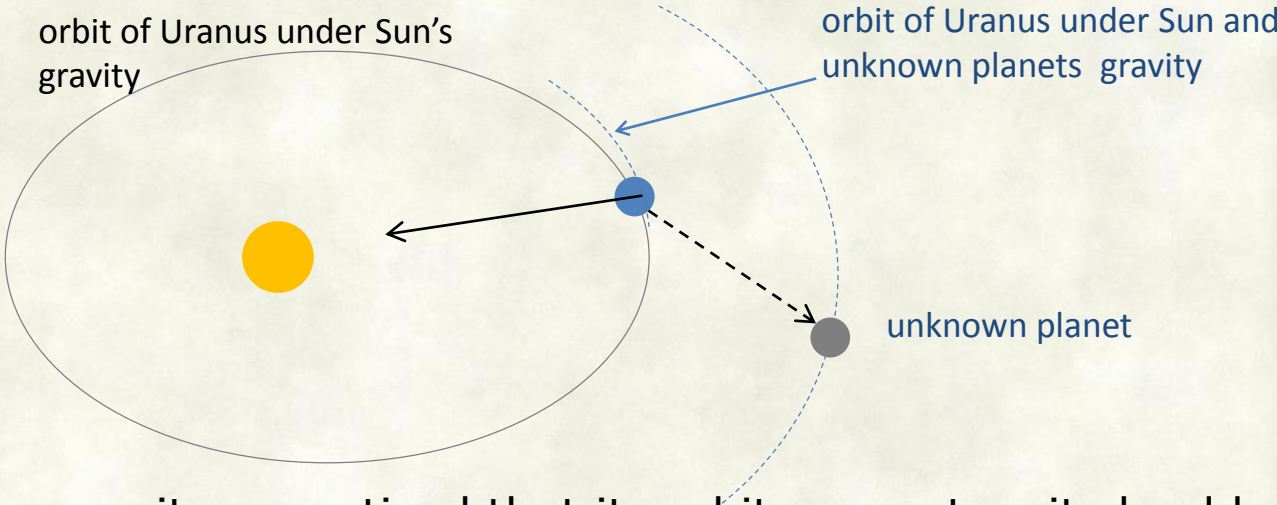
Neptune and Beyond, Asteroids, Comets

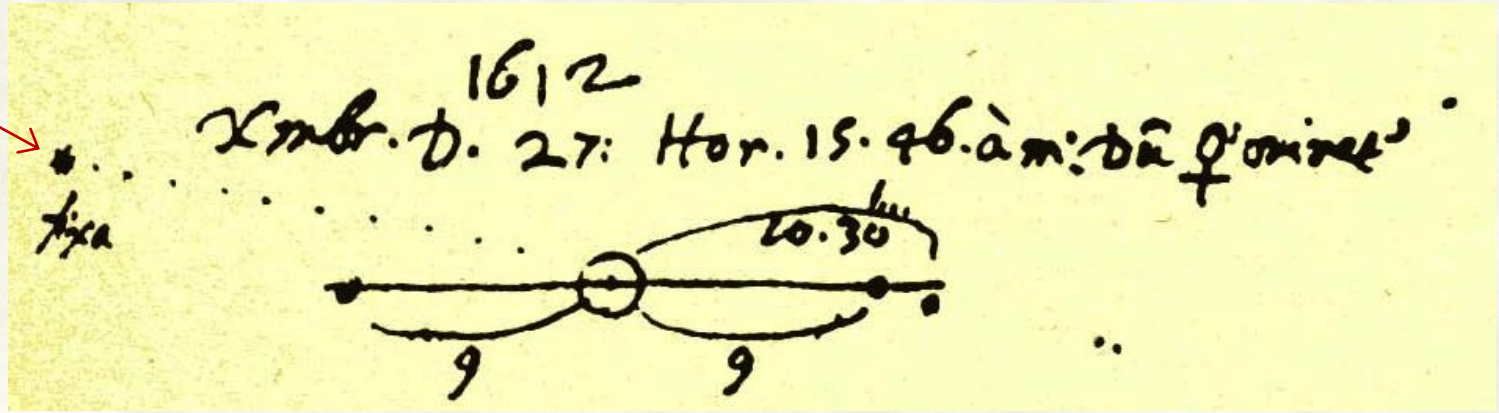
ASTR 101

11/07/2014

Neptune



- After the discovery of Uranus, it was noticed that its orbit was not as it should be in accordance with Newton's laws.
  - It was deviating about 1 arc second per year from the predicted orbit
  - Could be something wrong with Newton's laws of motion and gravitation
  - Or could be some unknown massive object pulling it away from the orbit around Sun.
- Two mathematicians, British John Adams and French Urbain Le Verrier thought it was due to the gravitational pull of hitherto unknown plant causing the deviation of Uranus orbit.
- They independently predicted the position of such an object that would account for the deviations observed.
- Neptune was first observed by Johan Galle and Heinrich d'Arrest on 1846 Sept 23 very near to the locations predicted from theoretical calculations based on the observed positions of Jupiter, Saturn, and Uranus and Newtonian mechanics.
- It was a big triumph of Newton's laws of motion and gravitation.



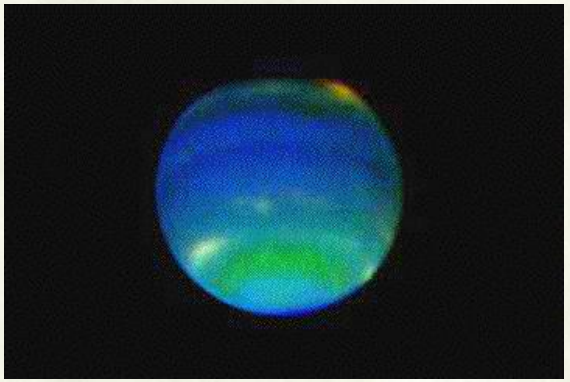
- Galileo's astronomical drawings show that he had seen Neptune while observing Jupiter.
- The ”fixed star” Galileo noted to left of Jupiter on his December 28, 1612 sketch was actually Neptune. (and again on January 27, 1613)
- On both occasions Galileo had mistaken Neptune for a fixed star!

Neptune

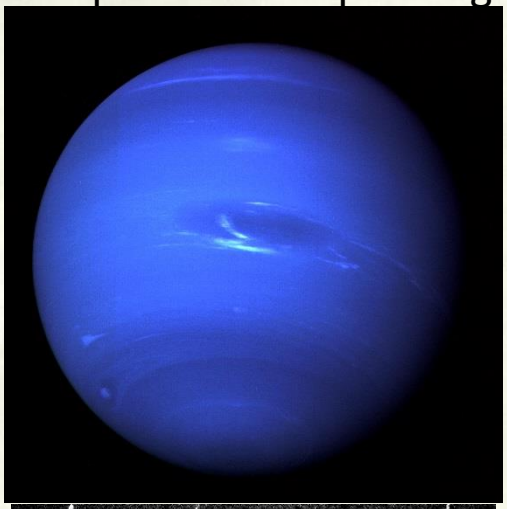
- Distance to Sun: 4.5×10^9 km (30.1 AU)
- Orbital period: 164.86 years
- Rotational period: 15.97 hours
- Diameter: 49528 km (3.88 times Earth's)
- Mass: 1.02×10^{26}kg (17.2 earth Masses)
- Temperature: 55K (-218^{o}C)

- Atmosphere: Hydrogen79%, Helium 18%, Methane 3%
- Many properties similar to Uranus.
- It has 14 known Moons,
  - only two can be seen from Earth: Triton(2705 km) and Nereid (340km) which have retrograde orbit.
  - Probably because they are captured objects.
- Neptune has a faint ring system, discovered in 1984.

- Voyager 2 flew by Neptune in 1989.

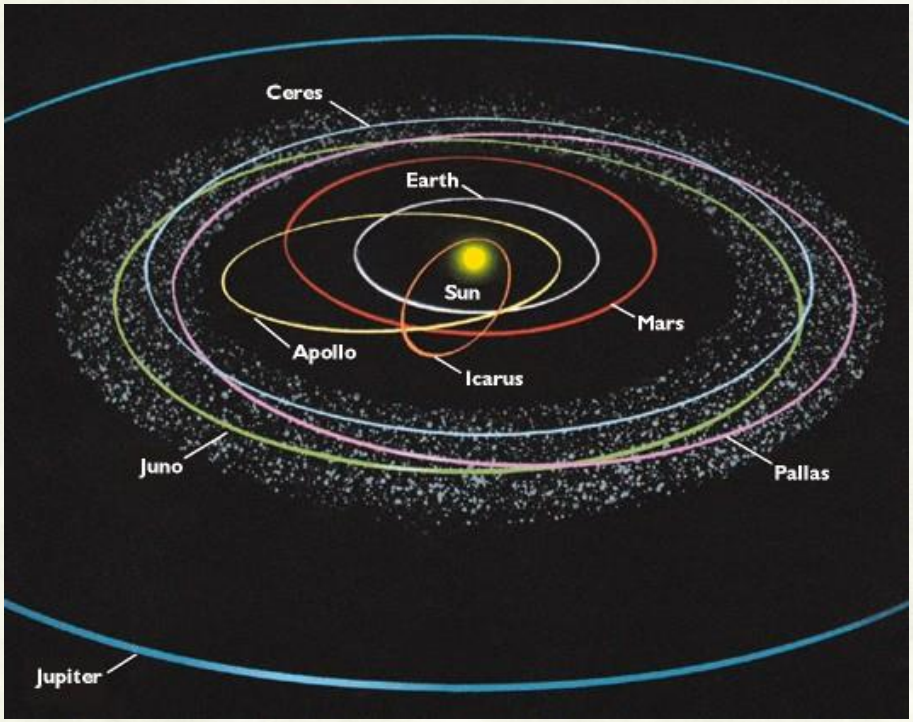


Hubble Space Telescope images



A Voyager 2 images of Neptune

Asteroids



- Asteroids range in size from Ceres, with a diameter of about 1000 km, down to a few centimeters or less.

- They are mostly concentrated between the orbits of Mars and Jupiter, called Astroid belt.
- They These are thought to be debris of the formation of the solar system that could not merge to form a planet due to influence of Jupiter's gravity.
- A search for a planet between Mars and Jupiter led to the discovery of asteroids

Titus-Bode's rule

In 1766 Johann Titius, a German astronomer pointed out that distances to planets follow a sequence of numbers. It was published and popularized by Johann Bode. It can be expresses as

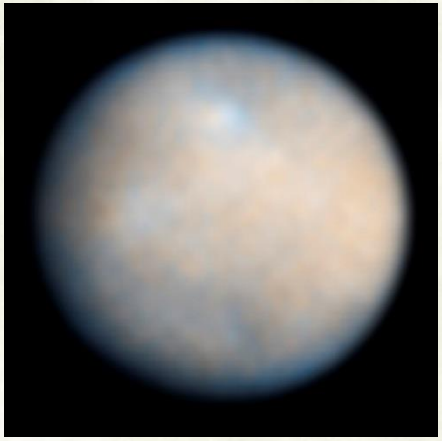
take the sequence	0	3	6	12	24	48	96	192
add 4	4	7	10	16	28	52	100	196
divide by 10	0.4	0.7	1.0	1.6	2.8	5.2	10.0	19.6
	Mercury	Venus	Earth	Mars	?	Jupiter	Saturn	Uranus

distance to Sun (AU)	**0.39**	**0.72**	**1.0**	**1.52**	**5.2**	**9.6**	**19.2**
planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus

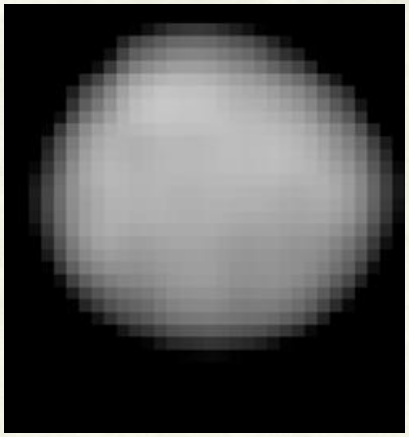
Distance between Sun and planets seems to follow the sequence closely, but one number has to be skipped between Mars and Jupiter.

When Uranus was discovered in 1781, its distance was also in agreement with the Titus-Bode's law.

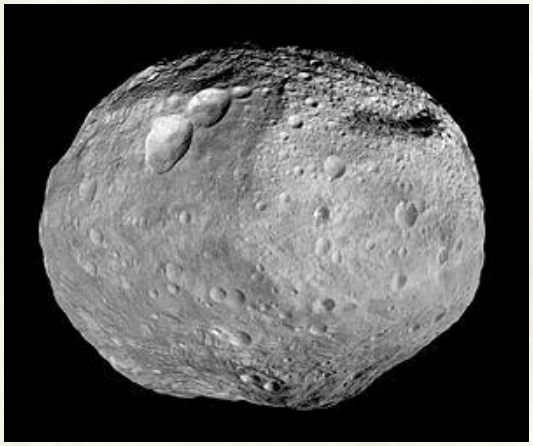
This leads to the speculation that there should be another undiscovered planet between Mars and Jupiter corresponding to the gap in the Titus-Bode sequence. Many astronomers started looking for it.



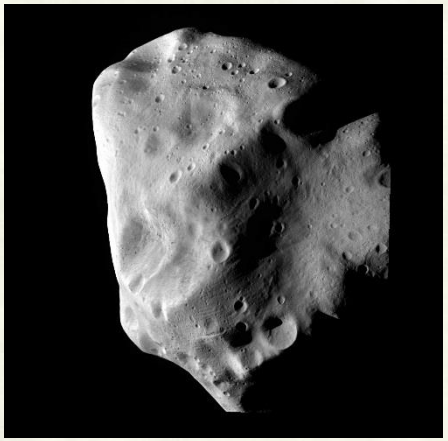
Ceres, 952km



Pallas, 544 km

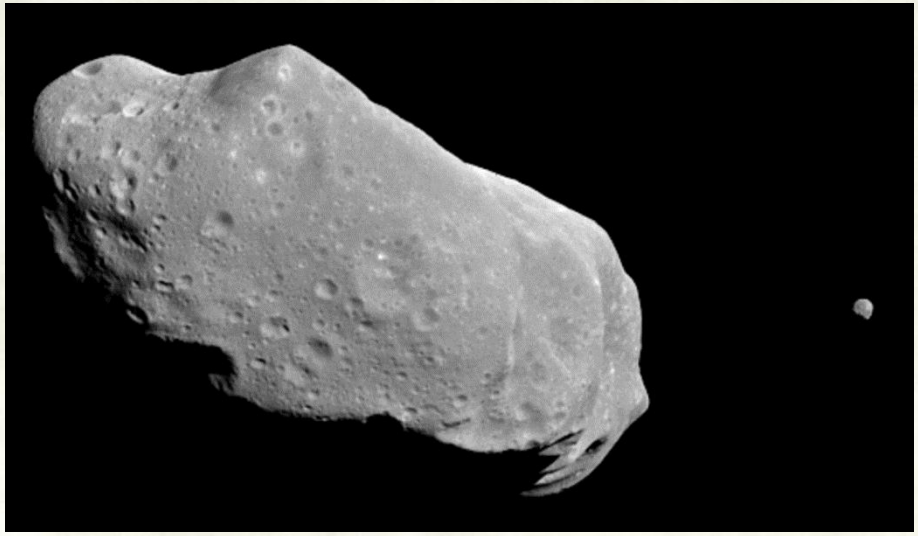


Vesta, 572km



Lutetia, 100km

- On January 1, 1801, an 8th magnitude object moving against stars was found by Giuseppe Piazzi, a catholic monk and astronomer in Sicily.
- the new object was declared a new planet and named Ceres.
- Fifteen months later, Heinrich Olbers discovered a second object in the same region and named Pallas.
- Over next few years few more found Juno in 1804 and Vesta in 1807.
- By the end of the century, several hundred had been found. By that time, it Ceres's designation had been changed from planet to a new term coined by Hershel 'asteroid' (meaning star-like object)
- 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.



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.
- The good news is that none of these will strike the Earth. The 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.

Barringer Crater in Arizona
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 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.
- The Barringer Crater (1.2 km across and 200m deep) in Arizona is one well preserved in the desert. is the result of a50 meter nickel/iron meteorite impact 50000 years ago.

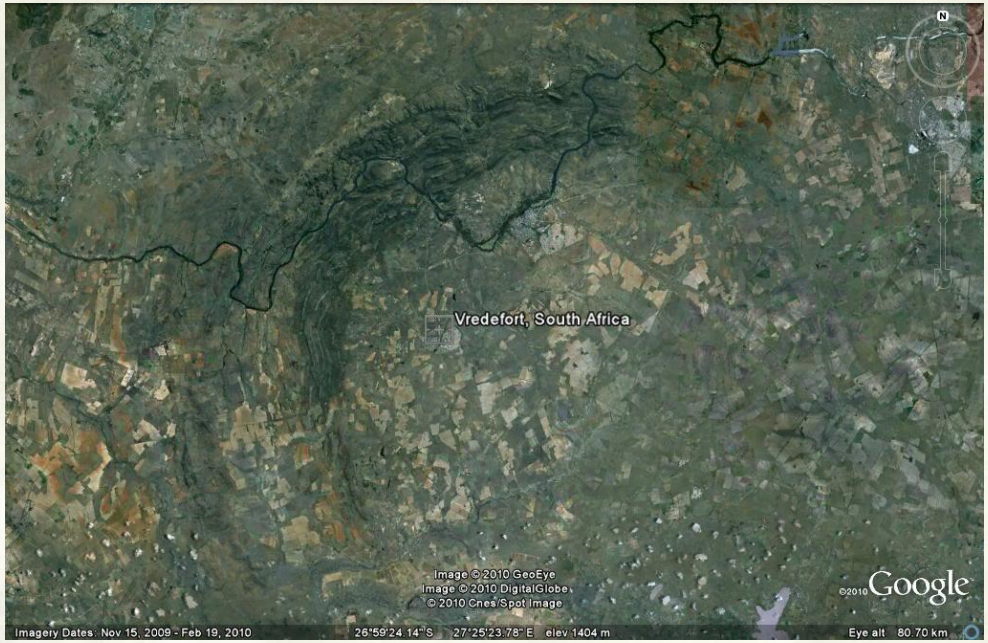
http://www.youtube.com/watch?v=RrL-cWaYdno

http://www.youtube.com/watch?v=rvWHoBJojp8

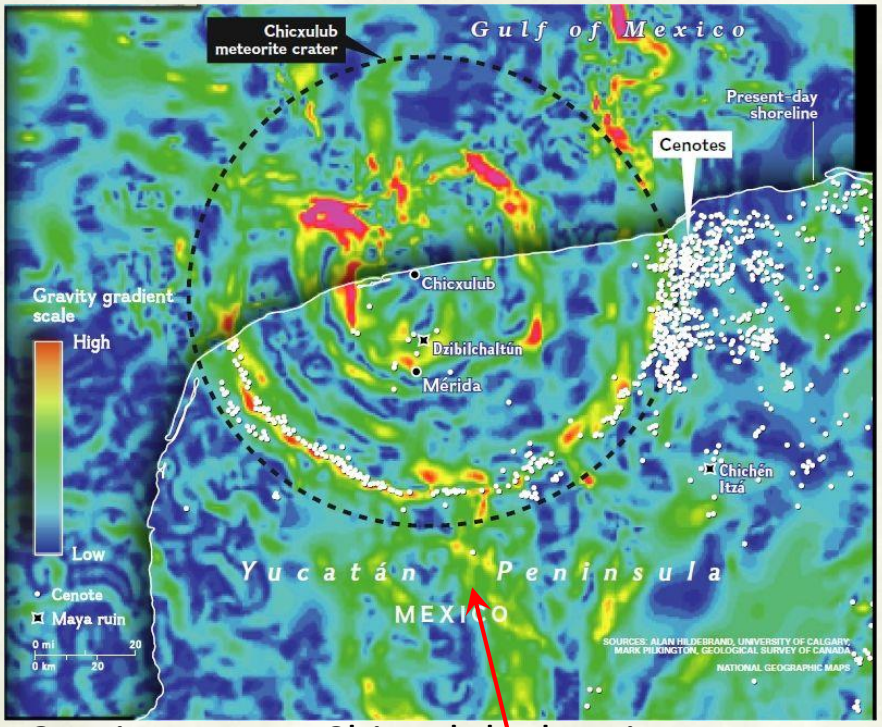
Peekskill Meteorite

On October 9, 1992, a fireball was seen streaking across the sky from Kentucky to New York. Estimated to be 12 kg and 0.30m) in size, 1kg piece fall to ground and damaged a car.

Russian meteorite impact of 2013



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

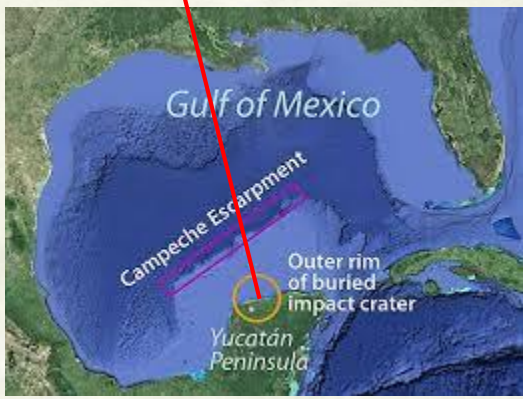


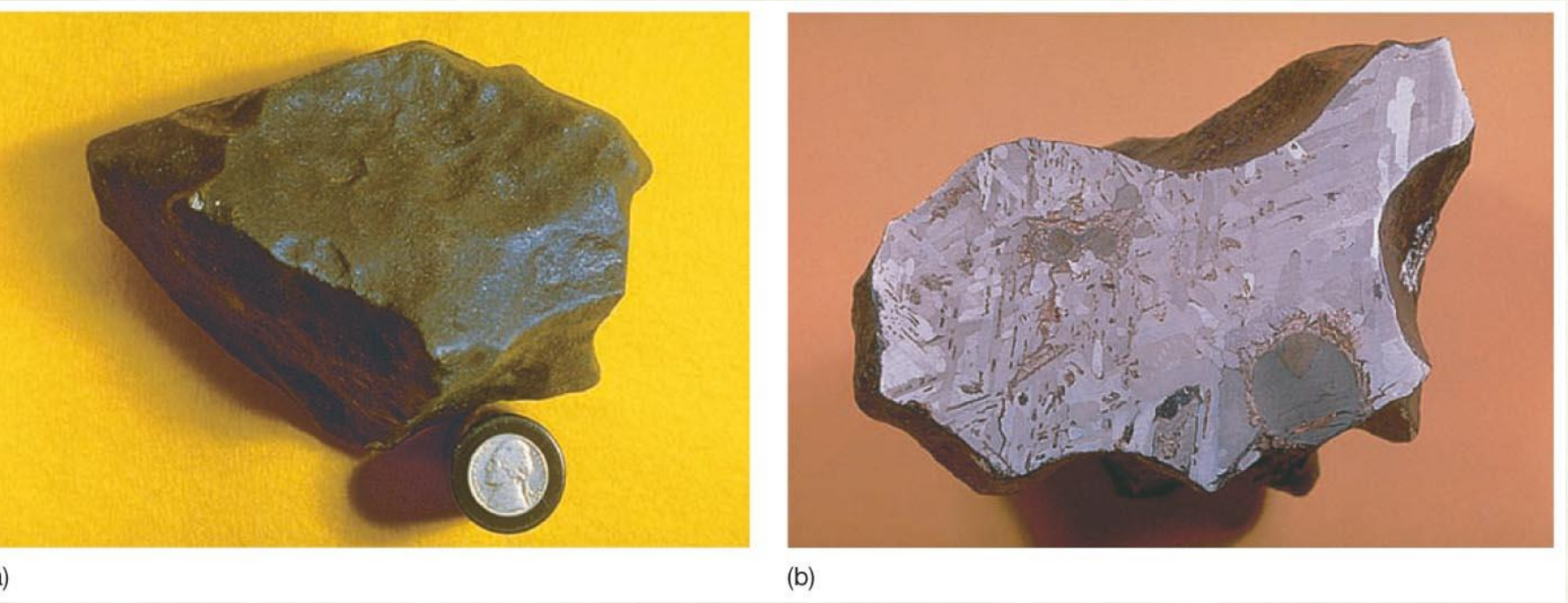
Gravity map at Chicxulub showing an anomaly 180km in diameter.

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 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.

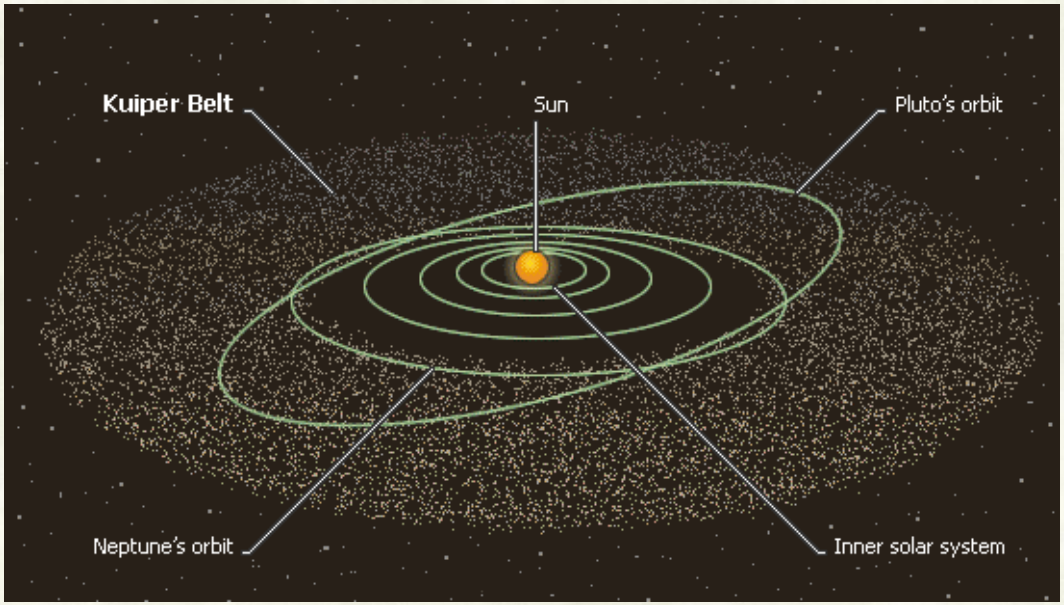




(b)

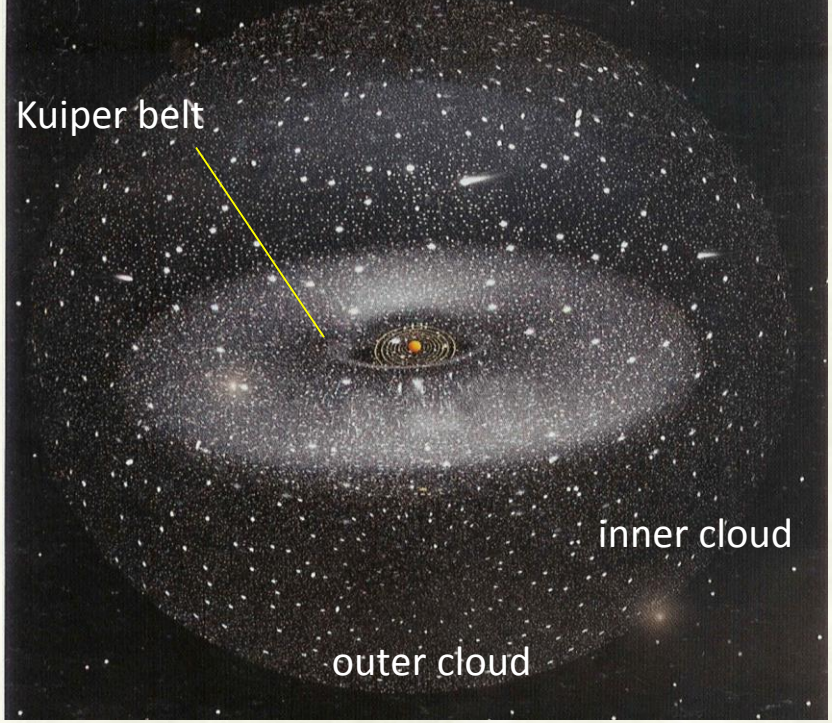
Most meteorites are rocky (left); some are iron (right)

Comets

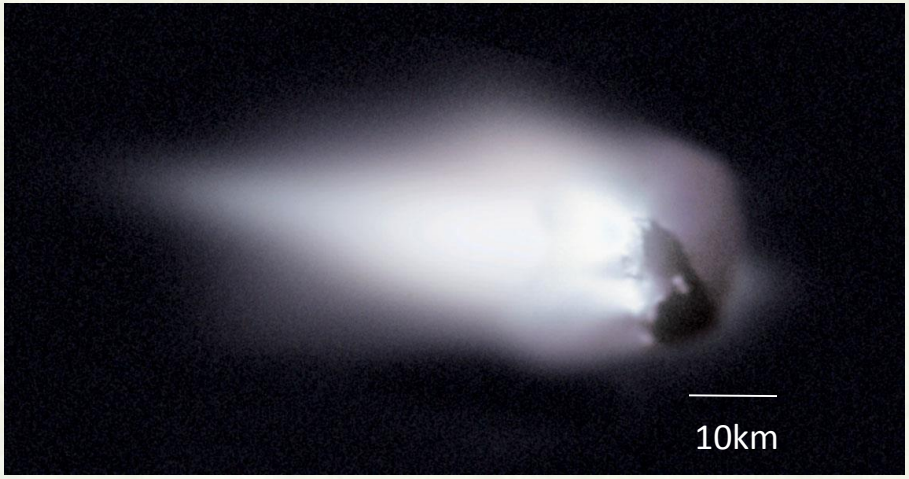


- Comets are also debris left over from the formation of the solar system.
- They were located beyond the frost line, so unlike for asteroids, in addition to metal and silicate dust, ice particles were also coalesce to form planetesimals
- But away from the Sun, beyond Neptune in coldest regions of the nebula, the density was low that planetesimals could not grow very large. They ended up like loosely packed dirty snow balls, most few kilometers in size.
- They became the family of Kuiper belt objects located in the region 30-50 AU from the Sun.
- Over 1600 Kuiper belt objects have been observed so far. Pluto is the largest and nearest known Kuiper belt object.

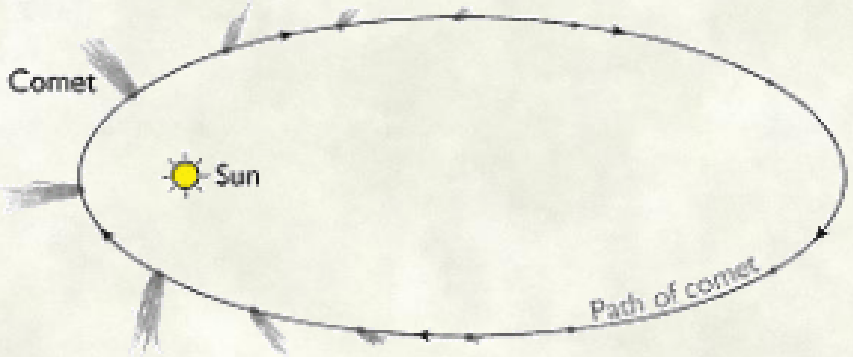
Oort Cloud



- Objects ejected from the solar system by gravitational interaction with larger planets (Jupiter, Saturn) are supposed to be lying around the outer edge of the solar system extending up to 50000 AU.
- No objects have been observed directly in the Oort cloud—it is simply too far away.
- Due to vast distance from the Sun, outer Oort cloud is only loosely bound to the Solar System, and thus is easily affected by the gravitational pull both of passing stars and of the Milky Way itself.
- These forces occasionally dislodge comets from their orbits within the cloud and send them towards the inner Solar System in an elliptical or parabolic orbit.



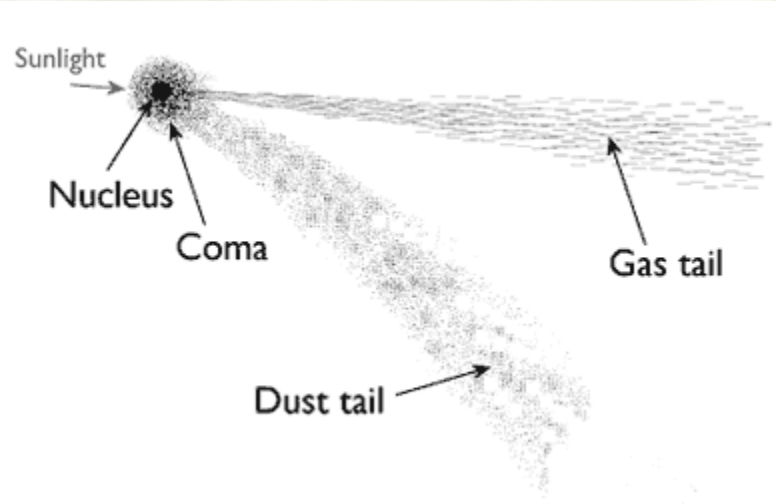
Gas and dust ejecting from the Nucleus of comet Halley, as it was approaching Sun Image taken by Giotto spacecraft in March 14, 1986. http://apod.nasa.gov/apod/ap100104.html



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

- A Kuiper belt or Oort cloud object thus driven into an orbit toward the inner solar system warms up as it nears the Sun.
- It partially vaporizes releasing dust and gases forming an atmosphere around it called coma, which can expand to millions of kilometers. main object becomes the nucleus of the comet.
- The solar wind then blows these gases and dust particles away from the direction of the Sun forming tails, when closest to sun tail could be extending over hundreds of millions kilometers

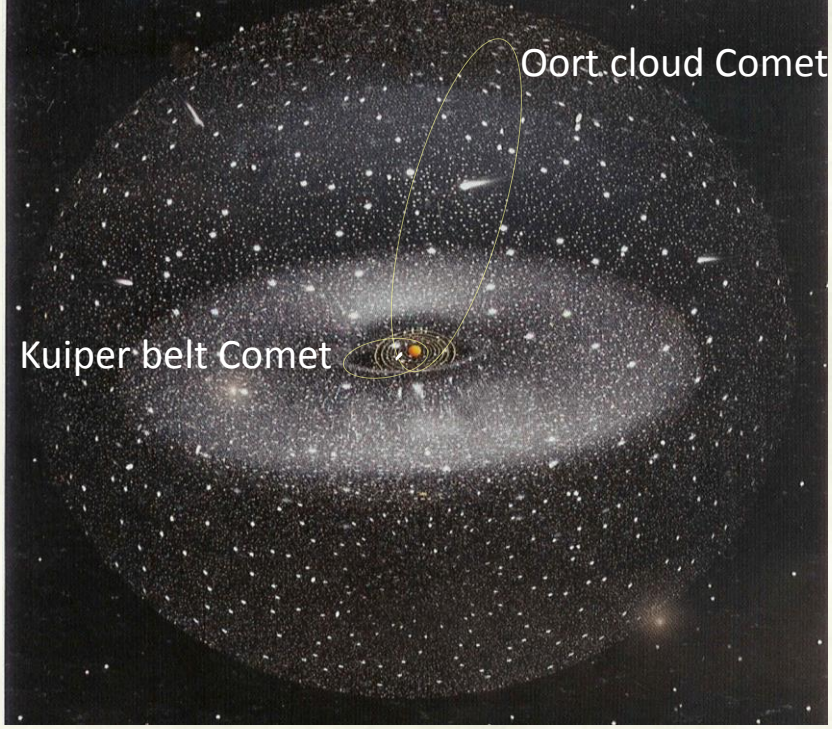
Comet tails



Comet Hale-Bopp (1997)

Often two tails are formed:

- Ion tail:
  - Ultraviolet radiation in sunlight rips electrons 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, on these small particles, gently shoving them away from the comet's nucleus.
  - Because the pressure from sunlight 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.



Comets can be divided into two basic groups depending on their orbital periods.

- **long period comets** :
  - orbital periods that can be thousands to millions of years long
  - Their orbits are oriented in all different directions
  - Likely originating in the Oort cloud

- **short period comets:**
  - with orbital periods less than about 200 years.
  - short period comets orbits are within about 30 degrees of the solar system plane (ecliptic).
  - Likely originating in the Kuiper belt

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

comet McNaught in 2007
non-periodic

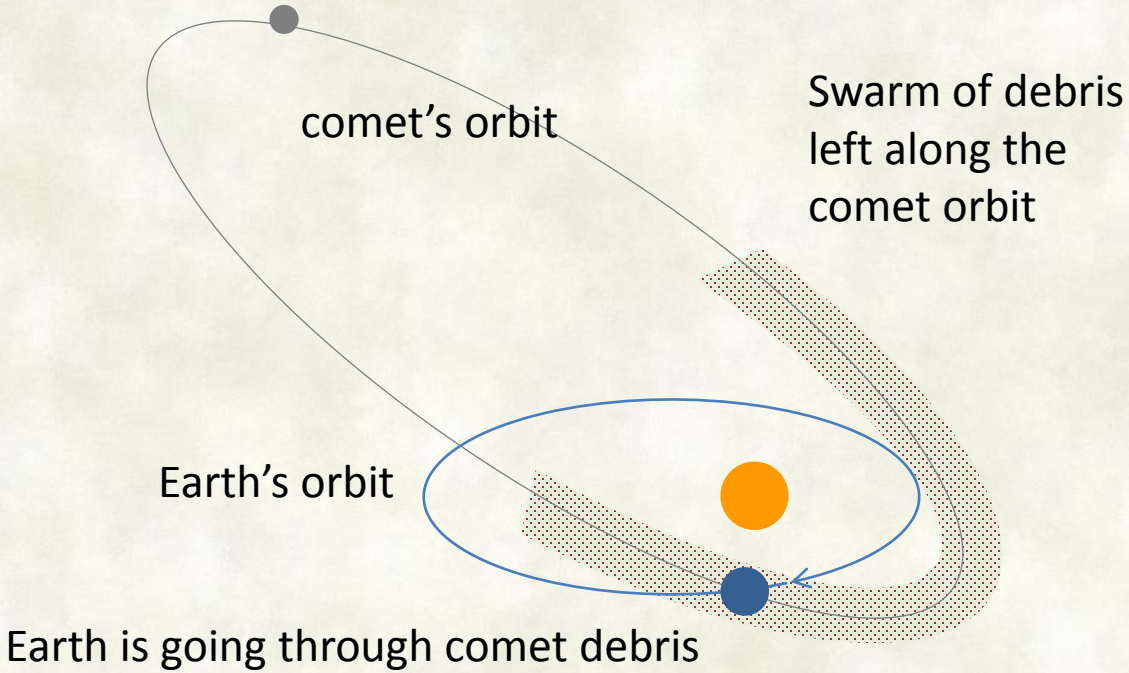
- A comet is visible only when it comes closer to sun and coma is expanded. Otherwise they ae too small to see even through telescopes from Earth.
- Many comets come closer to the Sun every year, but most are visible only through a telescope. Comets bright enough to see with naked eye are less frequent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

Meteor Showers

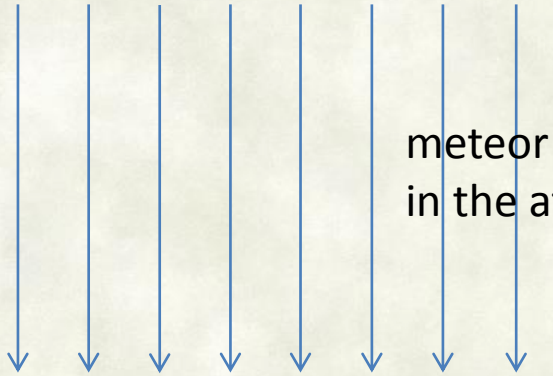
- Most meteors are tiny specks of dust and rapidly burn up in the atmosphere, they are common can usually observe a few per hour on any clear night.

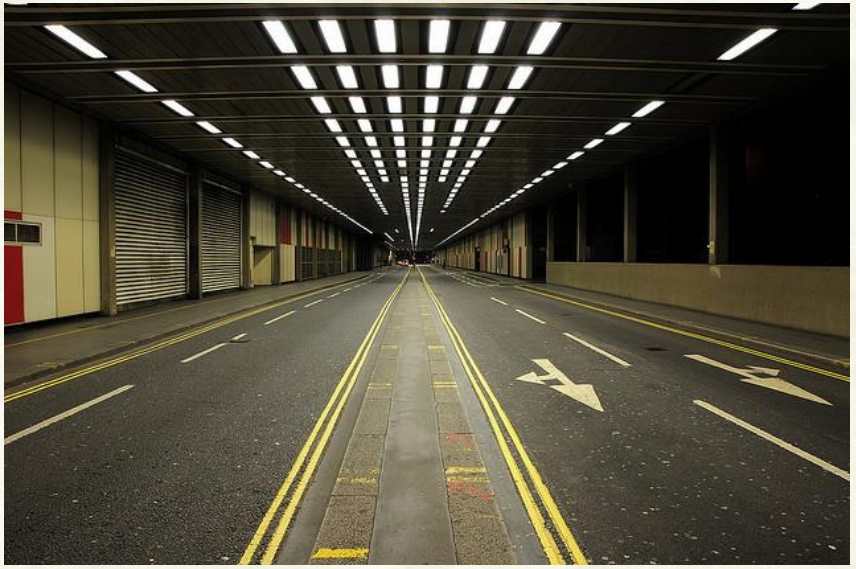
- Some are larger and produce spectacular *fireballs* that are very bright, and may explode, they are rare.

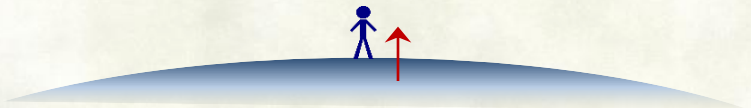
- Sometimes, meteors occur at a much higher rate, and seems to come from a particular point in the sky (called the radiant) They are called meteor shower
  - That happens when earth is passing through a stream of debris, usually left by a comet.
  - The meteor shower is commonly named after the constellation 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.
- At some point it may interest 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.
- As earth is moving through the debris, the all enter the atmosphere moving in the same direction. But it appears meteors are radiating from one point in the sky.

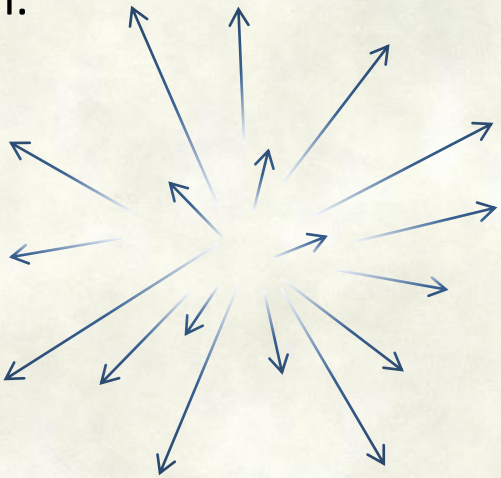


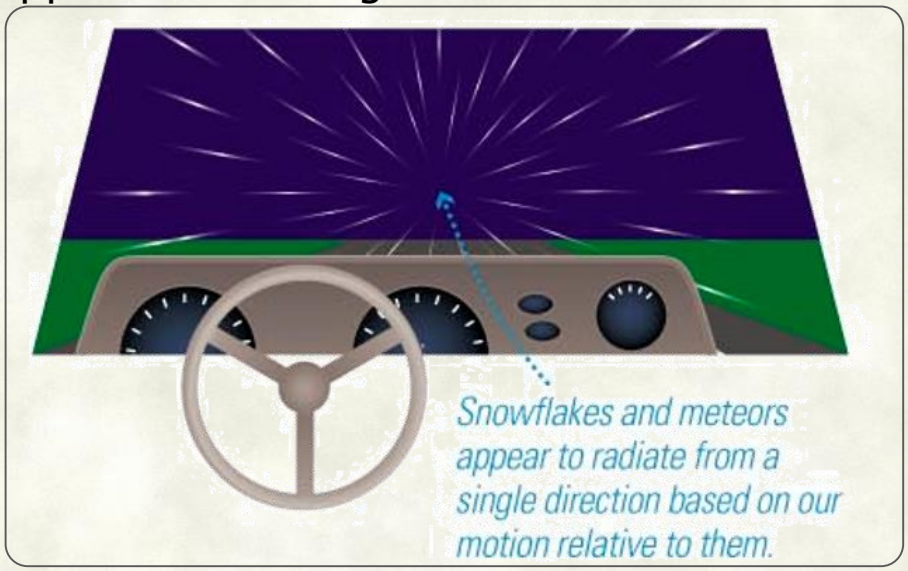




As earth is moving through the debris, the all enter the atmosphere moving in the same direction.

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
  Radiant: constellation Gemini Peak Activity: Dec. 13-14, 2014
  Peak Activity Meteor Count: 120 meteors per hour

Quiz

1 Answer B

2 Answer B

3 Answer D

Question 4

How old is the Solar system?

A. 100,000 years.
B. 100 million years.
C. 4.5 billion years.
D. 13.7 billion years.

Question 5

Most abundant material in the solar nebula was

A. Hydrogen and Helium gases
B. Metallic dust
C. Mineral (silicate) dust
D. Ice particles

Question 6

Plate tectonic activity which drifts continents on the Earth is due to

A. Earths crust floating on the liquid interior mental
B. Convection currents in the Earth's mental carrying the crust with them.
C. Due to water pressure of the oceans on the continental crust
D. Due to volcanic activity

Question 7

Why are most asteroids not round like planets are?

A. Their gravity is not strong enough to make them round.
B. They are irregularly shaped pieces of a planet that broke up.
C. Because they have suffered many more collisions.
D. Because they don't rotate as fast as planets do

Question 8

Which planet has the highest surface temperature and why

A. Mercury because it is closest to the Sun
B. Venus because it is closest to the Sun
C. Jupiter because it is large and still cooling off from its initial melting.
D. Mercury because it is rotation rate is slow.
E. Venus because green house gases in its thick atmosphere traps heat.

Question 9

Why are features on the Moon such as craters not as eroded as those on Earth?

A. The Moon lacks an atmosphere and geological activity
B. The crust of the Moon is made of harder material than the Earth's.
C. The Moon is much younger than the Earth.
D. There force of gravity is weaker on the Moon.

Question 10

According to the leading theory, how was the Moon formed?

A. Something the size of Mars collided with the Earth and Moon was formed out of the debris ejected.
B. The Moon used to be another planet, and it was captured by the Earth's gravity.
C. The Earth and the Moon formed side by side at about the same time.
D. The Earth was spinning fast, broke into two pieces, and one became the Moon

Question 11

What are rings of Saturn's made of?

A. hot plasma of ionized gas inside a strong magnetic field.
B. large number of icy particles and chunks of various sizes.
C. thin, shiny sheet of ice surrounding the planet.
D. smooth, spinning solid disk of dust covered rocky material

Question 12

Which of the following objects are likely to come from the Kuiper belt?

A. Auroras.
B. Asteroids.
C. Comets.
D. Meteorites.

Question 13

Where are most asteroids located?

A. In between Jupiter and Saturn
B. Between the orbits of Mars and Jupiter.
C. outside the orbit of Neptune
D. In space between the Solar System and nearest stars.