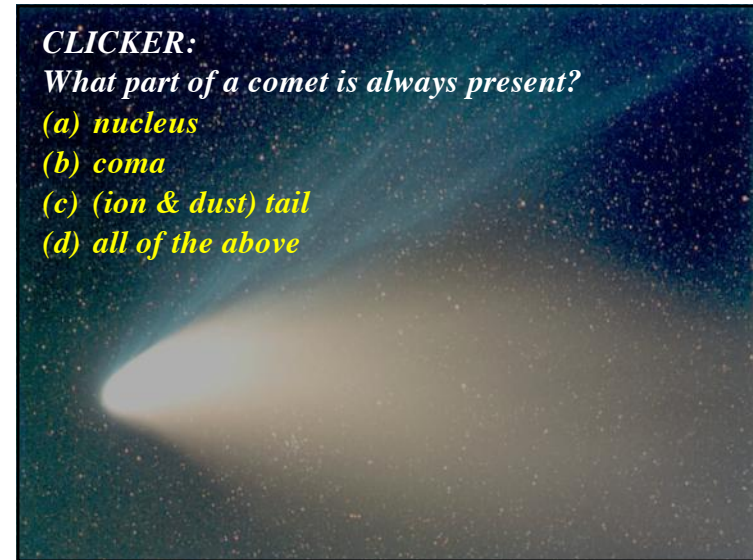
Comets have two tails!



CLICKER:

What part of a comet is always present?

- (a) nucleus
- (b) coma
- (c) (ion & dust) tail
- (d) all of the above



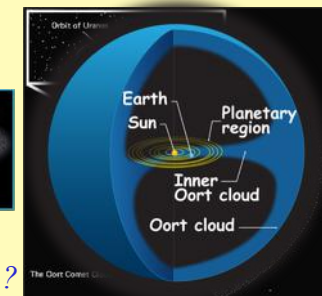
Meteor Showers

Prominent Yearly Meteor Showers

Shower	Date of maximum intensity	Typical hourly rate	Constellation
Quadrantids	January 3	40	Boötes
Lyrids	April 22	15	Lyra
Eta Aquarids	May 4	20	Aquarius
Delta Aquarids	July 30	20	Aquarius
Perseids	August 12	80	Perseus
Orionids	October 21	20	Orion
Taurids	November 4	15	Taurus
Leonids	November 16	15	Leo Major
Geminids	December 13	50	Gemini
Ursids	December 22	15	Ursa Minor

Cometary Origins

- **Kuiper Belt** beyond Neptune to ~ 50 AU
- **Oort Cloud** beyond that (~spherical distribution)



Q: How did Oort Cloud form?

Q: Why are comets NOT from inner solar system?

Barringer Crater



Earth crossing asteroids

THE MIDDLE SOLAR SYSTEM

This animation shows the motion of the middle part of the solar system over a two-year time period. The sun is at the center and the orbits of the planets Mercury, Venus, Earth, Mars and Jupiter are shown in light blue (the locations of each planet are shown as large crossed circles). Comets are shown as blue squares (numbered periodic comets are filled squares, other comets are outline squares). Main-belt minor planets are displayed as green circles, near-Earth minor planets are shown as red circles.

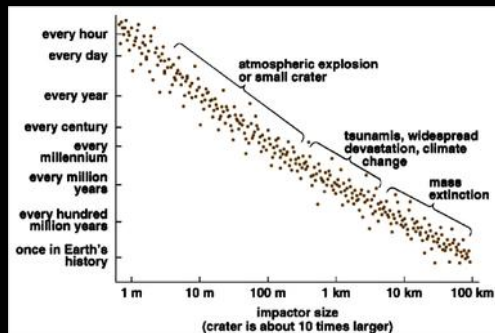
The individual frames were generated on an OpenVMS system, using the PGLOT graphics library. The animation was put together on a RISC OS 4.03 system using InterGif.

A Ride With The Earth

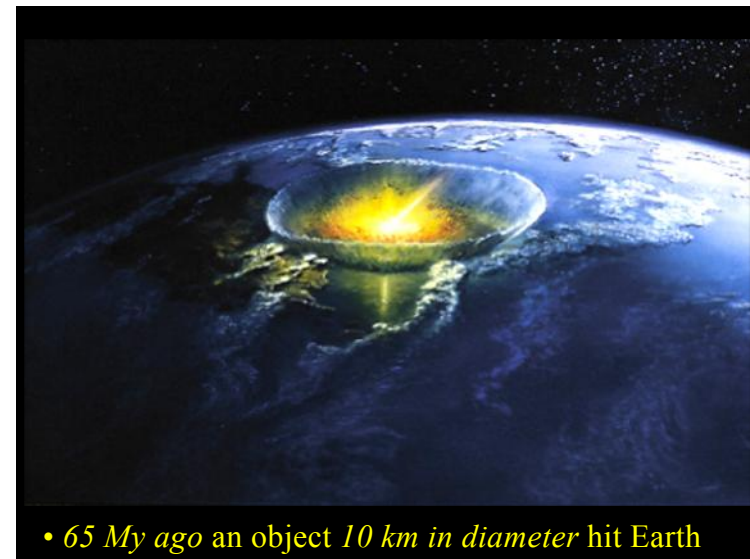
An animation centered on Earth showing the known objects that have approached to within 20 million km between July 2007 and June 2008. See the Animations Page on the MPC website for a description of the symbols used in this animation.

- objects within 20 million km of Earth in 2007-8
- red are < 6 million km; a few within Moon's orbit

How likely are collisions?



- **NEO**: within 1.3 AU of Sun
- **PHA (Potentially Hazardous Asteroids)**: within 7×10^6 km of Earth, 150+ m



- 65 My ago an object 10 km in diameter hit Earth

