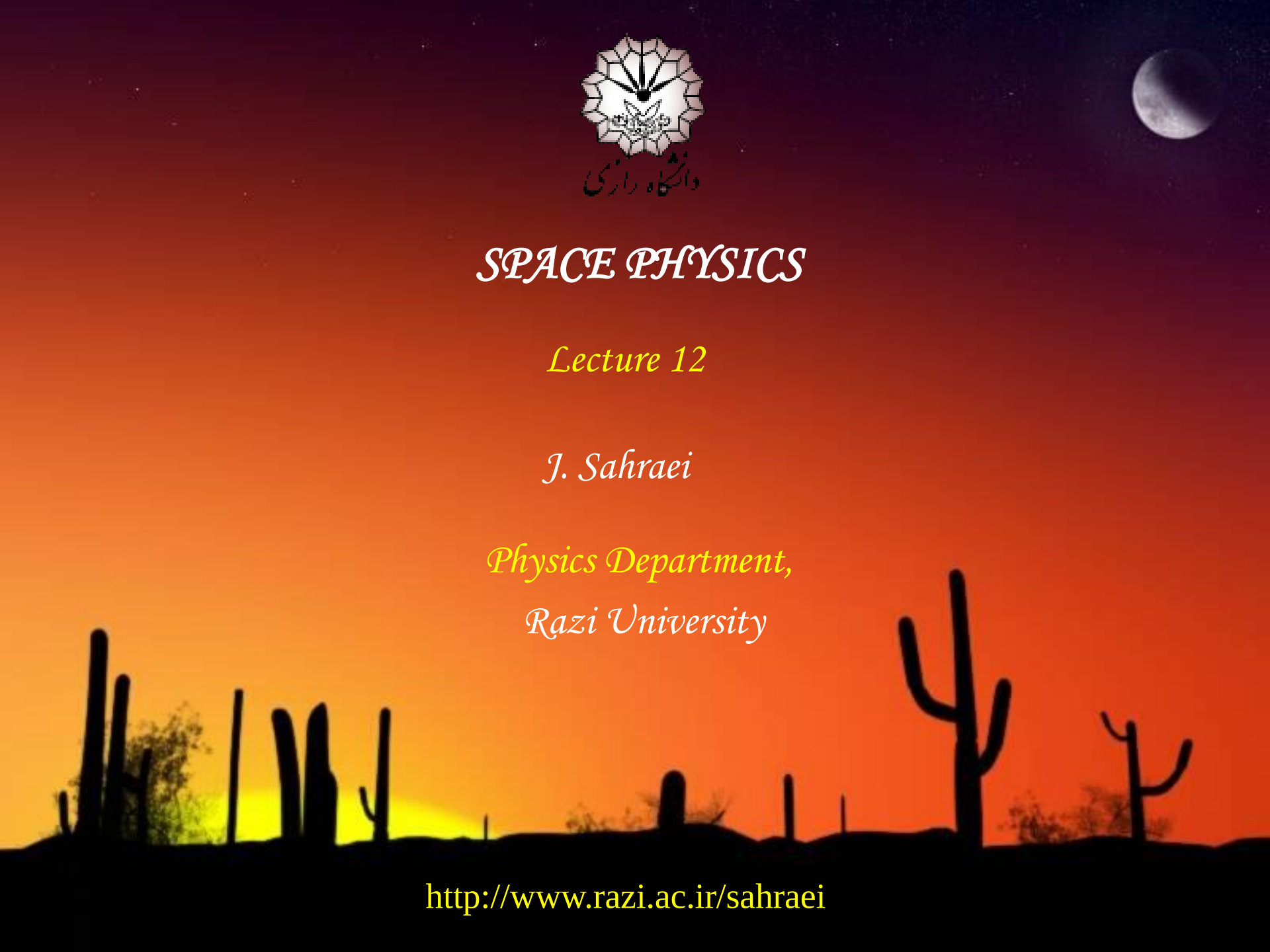

SPACE PHYSICS

Lecture 12

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OTHER BODIES

- Comets are giant dirty snowballs composed of frozen gases and icy lumps

- Asteroids are chunks of rock that range in size from dust particles to a few hundred miles across

- Meteoroids are tiny particles of dust and sand. Entering the Earth's atmosphere, they are called meteors. It if actually hits the surface, it is called a meteorite

What is an Asteroid?

Asteroids

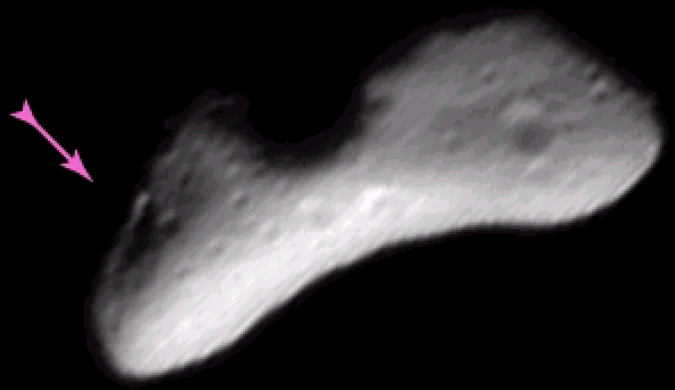
- Asteroids are small, rocky worlds.
- Most asteroids revolve around the sun between the orbits of Mars and Jupiter. (asteroid belt)

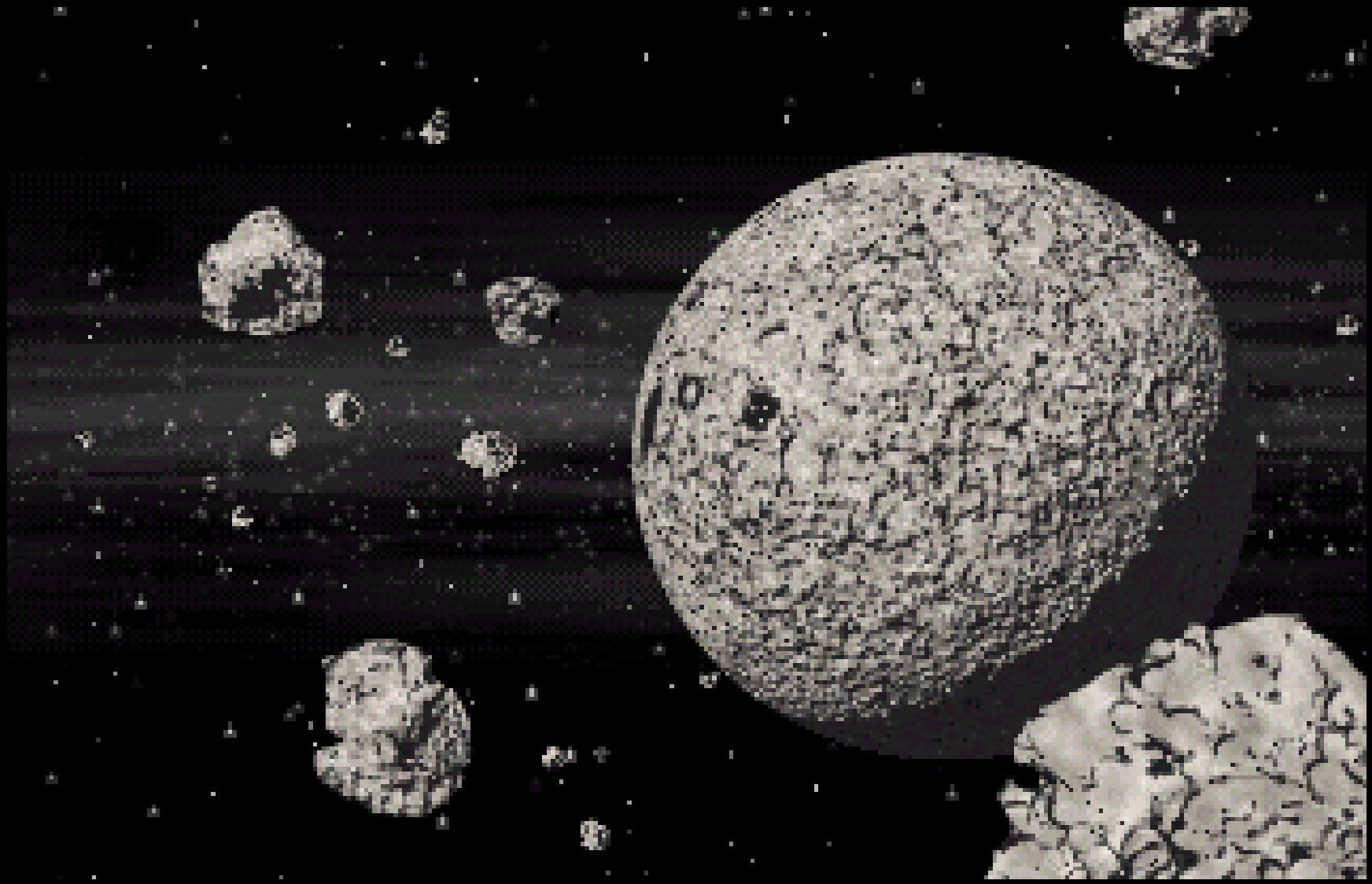
Asteroids and comets whose orbits are in close proximity to Earth's orbit.

- Near-Earth Asteroids:
  - Orbits are within region of inner planets.
  - No volatiles.
  - Very numerous:
    - Thousands with mean diameter > 1.5 km.
    - Possibly millions with mean diameter of a few hundreds of meters or less.

The asteroid “Gaspra”

Looks like a potato?

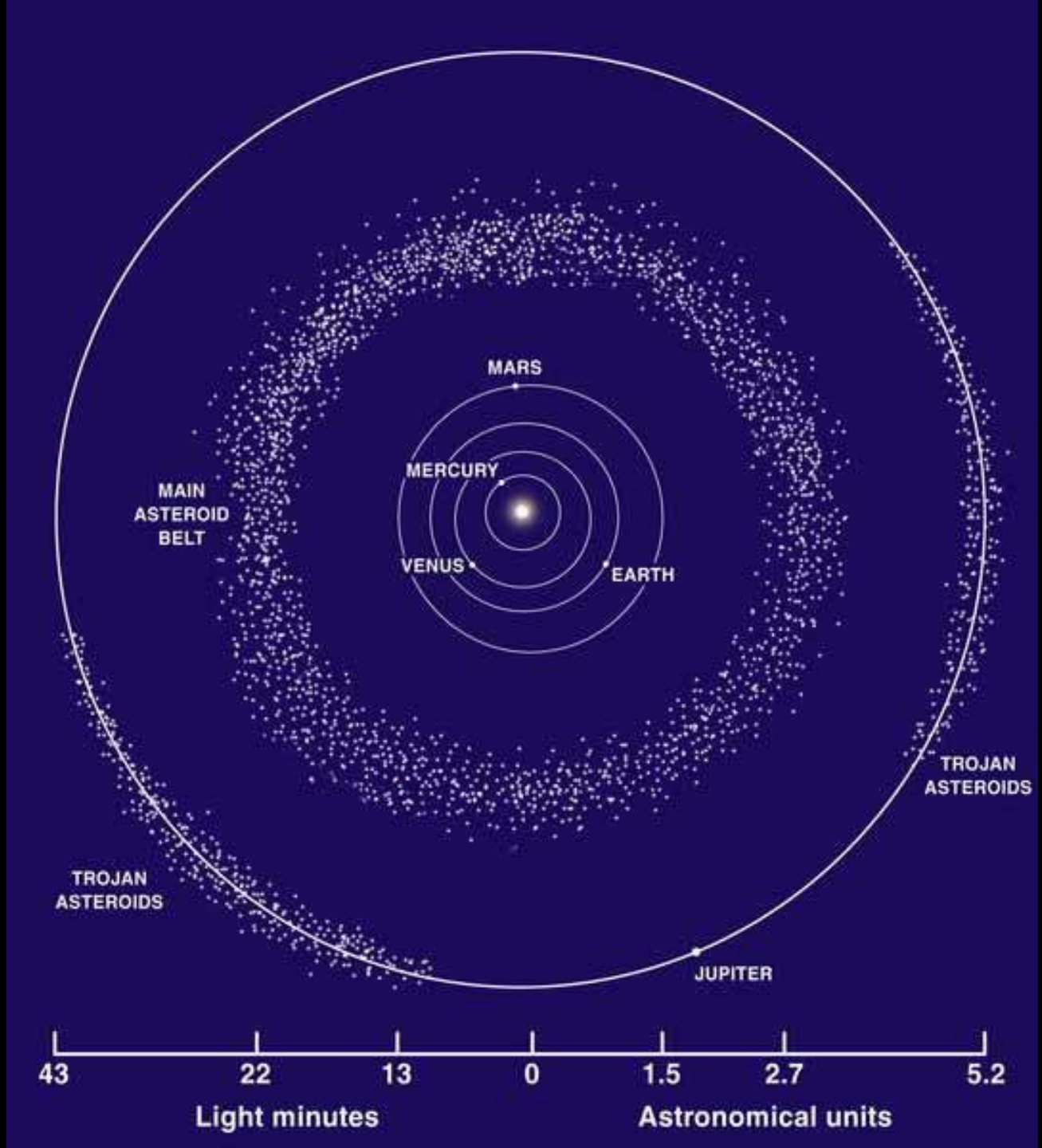


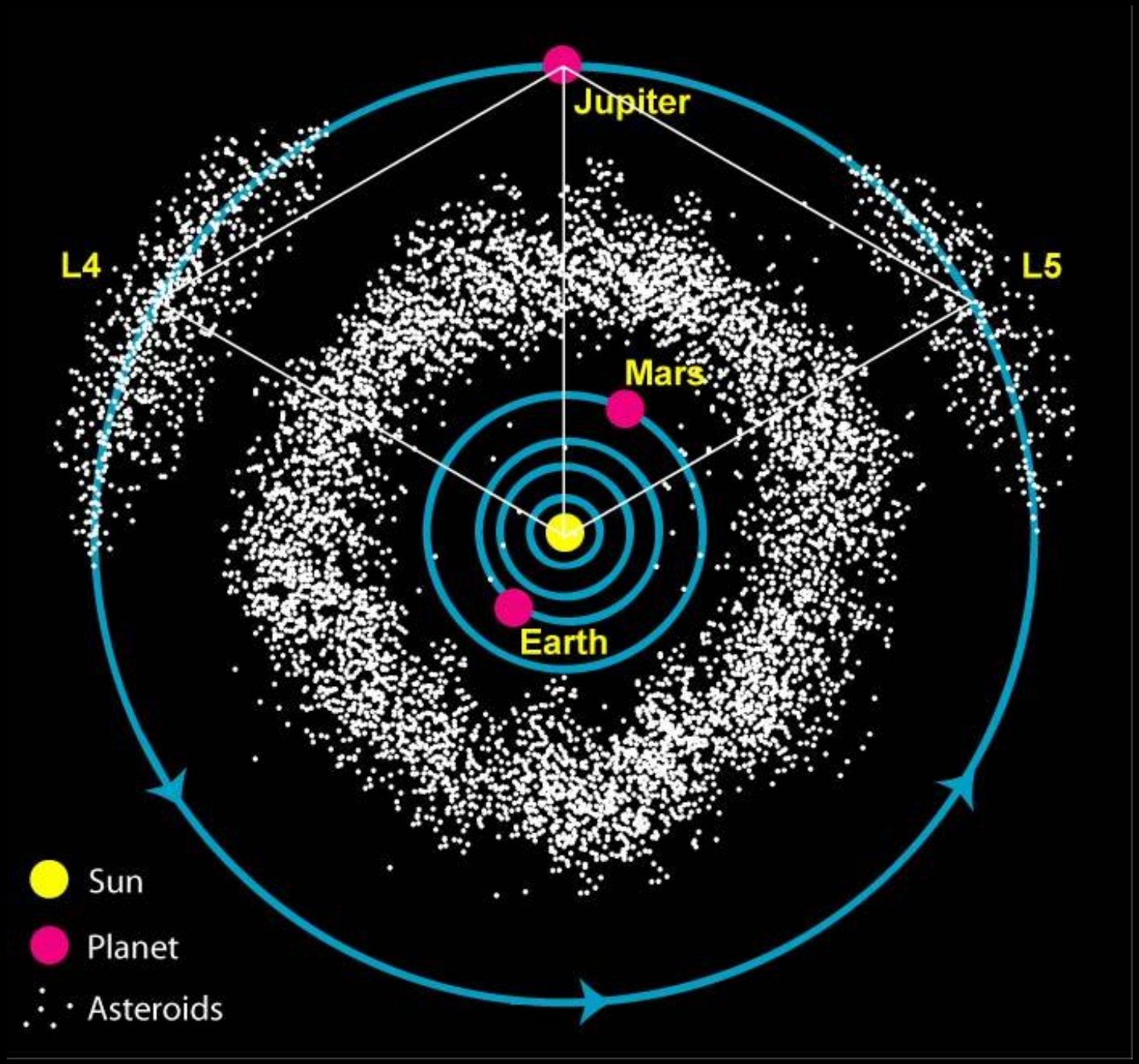


asteroid - a small rocky body orbiting the sun; usually found in the asteroid belt

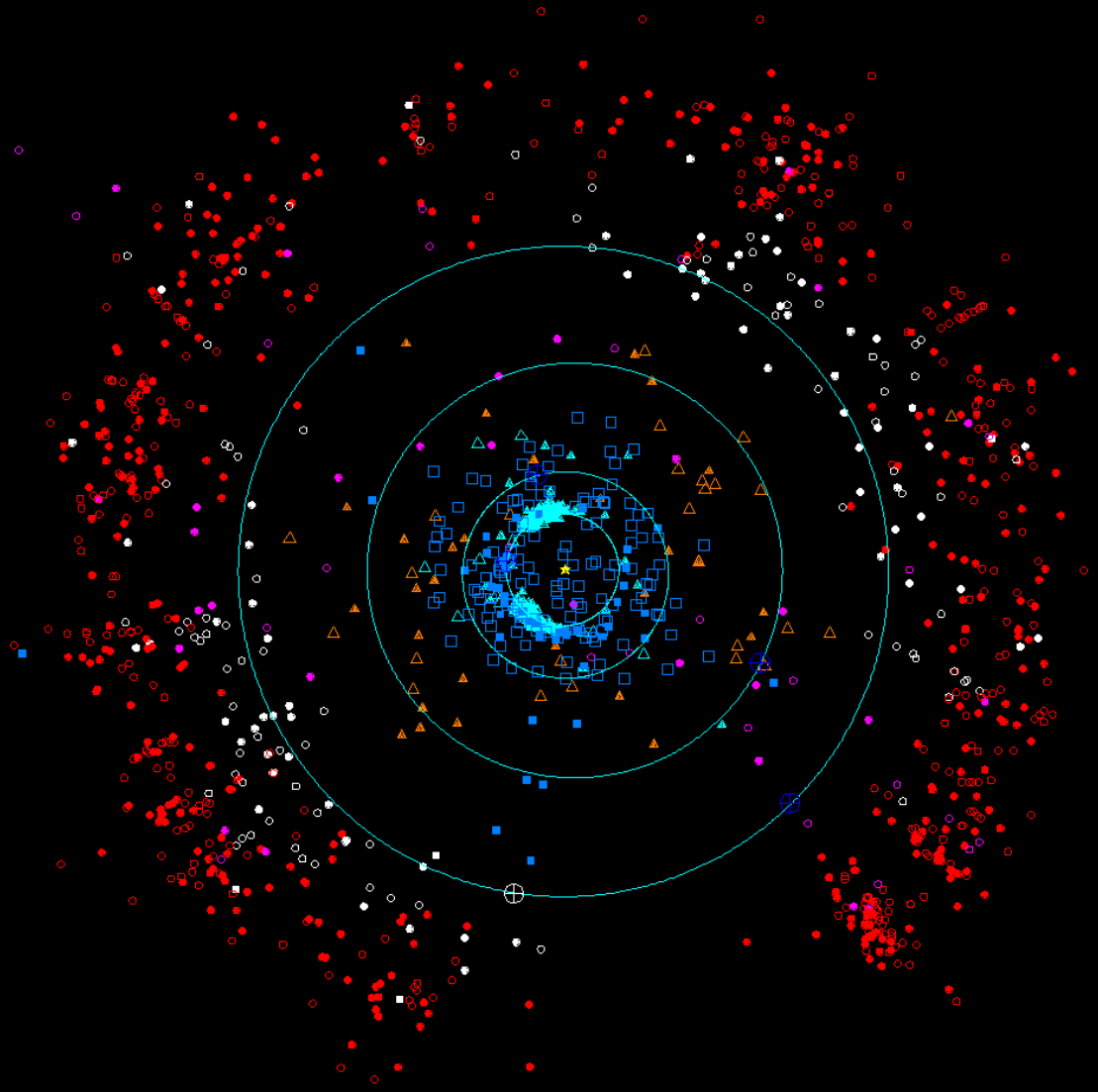
Where are they?

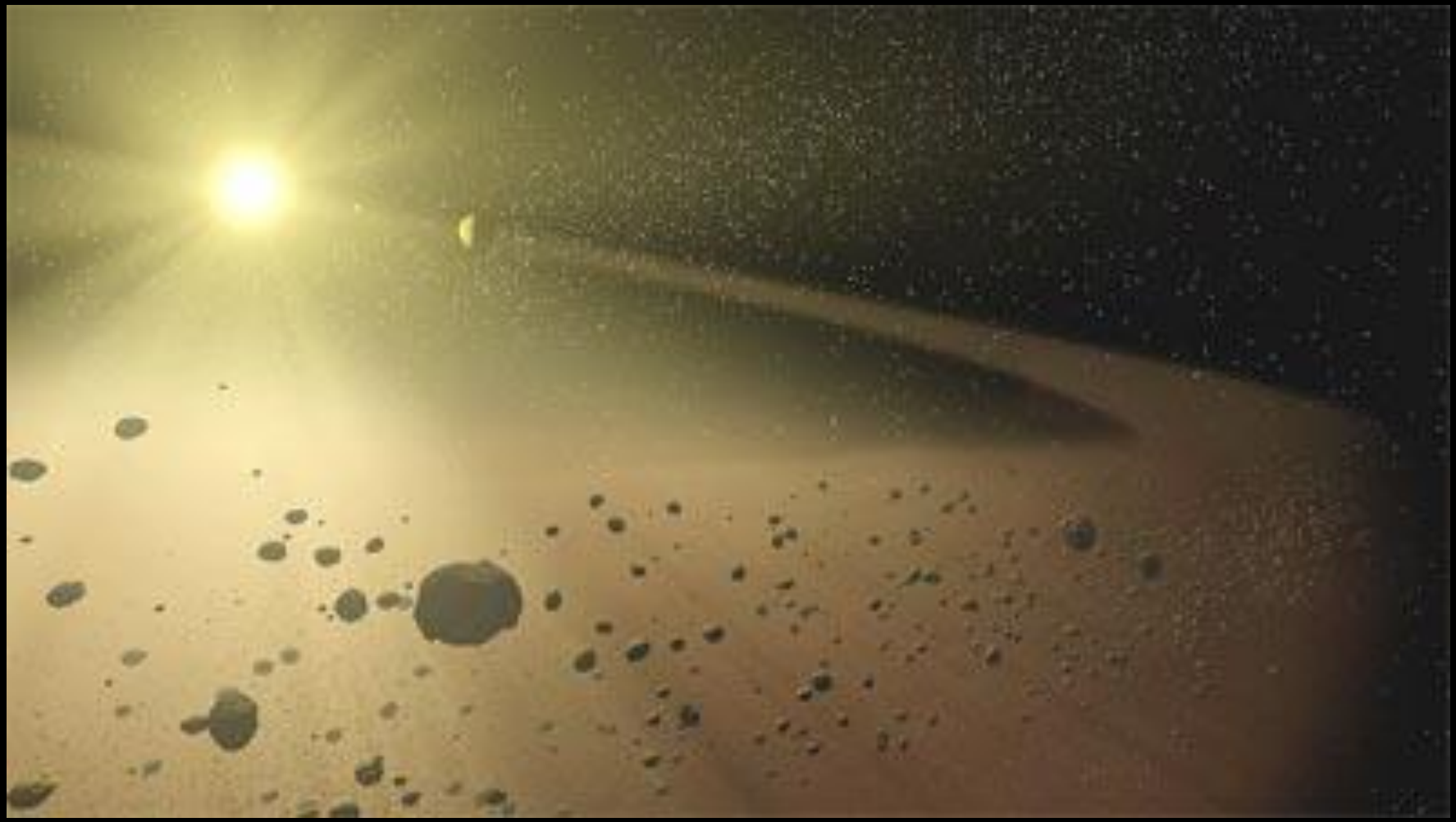
Where do they come from?


MARS
MERCURY
MAIN
ASTEROID
BELT
VENUS
EARTH
TROJAN
ASTEROIDS
TROJAN
ASTEROIDS
JUPITER
43
22
13
0
1.5
2.7
5.2
Light minutes
Astronomical units


Jupiter
L4
L5
Mars
Earth
Sun
Planet
Asteroids

Asteroids Elsewhere



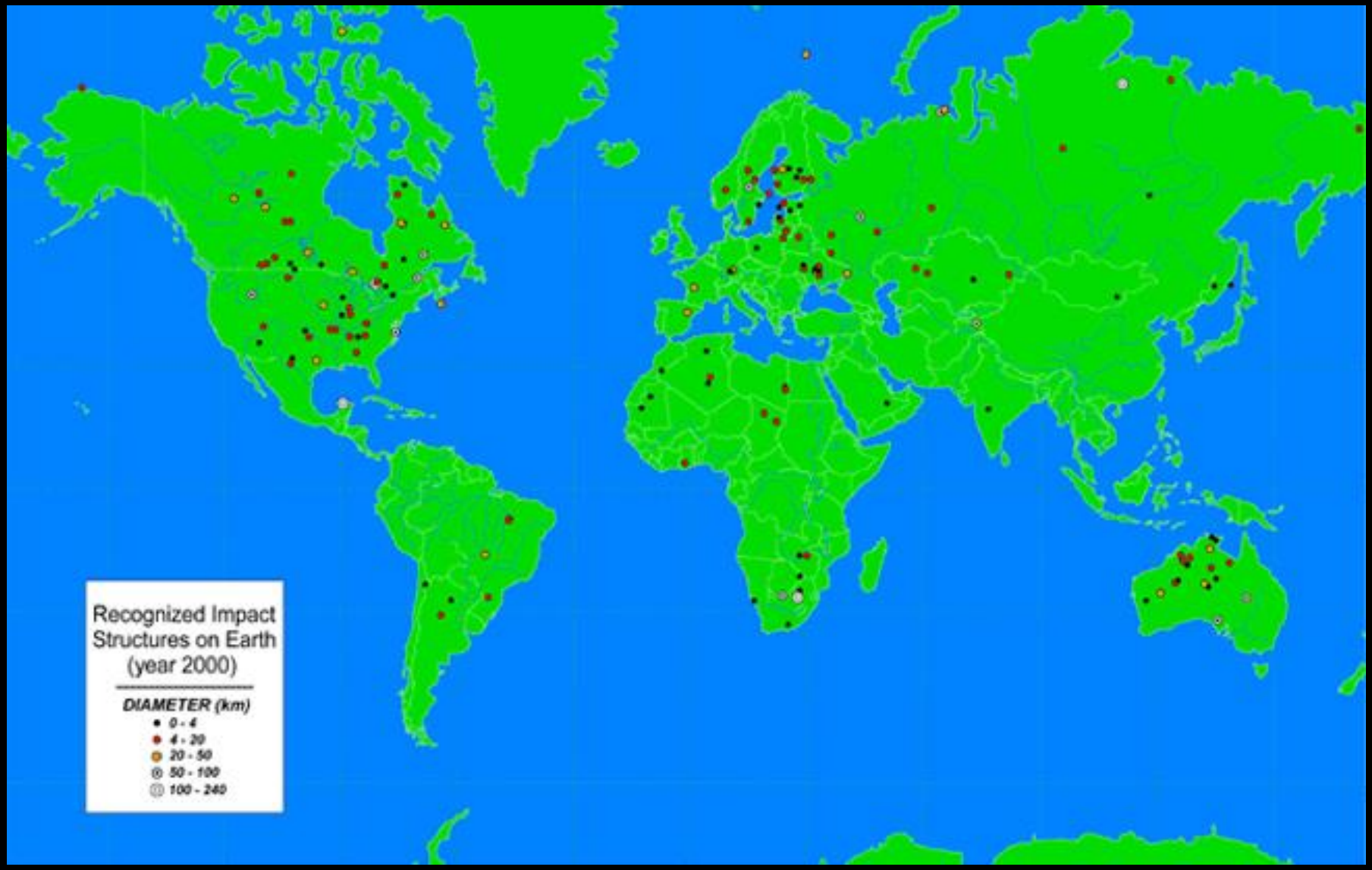


Asteroids

Earth has been struck many times in its history by asteroids.

Mass Extinction Impact

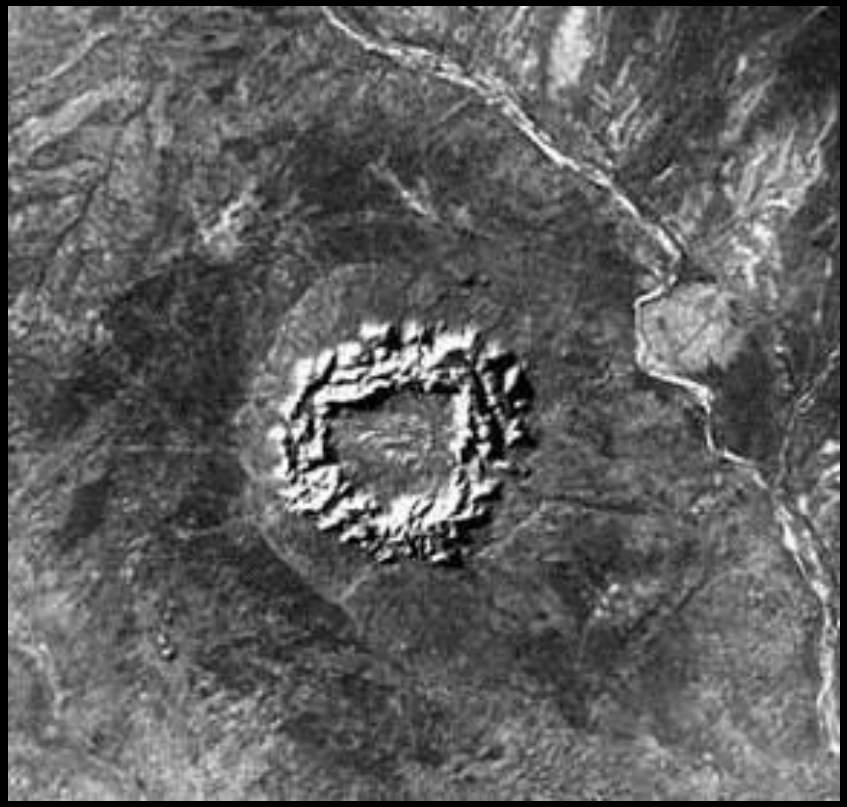
Mass Extinction Impact

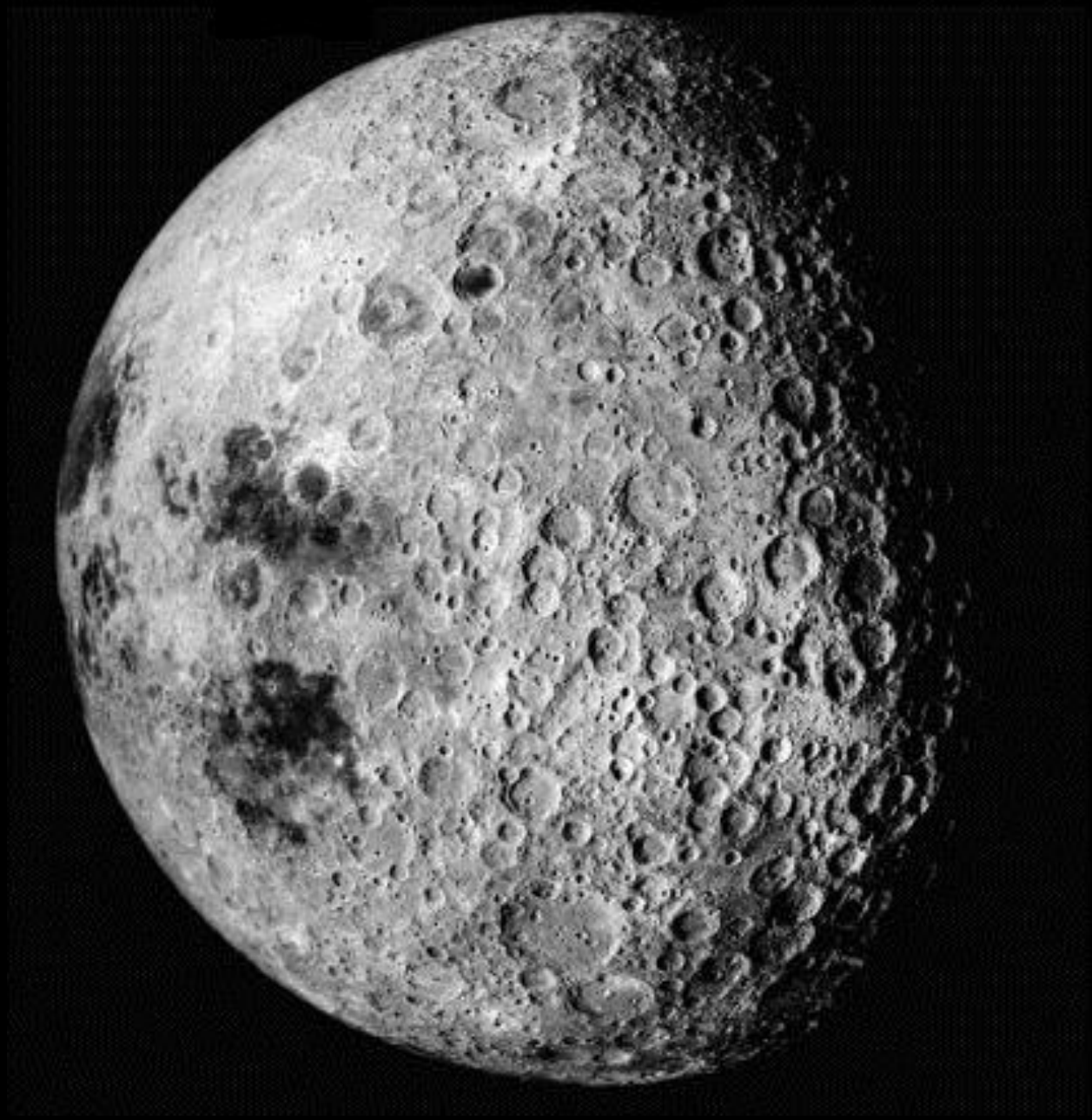

Recognized Impact Structures on Earth (year 2000)
DIAMETER (km)
0 - 4
4 - 20
20 - 50
50 - 100
100 - 240

- 100 km
- 212 Million years old
- Canada

What happens if an Asteroid hits the Earth?

This 142-million-year-old crater has a diameter of almost twenty-two km. Like many craters on Earth, it is misleading. The raised ring that is clearly visible to the left is not the crater rim. It is an erosional remnant. The remains of the actual rim are found farther out from the ring.





Near Earth

3439 known NEAs

Many asteroids in main belt, and big, but too far.

Asteroid	Size (km)
Ceres	940
Vesta	549
Eros	23
Apollo	1.4
Ida	58 x 23
Gaspra	17 x 10
Kleopatra	217 x 94

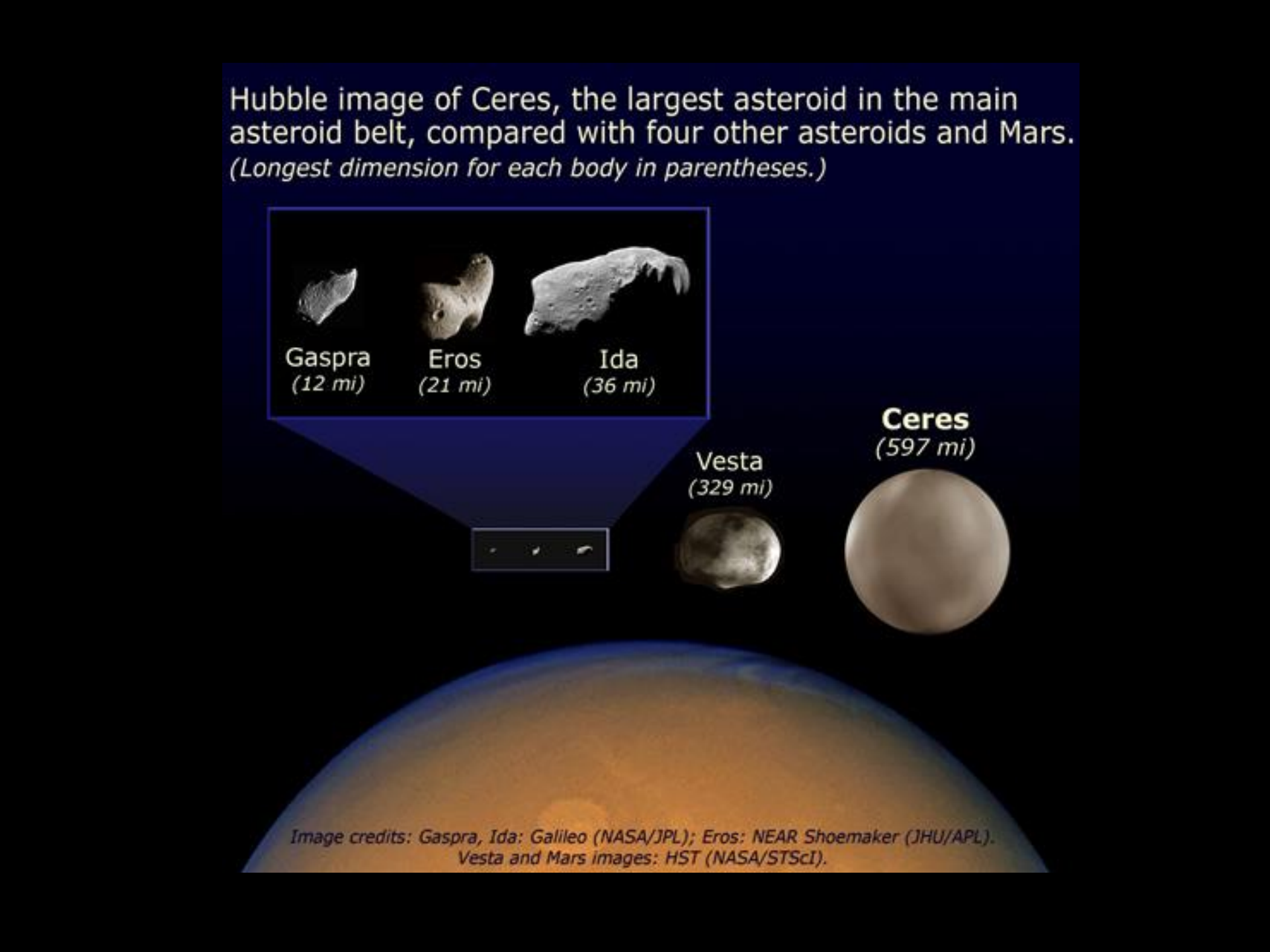
Asteroids: Years of Discovery

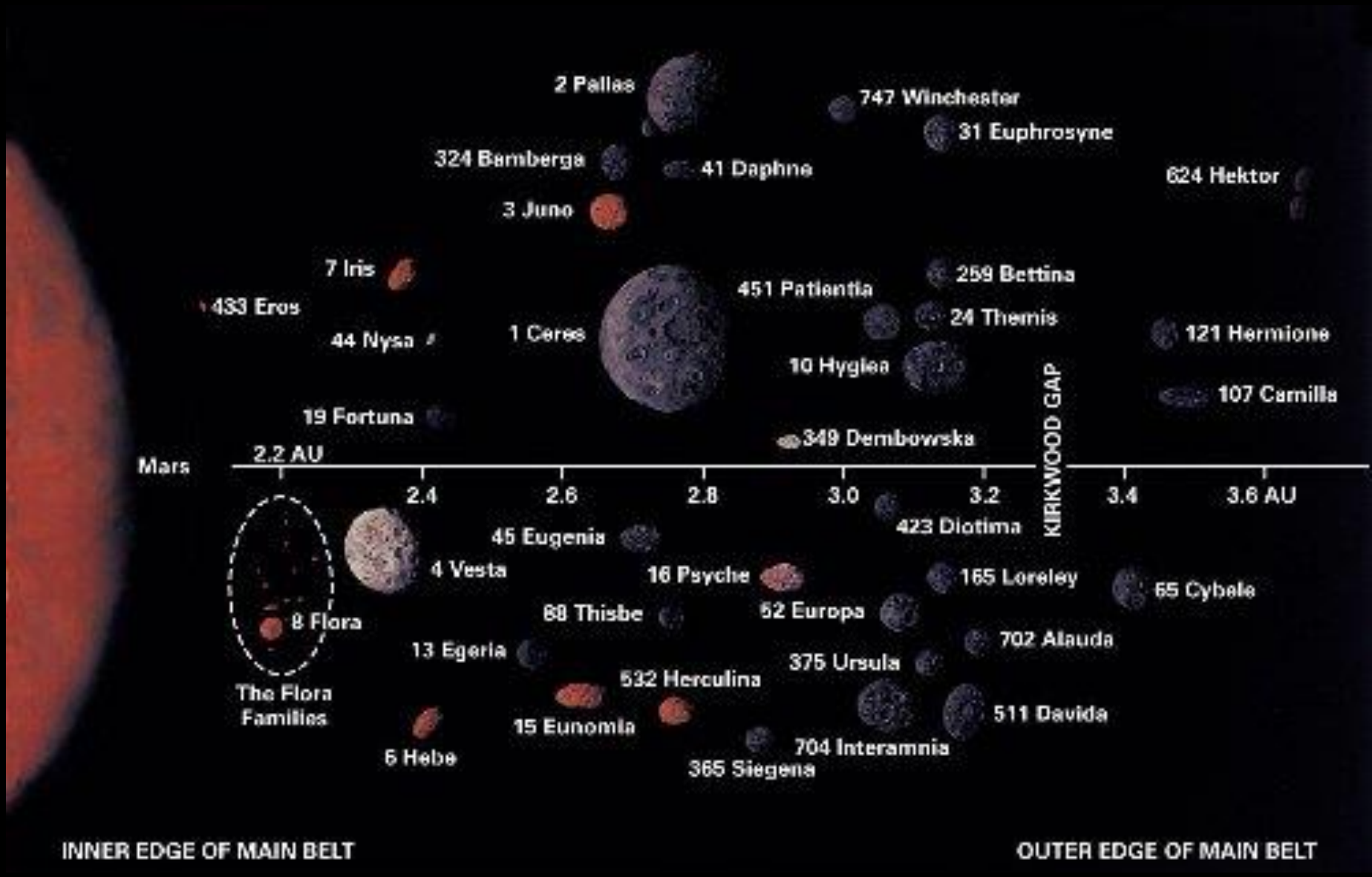
Number	Name	Year	Size km	Orbit AU
2062	Aten	1976	0.9	0.97
433	Eros	1898	23	1.46
1862	Apollo	1932	1.4	1.47
1221	Amor	1932	1.0	1.92
4	Vesta	1807	549	2.36
7	Iris	1847	210	2.39
44	Nysa	1857	73	2.42
6	Hebe	1847	201	2.43
21	Lutetia	1852	115	2.43
19	Fortuna	1852	215	2.44
3	Juno	1804	265	2.67
1	Ceres	1801	940	2.77
2	Pallas	1802	540	2.77
45	Eugenia	1857	228	2.72
16	Psyche	1852	265	2.92
10	Hygeia	1849	410	3.14
65	Cybele	1861	280	3.43
279	Thule	1888	60	4.26
624	Hector	1907	150x300	5.15
944	Hildago	1920	39	5.80

Earth years it takes the asteroid Ceres to travel around the sun

(Ceres – Biggest Asteroid with a 940 km circumference)

EROS Asteroid 433 – 23 km


Hubble image of Ceres, the largest asteroid in the main asteroid belt, compared with four other asteroids and Mars.
(Longest dimension for each body in parentheses.)
Gaspra
(12 mi)
Eros
(21 mi)
Ida
(36 mi)
Vesta
(329 mi)
Ceres
(597 mi)
Image credits: Gaspra, Ida: Galileo (NASA/JPL); Eros: NEAR Shoemaker (JHU/APL).
Vesta and Mars images: HST (NASA/STScI).


2 Pallas
747 Winchester
31 Euphrosyne
324 Bamberga
41 Daphne
624 Hektor
3 Juno
7 Iris
259 Bettina
451 Patientia
433 Eros
24 Themis
44 Nysa
1 Ceres
121 Hermione
10 Hygiea
107 Camilla
19 Fortuna
349 Dembowska
KIRKWOOD GAP
Mars
2.2 AU
2.4
2.6
2.8
3.0
3.2
3.4
3.6 AU
423 Diotima
45 Eugenia
4 Vesta
16 Psyche
165 Loreley
65 Cybele
68 Thisbe
52 Europa
8 Flora
702 Alauda
13 Egeria
375 Ursula
532 Herculina
The Flora Families
511 Davida
15 Eunomia
704 Interamnia
6 Hebe
365 Siegena
INNER EDGE OF MAIN BELT
OUTER EDGE OF MAIN BELT

Asteroid formation: growing by collisions

Asteroid evolution: collisions, decay

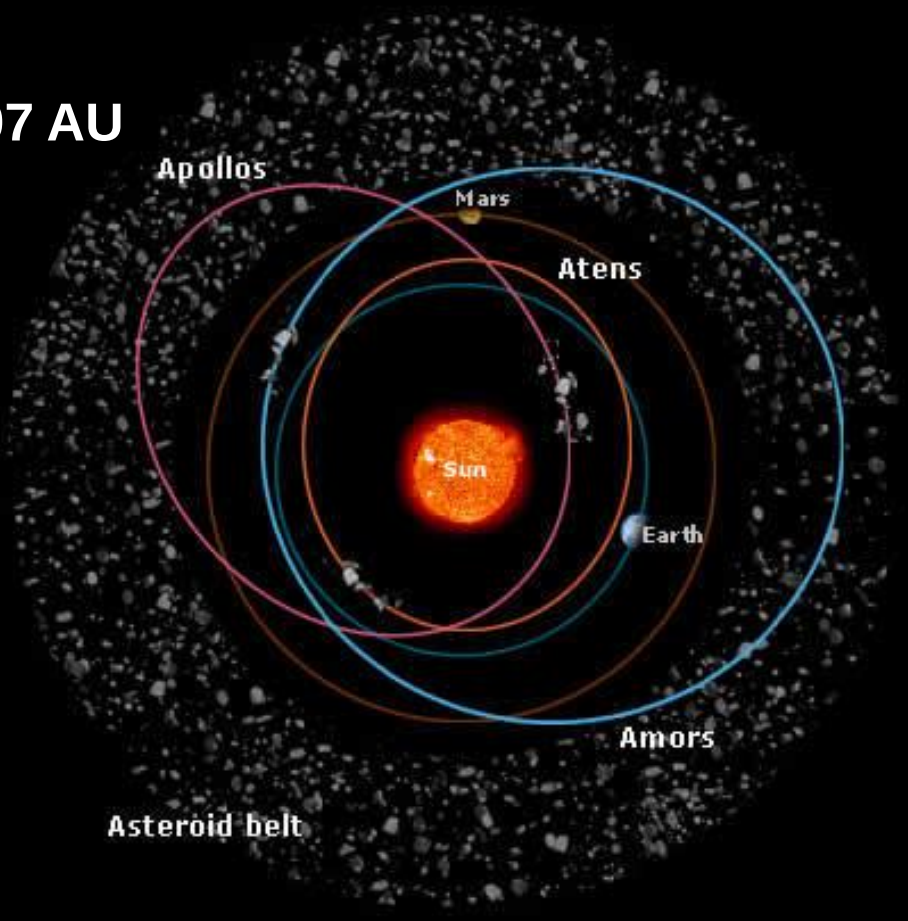
Asteroid orbit classifications:

Earth-crossing:

Apollos

Semi-major axis > 1.0 AU

Perihelion distance < 1.107 AU



Atens

Semi-major axis < 1.0 AU

Perihelion distance > 0.983 AU

Mars-crossing:

Amors

1.3 AU > perihelion distance > 1.017 AU

What are they made of?

Type	Composition	Percentage of Asteroids	Albedo (reflectivity)
Carbon (C-type)	Carbon	over 75 percent	0.03-0.09 (Very dark)
Silicate (S-type)	Metallic iron mixed with iron-silicates and magnesium-silicates	17 percent	0.10 -0.22 (Relatively bright)
Metallic (M-type)	Iron/ nickel	less than 7 percent	0.10-0.18 (Relatively bright)
Dark (D-type)	Water ice/frozen carbon monoxide mixed with rock	less than 1 percent	0.05 (Relatively dark and reddish)

M-type asteroid

Iron asteroids contain:

Metal, crystalline iron-nickel alloy, not an oxide mineral.

Up to 30% mineral inclusions, select one with ≤10%

Often >90% iron

5-62% nickel

Average:

88% Fe, 10 Ni, 0.5% Co

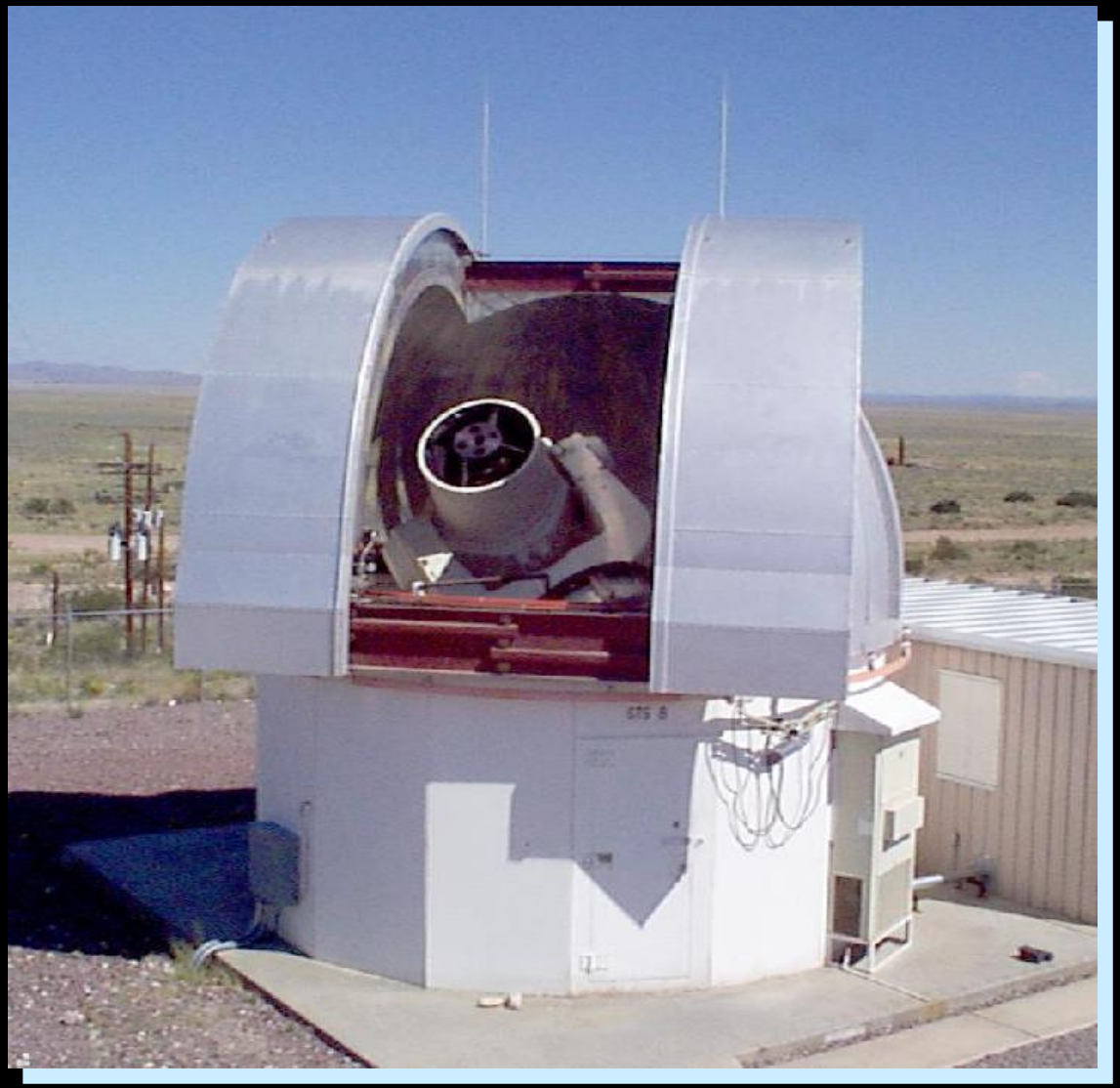
Silver & gold follow iron

PGM follow nickel

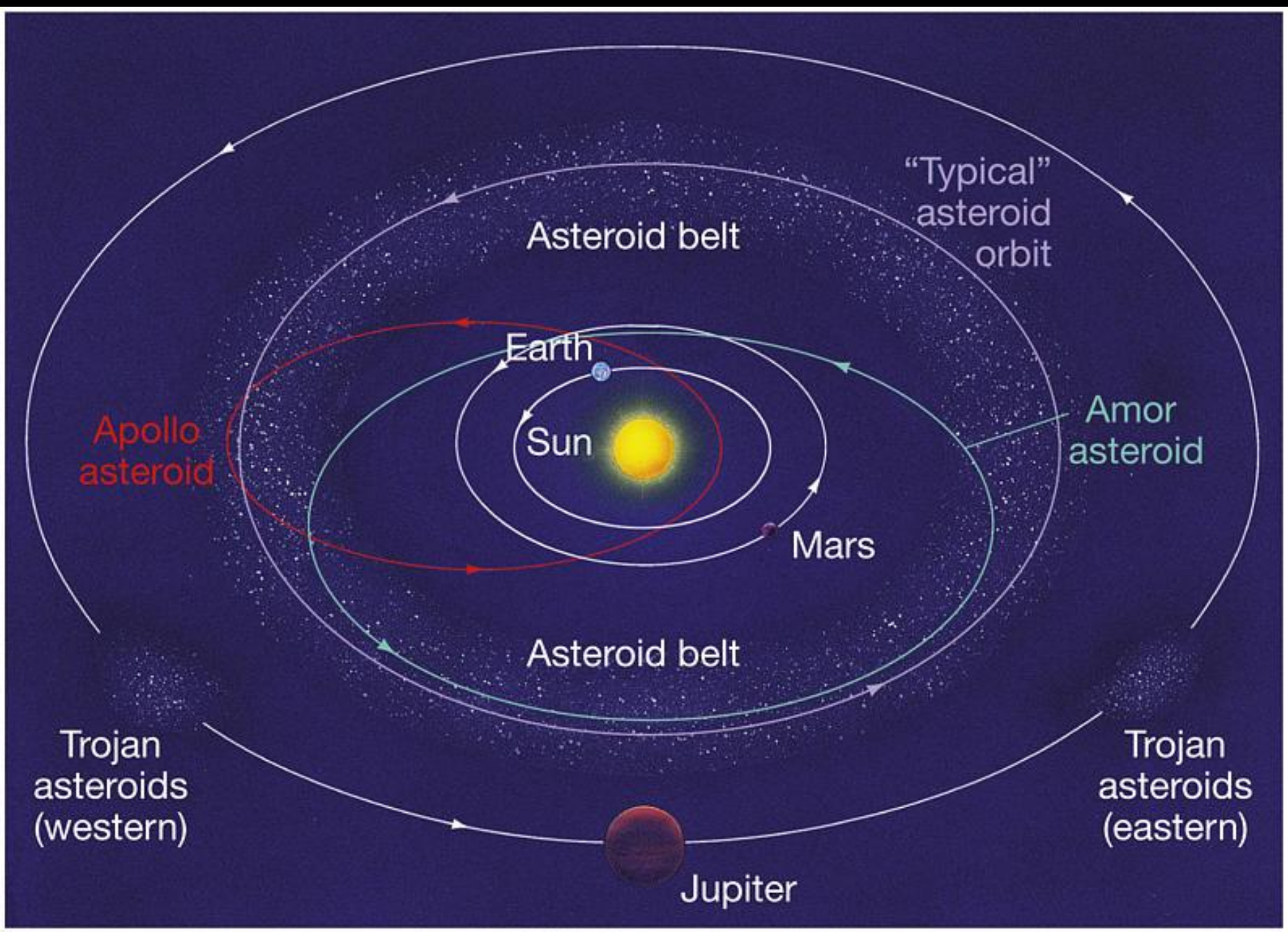
Select high Ni for platinum

How do we study asteroid?

LINEAR NEO Search Systems



Why are we interested in Asteroids?



What Happens When an Impact Takes Place?

Bolides (up to 5 MT)
- Great fireworks display, no damage

Tunguska-class (15 MT) impact
- Damage similar to large nuclear bomb (city-killer)
- Average interval for whole Earth: 100 yr.
- Minor risk relative to other natural disasters (earthquakes, etc.)

Larger local or regional catastrophes (*e.g.* 10,000 MT)
- Destroys area equivalent to small country
- Average interval for whole Earth: 100,000 yr.
- Moderate risk relative to other natural disasters

Global catastrophe (> 1 million MT)
- Global environmental damage, threatening civilization
- Average interval for whole Earth: 1 million years
- Major risk relative to other natural disasters

What Can We Do?

Strategies

- Detect
  - Project NEO (Near Earth Objects)
- Deflect
  - Gravitational Tractor

Impactor

- Destroy

LINEAR NEO Search Systems