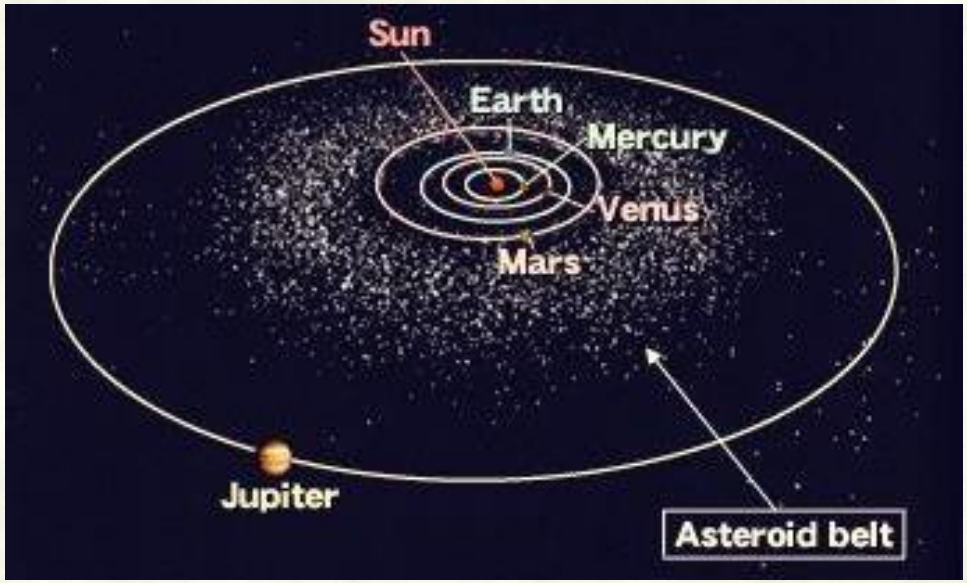
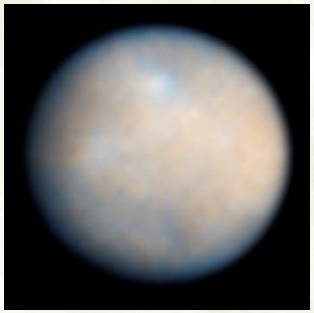
Comets, Asteroids, Meteors

ASTR 101

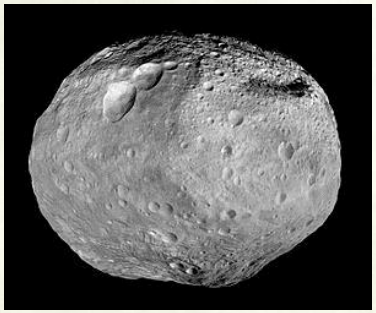
11/12/2017

Asteroids

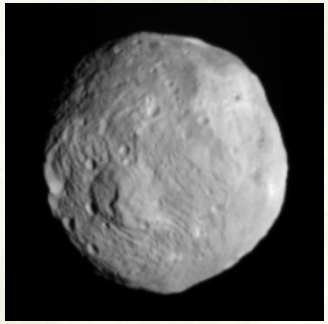


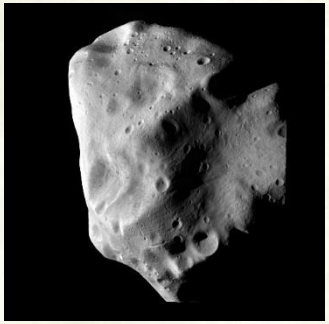


Ceres, 952km



Vesta, 572km

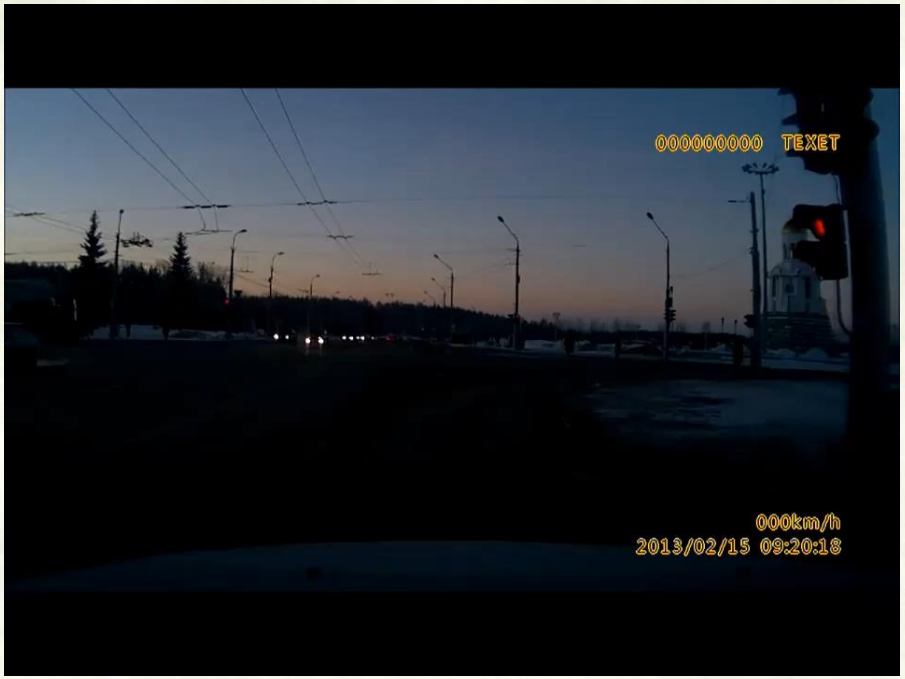




Lutetia, 100km

- Between Mars and Jupiter there are thousands of rocky planetesimals from 1,000 km to a few meters across called Asteroids.
  - Those are thought to be debris of the formation of the solar system that could not merge to form a planets due to influence of Jupiter's gravity.
- About 6 are larger than 300 km, most are smaller (< 10 km) and do not have enough mass to be spherical.
- More than 300,000 *asteroids* have been identified and cataloged, over a million asteroids lager than 1km are estimated to be there and many millions smaller ones.

Asteroids



http://www.youtube.com/watch?v=RrL-cWaYdno

Chelyabinsk meteor that entered Earth‘s atmosphere over Russia on February 15, 2013

http://www.youtube.com/watch?v=RrL-cWaYdno

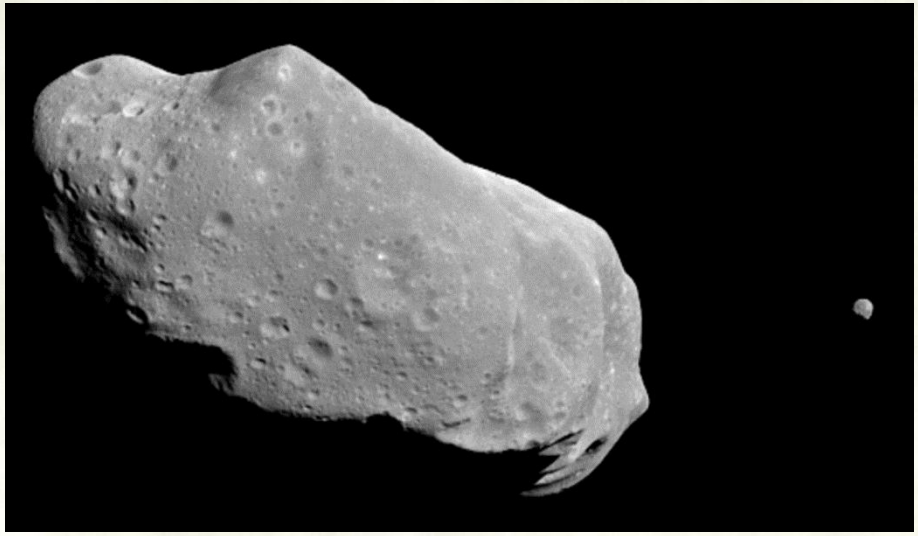
Peekskill Meteorite (October 9, 1992, (from Kentucky to New York, Estimated size 12kg)

- Sometimes those objects fall on he Earth, which are called meteor or meteorites.
  - Most of the time they are small, size of sand grains. They burn up in the Earth's atmosphere, causing them to glow (shooting stars).
  - Rarely larger metros survive burning and hit the Earth

Barringer Crater in Arizona (1.2 km across and 200m deep result of a50 meter nickel/iron meteorite impact 50000 years ago. http://www.barringercrater.com/about/

Manicouagan Crater, Quebec Canada. over 200 million years old, 70km in diameter now.

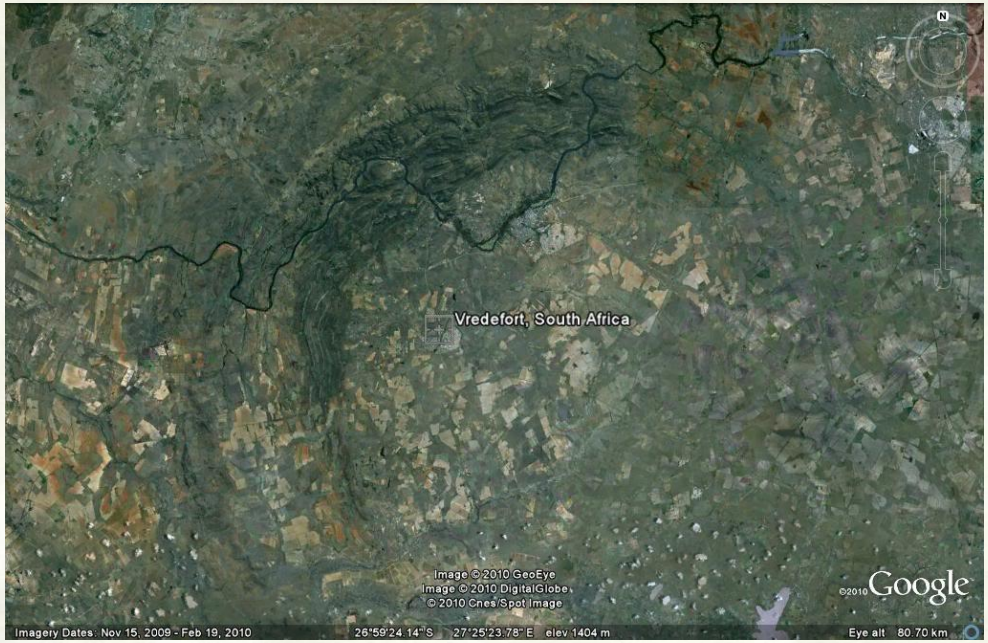
- Chunks of rock and debris in space that are in a collision course with the Earth are called ***meteoroids***.
- When meteoroids enter the Earth's atmosphere they heat up by friction and burn, and are called ***meteors*** (shooting stars)**.**
- Most meteors burn up in the atmosphere, but if they survive the burn and strike the surface of the Earth, they are called ***meteorites*****.**
- Though rare, the Earth has been struck by many meteorites, some quite large.
  - There are about 100 such craters on the Earth, more than 0.1 km in diameter;
  - erosion has made most of them hard to discern.



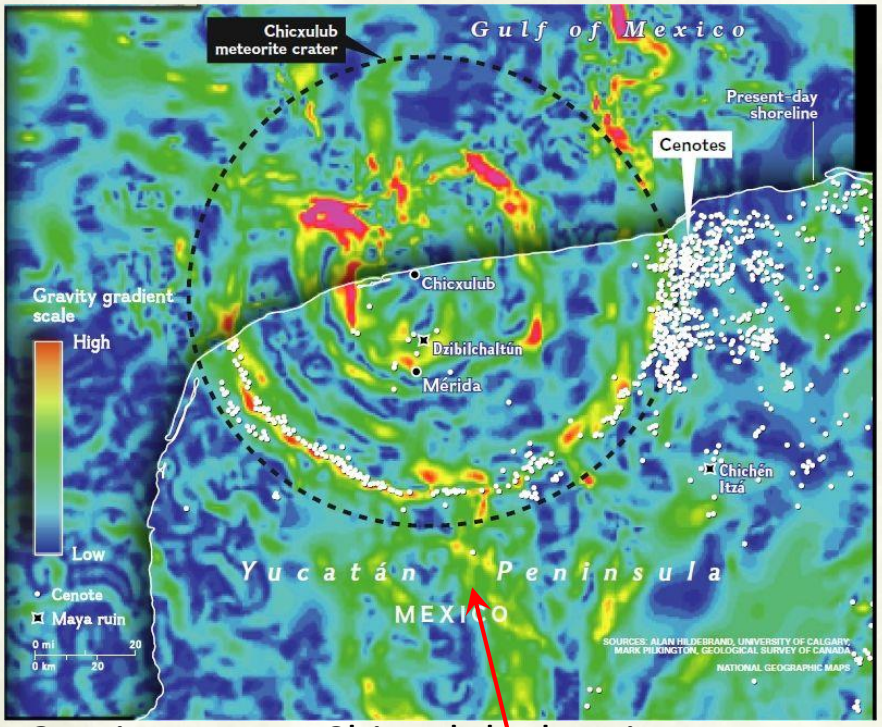
Apollo Asteroids

asteroid Ida (56km) accompanied a tiny moon (Dactyl 1.5 km) found when Galileo flew by

- Certain groups of asteroids have elliptical orbits that cross the orbit of the Earth and other inner planets.
- They are called Apollo asteroids and raise the concern of a possible collision with Earth.
- 10,000 such asteroids have been discovered so far, of which about 1400 have been designated as potentially hazardous, due to their size.
  - Good news: none of these will strike the Earth.
  - Bad news: is that we probably have discovered only a fraction of the total number of Earth-crossing asteroids
- According to estimates there could be over 1500 earth crossing asteroids larger than one kilometer and 135,000 larger than 100 meters in diameter.



Vredefort Crater, South Africa , 200 km crater formed by an impact billion years ago

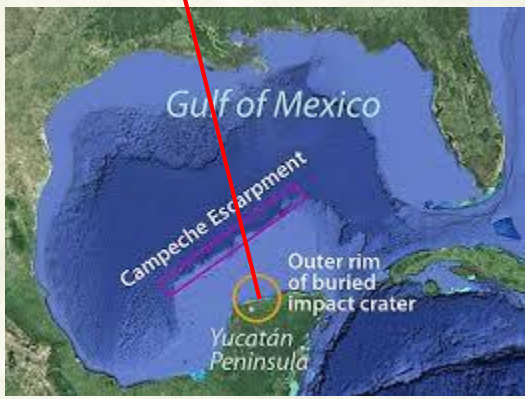


Gravity map at Chicxulub showing an anomaly 180km in diameter.

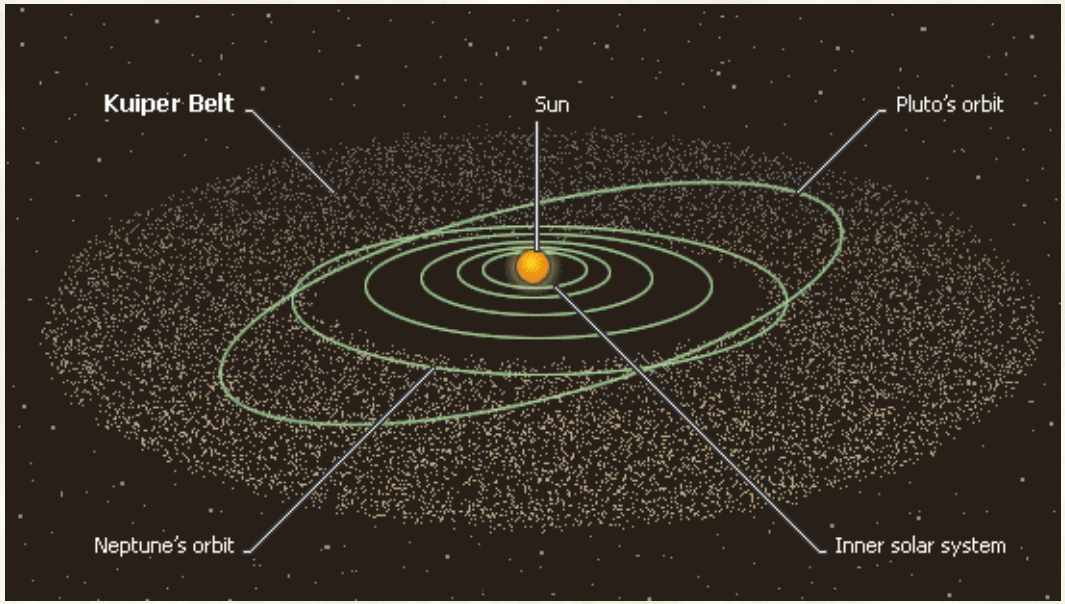
Cretaceous–Tertiary (K–T) extinction:

- Paleontological evidence suggests that there had been a mass extension of animals and other living organisms 65 million years ago. About 70% of all species then living On the Earth (including Dinosaurs) had disappeared within a very short period

- It has been proposed that this mass extension was a result of a huge meteorite (10km size) impact 65 million years ago, and the impact site has been traced to Chicxulub in Yucatan.

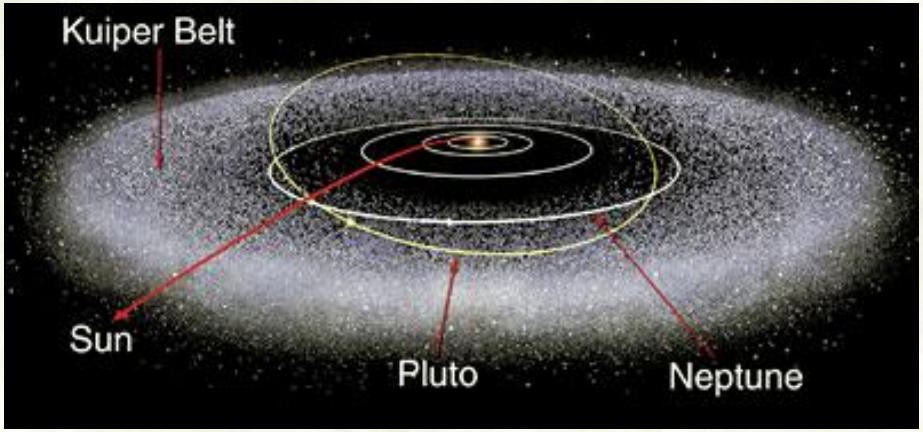


Comets



- Comets are also debris left over from the formation of the solar system.
- They were located beyond the frost line,
  - so unlike for asteroids, in addition to metal and silicate dust, ice particles were also coalesce to form planetesimals
- But away from the Sun, beyond Neptune in coldest regions of the nebula, the density was low that those icy/dusty planetesimals could not grow very large.

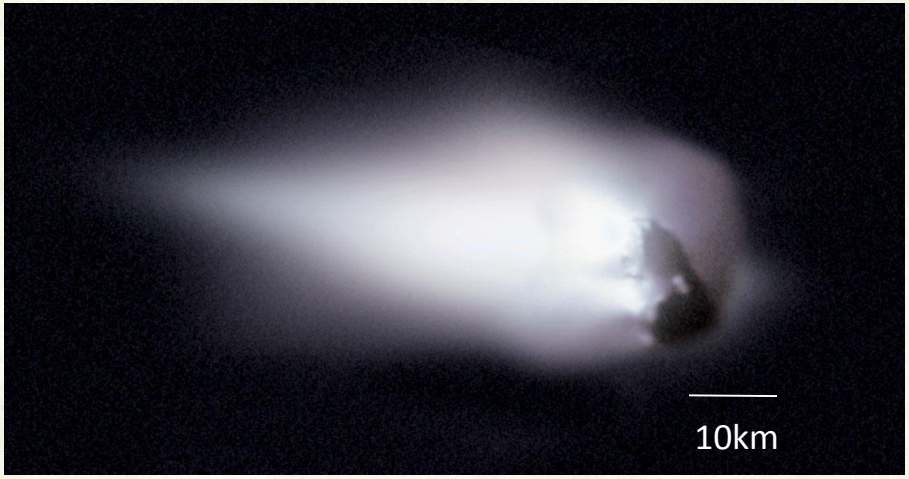
Kuiper belt objects



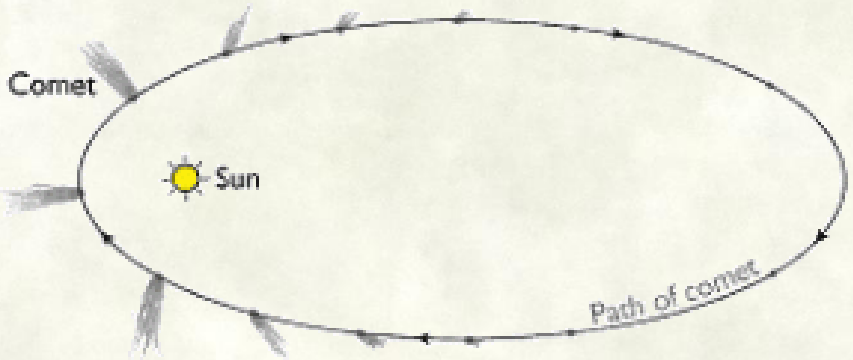
Comet 67P images taken by the Rosetta spacecraft

- Most of them ended up like loosely packed dirty snow balls, few kilometers in size extending out to as far as 1000 AU.
- They constitute the family of Kuiper belt objects.
- Pluto, a dwarf planet is the largest Kuiper belt object known.
- Because of their large distance from the Sun they were able to keep frozen ice (water, ammonia, methane…) on their surface.
- When (and if) they come close to the Sun those ice evaporate and they become comets.
- They (Kuiper belt objects/comets) may be the source of the water on the Earth.
  - Early collisions of them with the Earth replenished it with water.

Comets



Gas and dust ejecting from the Nucleus of comet Halley, as it was approaching Sun Image taken by Giotto spacecraft in March 14, 1986. http://apod.nasa.gov/apod/ap100104.html

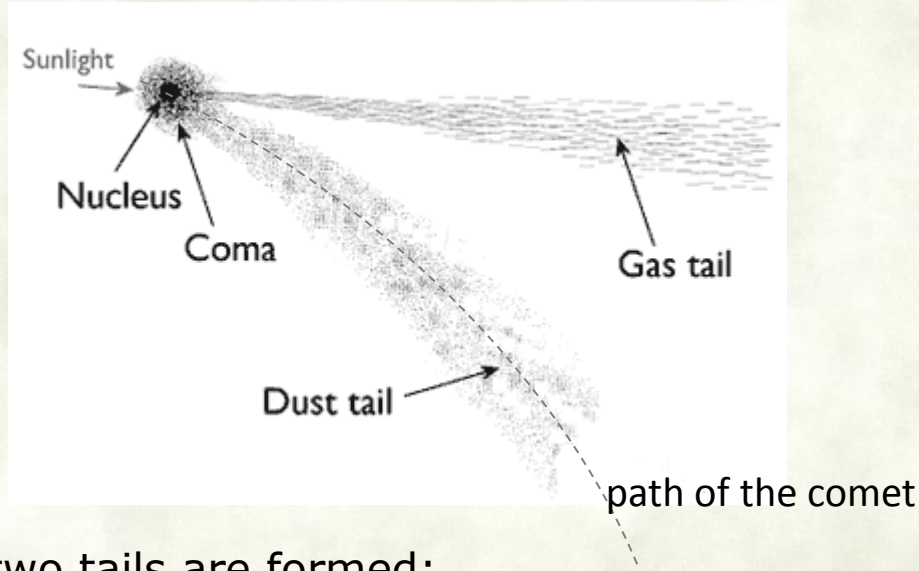


Comet tail(s) always directed away from the Sun, and gets longer as it is gets closer.

- As comes closer to the sun they warms up and partially vaporizes releasing dust and gases.
- Those released gas and dust form an atmosphere around it called coma.

- The solar wind then blows those gases and dust particles away from the direction of the Sun forming tails.
- When closest to the sun tail could be extending over hundreds of millions kilometers

Comet tails



Comet Hale-Bopp (1997)

Often two tails are formed:

- Ion tail:
  - Ultraviolet radiation in sunlight rips electrons off from gas atoms in the coma, ionizing them (making them electrically charged).
  - The solar wind then carries these ions straight outward away from the comet forming a straight and narrow tail.
- Dust tail:
  - sunlight pushes dust particles away from the nucleus gently shoving them away from the comet's nucleus.
  - force from solar wind on dust particles is relatively weak,
    - once dust particles leave the nucleus they follow the same path as the comet, giving rise to a slightly curved diffused tail.

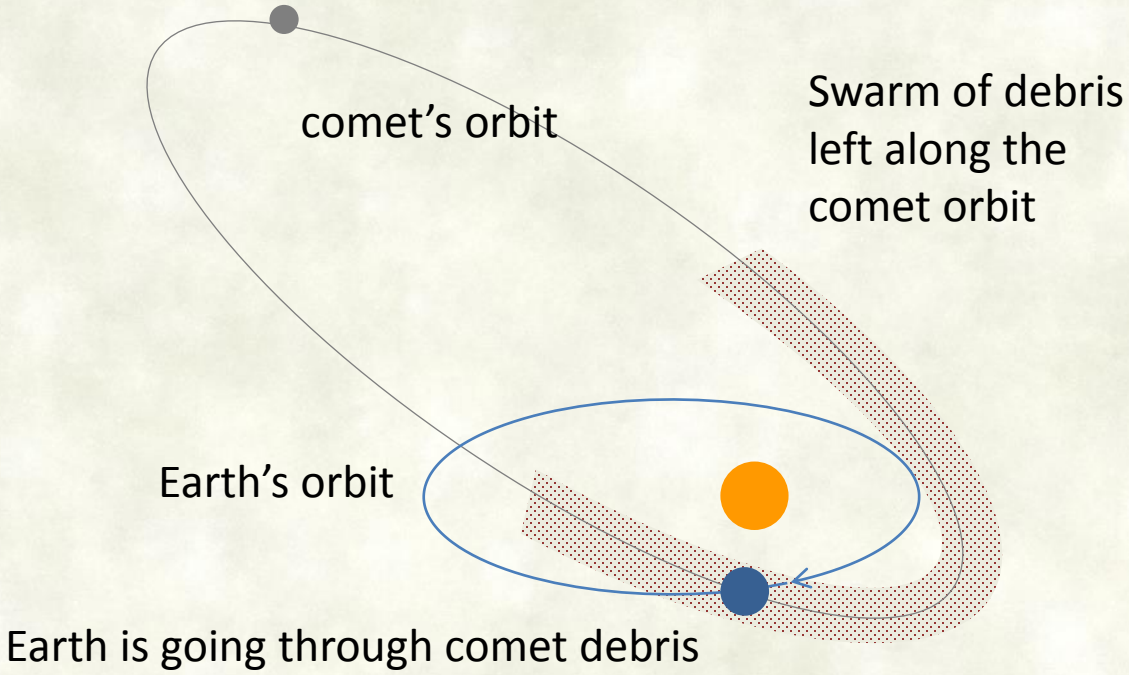
Comet Halley in 1910, and 1986
Period 75–76 years

comet McNaught in 2007
non-periodic

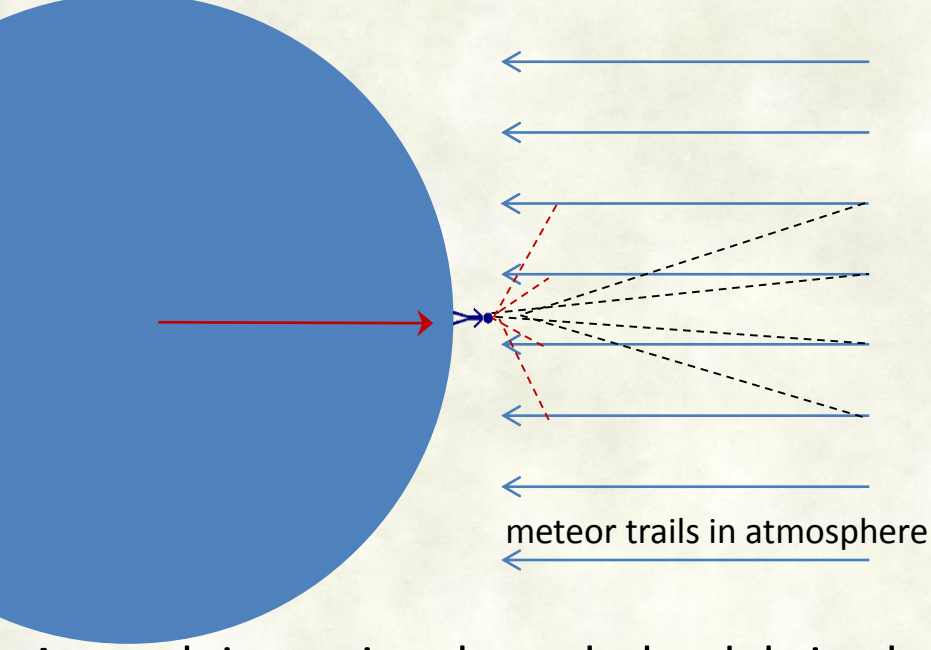
- A comet is visible only when it comes closer to sun and coma is expanded. Otherwise they ae too small to see even through telescopes from Earth.
- Many comets come closer to the Sun every year,
  - Most are visible only through a telescope.
  - Comets bright enough to see with naked eye are less frequent (about one in 10 years)
- Comets are named after the discoverer(s).

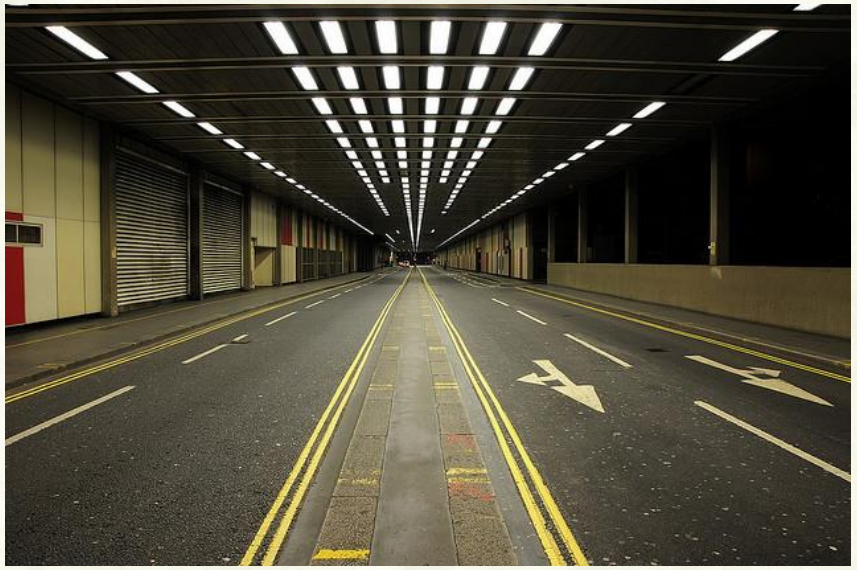
Meteor Showers

- Most meteors are tiny specks of dust and rapidly burn up in the atmosphere, they are very common, can usually observe a few per hour on any clear night.
- Some are larger and produce spectacular *fireballs* that are very bright, and may explode, they are rare.
- Sometimes, meteors occur at a much higher rate, and seems to come from a particular point in the sky (called the radiant) They are called meteor shower
  - That happens when earth is passing through a stream of debris, usually left by a comet.
  - The meteor shower is commonly named after the constellation in which this radiant is located.



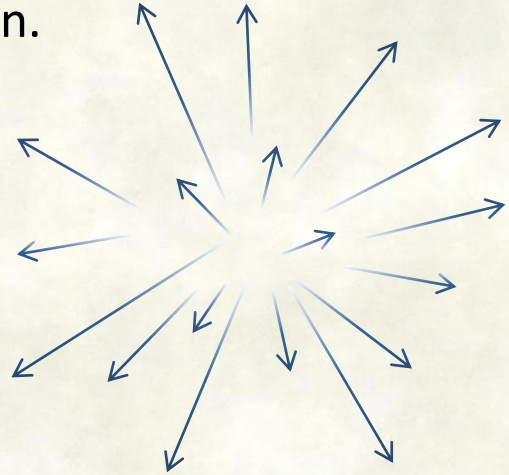
- A broad trail of debris (material blown off the comet) from the comet is left along its orbit, and move around the Sun in the same orbit.
- Paths of some of those debris fields may intersect with Earth's orbit.
  - Then that happens once a year earth is passing through the comet's debris field and those particles collide and burn in the atmosphere, forming a meteor shower.
- As earth is moving through the debris, the all enter the atmosphere moving in the same direction. But it due to perspective appears meteors are radiating from one point in the sky.

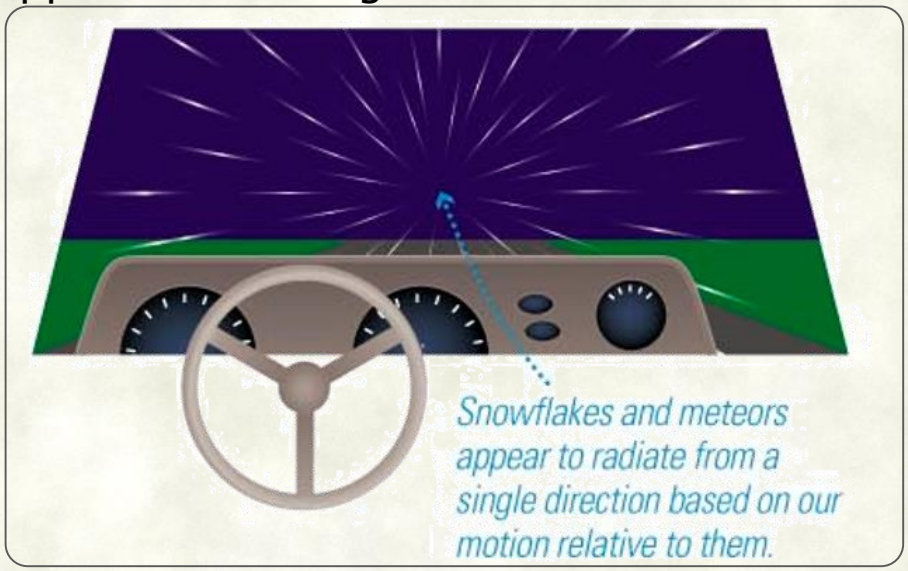




As earth is moving through the debris, the all enter the atmosphere moving in the same direction.

This effect is one of perspective, much like railroad tracks, or highway lanes that appear to converge.





But it appears meteors are radiating from one point in the sky.

Same effect is seen when driving in a snow storm or rain

Major Meteor showers

- **Lyrids** Comet of Origin: Thatcher
  Radiant: constellation Lyra Peak April 21-22, 2014
  Peak Activity Meteor Count: 20 meteors per hour

- **Eta Aquariids** Comet of Origin: Halley
  Radiant: constellation Aquarius Peak: May 5-6, 2014
  Peak Activity Meteor Count: 45 meteors per hour

- **Perseids** Comet of Origin: Swift-Tuttle
  Radiant: constellation Perseus Peak: Aug. 12-13
  Peak Activity Meteor Count: Up to 100 meteors per hour

- **Orionids** Comet of Origin: Halley
  Radiant: constellation Orion Peak: Oct. 21-22
  Peak Activity Meteor Count: 20 meteors per hour

- **Leonids** Comet of Origin: Tempel-Tuttle
  Radiant: constellation Leo Peak: Nov. 17-18, 2014
  Peak Activity Meteor Count: 15 meteors per hour

- **Geminids** Comet of Origin: Phaethon- an asteroid
  Radiant: constellation Gemini Peak Activity: Dec. 13-14, 2014
  Peak Activity Meteor Count: 120 meteors per hour

Review Questions

- How did the asteroid belt form?
- What are the Kuiper belt objects?
- What could be the reason that no large planets had formed beyond Neptune?
- Where are the asteroids located in the solar system?
- What are comets? How do they form?
- What causes meteor showers?
- Why do asteroids have irregular shapes instead being spherical
- What are shooting stars?
- Why do meteors in the meteor shower appear to be radiating from a point in the sky.
- What is the difference between comets and asteroids?
- Who do comet tails pointing away from the sun