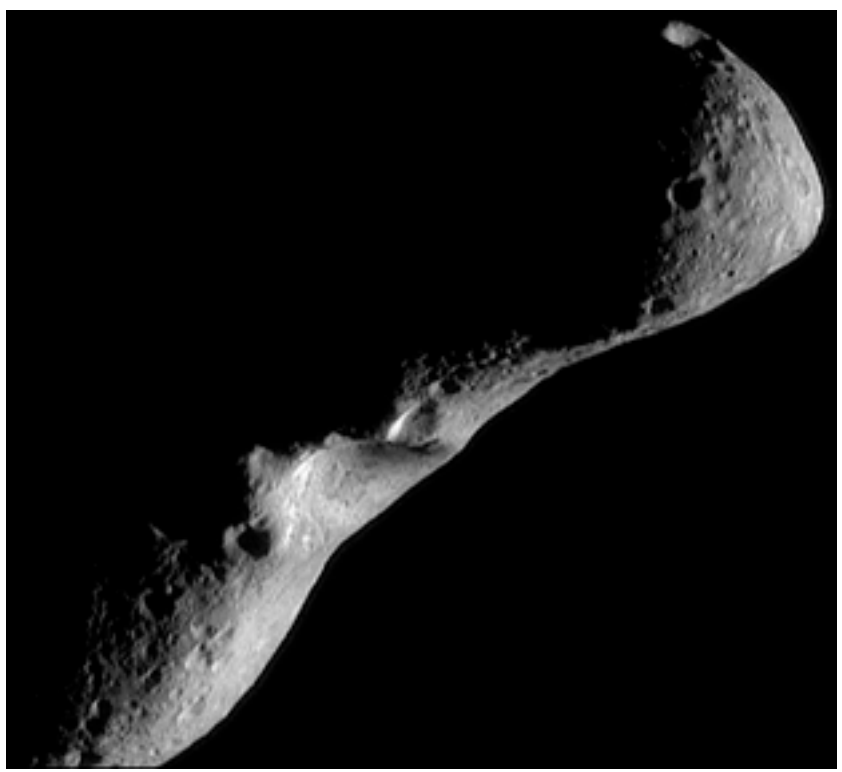
Astronomy 150: Killer Skies
Lecture 6, January 30

Last time: Meteors

Today: Asteroids and Comets

Homework:

- **HW 1 last chance! cutoff at 5pm today.**
- **HW 2 due this Friday at 1pm**



http://near.jhuapl.edu/iod/20000222/20000222.jpg

http://apod.nasa.gov/apod/image/0404/halebopp3_pacholka.jpg

Last Reminder: Register your i>clicker

Go to link on class web page to register your i>clicker

- Register with first part of your @illinois.edu email (NetID)

If you can't read your i>clicker ID

- Go the Illini bookstore bag-check counter
- Vote with your i>clicker
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https://online-s.physics.uiuc.edu/cgi/courses/shell/iclicker.pl

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Planetarium Session

Purpose:

- To help you understand the motions of the sky

Dates: 1/30, 1/31, 2/2, 2/6, 2/7, 2/8

@ Staerkel Planetarium, Parkland College

- Show starts at 7pm, runs ~80 minutes
- $3 door charge, please bring exact change

Report due Feb 24th in class

- Details on class website
- Attach ticket from the show to your report

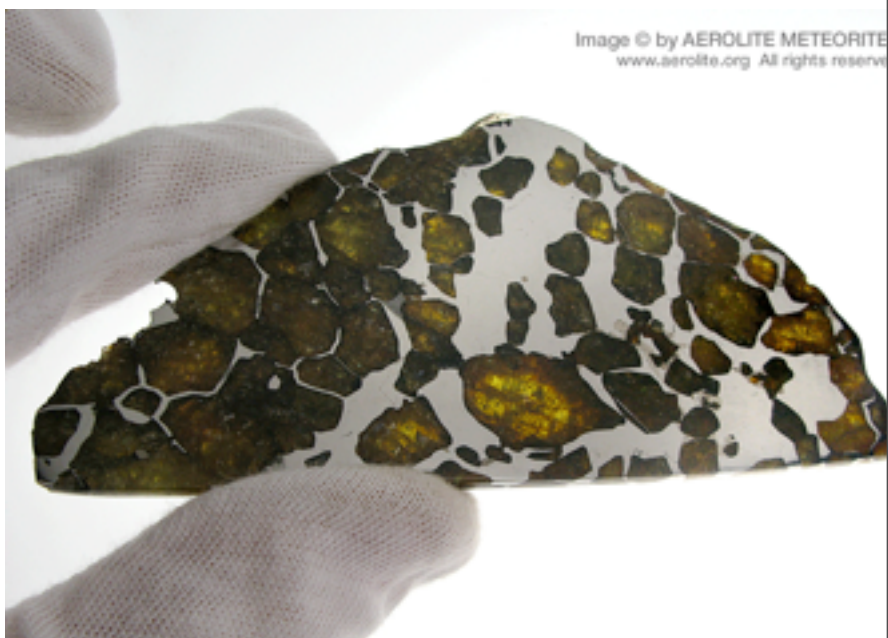
Reserve a seat online

- Link to reservation site on class website

Who Ordered That?

Last time:

- meteors = extraterrestrial rocks are falling on our heads!
- the sky really is falling! (occasionally)
- how did that happen!?



Where do these rocks come from?

How do they connect to our Solar System?

What do they tell us about the history of our Solar System?

Are we doomed?

Two Types of Solar System Debris

Asteroids

- Closer to the Sun
- Largely composed of rock/metal

Comets

- Further from the Sun
- Largely made up of “icy” material

Asteroids

Eros from NEAR: http://near.jhuapl.edu/iod/

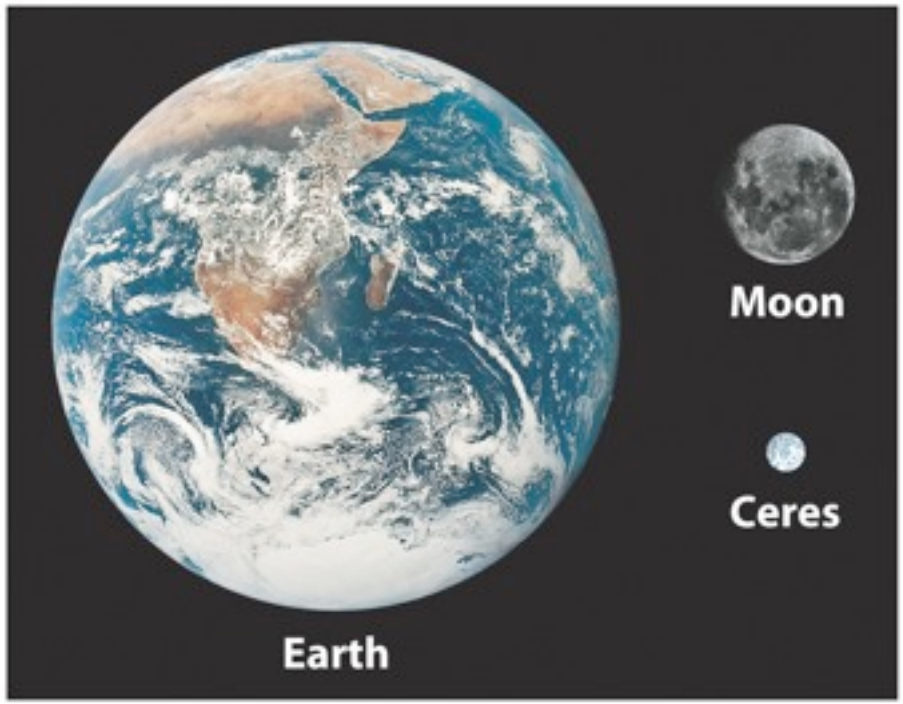
Asteroids

Small sizes

- Largest – Ceres: 940 km across
- Only 3 more than 300 km
- About 240 bigger than 100 km
- Millions under 1 km

Composition

- Rocks (silicates) and iron/nickel



What are asteroids like?

- **Because they are small, they are mostly unchanged since formation 4.6 billion years ago**
- **Most have irregular shapes: not spherical**

why not? why are planets spherical?

http://www.youtube.com/watch?v=iiM7VHSRz4c

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  why not? why are planets spherical?

  - **planets larger, more massive: gravity crushes them into sphere**
  - **asteroids small, low-mass, gravity too weak to overcome rock rigidity**

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  - asteroids small, low-mass, gravity too weak to overcome rock rigidity
- Pulverized rock "soil" like that of the Moon
- boulders on surface
- Heavily cratered surfaces

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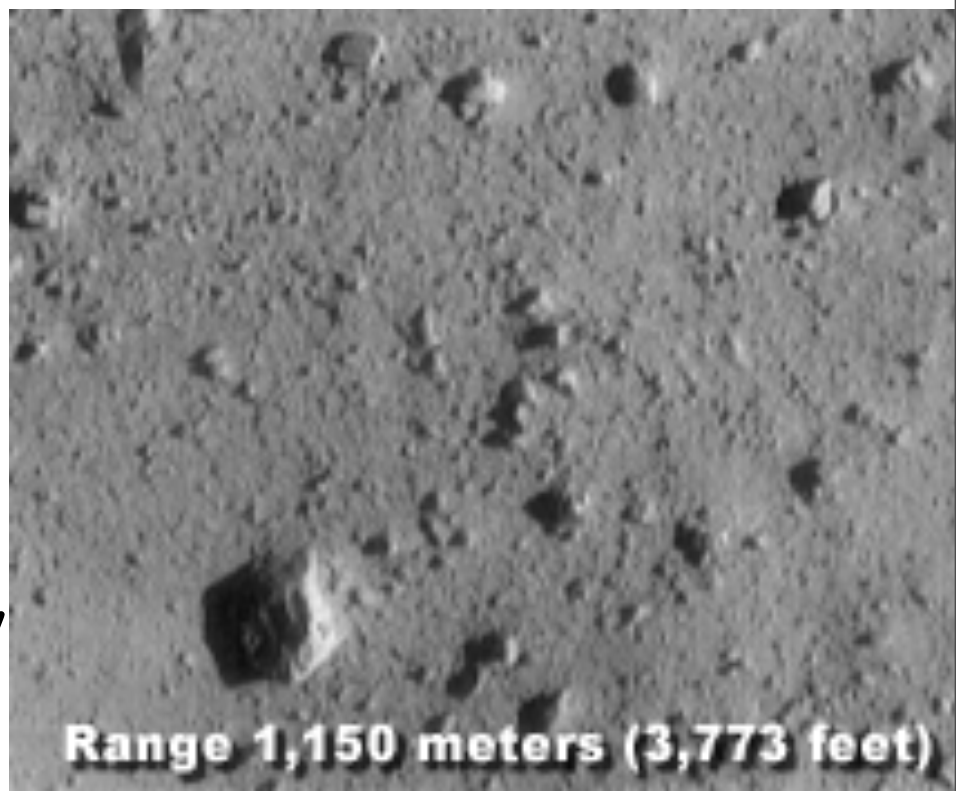


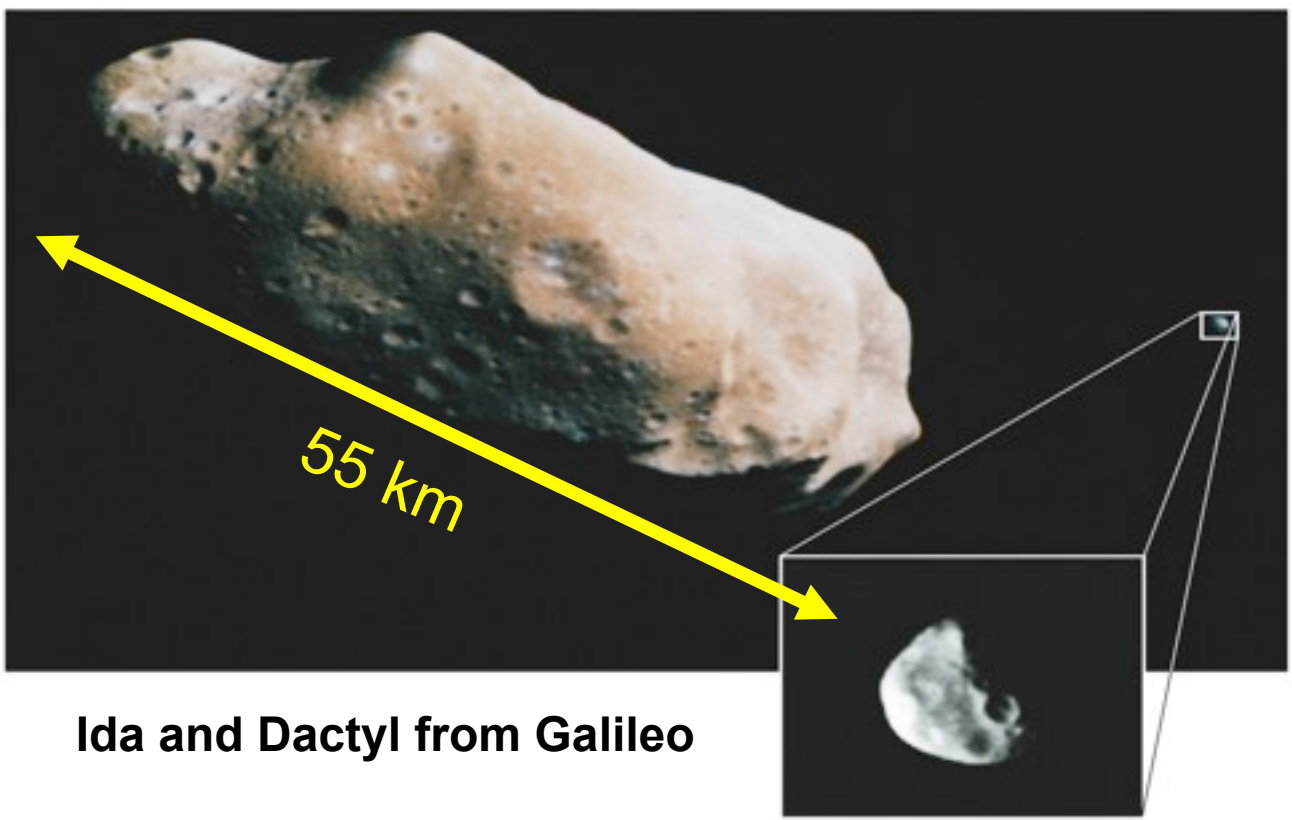
NEAR crash landing on asteroid Eros

http://www.youtube.com/watch?v=iiM7VHSRz4c

Asteroids with Moons

Some large asteroids have their own moon

Asteroid Ida has a tiny moon named Dactyl



Ida and Dactyl from Galileo

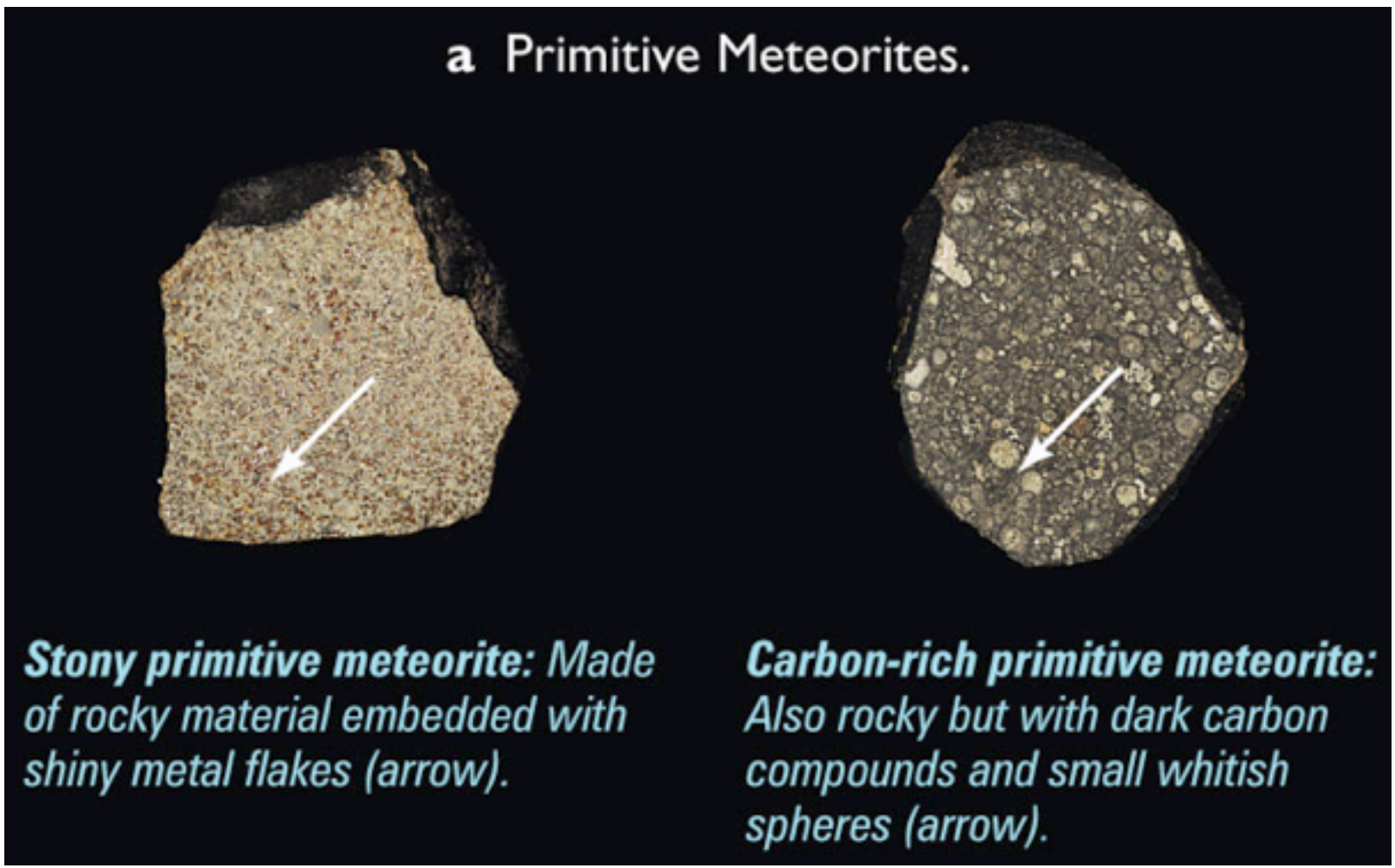
Rubble Pile Asteroids

- Rubble piles form when an asteroid is smashed to pieces by an impact
- Then the shattered pieces fall back together

Asteroid 25143 Itokawa is a “rubble pile” asteroid

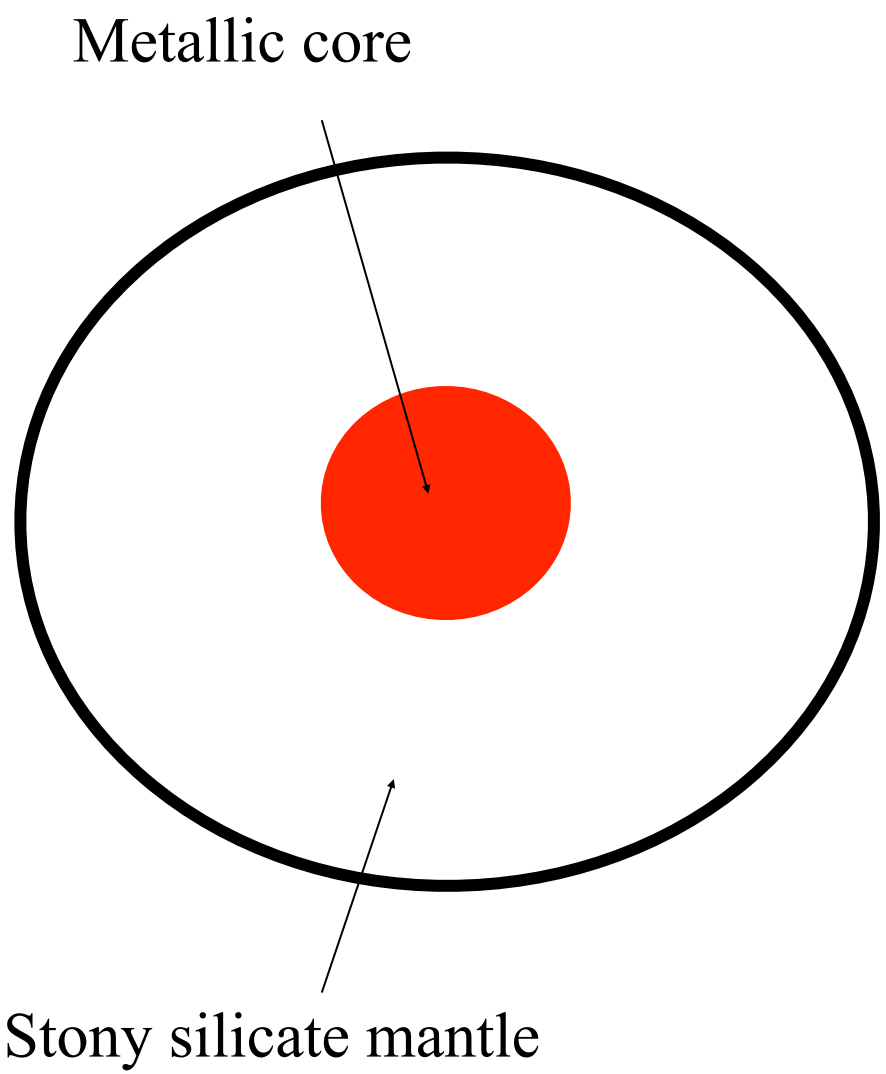
Types of meteorites derived from asteroids - primitive

- Small asteroids are primitive - unchanged since they solidified ~4.6 billion years ago



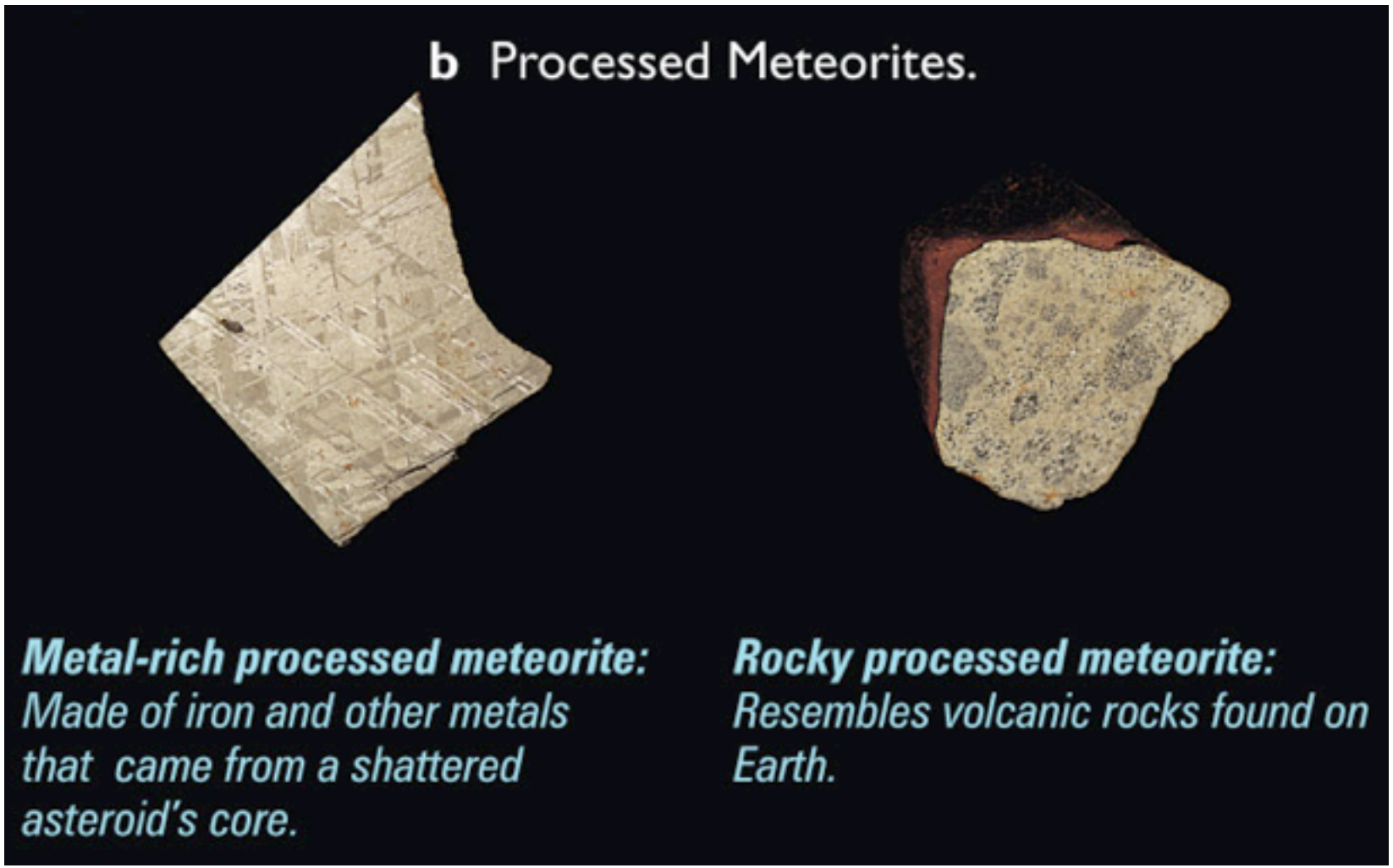
Types of meteorites derived from asteroids - processed

- Larger asteroids are differentiated -
  - in past, were melted
  - metals sink to center
  - have a metallic core and rocky mantle
- As asteroids fragment, both metallic and rocky pieces are produced
- Called processed meteorites



Processed Meteorites

- All irons and stony-irons are processed
- Some stonys are processed, most are primitive



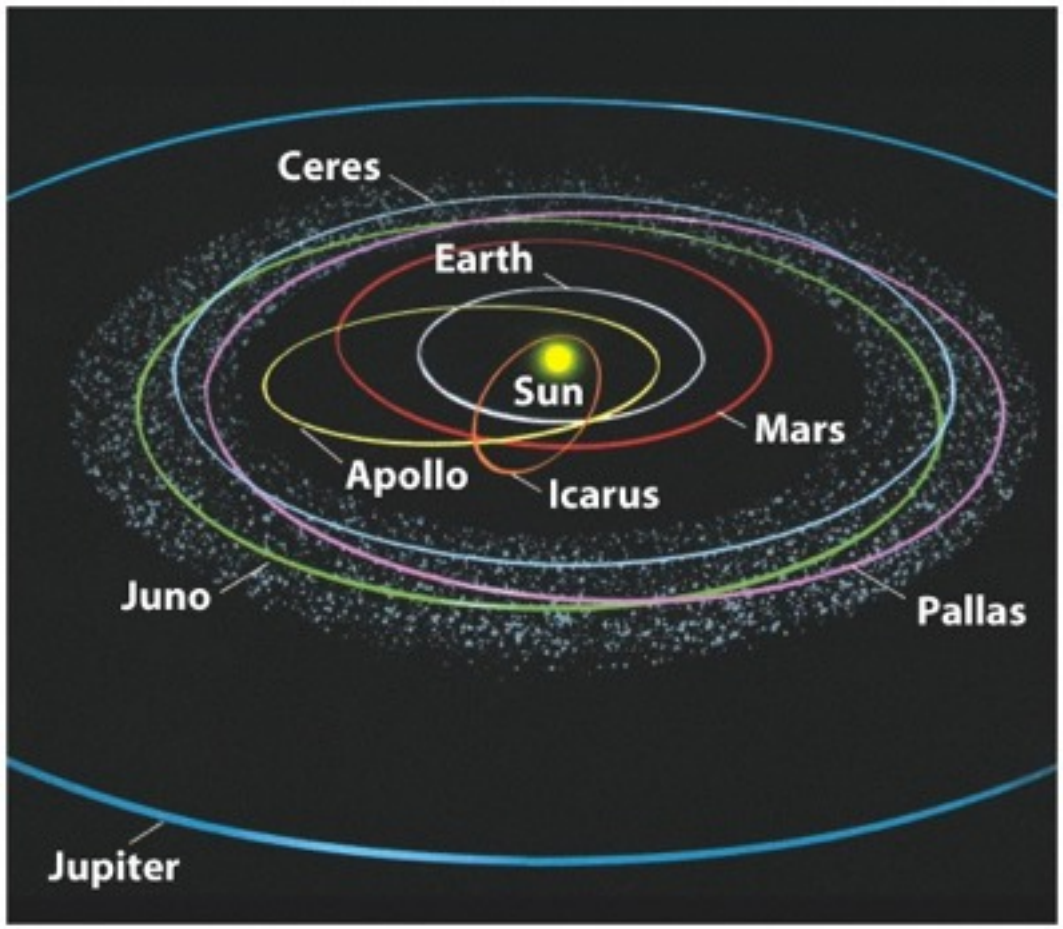
The Asteroid Belt

Most, but not all, asteroids are found between the orbits of Mars & Jupiter

Region is called the Asteroid Belt

Orbits in same direction as planets, orientations near same plane (Ecliptic)

As asteroids collide with one another, they fragment and send pieces into near-Earth orbits



orbits from top and side:
http://www.youtube.com/watch?v=kSqYk6yD75I&feature=related

The possibility of successfully navigating an asteroid field…

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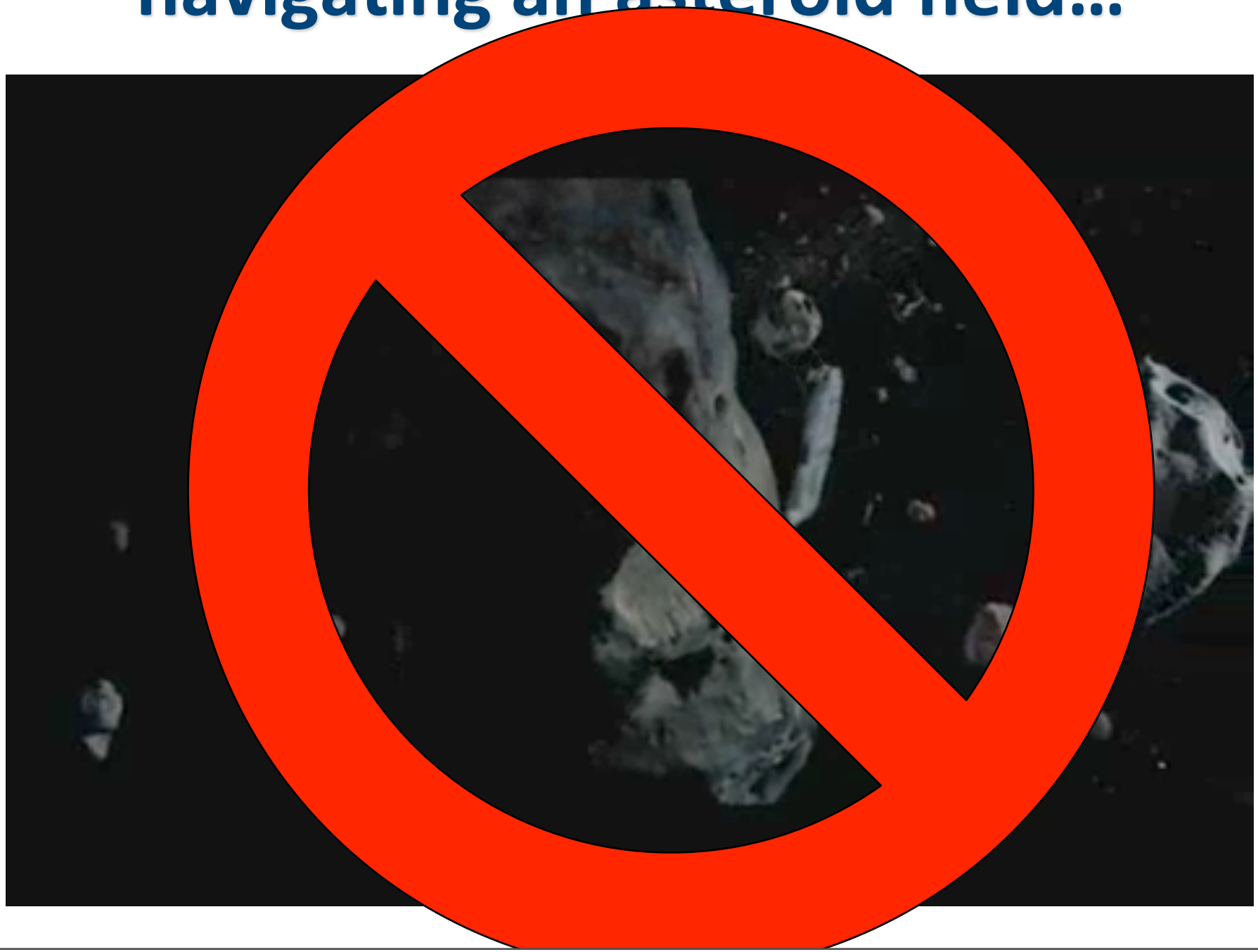
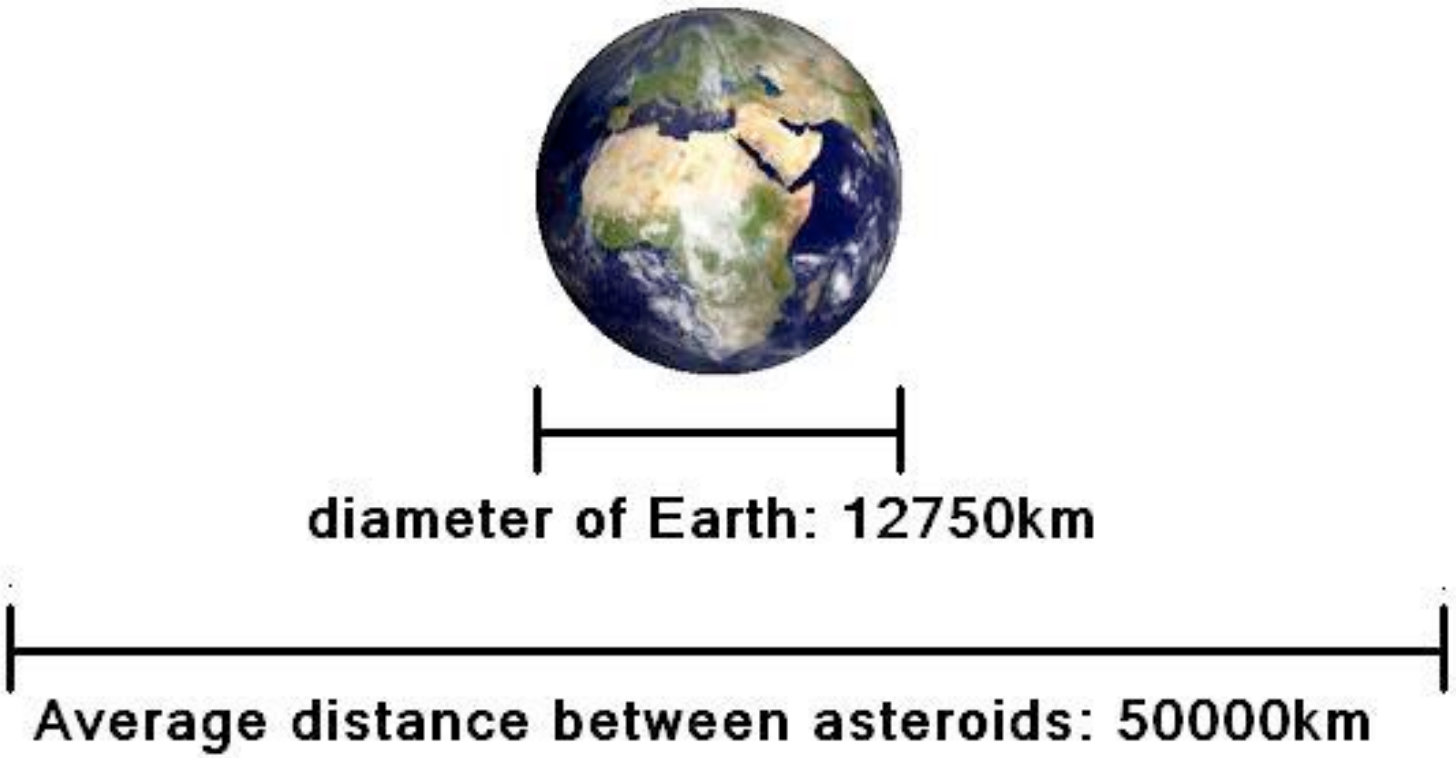


Scientific View of the Asteroid Belt:
Mostly Empty Space!



Average spacing between sizable asteroids is bigger than Earth's diameter!

NASA has sent many spacecraft safely through the asteroid belt with no problems!

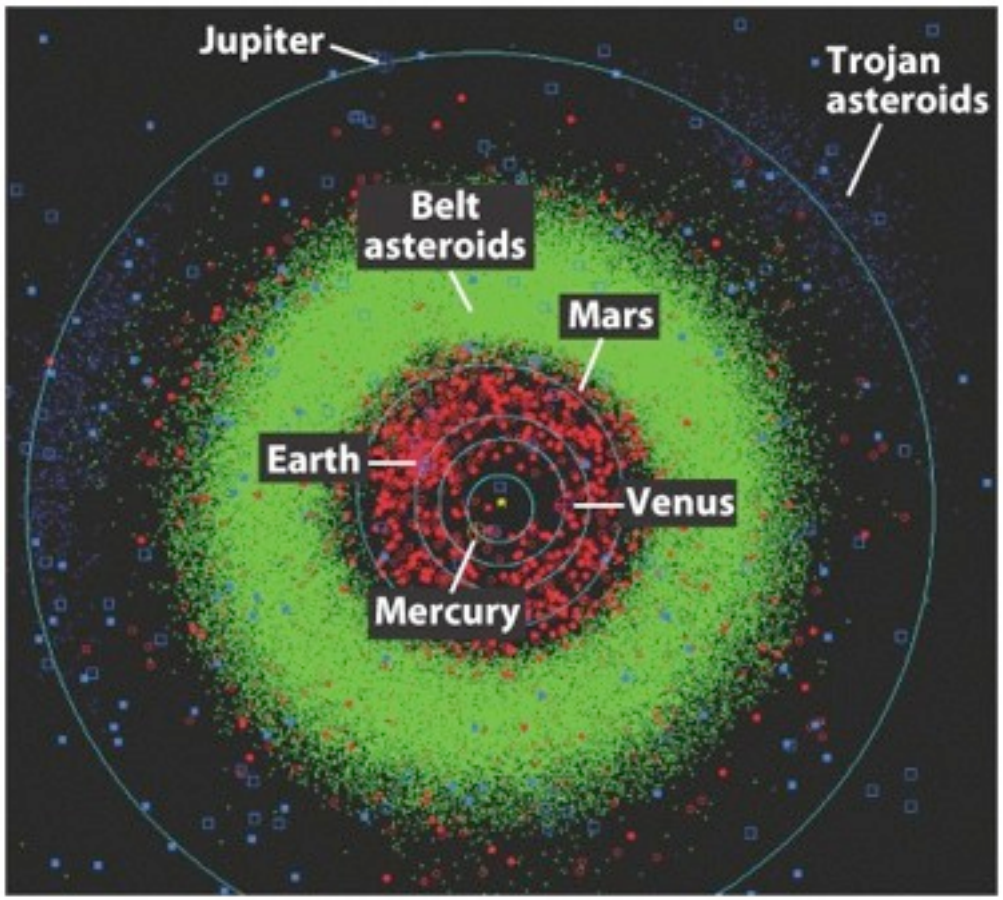
Apollos

Some asteroids are on orbits that cross Earth's orbit

Called Apollo asteroids

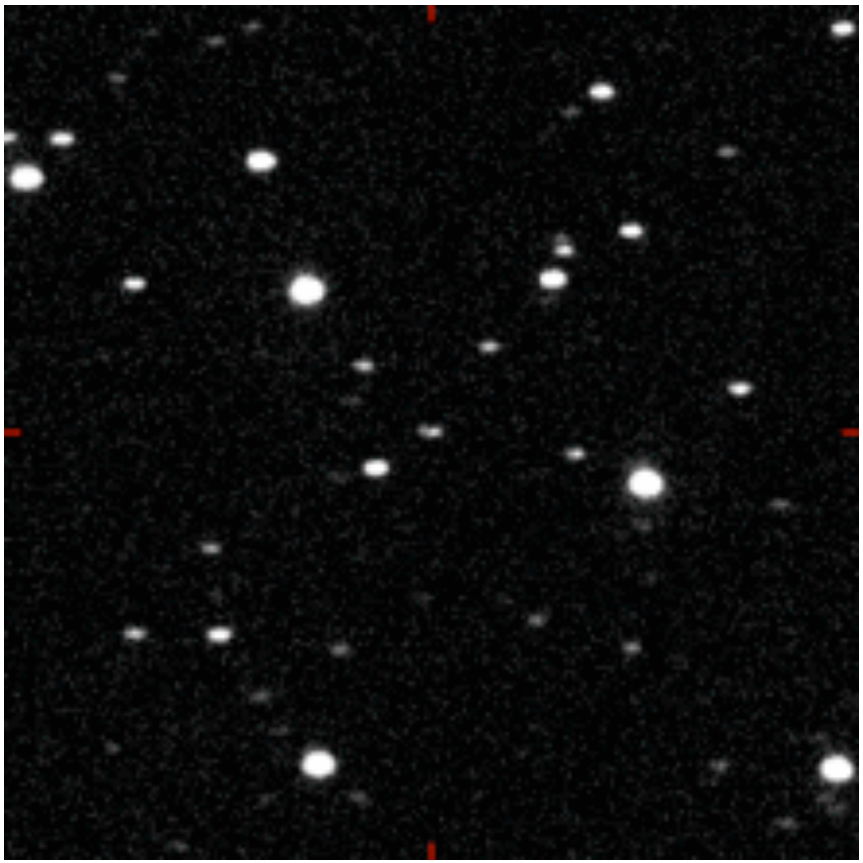
At least 3000 are known

In 1972, one skipped off the Earth's atmosphere



Near Earth Asteroids

- Short-lived (few million years)
  - Orbital decay and Sun accretion
  - Collision with inner planets
  - Ejected from system by interactions
- Must be replenished
- Gravity interactions with asteroids and Jupiter can send them to Earth



2004 FH (30 meter) passing 10% the Earth-Moon distance

http://www.cfa.harvard.edu/iau/Animations/Animations.html

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 PGPLOT graphics library. The animation was put together on a RISC OS 4.03 system using !InterGif.

THE INNER SOLAR SYSTEM

This animation shows the motion of the inner 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 and Mars 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.

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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.

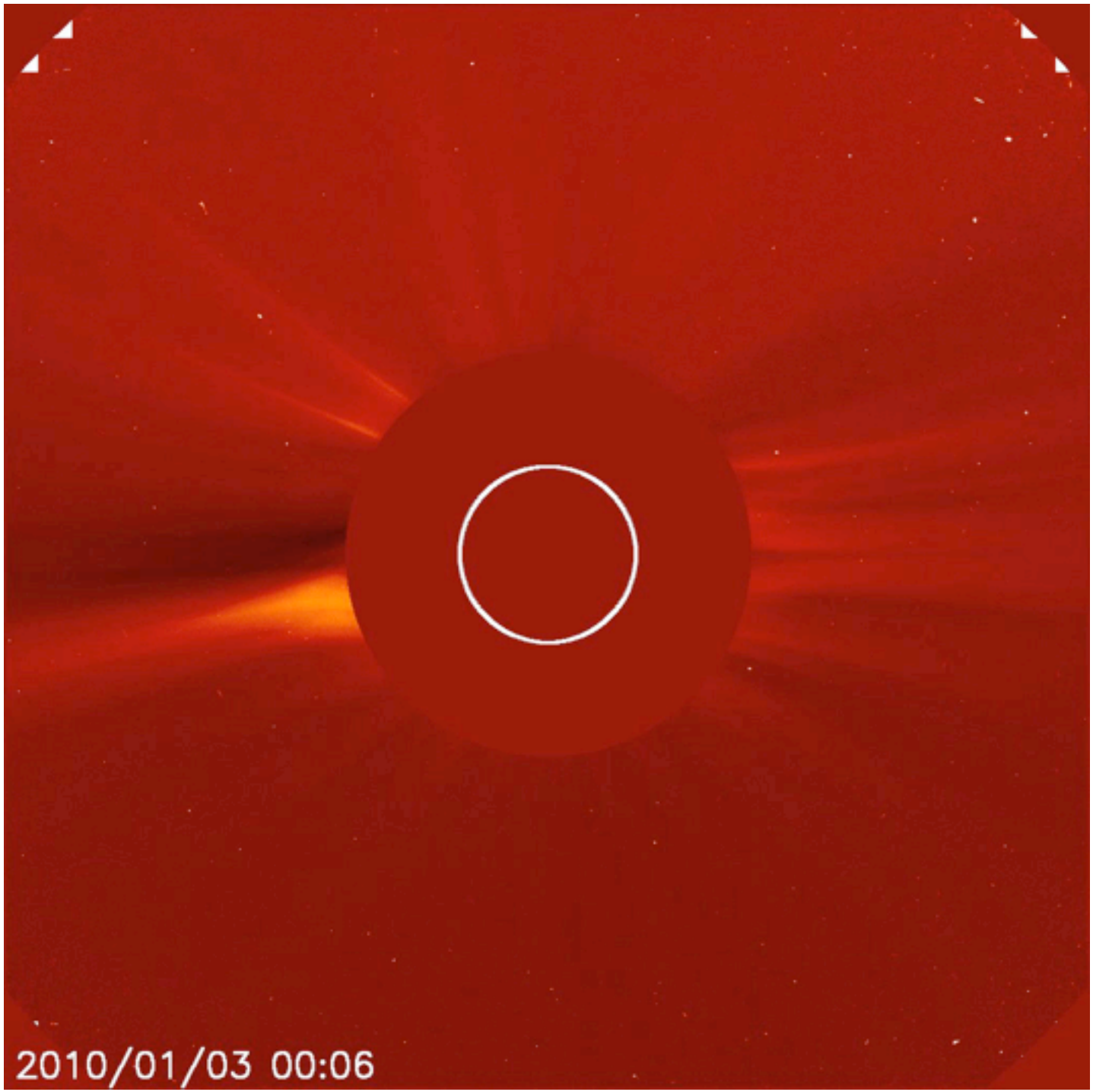
Near Earth Asteroids

And we're still finding them!

http://www.youtube.com/watch?v=S_d-gsOWoUw

And since they are replenished, it is a never ending job!!!

Comets



Halley's Comet

In 1705, Edmund Halley used Newton's Law of Gravity to determine that comets observed in 1531, 1607, & 1682 were the same object

Successfully predicted its return in 1758

Last appearance, 1986

Next appearance, 2061

Halley's Comet in 1986

Comets: Basic Facts

Comets have very eccentric, elongated orbits

- most time spent far from Sun: small & difficult to see
- when near Sun, grow long tails which shrink and disappear as they go far away again

Two main groups of comets

Short period comets

- periods $P < 200$ years
- Orbits near the same plane as the planets

Long period comets

- periods P = thousands to millions of years
- Orbits on random orientations

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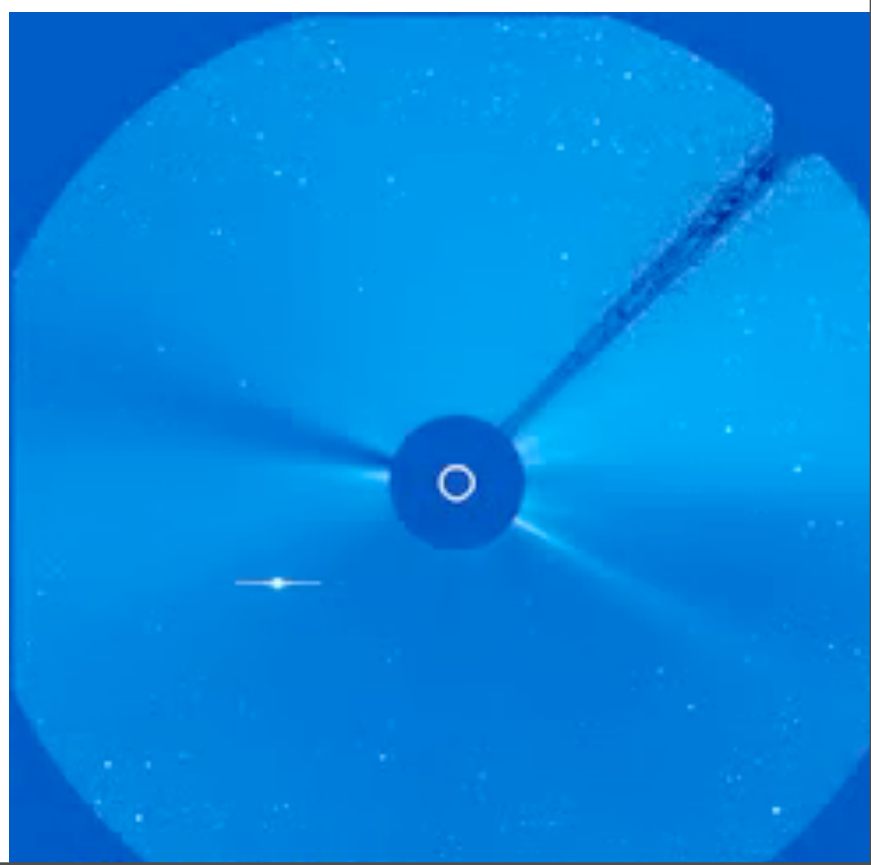


iClicker Poll: Comet Orbits and Locations

Short-Period Comets: $P_{\rm short} < 200$ years

Long-Period Comets: $P_{\rm long} = 10^5$ to 10^6 years

What does this tell us about where these groups of comets live?

A. short-period comets are farther away, long-period comets are closer

B. short-period comets are closer, long-period comets are farther away

C. trick question! orbit period unrelated to distance

D. Mmmmm... cake!

Where do comets come from? Do the math!

Kepler's mighty 3rd law:

$$(a_{\text{in AU}})^3 = (P_{\text{in yr}})^2$$

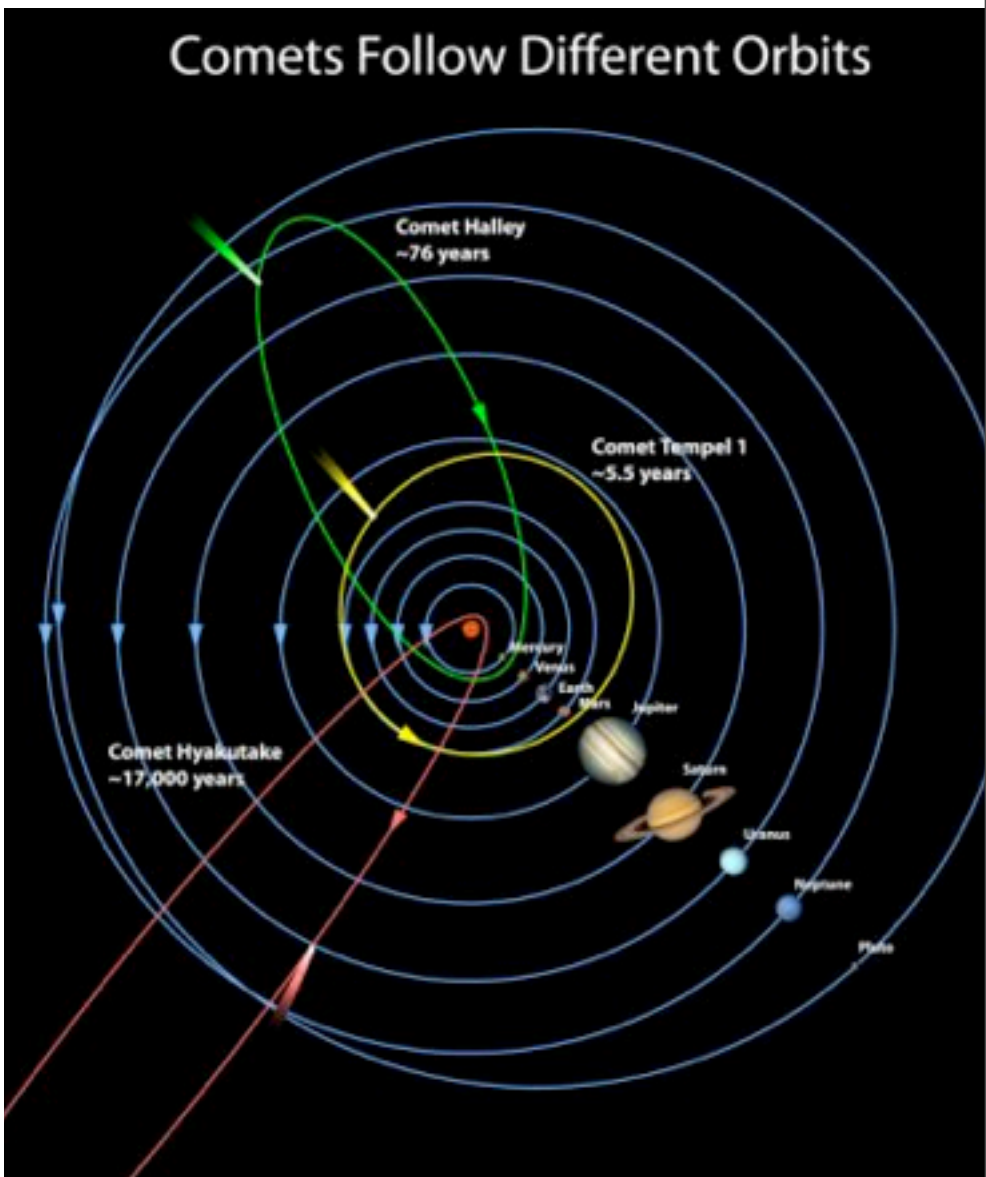
$$a = P^{2/3}$$

Short period comets

- ***P = 200 years***
- $a_{\text{short}} < 200^{2/3} = 34 \text{ AU}$
- **just beyond Neptune**

Long period comets

- **for *P* = 1 million years = 106 yr**
- $a_{\text{long}} = (10^6)^{2/3} = 10,000 \text{ AU}$
- **way beyond all planets!**
- **most distant objects in Solar System!**



Short Period Comets: Kuiper Belt

Distances from Sun

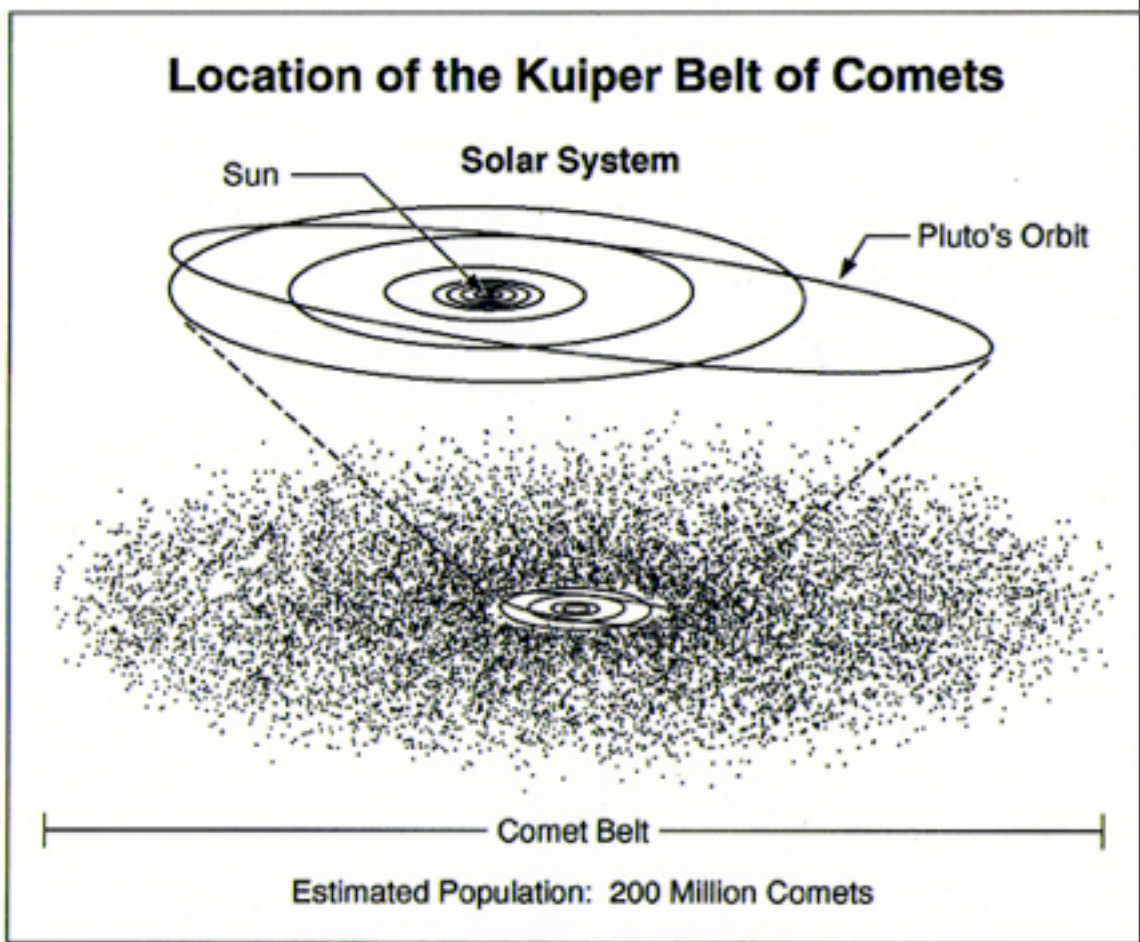
- 30-100 AU: Neptune's orbit and beyond

Orbit orientations:

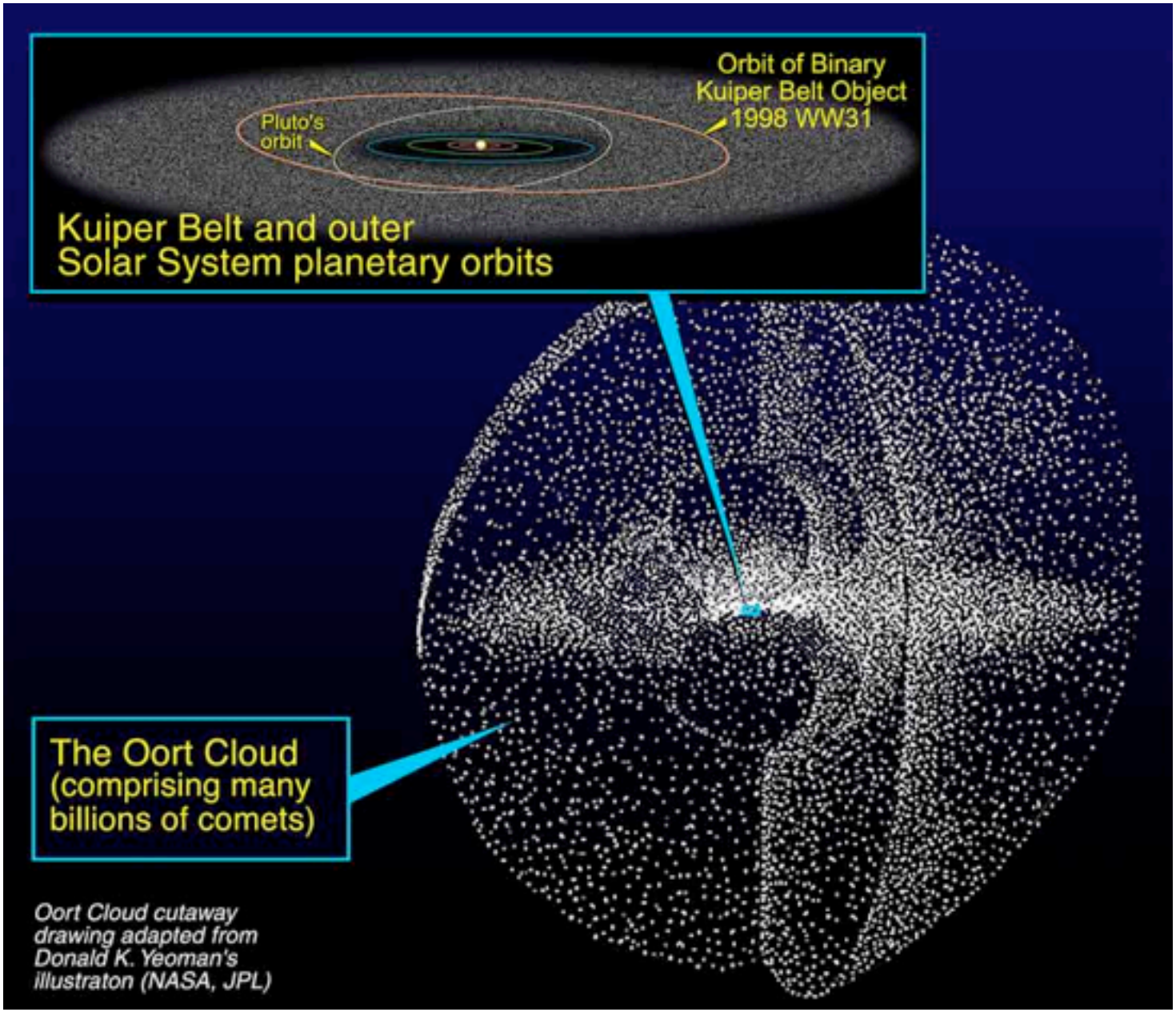
- orbits concentrated near same plane as Earth-Sun orbit (Ecliptic) but can be "tilted" significantly
- A 'thick disk' of short-period comets beyond the orbits of the planets

How many?

- Estimated: 100s of millions of short-period comets



Long Period Comets:
Oort Cloud



Basic parts of a comet

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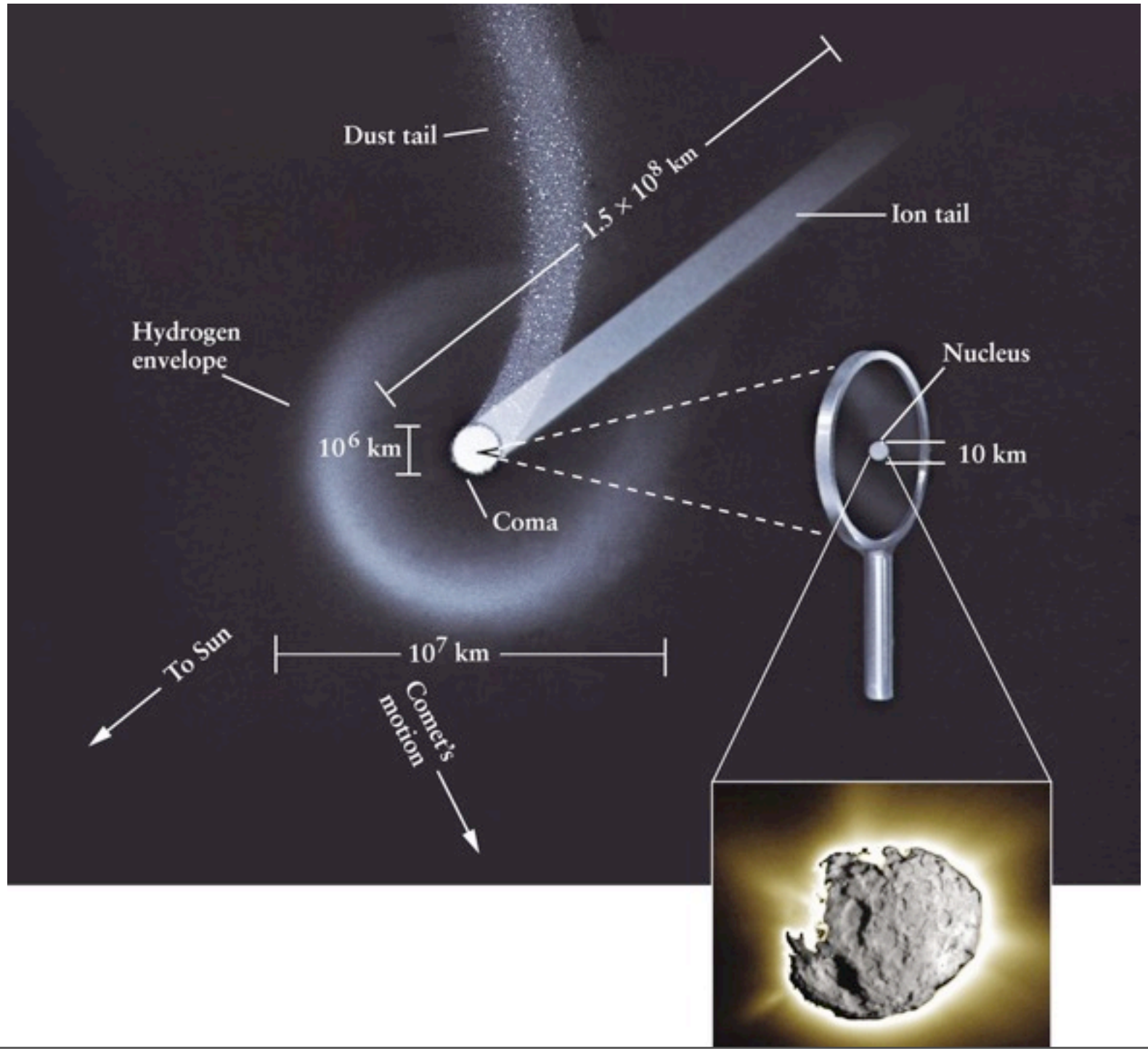

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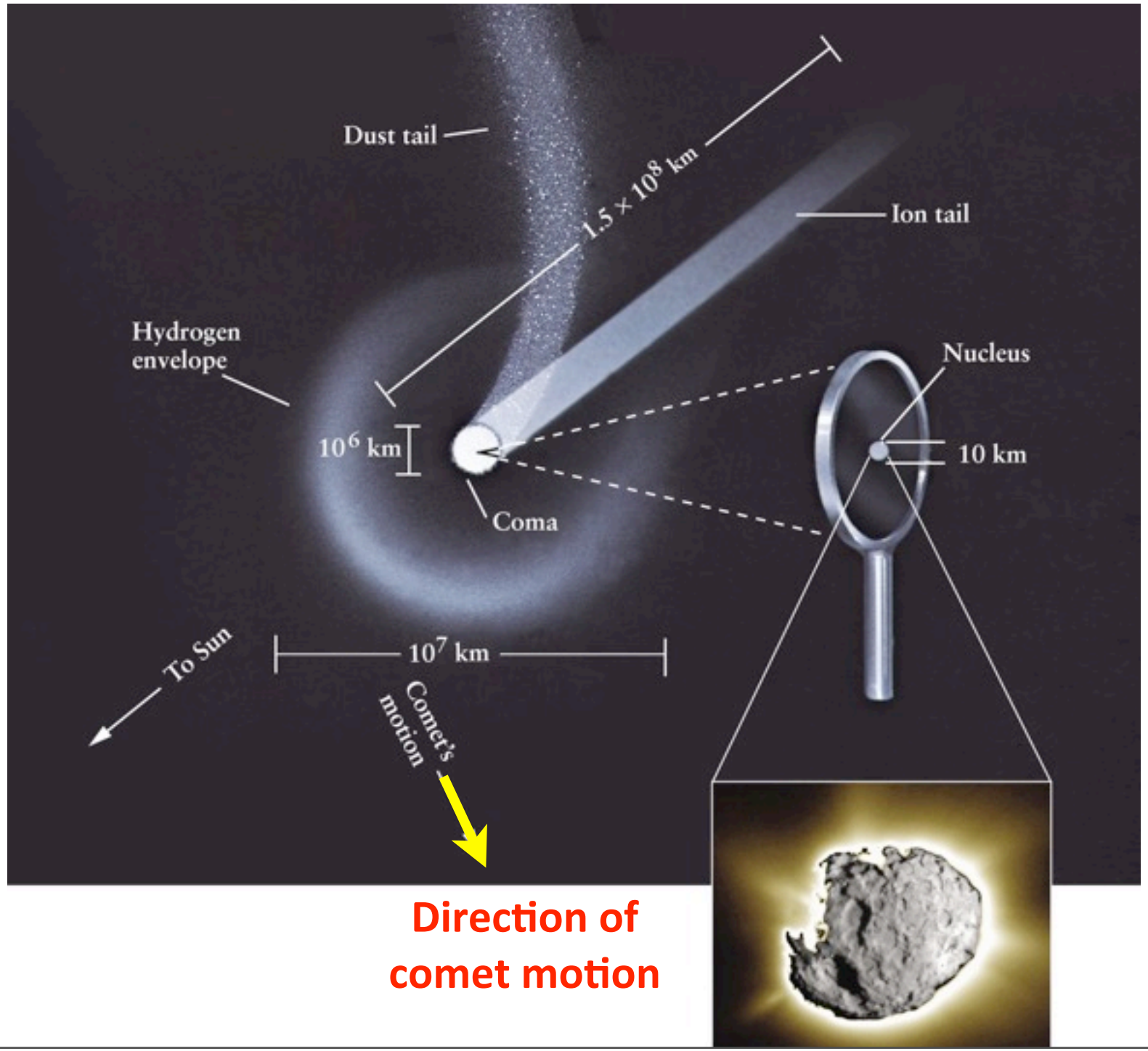

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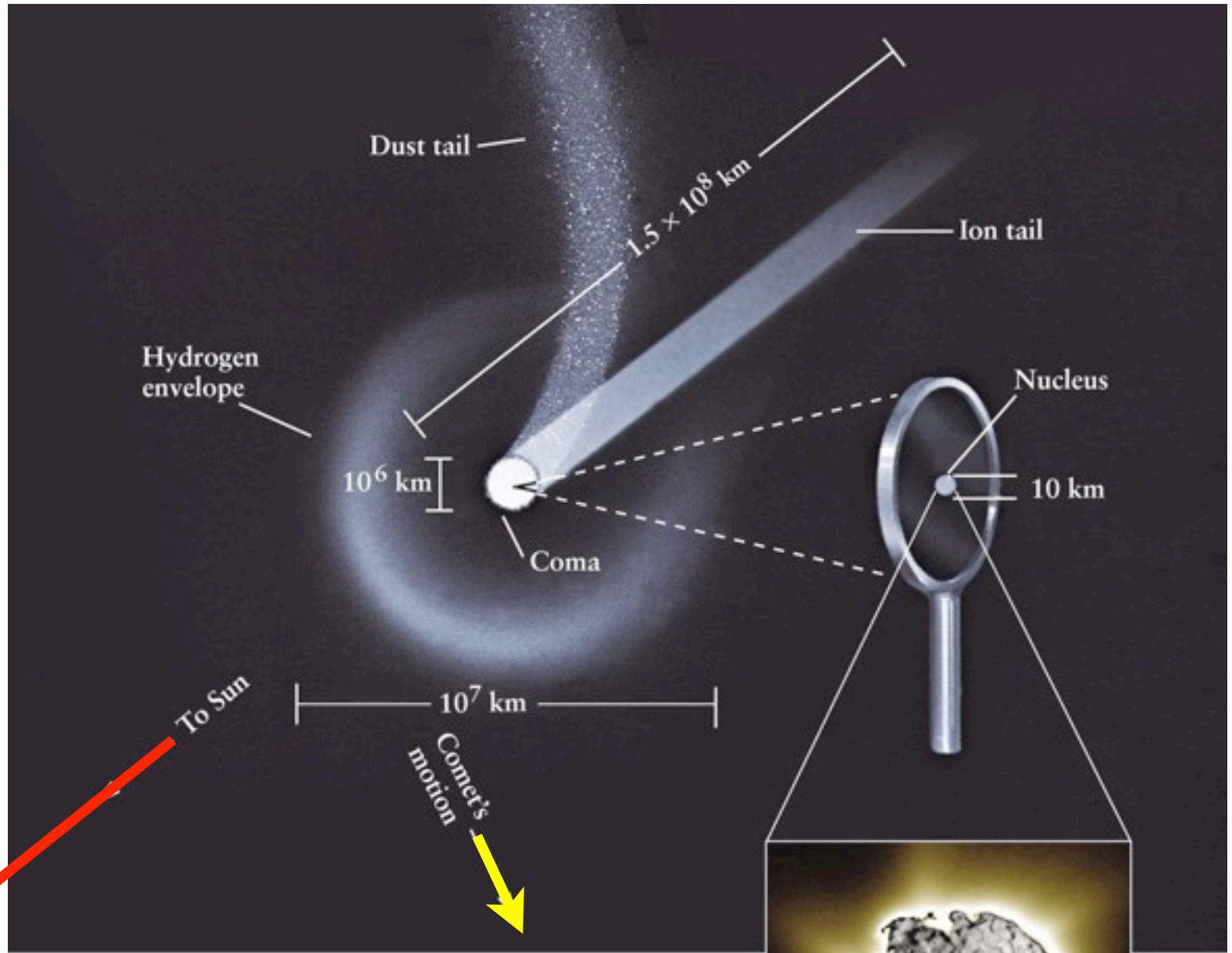
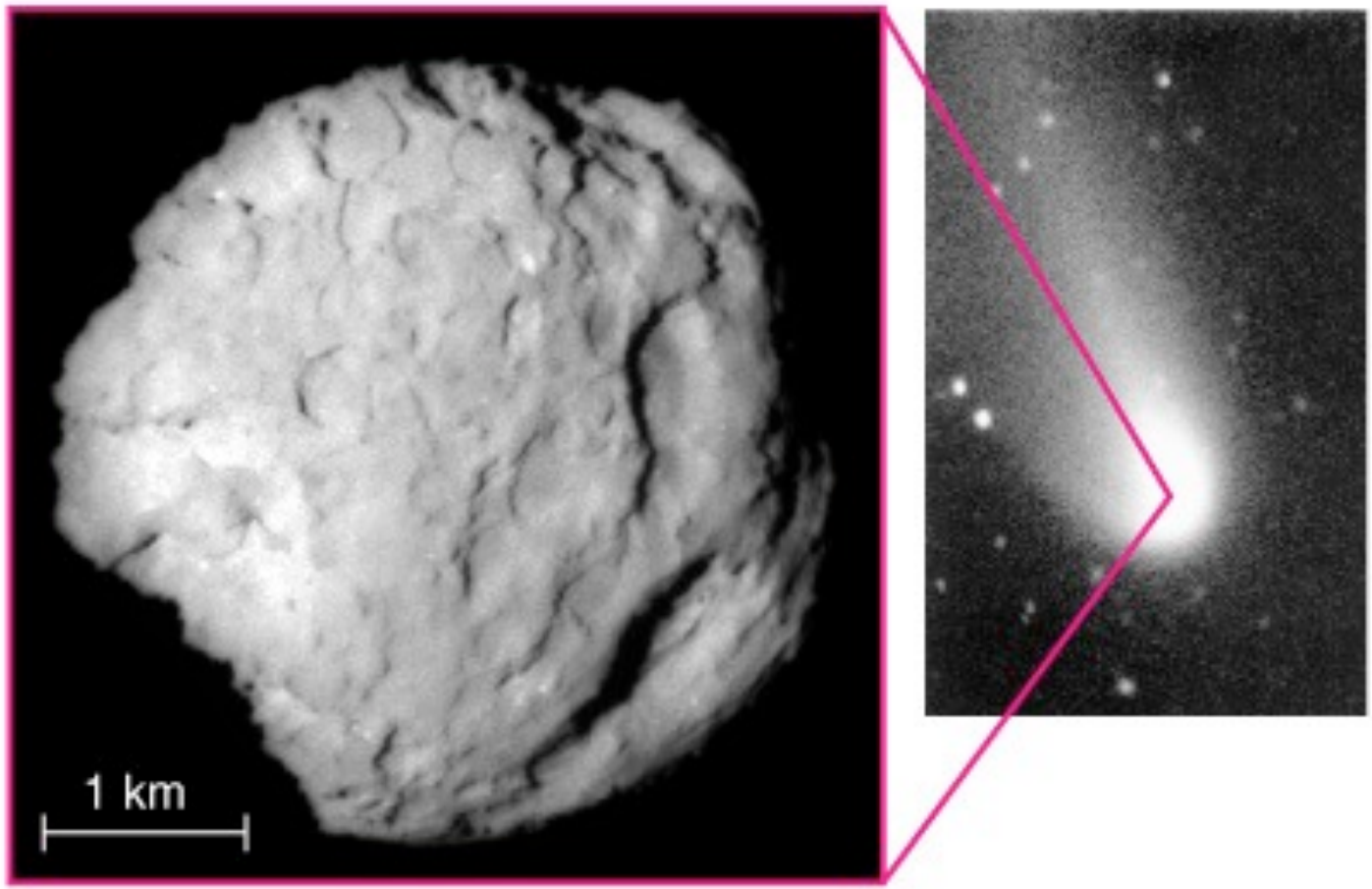


Sun direction

Sun size and distance not to scale!

Direction of comet motion

Nucleus of Comet: "dirty snowball"



"crunchy center" ingredients

- ices of water, CO_2, methane, and ammonia,
- plus dirty dust: small rocky particles

Near the Sun, comet ices evaporated into gases

Important solar system fact:

- hotter when closer to Sun!

When a comet nears the Sun, its ices start to vaporize = “sublimate”

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- Produce a comet's coma

The nucleus of Halley's Comet, imaged by the Giotto probe in 1986.

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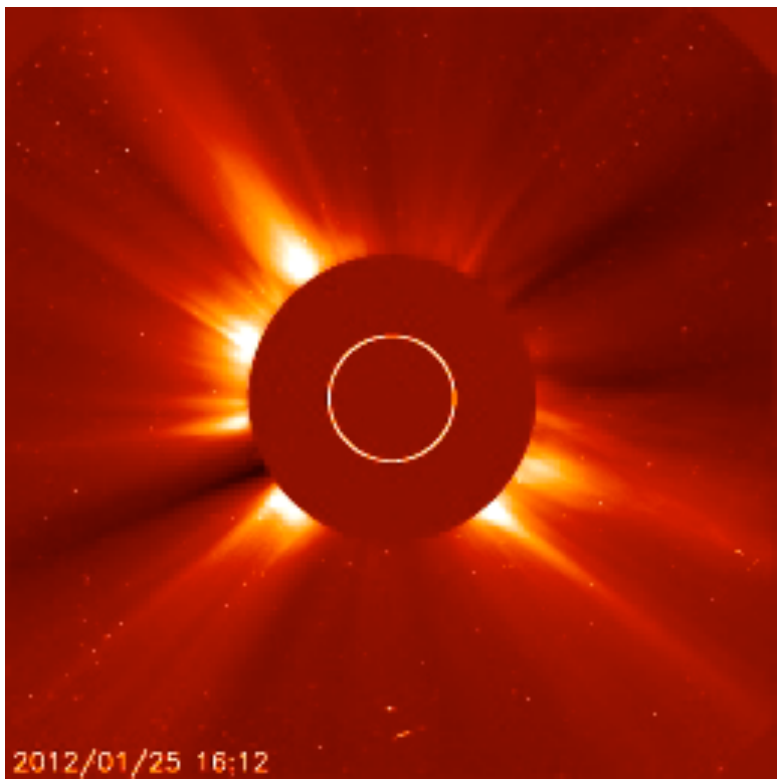
When a comet nears the Sun, its ices start to vaporize = "sublimate"

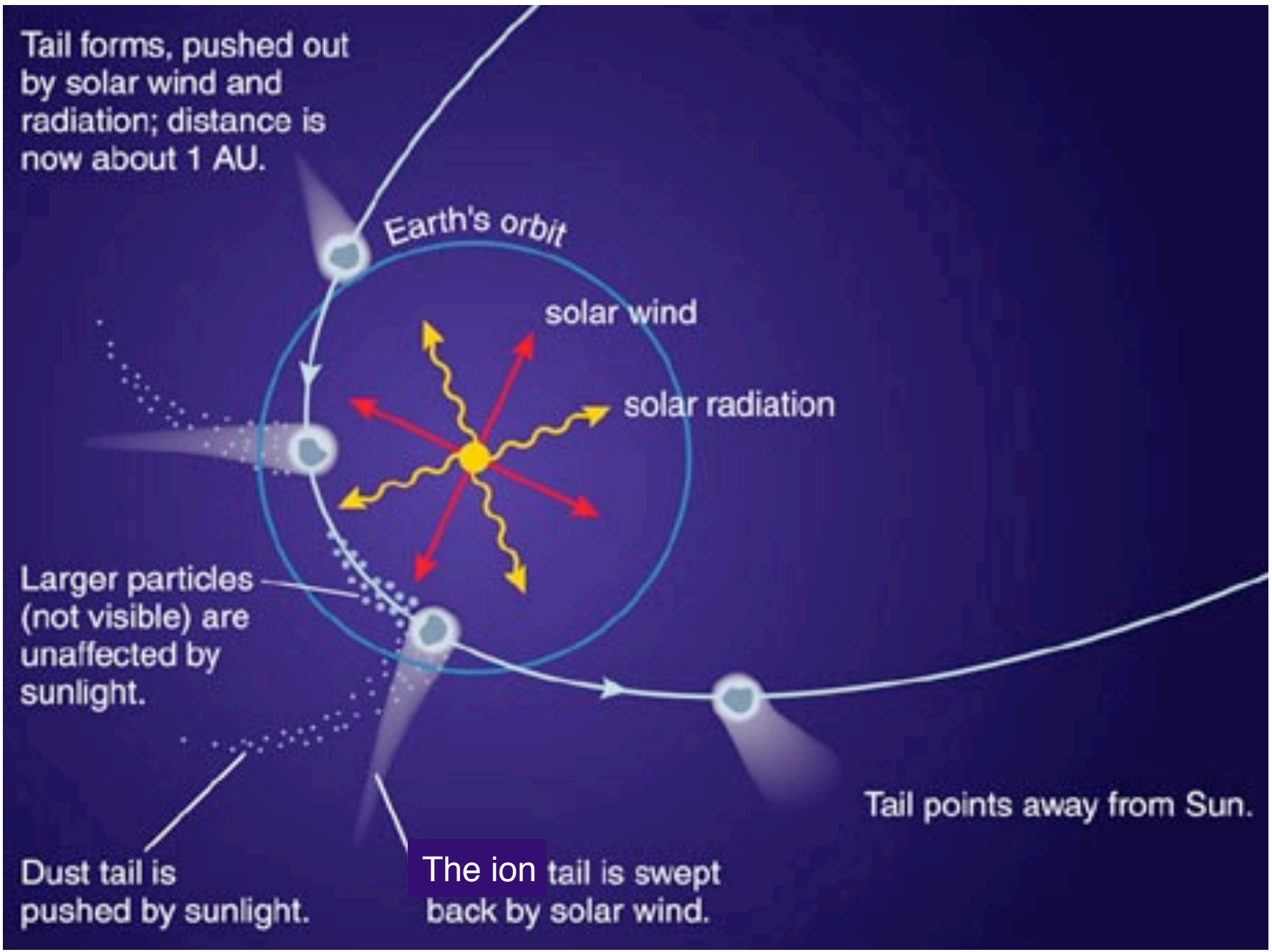
- Jets of dust and hot gas erupt from its surface
- Produce a comet's coma
- stream of hot, magnetized gas from Sun = solar wind, and sunlight too both push hot gas (ions) and dust away from Sun: forms tail

The nucleus of Halley's Comet, imaged by the Giotto probe in 1986.



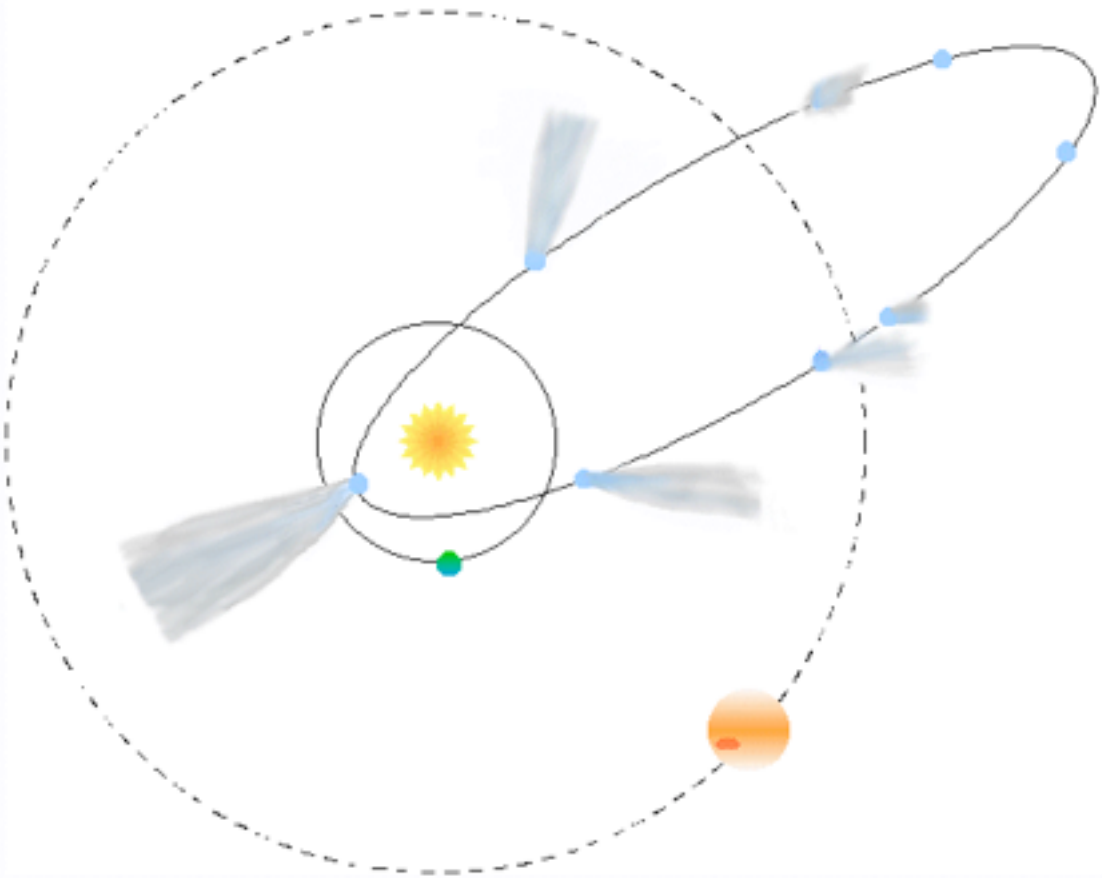
The Sun today: NASA SOHO

Why do comets have tails?



Comets that pass close to the Sun have elongated orbits

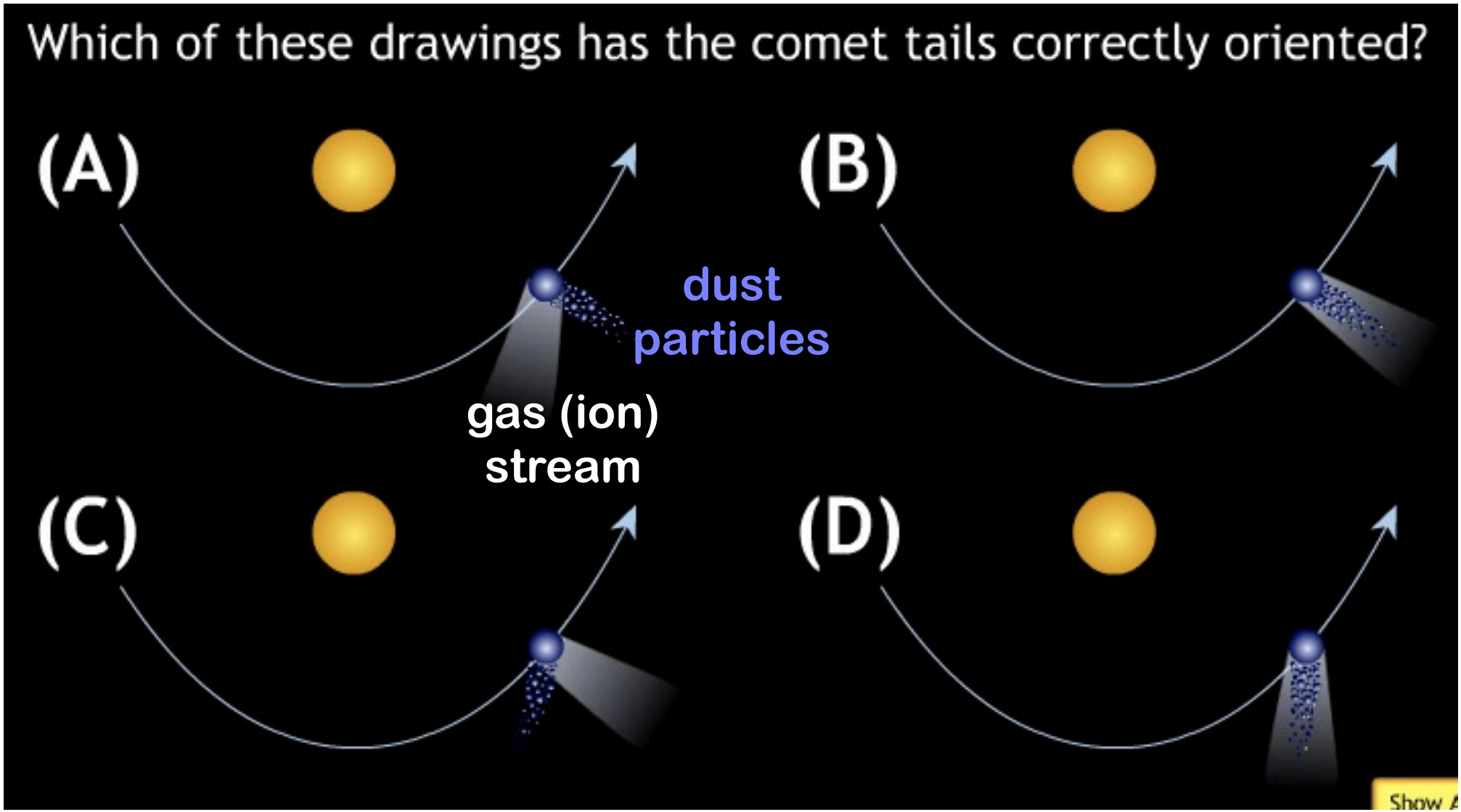
- Very eccentric / elongated long orbits
- Most spend the majority of their orbit far from the Sun: too cold to burn away gas and dust
- So comets only have a tail during a relatively brief period



Comets only show tails when close to the Sun


Comet 73P/Schwassmann-Wachmann 3
NASA/ESA Hubble Space Telescope

iClicker Poll



Comet debris produces meteor showers

Over time a comet leaves trail of dust along its orbit

If the Earth passes through the comet's orbit, we pass through dust, get a meteor shower

Since Earth crosses the comet orbit every year, meteor showers are periodic, annual events