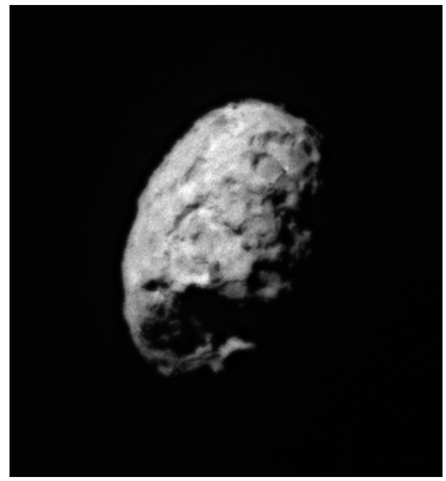
Old men and comets have been reverenced for the same reason:
their long beards, and pretenses to foretell events.
Jonathan Swift

Cold Hearted Orbs

Hi Astronomy 111. In this module we'll explore comets - what they are like, how big they can get. and how they are related to so-called "meteorite showers".

Credit: NASA, ESO



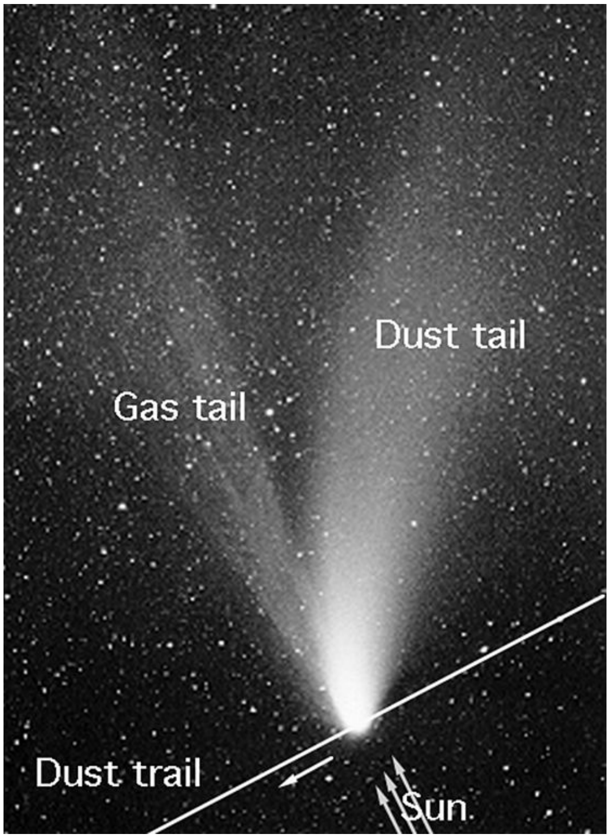
So what are comets like? Comets are the icy leftovers from the era of planet formation. They are dirty snowballs! Most still orbits far from the sun. That's why they're still icy. The image above left shows Comet 67P. Its not round. The European Space Agency's Rosetta mission entered orbit in September 2014. Its lander, Philae, touched down on its surface in November 2014, becoming the first spacecraft to land on a comet nucleus. The landing was not as smoothed as planned as it bounced three times and came to rest in the shadows. Contact was lost as the battery drained. However, in June 2015 the spunky Philae reestablished communications and reported a healthy spacecraft. Cool beans!

The image above right shows Comet Wild2. For most of its 4.5 billion year lifetime, Wild 2 probably had a more distant and circular orbit. But in 1974, it passed too close to Jupiter, whose gravitational influence changed the Comet's orbit so that it now resides in the inner solar system. Its period is about 6 years and its perihelion distance is about the same as Mars'.

The image above middle shows Comet Tempel 1. We've smashed stuff onto the surface. The impactor returned images up to about 3 seconds before impact. The image is taken about 1 minute after the Deep Impact mission's probe impacted the surface in July 2005. The impact formed a crater. The energy from the collision was similar in size to exploding five tons of dynamite. Much more dust was kicked up than was estimated. The dust was also finer than expected - more like talcum powder than sand.

If a comet approaches the Sun its nucleus, the dirty snowball itself, heats up. Its ice sublimates into gas. So you go directly from the solid phase to the gas stage. The image above shows Comet 17P. It lives in the inner Solar System with period of about 6 years. Its aphelion distance is about 5 AU and its perihelion distance is about 2 AU.

The escaping gases also carry some of the dirty snowball dust . Dust is heavier than gas. This is what causes the formation of two tails as shown in the image below on the left. You form a plasma tail of the gases and you form a second tail from the dust. The image below shows Comet Hale-Bopp with its two prominent tails. The blue one is the gas tail. Its blue because the molecules in the gases are getting ionized by the Sun's light. Molecules like carbon monoxide are the most common and they scatter blue light much more strongly than red light, so to our eyes the gas tail looks blue. The gas tail is the thinner of the two tails and always points directly way the from the Sun. The heavier dust tail appears white or pink-ish. This is because dust scatters sunlight the same for all wavelengths, but just a smidgeon more efficiently at red wavelengths. The dust tail also curves away from the comet nucleus because they are heavier.

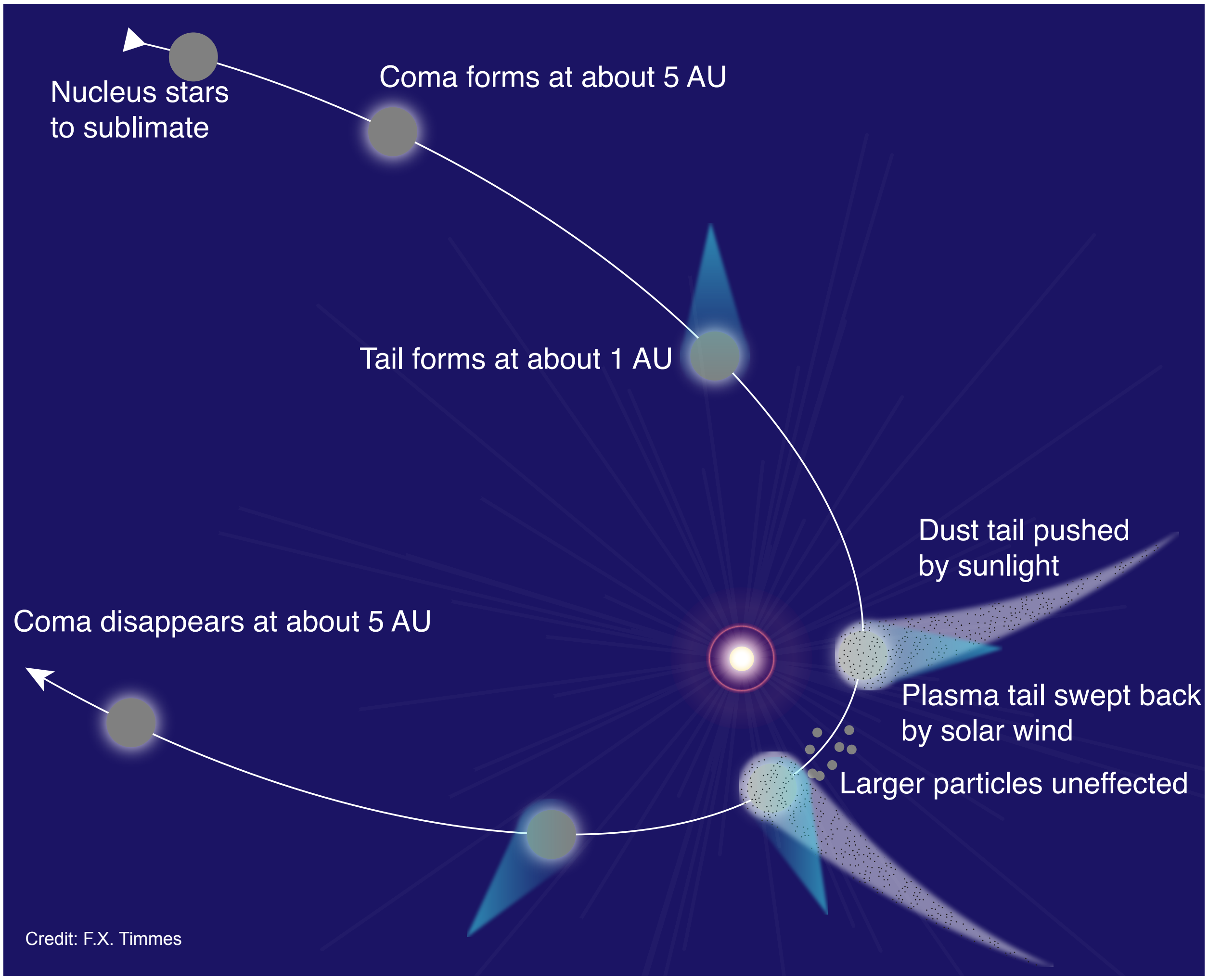


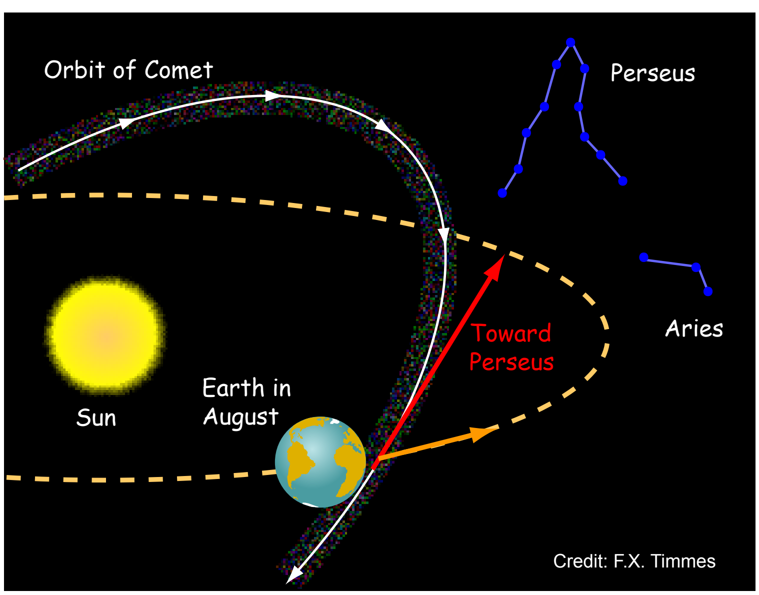
Credit:Wikipedia, Creative Commons

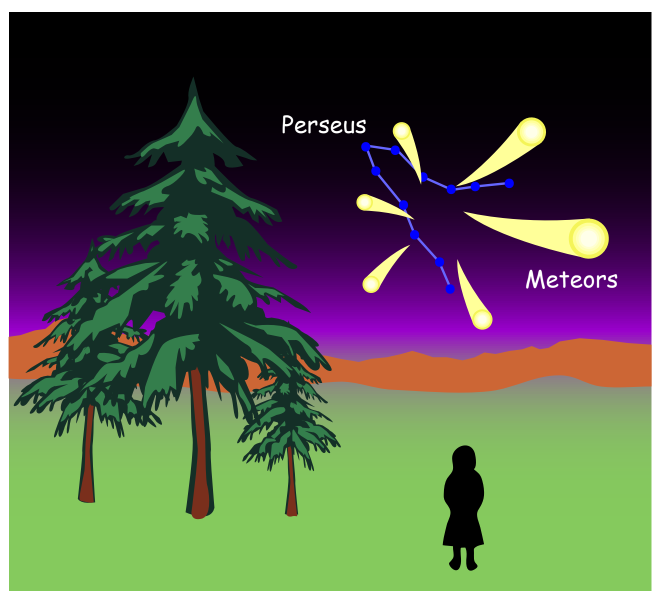
The illustration below shows the evolution of a comet as it enters the inner solarsystem and then leaves the inner solar system. The comet comes in, usually from the the Kuiper belt or the Oort cloud unless Jupiter has turned it into a comet with a bound orbit.

As they start approaching the Sun, they start to heat up, the nucleus begins to sublimate. By about 5AU, the distance to Jupiter, the coma begins to form. The coma is a large diffuse cloud of gas and dust surrounding the nucleus. By the time they get o about 1 AU, the distance of Earth, they form their tails.

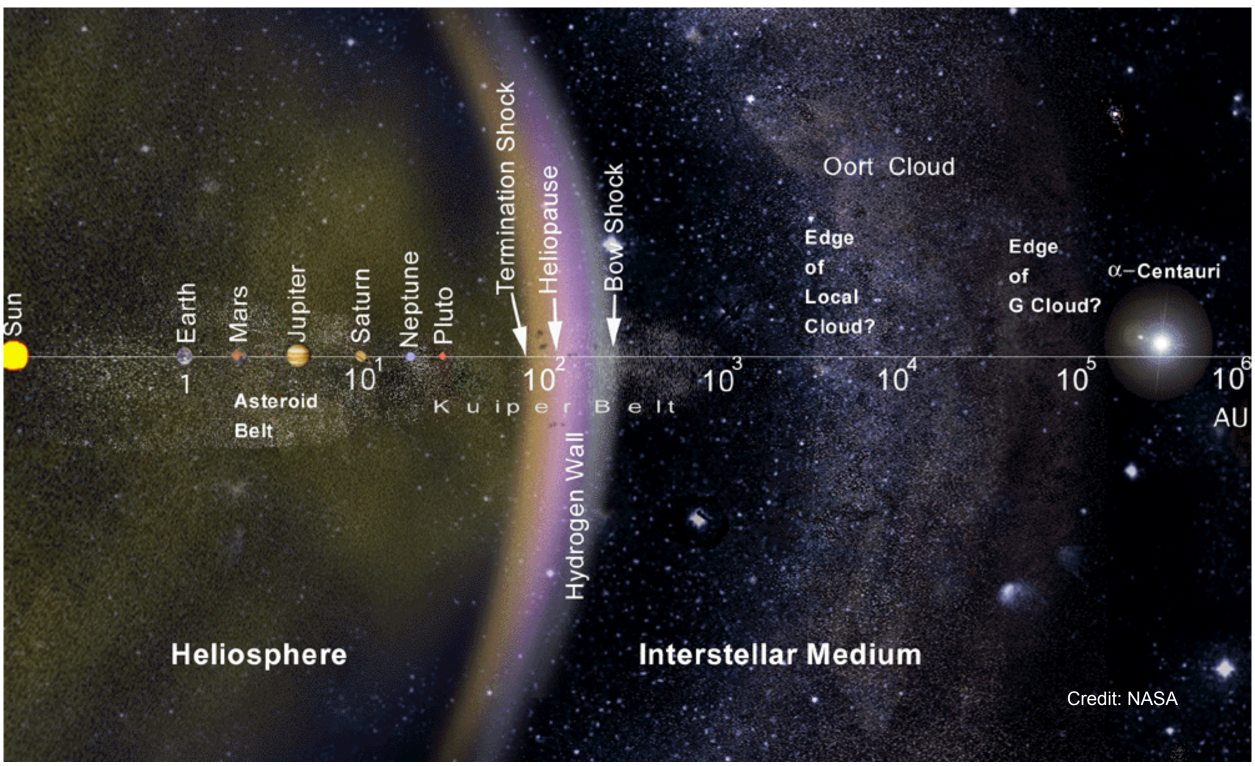
The tails always point away from the Sun. The tail does not follow behind the comet as though it was some rocket exhaust going out the back. The tails are strictly a Sun-driven event - sunlight and the solar wind. So the two tails aways point away from the sun as it goes around the Sun. After its perihelion approach, the process reverses itself. The tails fade and disappear, then the coma disappears. then as it heads away from the Sun.


Nucleus stars
to sublimate
Coma forms at about 5 AU
Tail forms at about 1 AU
Dust tail pushed
by sunlight
Coma disappears at about 5 AU
Plasma tail swept back
by solar wind
Larger particles uneffected
Credit: F.X. Timmes


Orbit of Comet
Perseus
Toward
Perseus
Aries
Sun
Earth in
August
Credit: F.X. Timmes


Perseus
Meteors

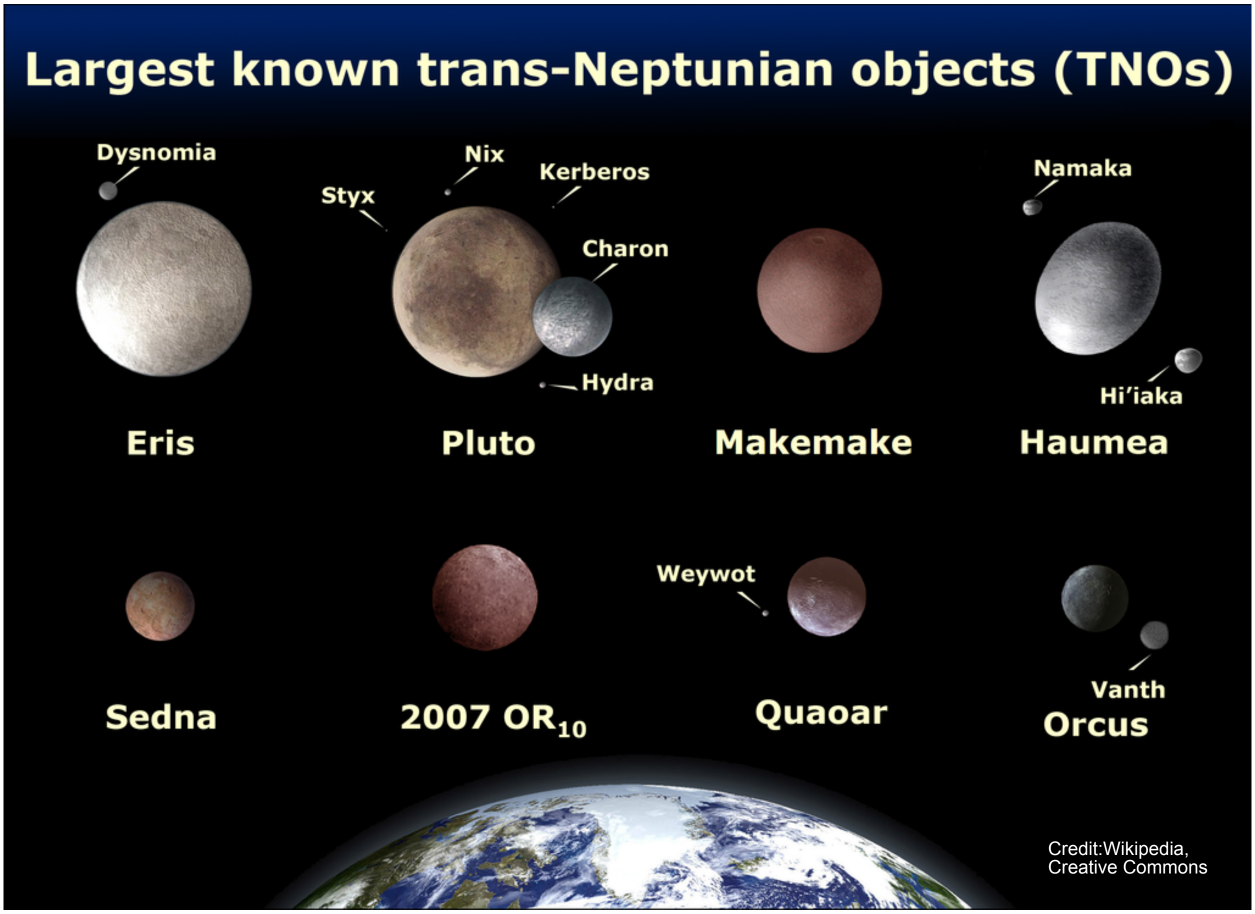
Larger sized particles can escape from the comet. They go into orbit all by themselves. This is what causes the meteor showers that we see on Earth. For example, the Perseid meteor shower in August every year is caused by the debris of Comet Swift-Tuttle. The illustration above shows the geometry of the situation. The comet has some orbital path about the Sun. The debris from the comet will populate that orbit path. It may happen that Earth's orbit crosses the orbit of the debris trail. When it does, we see a meteor shower in the direction that the Earth happens to be traveling in. For the Perseid meteor shower, the intersection point is in the direction of the constellation Perseus. All the meteors appear to originate from the constellation Perseus. Of course they do not come from the constellation but from the debris of a comet. Physically what's happening is the debris trail enters the upper part of Earth's atmosphere and they burn up. OK, clear?



So where do comets come from? We know by now in this course that comets come from two reservoirs. They come from the Kuiper belt and the Oort cloud. The Kuiper belt comets reside in the region beyond Neptune, where they formed and still reside. Oort cloud comets formed in the region between Jupiter and Neptune but were ejected in random directions by their gravitational influences of the Jovians.

The two reservoirs and shown in the image above. You've got a disk shaped reservoir of comets in the Kuiper belt and you've got a spherical shaped reservoir in the Oort cloud. Comets from the Kuiper belt come into the inner solar system on orbits that are more-or-less aligned with the ecliptic. Comets from the Oort Cloud enter the inner solar system at random inclinations and random eccentricities and usually on unbound parabolic or hyperbolic orbits.

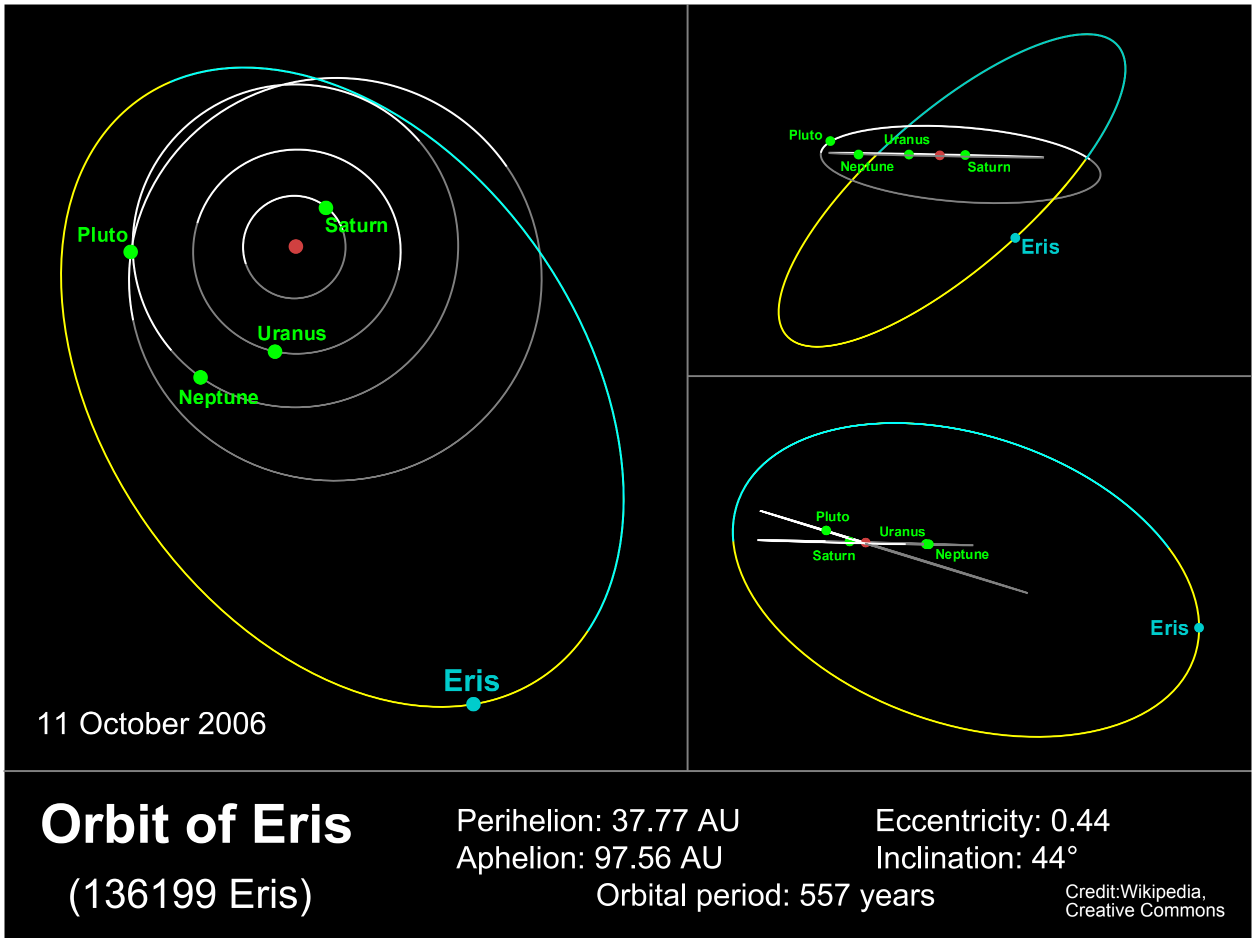
So how big can you make a comet? Well in the Kuiper belt, icy planetesimals were able to grow to thousands of kilometers in size. Eris is the largest known of these objects and Pluto is the second largest. Nomenclature. Since these objects orbit about then Sun beyond Neptune, they are sometimes called "trans-Neptunian" objects, as the image below says.



The orbit of Eris, Pluto, Neptune and a few other Jovian worlds are shown below. Note that part of Pluto's 248 year orbit slips inside the orbit of Neptune. For a 20 year period Pluto is closer to the Sun than Neptune! The last time this happened was in 1979 - 1999. It won't happen again until the year 2227. While their orbital paths cross, Pluto and Neptune will not collide because they share an orbital resonance. Eris orbits further out than Pluto. Its orbit is even more inclined relative to the ecliptic plane than Pluto's.

Eris is named after the Greek goddess of strife and discord. Eris is the object that led to the debate on the definition of a planet, so the name is appropriate. Eris and Pluto are classified as dwarf planets because they have not cleared out their respective neighborhoods. But no matter what you call them, their orbital and physical properties identify them as members of the Kuiper belt. Pluto, and Eris, are loners no more. As teh illustration below suggests, they found their own family in the Kuiper belt.

Thanks. Bye Bye!



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