FRS 155

The Asteroid Belt

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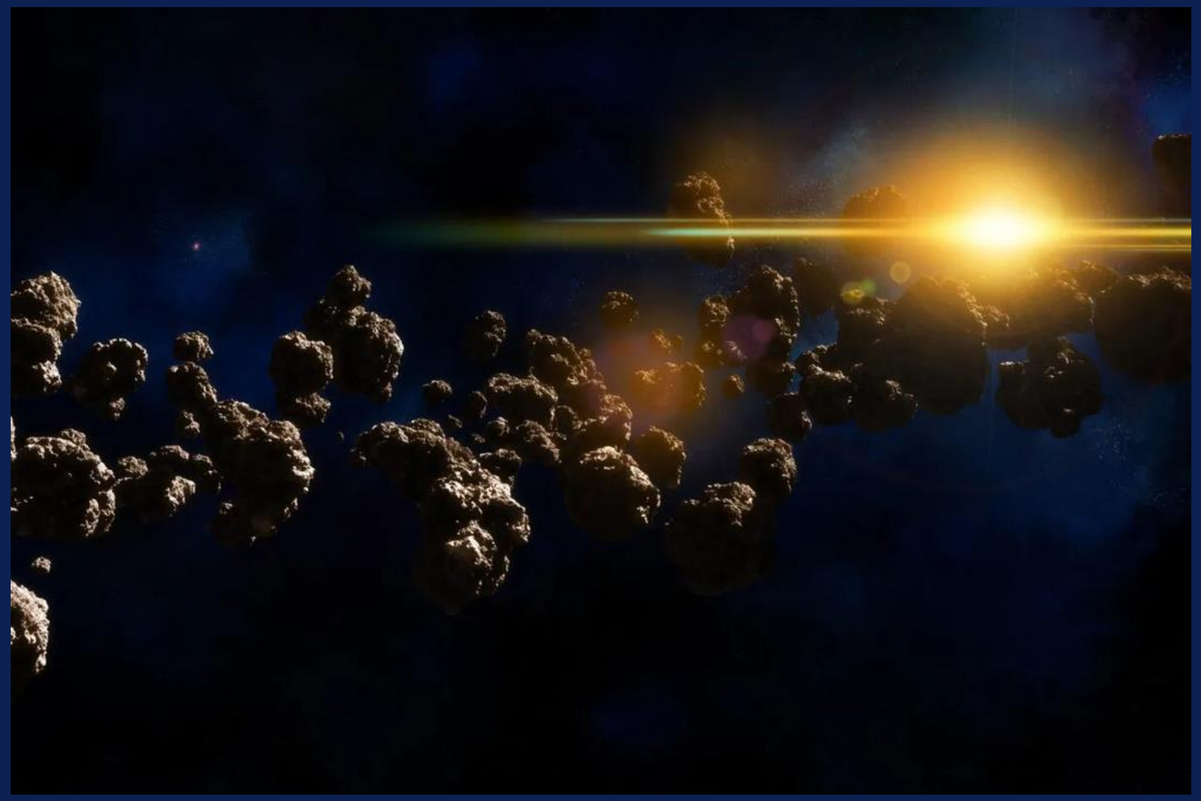
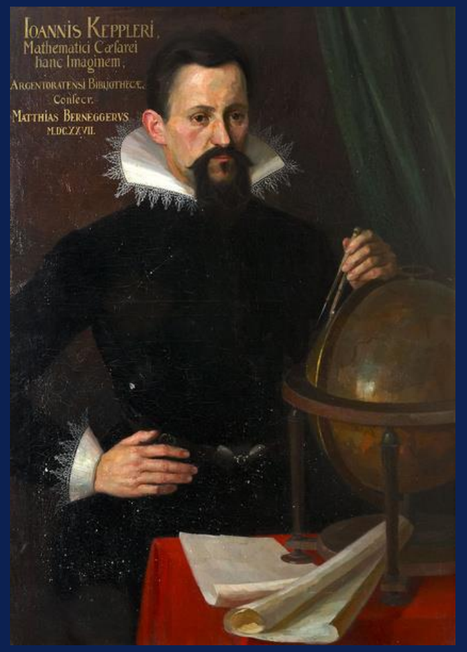
The Asteroid Belt



History of Discovery

- **In 1596, Johannes Kepler hypothesized a celestial body btw Mars & Jupiter**
- **Then in 1766, Johann Daniel Titius discovered a pattern for planetary orbits, provided a body btw Mars & Jupiter (Titius Bode Law)**

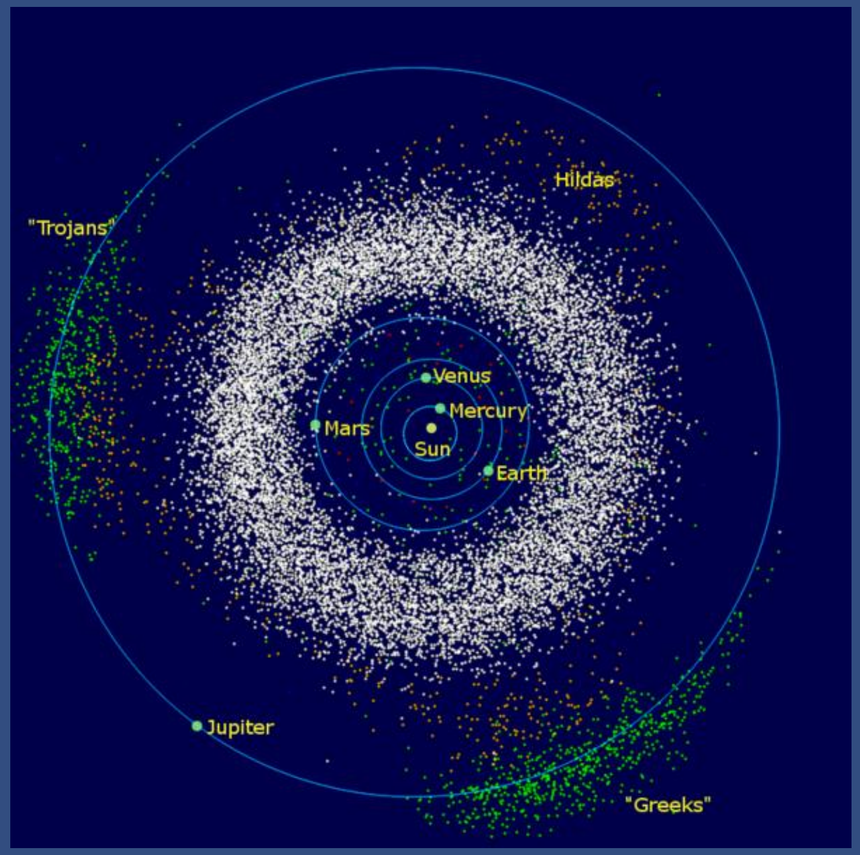


History of Discovery (contd.)

- Giuseppe Piazzi resolved this inconsistency with his discovery of Ceres
- Team of 24 astronomers set out to find other celestial bodies
- Soon after, Heinrich Olbers discovered a second object he named Pallas
- Under telescope, these objects were indistinguishable from stars
- BUT they moved too fast to be stars...so they were named “asteroids”
- More and more were discovered around the mid 1800s-->the belt
- Titius Bode law later disproved, but it drove the discover of the belt

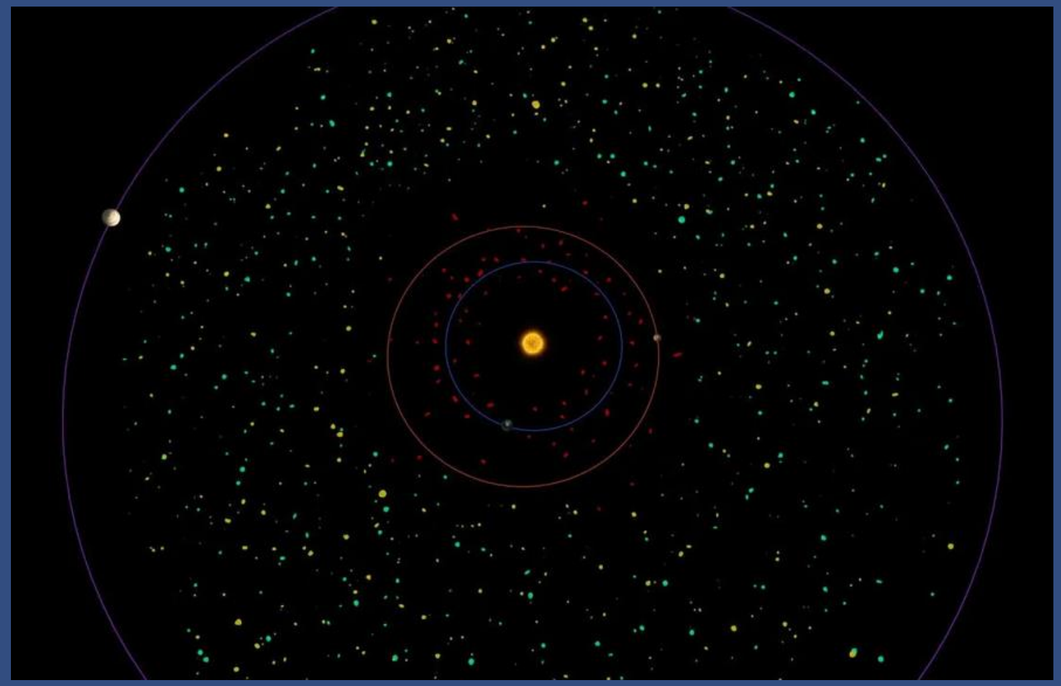
General Information

- The asteroid belt lies btw the orbits of M&J-->border btw inner rocky planets and outer gas giants
- 1-2 million large asteroids (>1km)
- Millions more smaller asteroids
- Spans about 140 million mi across
    - The belt is mostly empty space



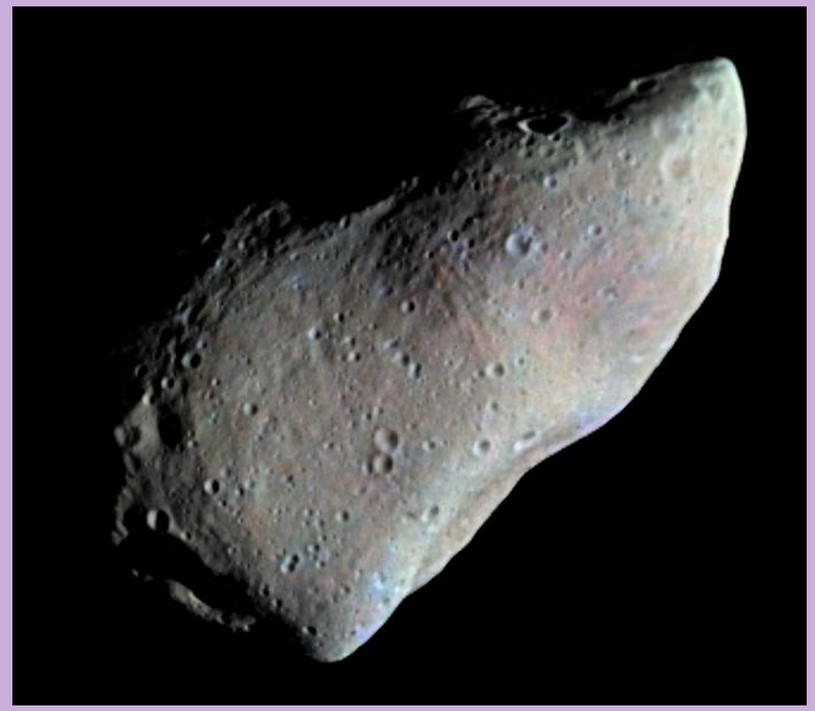
Size of the Asteroid Belt

- **Despite SO many asteroids, the belt is relatively small**
- **Total mass is 1/1000 of Earth**
- **Only 3% of the Moon's mass**
- **Most of this mass comes from the largest asteroids in the belt**



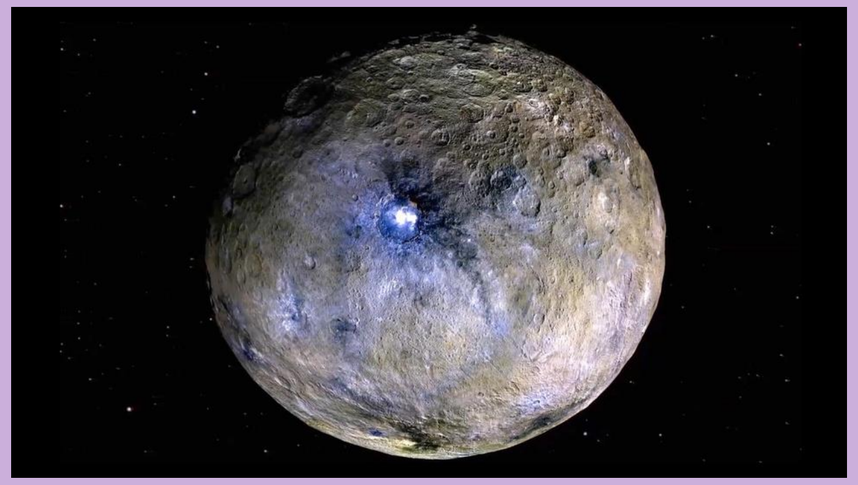
The Asteroids of the Belt

- **Millions of asteroids with great variation in asteroid size**
- **Larger ones may have a companion moon**
- **3 types of asteroids:**
  - **C-type (carbonaceous): 75%**
  - **S-type (silicaceous): 17%**
  - **M-type (metallic; Ni, Fe): 8%**



Ceres (Asteroid/Dwarf Planet)

- Comprises over 1/3 of the mass of the entire belt (largest body)
- Rich in water, but unclear how it got there (comet strikes or formation location?) (in between a comet and asteroid)
- Bright spots=patches of salt, probably hydrated magnesium sulfates



- Other notably large asteroids include Vesta, Pallas, and Hygiea
  - Together with Ceres, these bodies make up 62% of the belt's mass

How Did the Asteroid Belt Form?

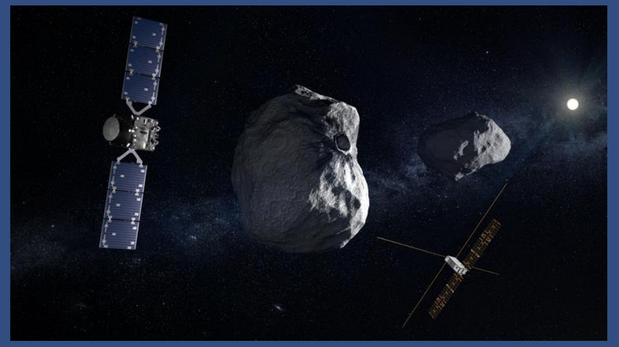
- One theory is that in the primordial soup of the early solar system, a disk of asteroids emerged as a swarm of unused planetesimals
- Then much of this thick swarm of asteroids was flung out of its orbital disc by interactions with a migrating (or stagnant) Jupiter and Saturn
- Another theory maintains that the belt started as empty space
- Then gravitational forces caused it to accumulate material that was flung away during planet formation
- Depletion vs. Accumulation model

How to Observe

- Observations use both ground-based telescopes and space-based instruments:
  - Telescopes like Pan-STARRS and Zwicky Transient Facility (ZTF) detect new asteroids, track their orbits, and help our understanding of their distribution
  - Radar facilities, like those at Arecibo Observatory (before its collapse in 2020) and Goldstone Solar System Radar (larger asteroids, such as studying their spin rates, shapes, and surface characteristics)
  - Infrared observations, especially from NEOWISE (asteroid size, shape, and composition)
  - Hubble Space Telescope has also provided detailed images and spectra of large asteroids and dwarf planets within the belt

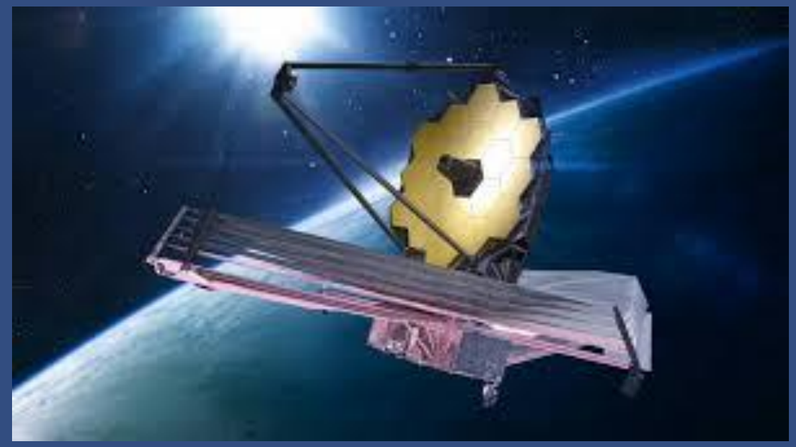
Current Observations of the Asteroid Belt

- NASA's OSIRIS-REx
- JAXA’s Hayabusa2
- NEOWISE (NASA)
- NASA's DART mission
- Pan-STARRS and ZTF



Future Observations and Missions

- NASA’s Lucy mission
- ESA’s Hera mission
- James Webb Space Telescope (JWST)
- Asteroid Mining
  - (SpaceX driven interest)
- Asteroid Impact Threat Assessment



Open Questions

- Origin and Evolution of the Asteroid Belt
- Asteroid Composition
- Asteroid Collisions and Fragmentation
- Trojan Asteroids
- Hazardous Asteroids
- Resource Utilization

Modern Observatory

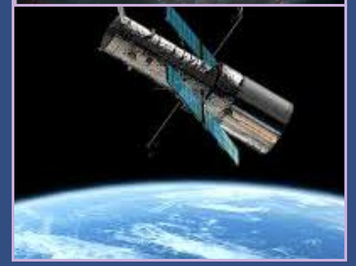
Ground-based observation

Space-based Observation

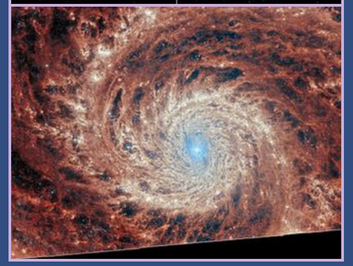
Optical

Radio

Hubble Space



Infrared



X-ray

Sources

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