Comets and Asteroids

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Outline

Asteroids

Discovery
Orbits
Composition

Comets

Appearance and Composition
Orbits
Origin

Solar System Visitors

Asteroids

Most orbit between Mars and Jupiter where early astronomers thought a planet should be located.

Most appear to be composed of rocky and metallic material.

Discovery

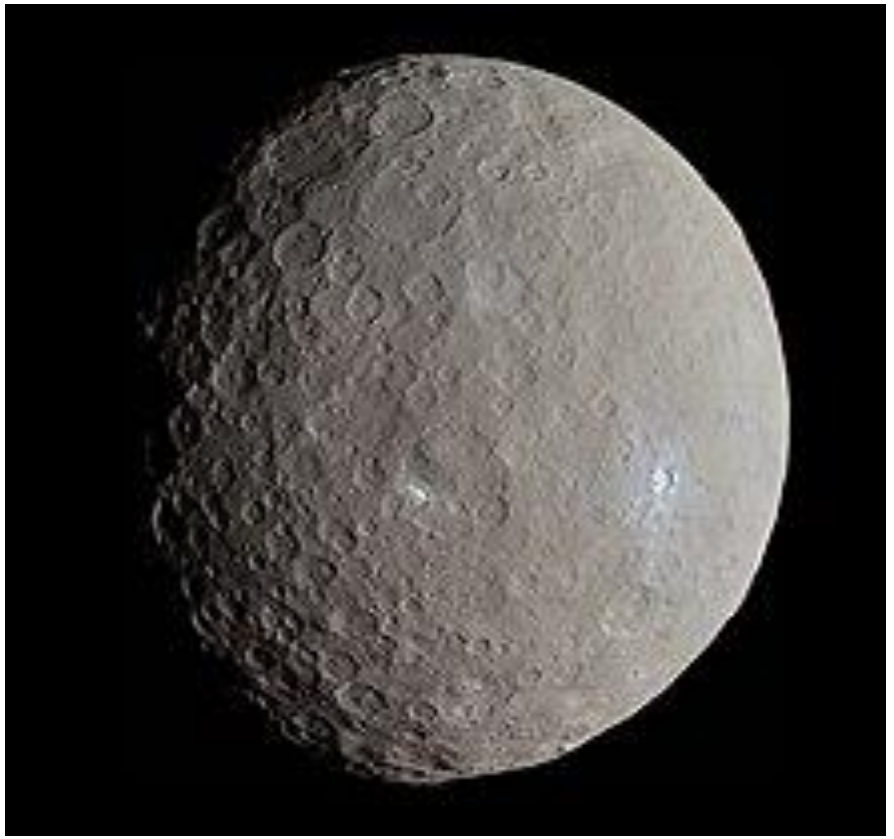
Ceres was discovered in 1801 - The “missing” planet

Three more quickly discovered

300 known by 1890

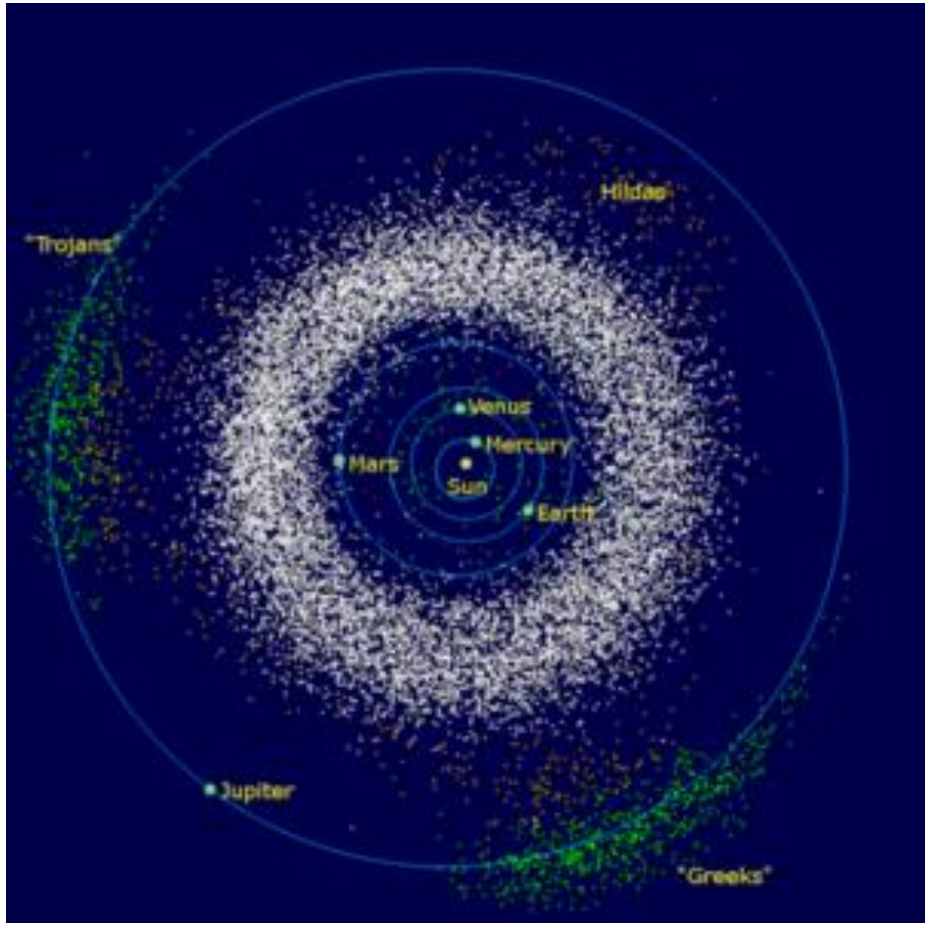
About 1,000,000 with a diameter > 1 km

About 150,000 cataloged today



1 Ceres from Dawn

Location



Asteroid average semi-major axes

Two principal locations

"Belt" asteroids
Orbit the Sun between Mars and Jupiter

Trojan asteroids
Precede and follow Jupiter in its orbit around the Sun

Asteroid Composition

Primitive – unchanged since formation

C Type – dark, contain carbon, more common in the outer part of the asteroid belt
S Type – lighter, mostly silicon, more common in the inner part of the asteroid belt

Processed – have undergone differentiation and volcanic activity

Vesta
M Type – mostly metals

How do we know?

Meteorites
Spacecraft visits

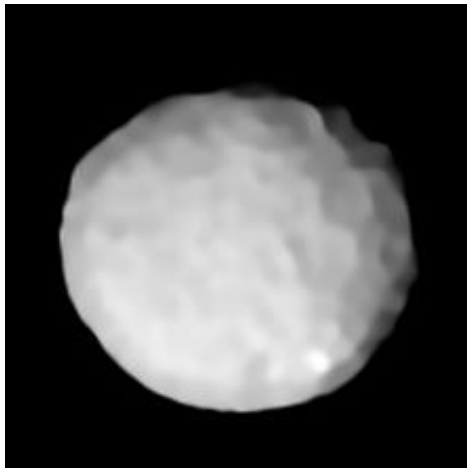
Asteroid Composition

Some asteroids may not be solid objects.

Mass and therefore density may be determined from small moons orbiting some asteroids.
Density may also be determined by asteroid gravitational affects on spacecraft.
The density of some asteroids, such as 253 Mathilde, is just slightly more than water and less than half that of a typical C Type asteroid.
It is considered a loosely packed “rubble pile”.

Asteroid 253 Mathilde

Asteroid Composition



Left - 3 Pallas, a C type asteroid

Right – 433 Eros – an S type asteroid

Above – 16 Psyche – an M type asteroid

Robotic spacecraft visits

Dawn orbited Vesta for a year before leaving Vesta and orbiting Ceres.

Hyabusa returned samples of the asteroid Itokawa to Earth.

NEAR Shoemaker orbited the asteroid Eros.

Other “flybys” have taken place

Dawn just before launch

Vesta

Vesta is the third largest asteroid

Surface is basaltic composition – a Processed asteroid

Leftover planetesimal?

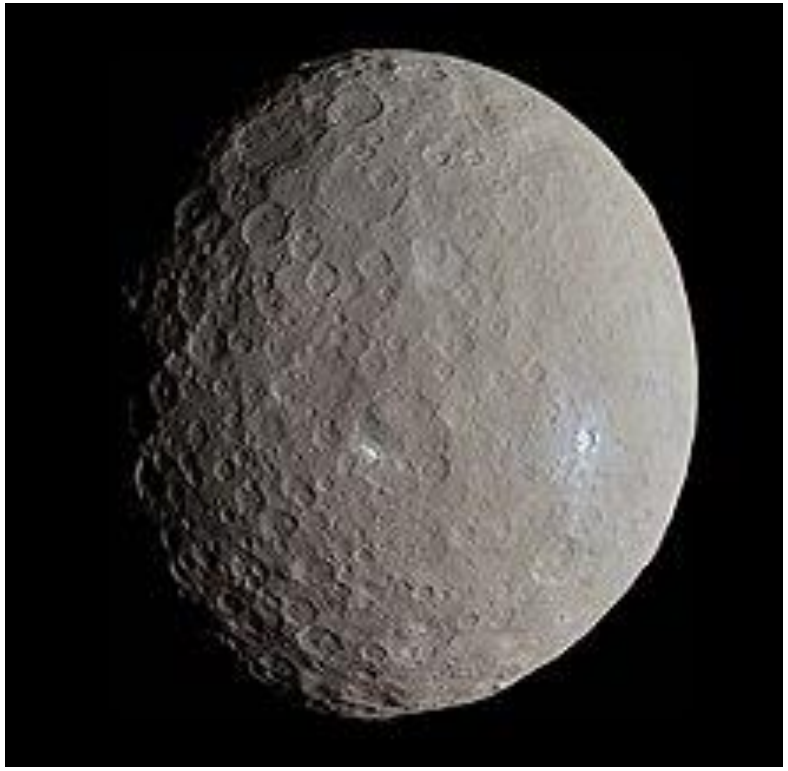
Above – 4 Vesta

Ceres

Ceres is the largest member of the asteroid belt

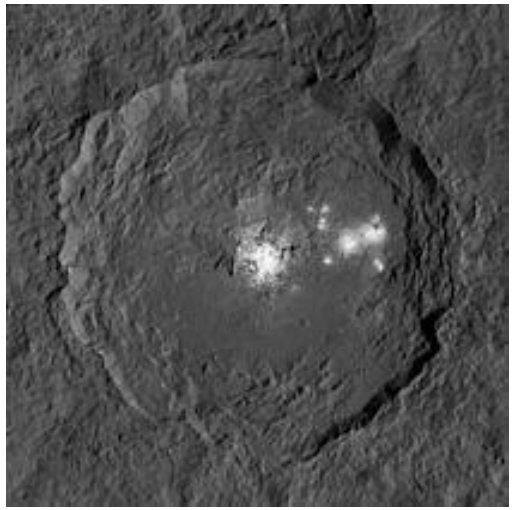
Although classified as S type, it apparently contains significant amounts of water ice

Apparently at one time there was an ocean of water underneath the surface



1 Ceres in true color

Ceres



Above left – bright spot in Occator crater

Above right – Ahuna Mons

The bright spots are thought to be a type of salt deposited on the surface from brine.

Ahuna Mons is a cryovolcanic feature thought to have formed from muddy water ice.

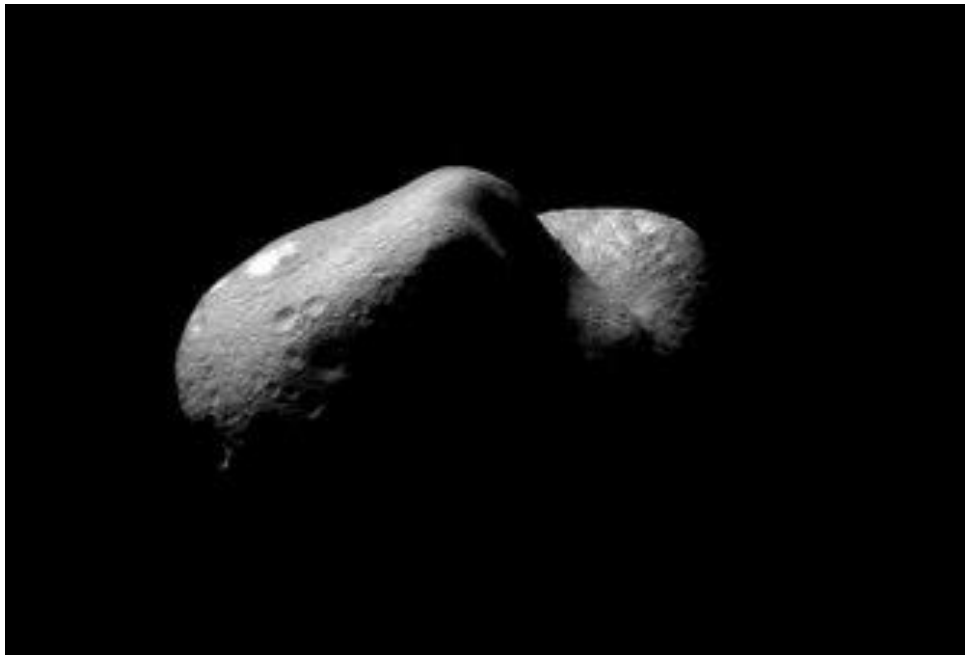
Eros

Eros is the second largest Near Earth Object

Diameter of 17 km – about 5 times larger than the asteroid that killed the dinosaurs

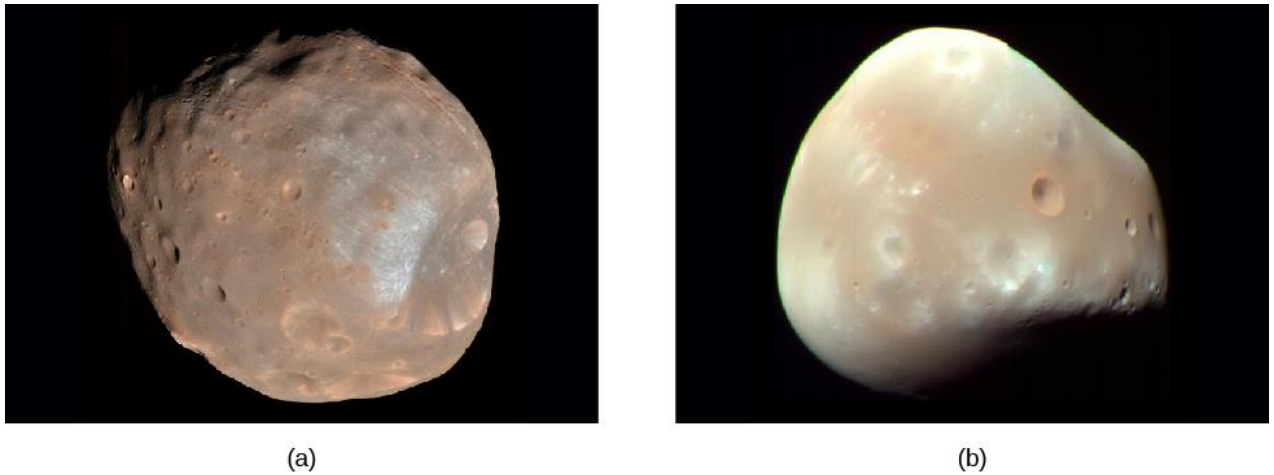
NEOs or Near Earth Objects are objects whose orbits bring them near the Earth

So far, we don’t know of any that may collide with Earth in the foreseeable future



433 Eros viewed from one end

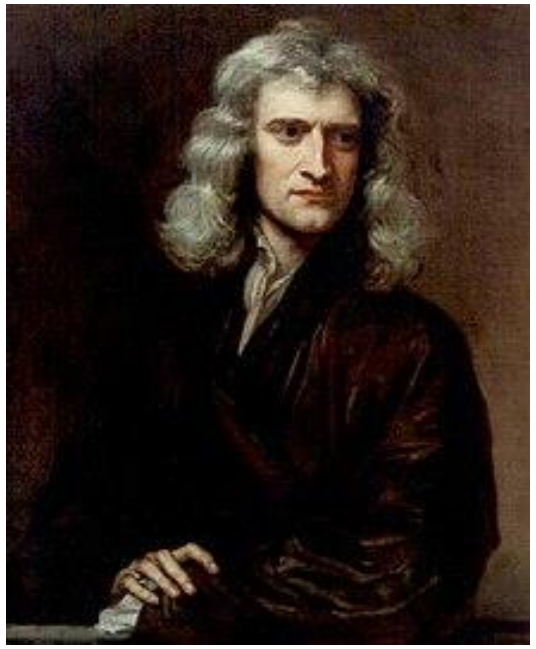
Captured Asteroids



Moons of Mars – left Phobos, right Diemos

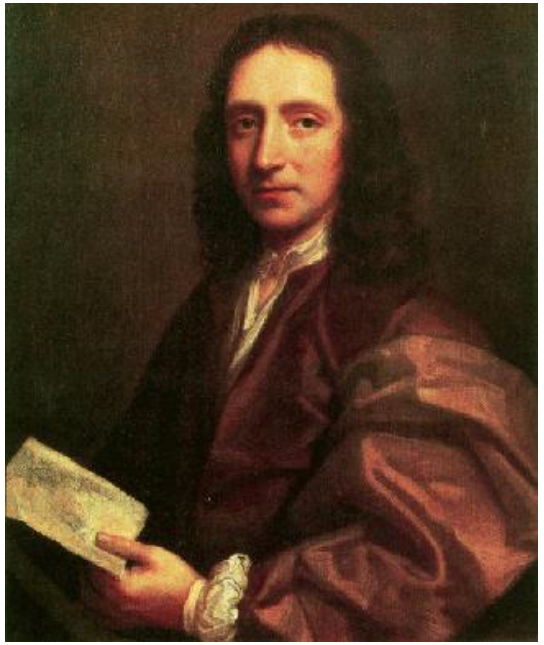
The moons of Mars and the outer moons of Jupiter and Saturn are likely captured asteroids.

Comet History

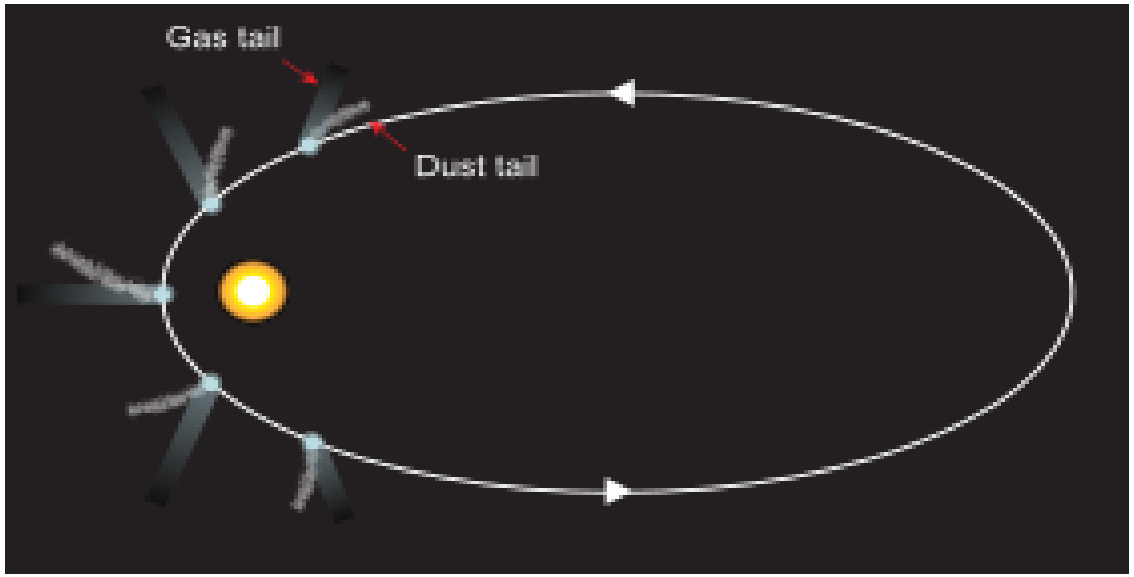


Isaac Newton first proposed that comets are solar system objects that orbit the Sun.

Edmund Halley proposed a particular comet would return in 75 years. Now called Halley's Comet.



Comets



Most are on highly elliptical orbits that take them very far from the Sun.

Comets are called dirty snowballs by astronomers – nucleus of Comet Hartley.

Comet Composition

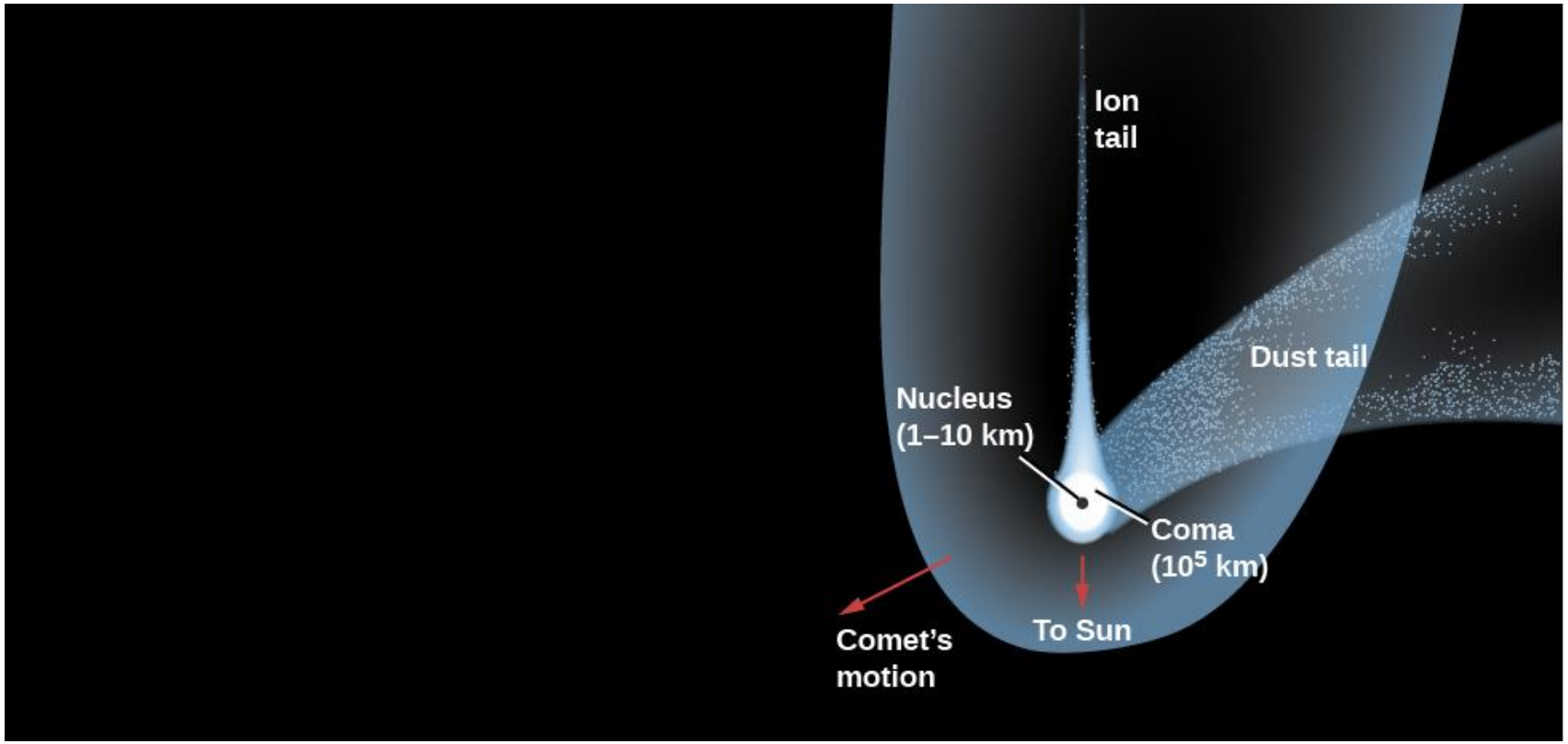
Dirty snowball

Fred Whipple, an American astronomer, coined the term

The central core of a comet is called the nucleus

Composed of ices of water and other common compounds with imbedded rock and dust

Comet Appearance



Comet diagram

Comet Appearance

Nucleus – solid body of ices with imbedded rock

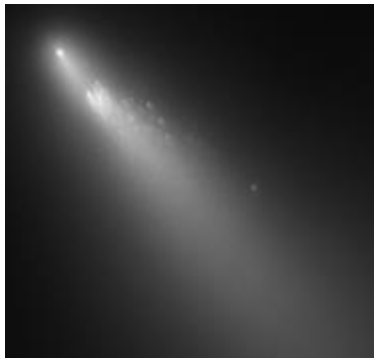
Coma – near the Sun the ices sublime and gasses expand

Ion Tail – gasses ionized by sunlight are swept away from the nucleus by the solar wind

Dust Tail – released imbedded rocky material is swept away from the nucleus by light pressure

Comet Sources

Above left – impact of Shoemaker-Levy 9 on Jupiter



Above right – breakup of comet Schwassman-Wachmann

Comets don't last forever. They have been seen to:

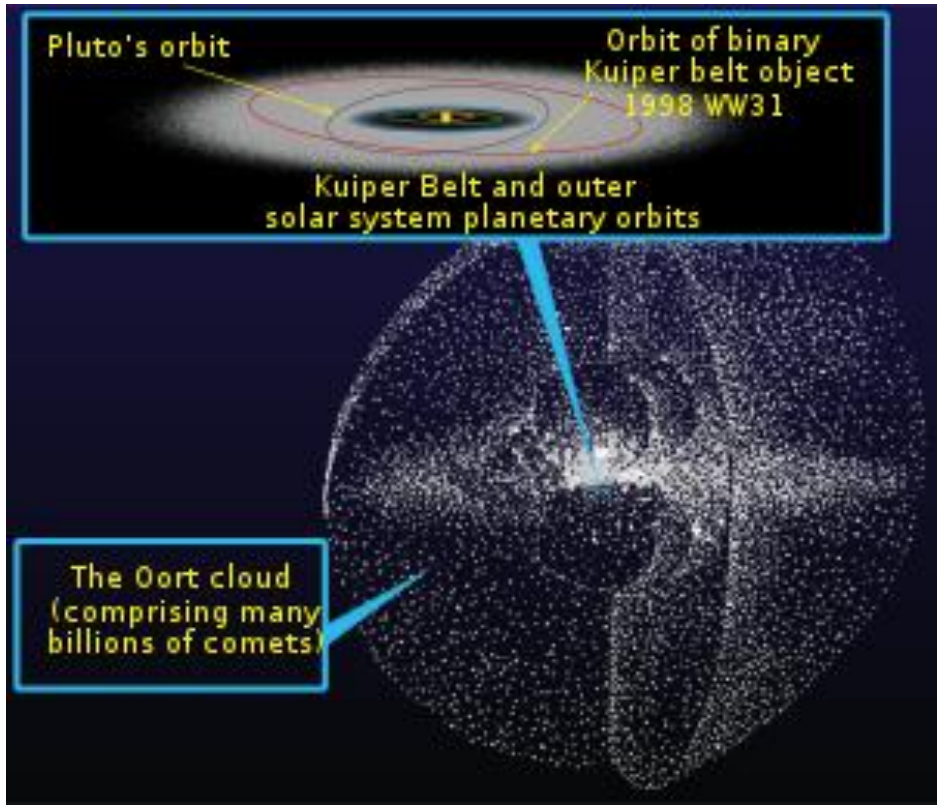
- Break up
- Impact planets
- Pass too close to the Sun and vaporize

But the average number of comets per year is relatively constant. Where do new comets originate?

Comet Sources

About half of all comets orbit in the same direction and plane as the planets – the Kuiper Belt:

Donut shaped region beyond Neptune.
Location of Pluto and similar objects.
Contains millions of small, icy bodies.

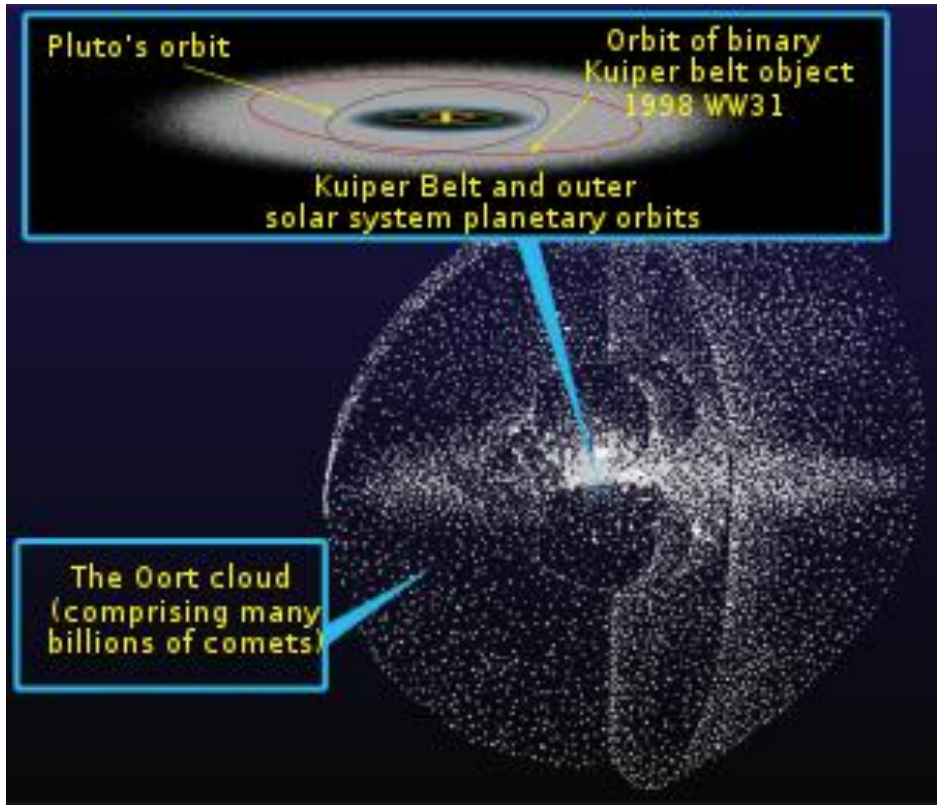


Artist's Conception of Kuiper Belt and Oort Cloud

Comet Sources

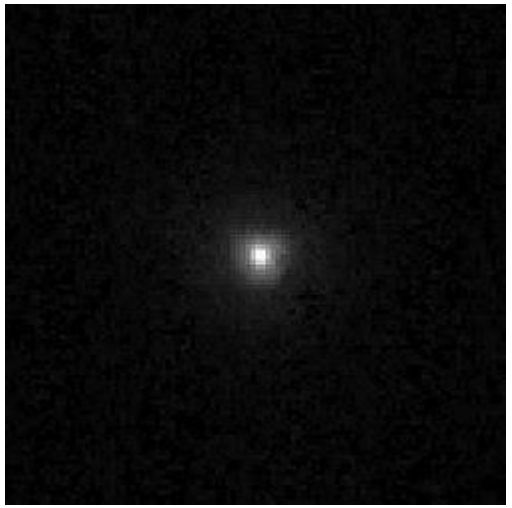
The other half orbit at random angles to the ecliptic and in both prograde and retrograde directions. They are thought to originate in the Oort Cloud.

Spherical region between 2000 and 200,000 AU from the Sun.
May contain over one billion objects.

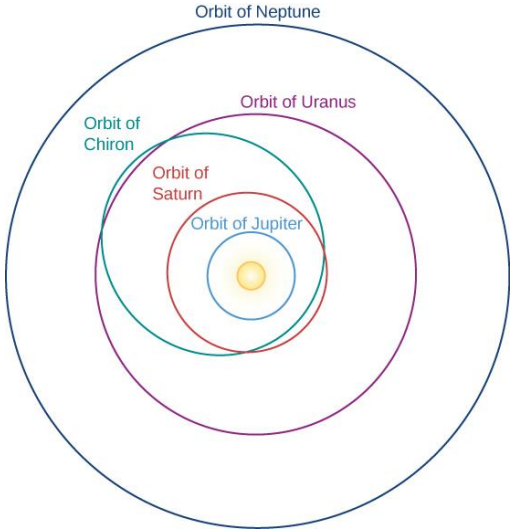


Artist's conception of the Kuiper Belt and Oort Cloud

Centaurs



Above left – 2060 Chiron



Above right – orbit of Chiron

Recently discovered objects orbiting between Jupiter and Neptune.

Have physical and orbital characteristics of both comets and asteroids.

Unstable orbits

Interstellar Comets

Comets are loosely bound to the Sun. The Oort Cloud objects are thousands of AU away.

Many observers expected interstellar comets to travel through our solar system – escapees from other systems.

Conclusions were that they would be too faint to see.

Until …2017

Interstellar Something

‘Oumuamua discovered in 2017.

Dimensions: 100 to 1000 m by 167 m by 35 m
Extreme elongation compared to solar system objects.
May possibly be pancake shaped.
Reddish color
Orbit indicates interstellar origin.
Doesn’t appear to be comet-like or asteroid-like.
Accelerating away from the Sun.

Artist’s conception of ‘Oumuamua

Interstellar Comet

2I Borisov discovered in 2019.

Believed to be a rounded shape.
Releases gases as ice sublimates like a comet.
Dimensions: 400 - 500 m radius
Orbit indicates interstellar origin.

This is the type of object that was expected.

Borisov in 2019

Asteroids and Comets

End of Chapter

Asteroid 253 Mathilde

Halley’s Comet in 1910