18. Asteroids
Overview: Structure

**Inner system:** terrestrial planets, asteroids.

**Outer system:** giant planets and moons, “KBOs”.

**Oort Cloud:** comets.
Samples From the Asteroid Belt

**Primitive** meteorites are relics of the solar system’s formation, 4.6 Gyr old.

**Processed** meteorites come from differentiated asteroids, later broken up by collisions.
Element Abundances
Eros

\[ a = 1.5 \text{AU}, \quad e = 0.22 \]
\[ 34 \times 11 \times 11 \text{ km} \]

S-type
Density = 2700 kg m\(^{-3}\)
\[ P_{\text{rot}} = 5 \text{ hr} \]

Disc. 1898 (Carl Witt)
V \sim 8.1 \text{ mag (binoculars)}

Visited by NEAR-Shoemaker probe
Mission to Eros
Asteroid Light Curves
Some asteroids are **rubble piles**: loose collections of fragmented rock held together by self-gravity.
Some small asteroids rotate so fast that they must be **monoliths** held together by material strength.
Giant Asteroids
Giant Asteroids

Large asteroids are complex objects which appear to have differentiated.
Belt Structure

- Inner Belt: $a < 2.5$ AU
- Mid Belt: $2.5$ AU $< a < 2.8$ AU
- Outer Belt: $a > 2.8$ AU
Kirkwood Gaps

*Resonances* with Jupiter group asteroids by orbit period; period determines semi-major axis (Kepler III: $P^2 = a^3$).
Trojan Asteroids
Orbits starting near L₄

$m_a/m_b = 49$
Orbits starting near $L_1$.

\[ \frac{m_a}{m_b} = 49 \]
Hilda Asteroids

2:3 MMR; stable since they avoid Jupiter ($e \sim 0.3$).

Small inclinations ($i \approx 20^\circ$).
Asteroid Families

Many asteroids are members of families; they have similar orbits and compositions (indicated by colors).

Inner belt asteroids (left) and families (right).
Origin of Families

Fragments are scattered on similar orbits.
A Suspected Asteroid Collision Leaves Odd X-Pattern of Trailing Debris