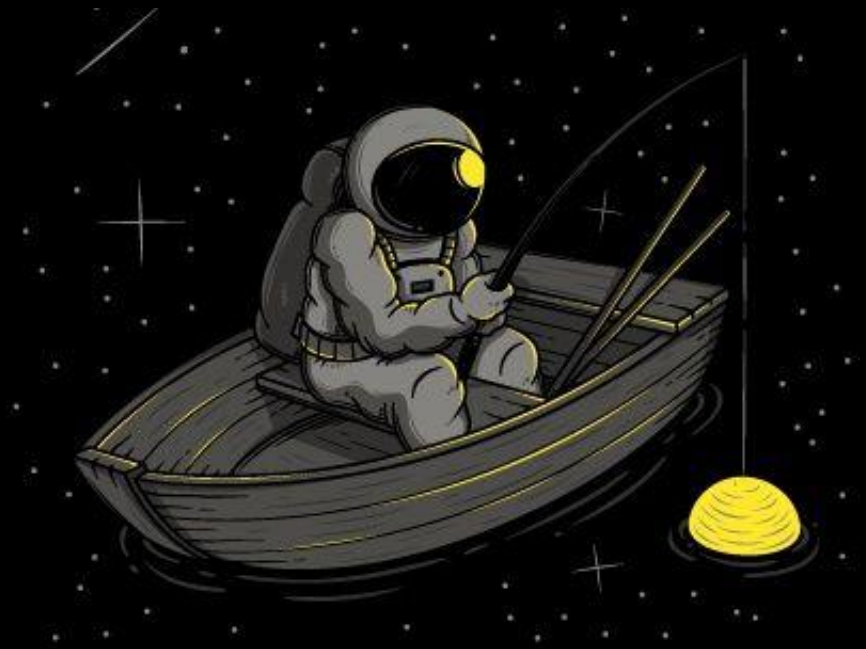
Lonely Travels



Karl Steffin

Astronomy, 2006

8/9/2024

Galaxy

- Galaxy (Greek: “milky“): A gravitationally bound system of stars, remnants, interstellar gas and dust, plasma, and unseen dark matter.
- Typical galaxies may contain 10 million to 1 trillion stars, all orbiting a common central point.
- Hubble gave galaxies a type based on their shapes.

Elliptical Galaxy

- Motion of stars is dominated by random movement.
- Very small amount of interstellar matter, no young stars, no open star clusters.

Sombrero

ESO 325-G004

Spiral Galaxy

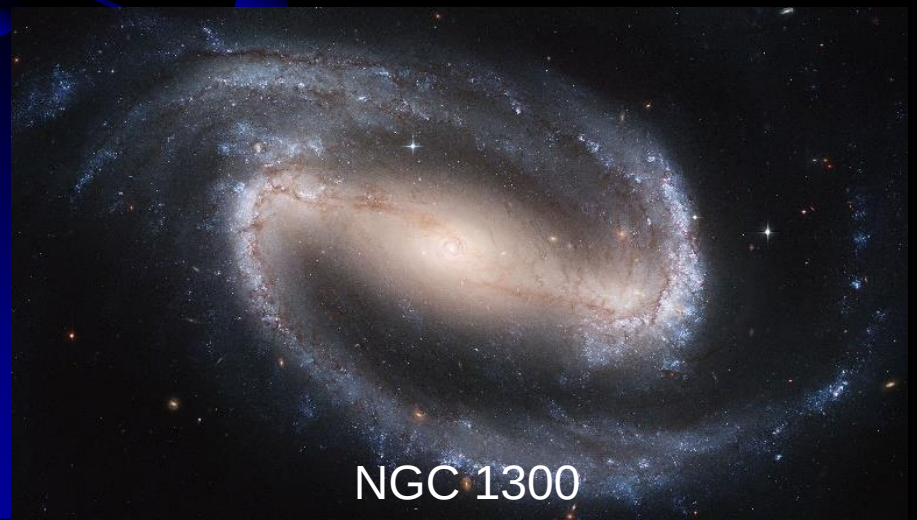
- Motion of the stars is dominated by an angular momentum.
- Composed of a central bulge surrounded by a disk.
  - The bulge resembles an elliptical galaxy
  - Contains old stars and usually a central massive black hole.

Andromeda

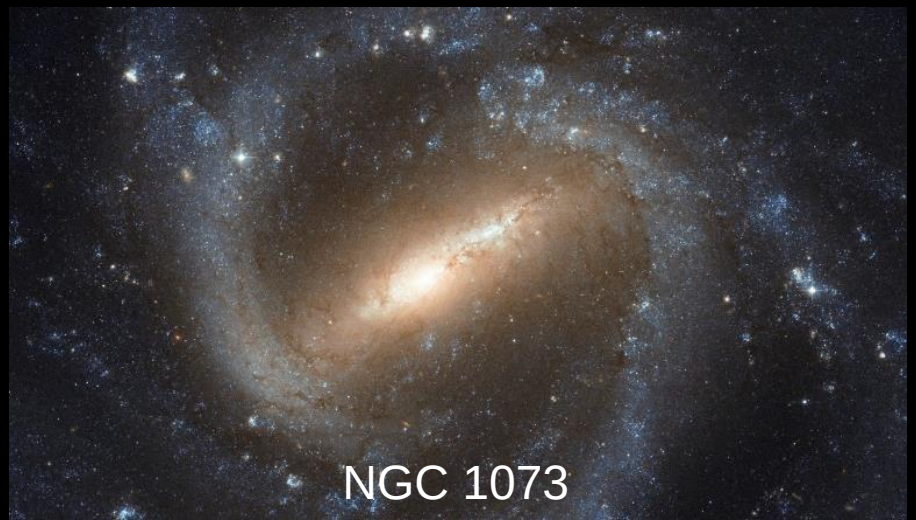
Messier 81

Barred Galaxy

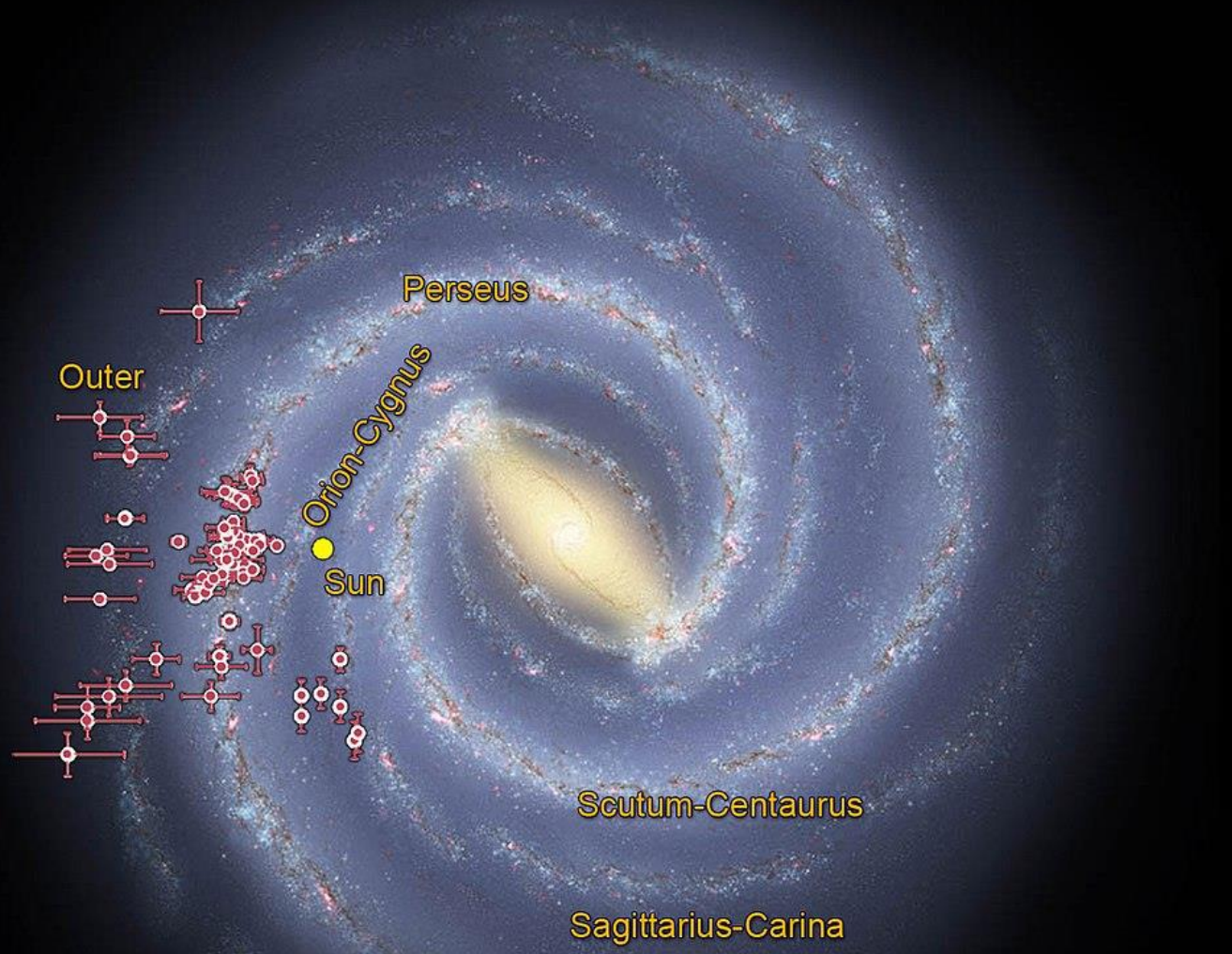
- Two thirds of all spirals contain a bar in the middle.
  - The bar is thought to funnel in gas to make new stars.
  - Milky Way galaxy is a barred spiral (SBb,SBc)



NGC 1300

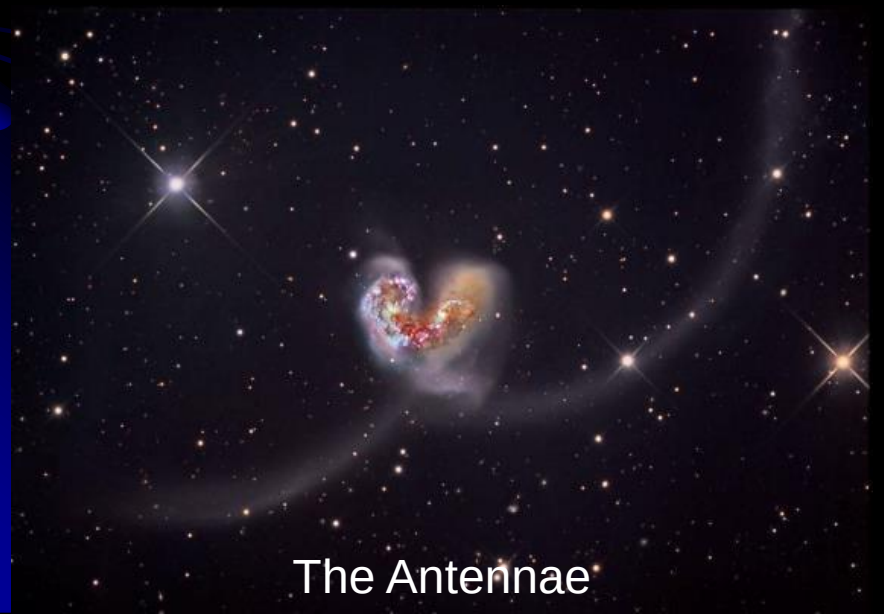


NGC 1073


Perseus
Outer
Orion-Cygnus
Sun
Scutum-Centaurus
Sagittarius-Carina

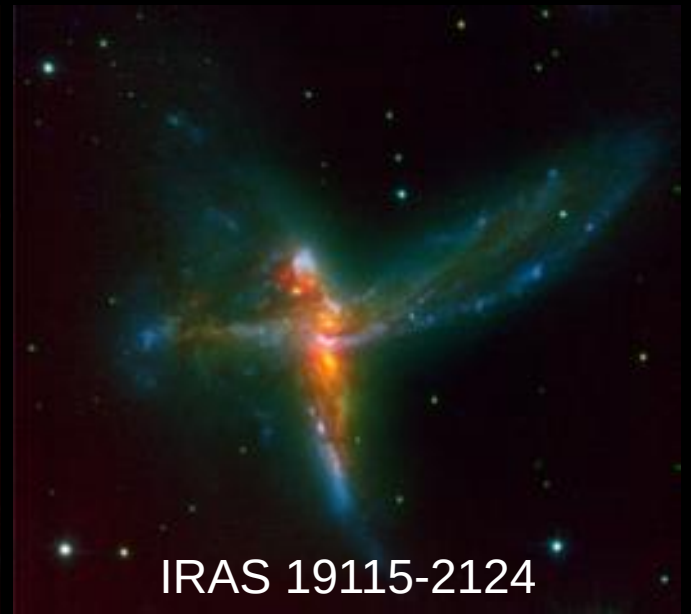
Irregular Galaxy

- An irregular galaxy is a galaxy that does not fall into the Hubble classification for galaxies.
  - May be due to a collision between galaxies.

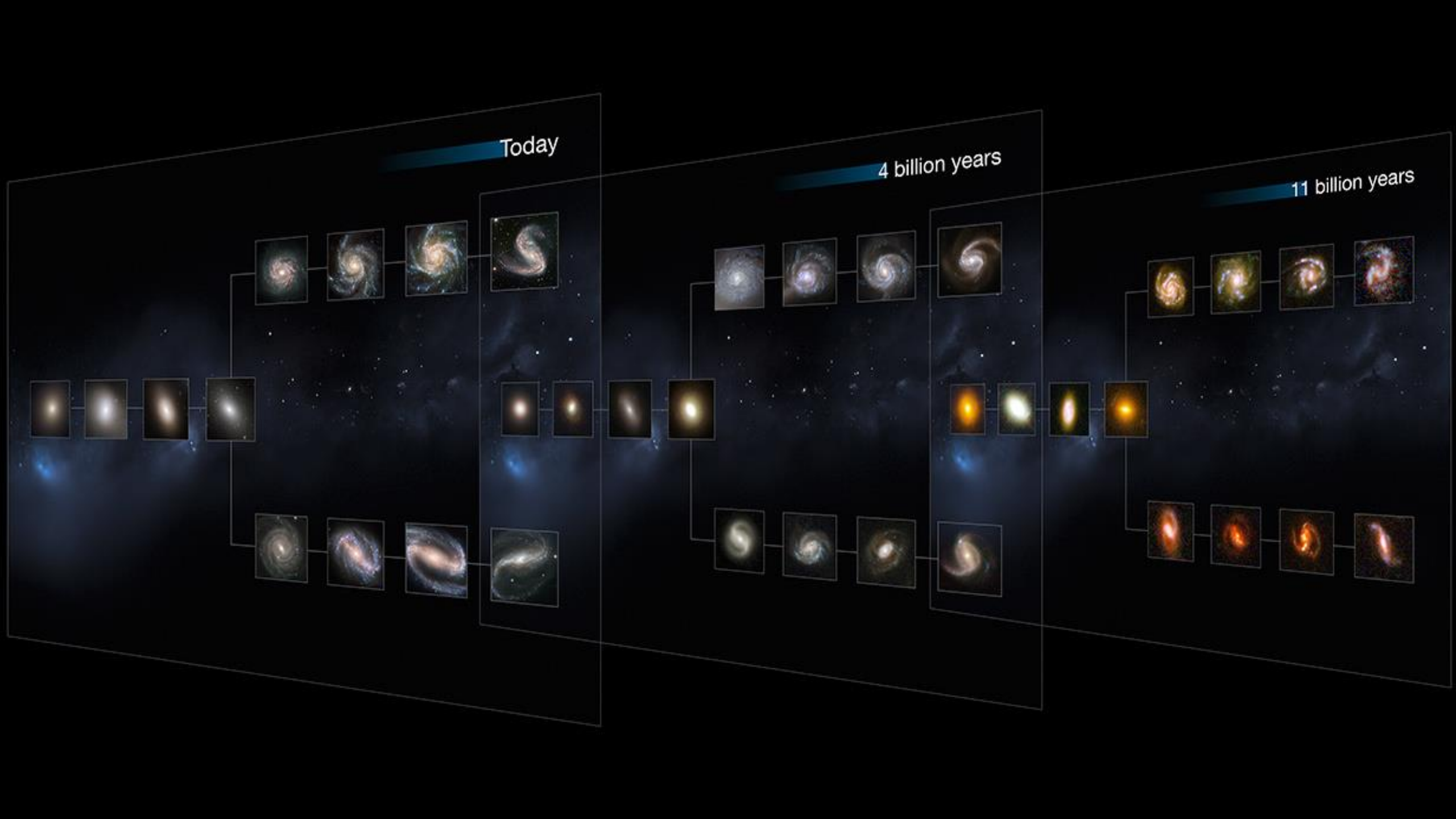


The Antennae

Messier 82



IRAS 19115-2124


Today
4 billion years
11 billion years

Nebula's

- Nebula (Latin: "fog/mist"): An interstellar cloud of dust, gas and plasma.
- Originally nebula was a general name for any astronomical object, including galaxies beyond the Milky Way.
  - The Andromeda Galaxy is sometimes referred to as the Andromeda Nebula.

Emission Nebula

- Internally illuminated clouds of ionized gas.
  - Ions normally come from a nearby hot star.

North American Nebula

Veil Nebula

Orion Nebula

Cone Emission Nebula

Reflection Nebula

- Illuminated by reflections from nearby stars.

VdB1 Nebula

Pleiades Nebula

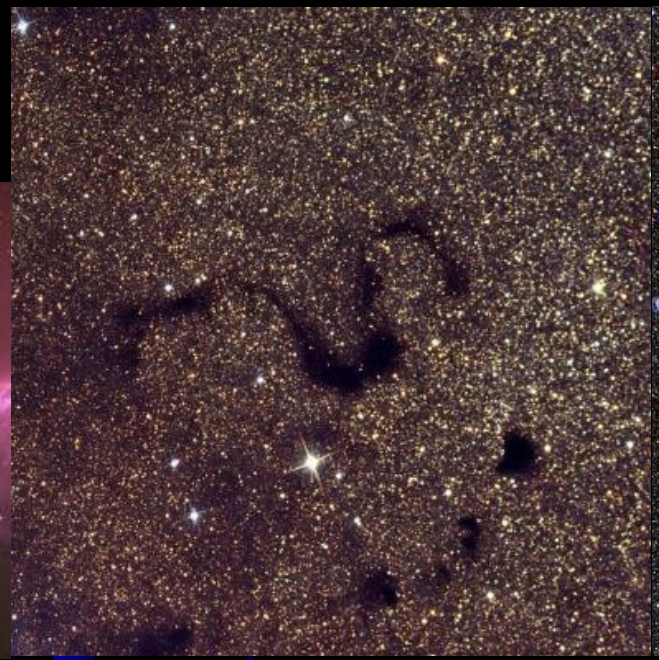
IC 2631 Nebula

Witch Head Nebula

Dark Nebula

- Non-illuminated; detected when they obscure stars or other nebulae

Horse Head Nebula



Snake Nebula

Dark Cloud Lupus

Finger of God Globule

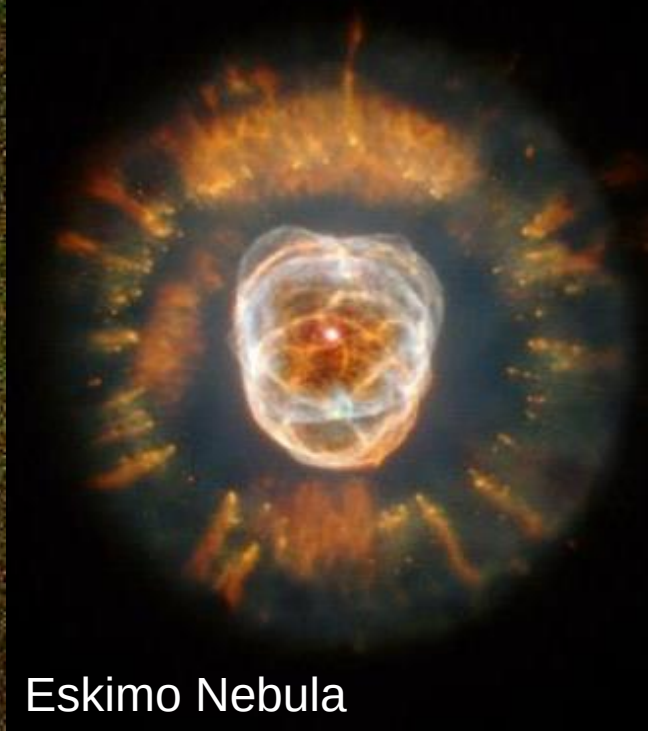
Planetary Nebula

- Compact shells of gas and plasma around a dead star or an intermittently active star.

Cat’s Eye Nebula

MyCn18 Nebula

Lemon Slice Nebula

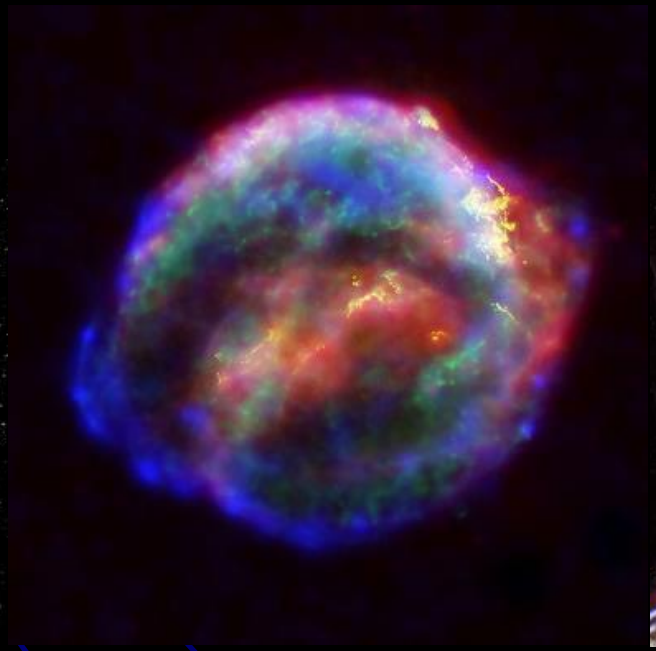


Eskimo Nebula

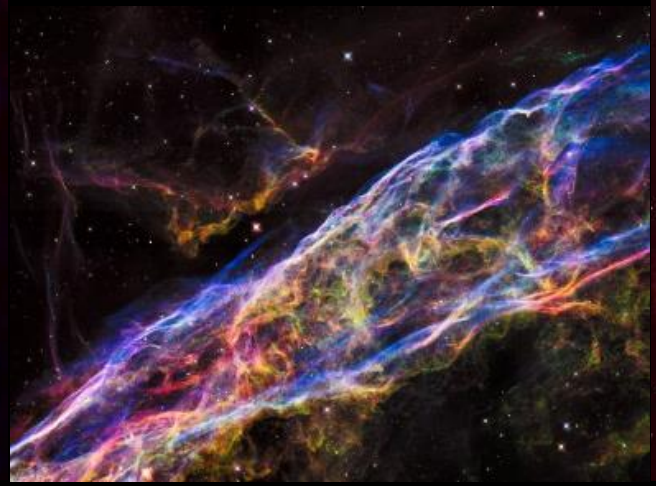
Supernova Remnant

- Heated by colliding with (relatively) slow moving galactic dust and gas.

Cassiopeia A



Kepler’s Supernova

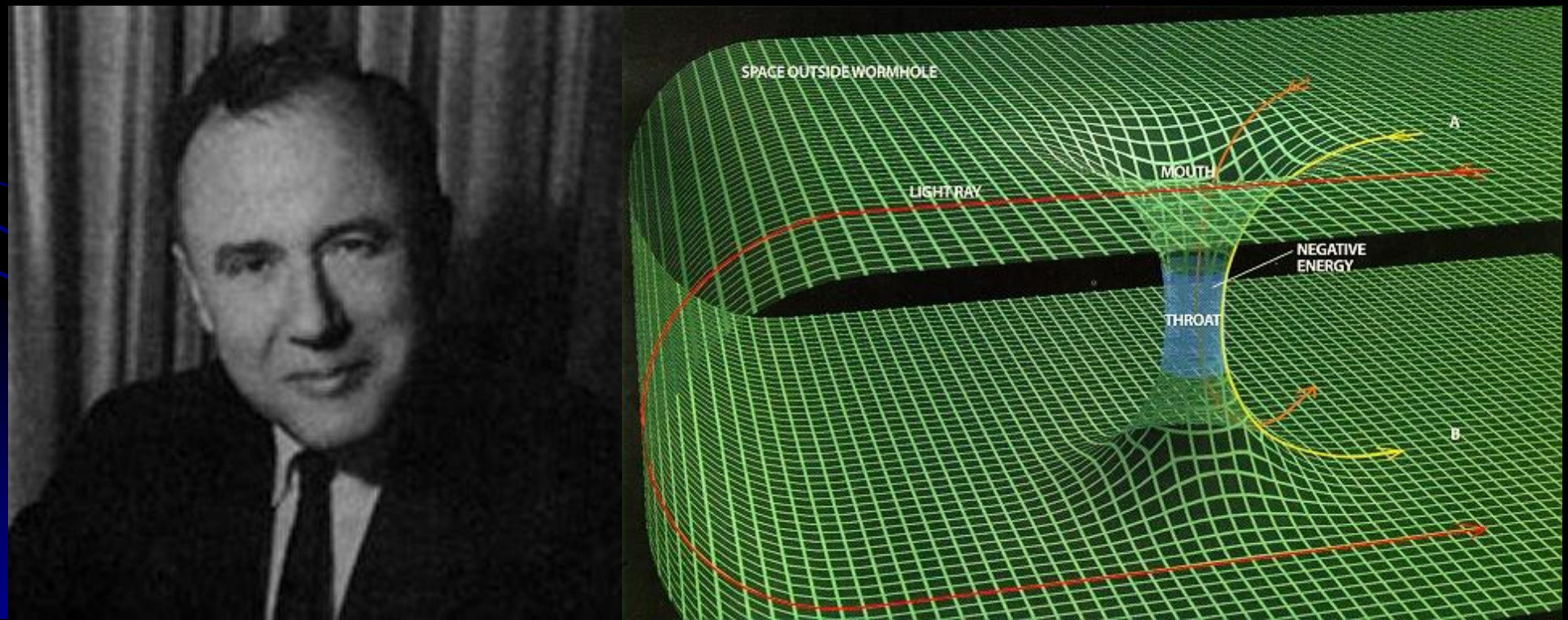


Veil Nebula

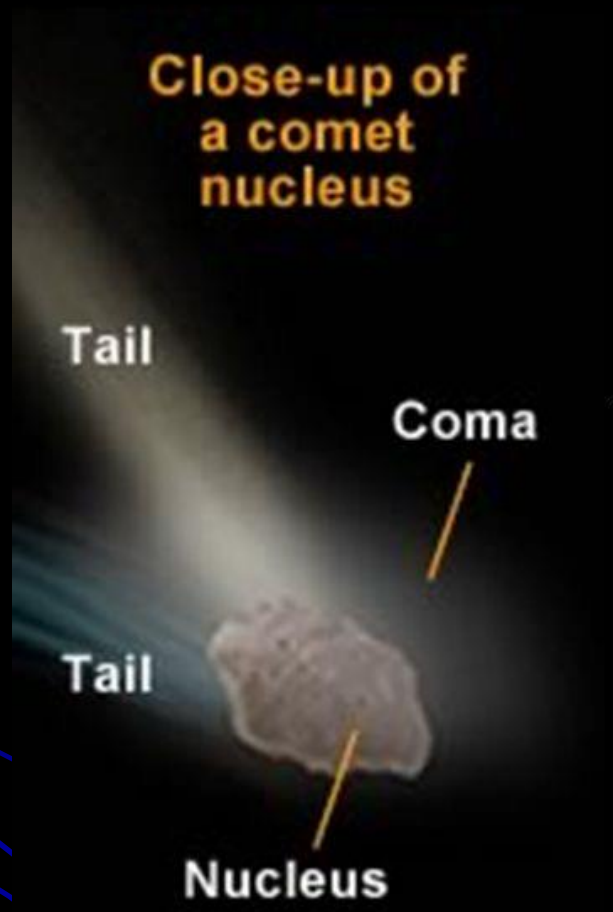
Crab Nebula

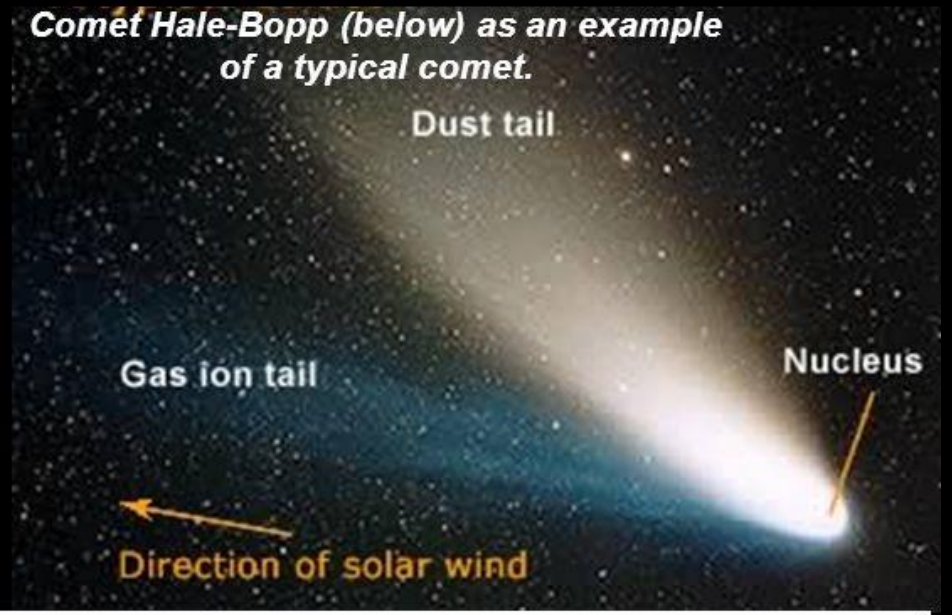
Wormholes

- A theoretical folding of space time that would connect two points in space allowing travel faster than the speed of light.
  - Theory coined in 1957 by Theoretical Physicist John Wheeler.
  - Also referred to as Schwarzschild Wormholes or Einstein-Rosen Bridge.



Comets





A comet is commonly described as having 3 parts:

Nucleus – the dark dirty snowball composed of ice, dirt, rock and gas

Coma – the halo of gas, ice and rock bursting forth from the nucleus

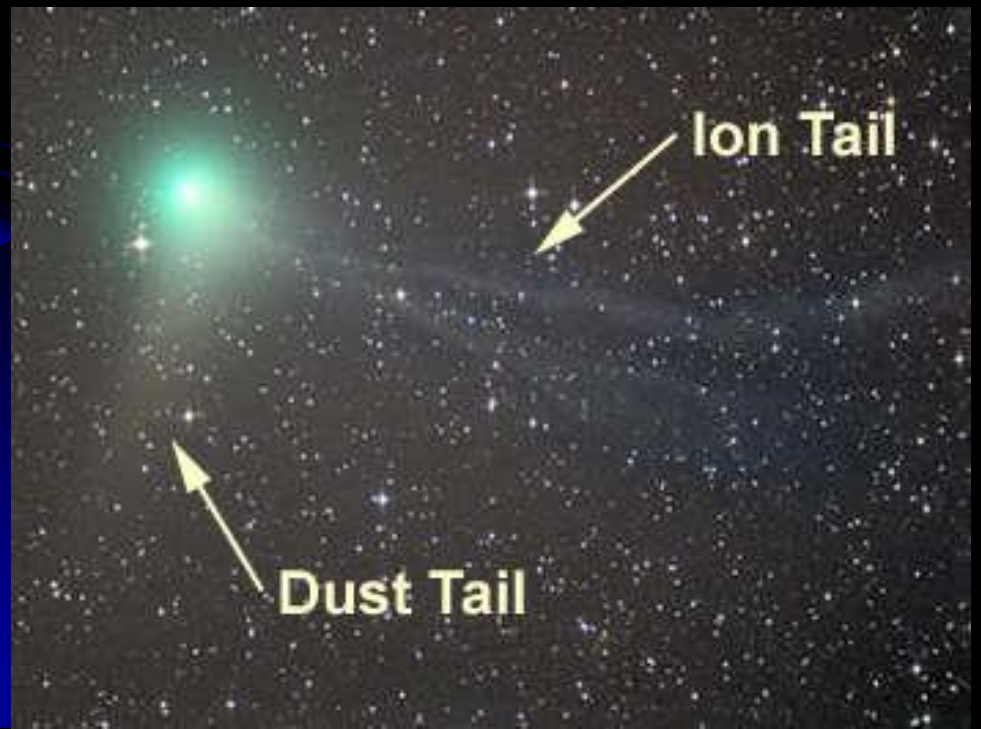
Tail – may include both the dust and ion tail

- (GR: long-haired) Chunk of frozen gas, water and other debris that periodically orbits the sun.

Tail

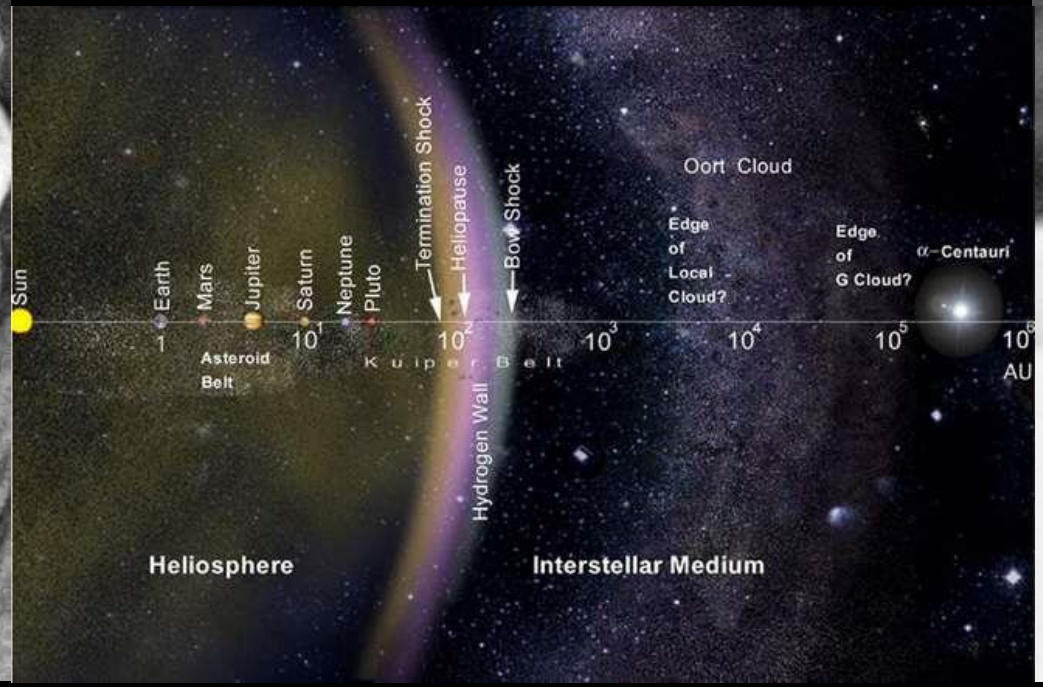
Between the Asteroid Belt and Sun:

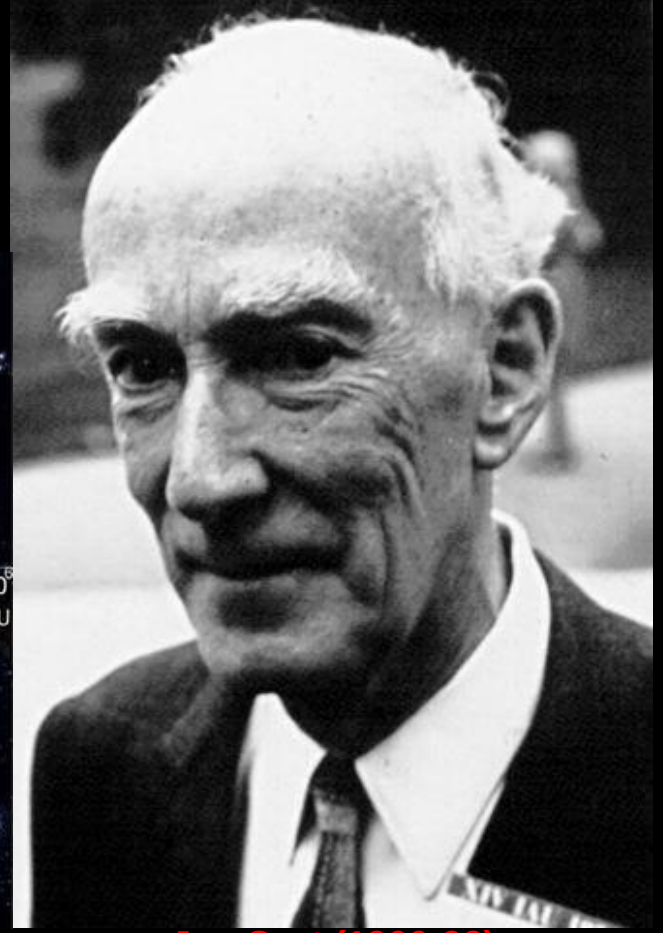
- **Dust Tail**: Shorter, composed of dust particles driven off the nucleus by escaping gases; easiest to see by an unaided eye. (Points away from the comet)
- **Ion Tail**: Longer, composed of plasma due to interactions with the solar wind. (Points away from the sun)



Birth Place

Gerard Kuiper (1905-73)





Jan Oort (1900-92)

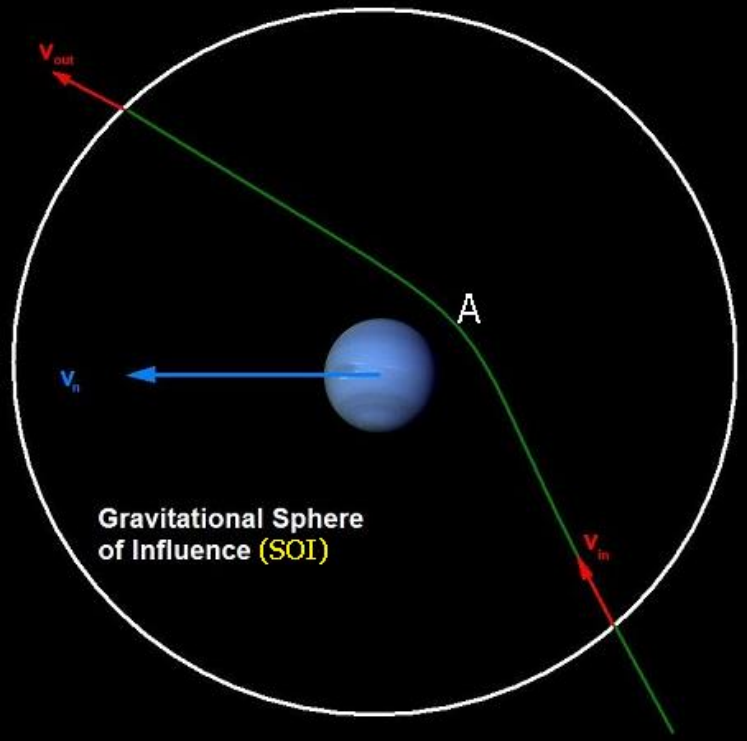
- Kuiper Belt- Disk shaped region located beyond Neptune (30-50 AU) and is thought to contain short period comets (>200 yrs).
- Oort Cloud- In the outer reaches of our solar system that may contain up to a trillion comets. Speculation is that the mass of the Oort Cloud may be more than Jupiter.
- As of 1/23, 3743 comets have been cataloged!

Facts

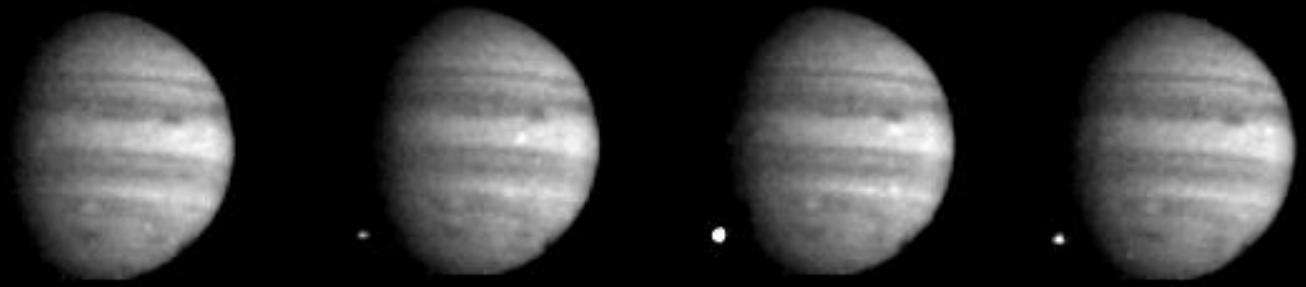
- Many comets are first discovered by amateur astronomers.
- Meteor showers occur when the Earth passes thru the orbit of a comet.
  - The **Perseid** meteor shower occurs every year between August 9 and 13 when the Earth passes thru the orbit of **Swift-Tuttle** Comet.
  - Comet **Halley** is the source of the **Orionid** shower in October.

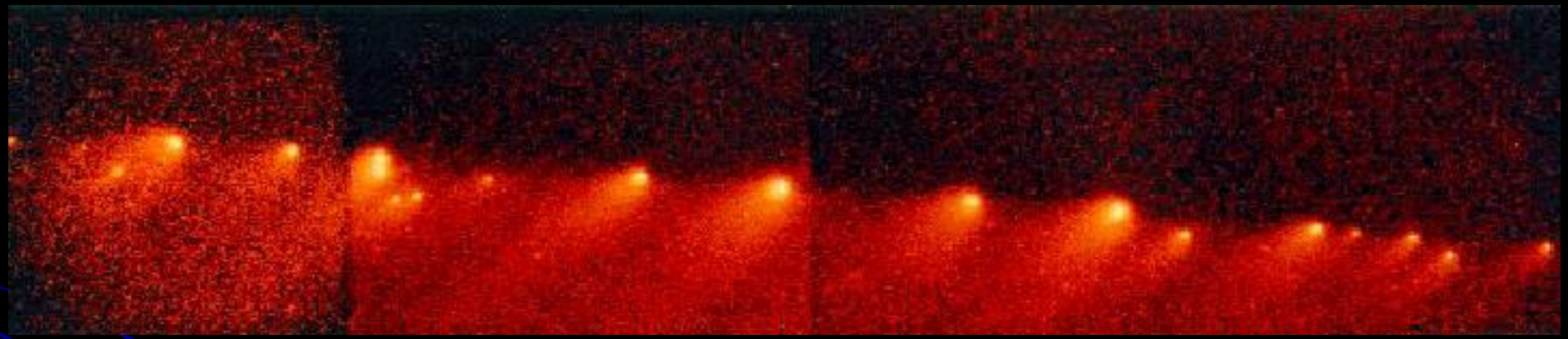
Facts Cont.

- After 500 or so passes near the Sun most of a comet's ice and gas is lost leaving a rocky object very much like an asteroid in appearance.
  - It is thought that half of the near-Earth asteroids may be "dead" comets.
- A comet whose orbit takes it too close to the Sun is likely to be effected by the gravity of a planet (or Sun) and either impact one of the planets or to be ejected out of the solar system.



Shoemaker-Levy 9





Initially skipped off Jupiter atmosphere but was trapped in the gravity well.

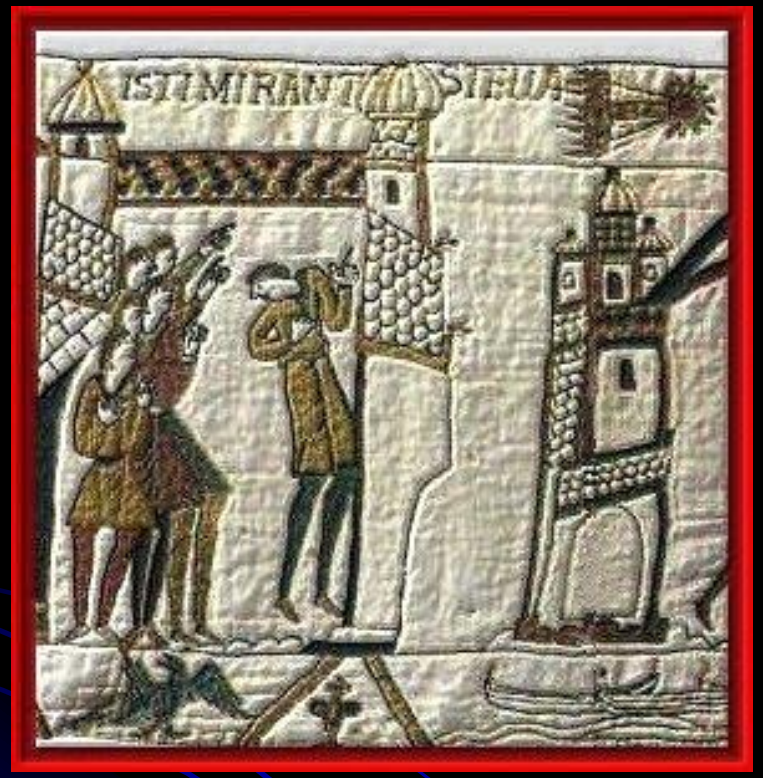
Skip broke comet up into 21 fragments, impacted Jupiter in mid-July of 1994.

The fragments stretched across 1.1 million km of space.

The impact was the equivalent of 6 million megatons of TNT

This is more than 4000x the world's nuclear arsenal.

Halley

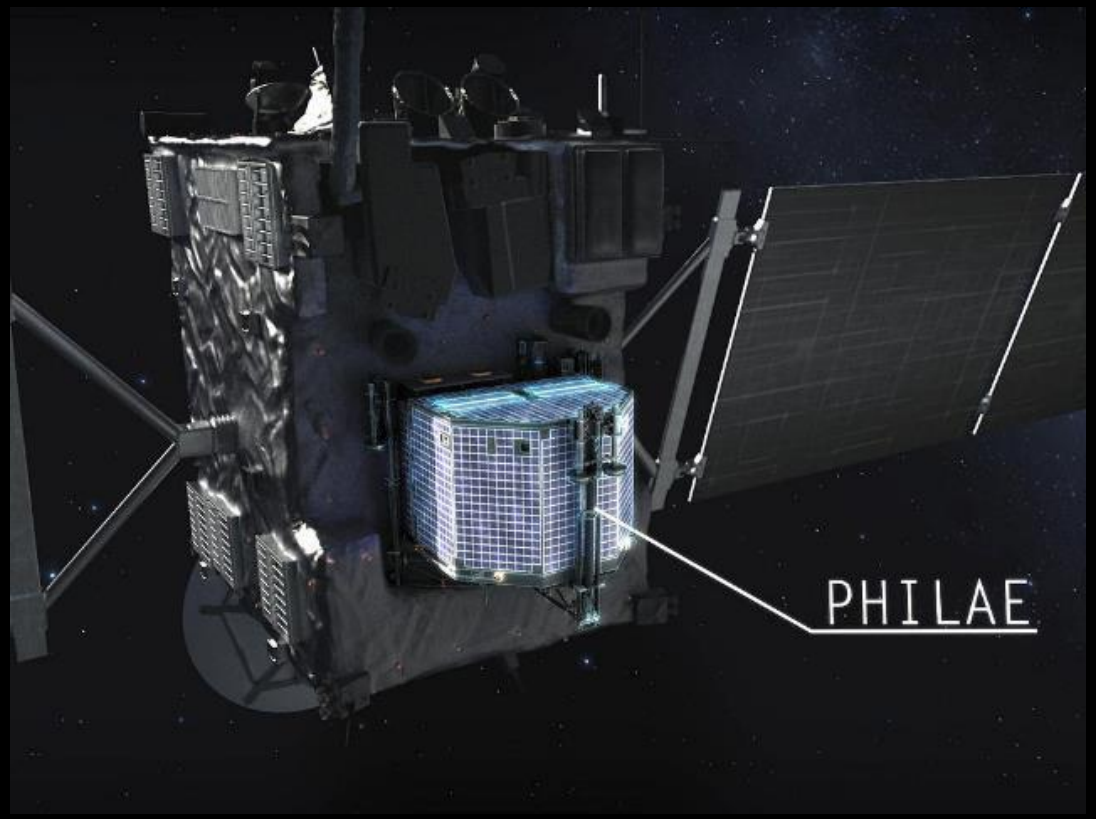


One of the ‘great comets’. There are Chinese records of Comet Halley going back to at least 240 BC. In 1705 Edmond Halley predicted that it would reappear every 76 years.

Hale-Bopp

Hale-Bopp, also a ‘great comet’, was discovered July 1996. In 3/97 it came to within 190 million km (500x moon) of Earth, the closest since 2000 BCE. Its icy nucleus (25-mi) is twice the size of Comet Halley. Is one of the brightest comets to reach the inner solar system.

67P/Churyumov–Gerasimenko

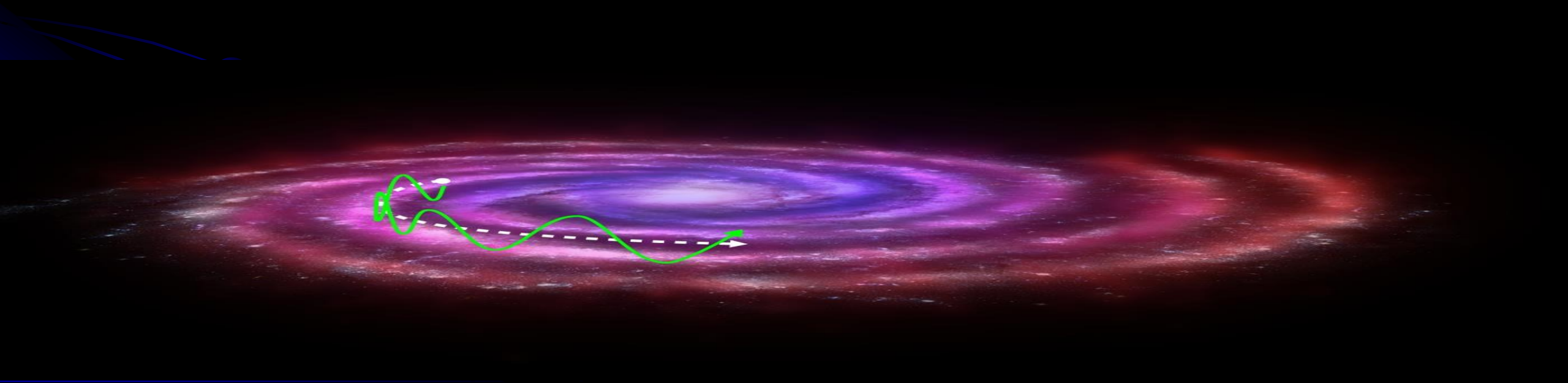


Discovered by Russian scientists in 1969, with an orbital period of 6.5 years.

The Rosetta mission was launched to land on the comet in 2014. Philae and other instruments provided unprecedented data on the comet originating from the Kupier belt.

Too Close for Comfort

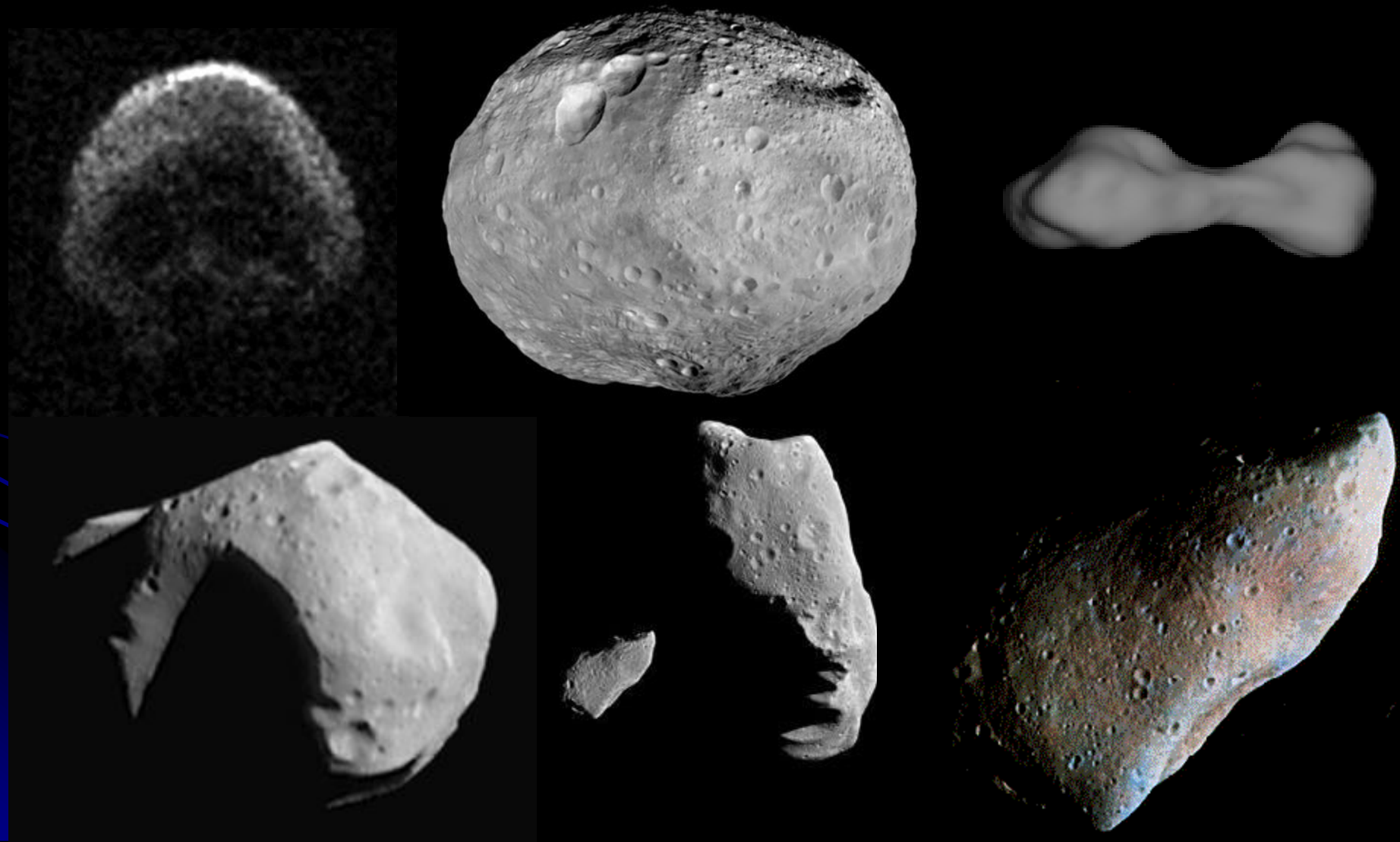
- Comets are constantly ejected towards the center of our solar system.
  - This is due in part to the motion of the galaxy.
  - While the Solar system orbits around the center of the galaxy, it also moves up and down. (Like a ball on a wave).
  - As we pass through denser areas, higher gravity objects make the comets fly off like pool balls.



Asteroids

- On January 1, 1801, Giuseppe Piazzi discovered an object which he first thought was a new comet.
  - After its orbit was better determined it was clear that it was not a comet but more like a small planet.
  - By the end of the 19th century there were several hundred small ‘planets’ discovered.
  - They were called asteroids after the joining of Greek words ‘star’ and ‘like’.

Asteroids



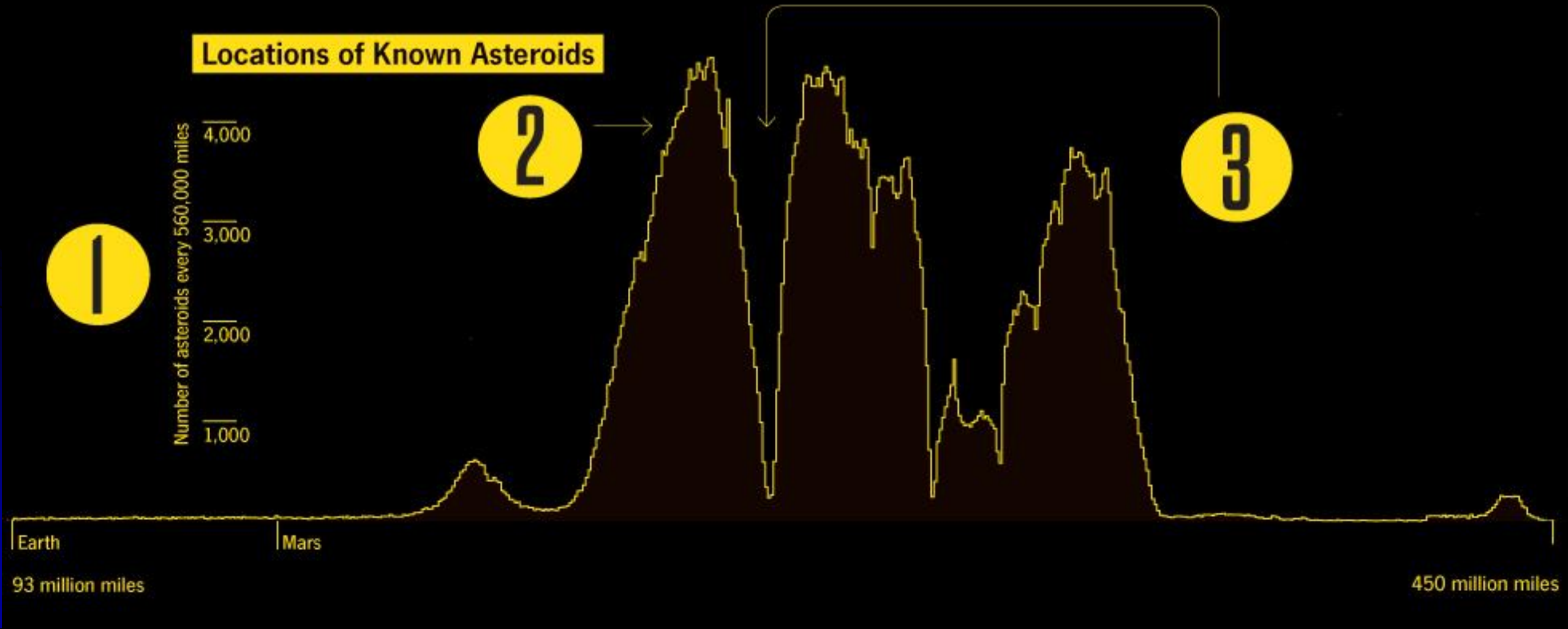
Asteroid Belt

- Most of the Asteroids reside between Mars and Jupiter (2-4 AU).
- Can be classified by orbit or composition.
- Tholen classification: chemical composition and albedo.
  - **C(hondrite)-Type**, 75%+ of known asteroids: extremely dark, large amounts of carbon, helium and other volatiles;
  - **S(tony)-Type**, ~17% of known asteroids: relatively bright, Iron mixed with Magnesium-silicates;
  - **U/X-Type**, ~8% are abnormal/rare. Includes Metallic: made of pure nickel-iron.

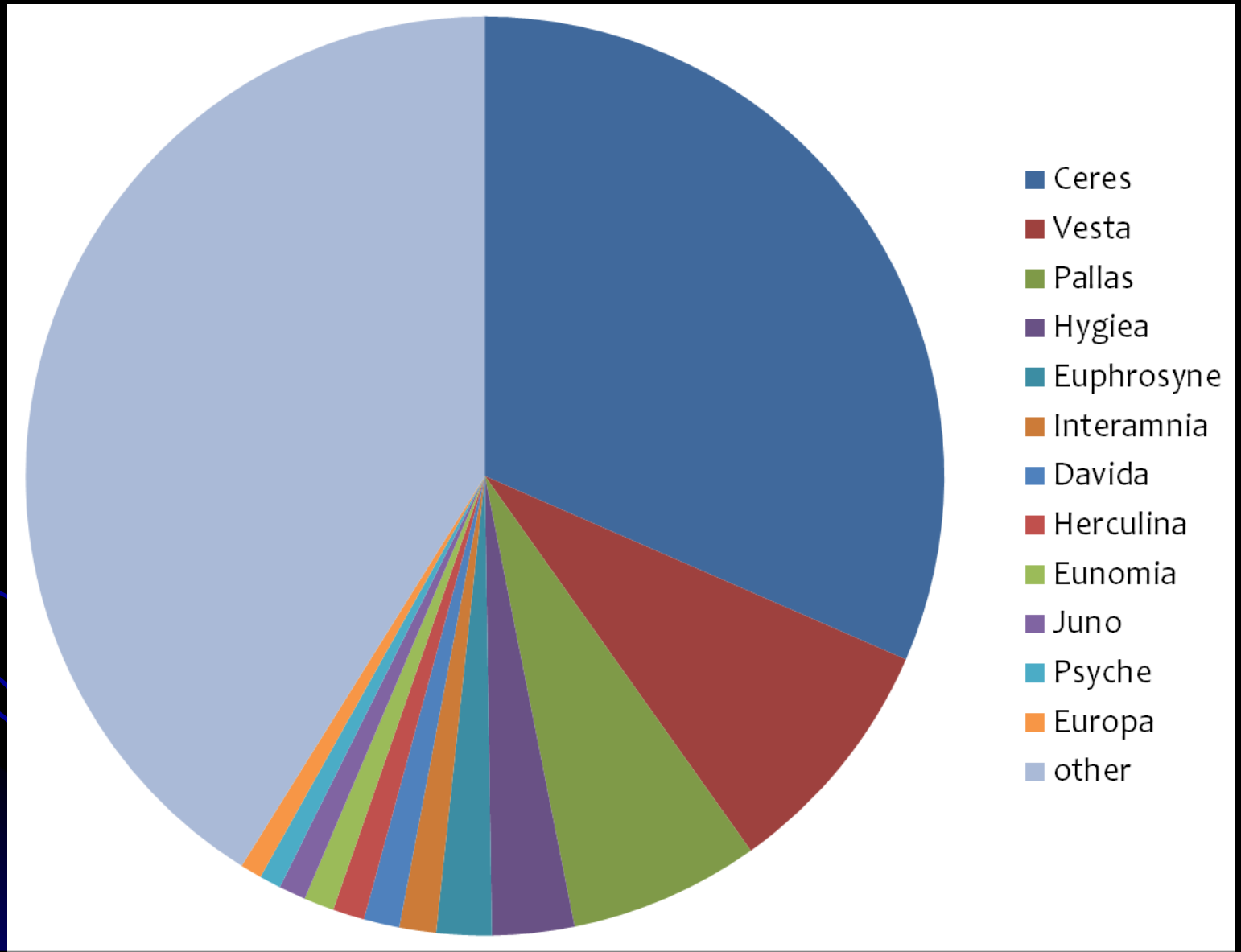
Billions and er… Millions

- There are 26 known asteroids larger than 200 km in diameter.
- 99% of the asteroids larger than 100 km in diameter have been documented.
- There are probably considerably more than a million asteroids in the 1 km range.

Where are they

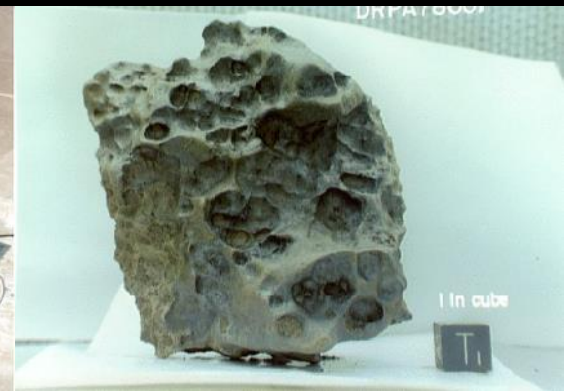


Distribution of Asteroids Mass



What is What?

- Asteroid: A space rock (smaller than a planet) orbiting the sun.
- Meteor(oid): A space rock that has entered Earth's atmosphere. Bolide (Gr Missile) is used for very bright ones that may explode in the atmosphere.
- Meteorite: A space rock that has fallen to earth.



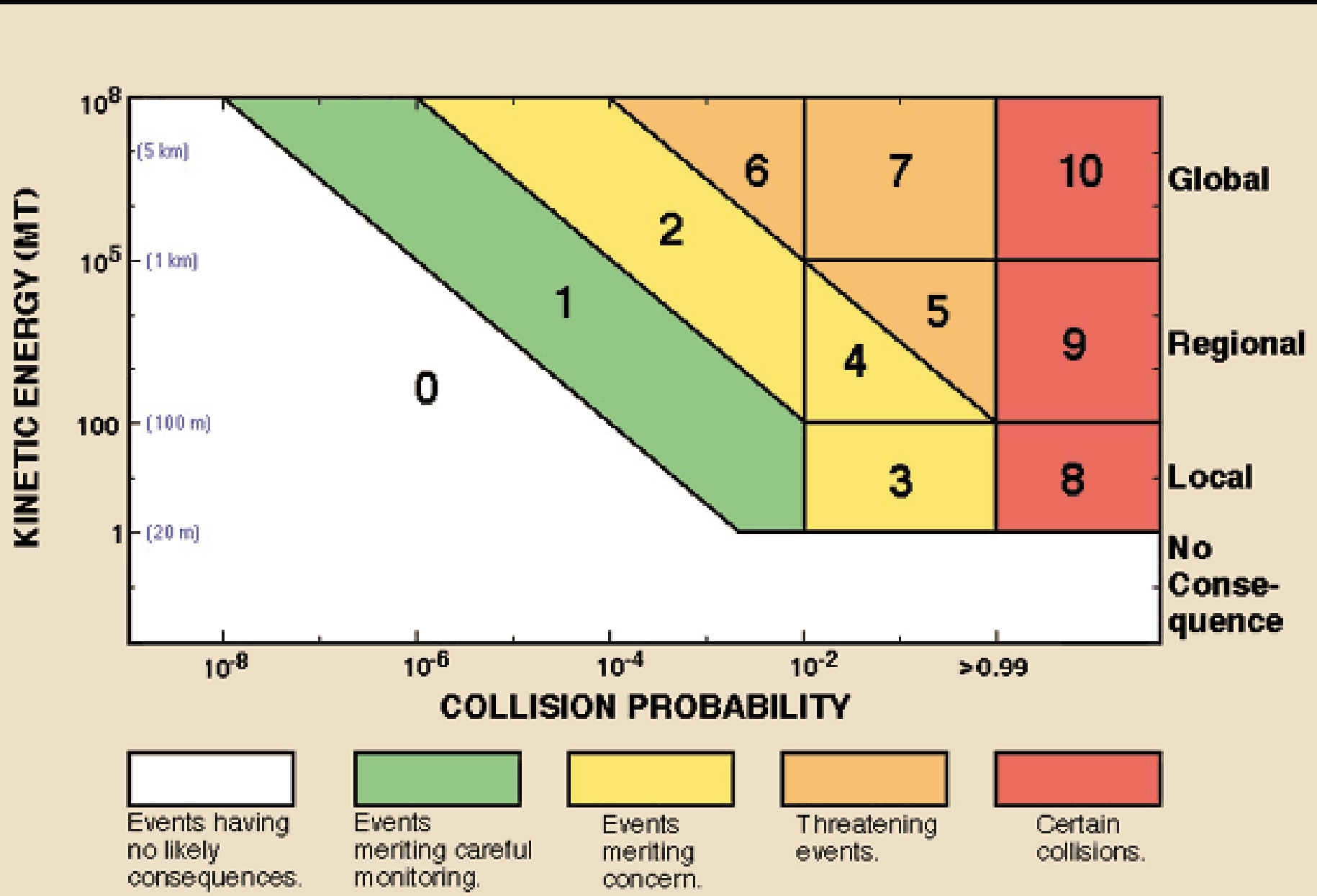
Near Earth Objects (NEO's)

- Objects hitting Earth are an inevitability.
- Two things determine the potential damage.
  - Size of the Object. (Mass)
  - Speed of the Object. (Velocity)
- These variables relate to Kinetic Energy.
  - $Energy_{Kinetic} = ½ \text{ mass} \times \text{velocity}^2$.
- To put this into understandable terms a scaled system was developed.

7 grams (center) shot at 7 km/s (the orbital velocity of the ISS) made this 15 cm crater in a solid block of aluminum.

Torino Scale

- Originally the NEO hazard index was created in 1995.
- In 1999 at a conference in Turin, Italy the idea was adopted, and name was changed.
- In 2002 JPL established Sentry to monitor and scan for threats.
- In 2005 the scale was reworded to be more user friendly.
  - Media misinterpreted the scale… panic!
- Palermo Scale is also in use (much more complicated).


KINETIC ENERGY (MT)
10^8
(5 km)
10^5
(1 km)
100
(100 m)
1
(20 m)
0
1
2
6
7
10
5
4
9
3
8
Global
Regional
Local
No Conse-quence
10^{-8}
10^{-6}
10^{-4}
10^{-2}
>0.99
COLLISION PROBABILITY
Events having no likely consequences.
Events meriting careful monitoring.
Events meriting concern.
Threatening events.
Certain collisions.

Torino: No Hazard-Normal

0: Any Energy, likelihood of a collision is zero, or is so low as to be effectively zero.

Also applies to small objects such as meteors and bodies that burn up in the atmosphere as well as infrequent meteorite falls that rarely cause damage.

1: Low/High Energy, a pass near the Earth is predicted that poses no unusual level of danger.

Current calculations show the chance of collision is extremely unlikely with no cause for public attention or public concern.

Torino: Meriting Attention

2. High Energy but low impact probability.

There is no cause for public attention/ concern as an actual collision is very unlikely.

3. Low Energy, 1% or greater chance of collision.

Capable of *localized destruction*. Public awareness if less than a decade away.

4. Mid Energy, 1% or greater chance of collision

Capable of *regional devastation*. Public awareness if less than a decade away.

Torino: Threatening

5. Mid Energy, 1% or greater chance of collision.

Impact would cause serious threat of *regional devastation*. Critical attention by is needed to determine whether a collision will occur. Governmental contingency planning may be warranted.

6. High Energy, less that 1% chance of collision.

Impact would cause serious threat of a *global catastrophe*. Critical attention by is needed to determine whether a collision will occur. Governmental contingency planning may be warranted.

7. High Energy, 1% or greater chance of collision.

Impact would cause serious threat of a *global catastrophe*. Critical attention by is needed to determine whether a collision will occur. Governmental contingency planning may be warranted.

Torino: Certain Collisions

8. **Low Energy, collision is certain.**

   Capable of causing *localized destruction* for an impact over land or possibly a tsunami if close offshore. (Chance: 50-1000's years)

9. **Mid Energy, collision is certain.**

   Capable of causing *unprecedented regional devastation* for a land impact or the threat of a major tsunami for an ocean impact. (Chance: 10,000-100,000 years)

10. **High Energy, collision is certain.**

    Capable of causing *global climatic catastrophe* that may threaten the future of civilization as we know it. (Chance: 100,000+ years)

How Bad is Bad?

- Currently 23 entries on Sentry database.
  - All but two have a 0 on the Torino Scale.
  - The following are 100+ yrs out (no Torino)
- 29075 (1950 DA)
  - 1:8,300 chance around 2800 (.00012%)
  - 1.3-km, 75000-Mt (last Yellowstone eruption)
- 101955 Bennu (1999 RQ36)
  - 1:2,700 chance from 2175-2199 (.00037%)
  - .490-km, 1200-Mt (~global arsenal)

Burj Khalifa, Dubai, UAE

Central Park Tower, NY

Prior ‘Impact’

- June 30, 1908: an object exploded in the upper atmosphere (~6-km) near the Tunguska River in Russia.
- The explosion leveled the area, 2150-km^2 (80% RI), even though it never hit the ground.
- The shockwave was estimated between 3 to 30-Mt (biggest H-bomb-Mt St. Helens) and would have registered 5.0 on the Richter scale.