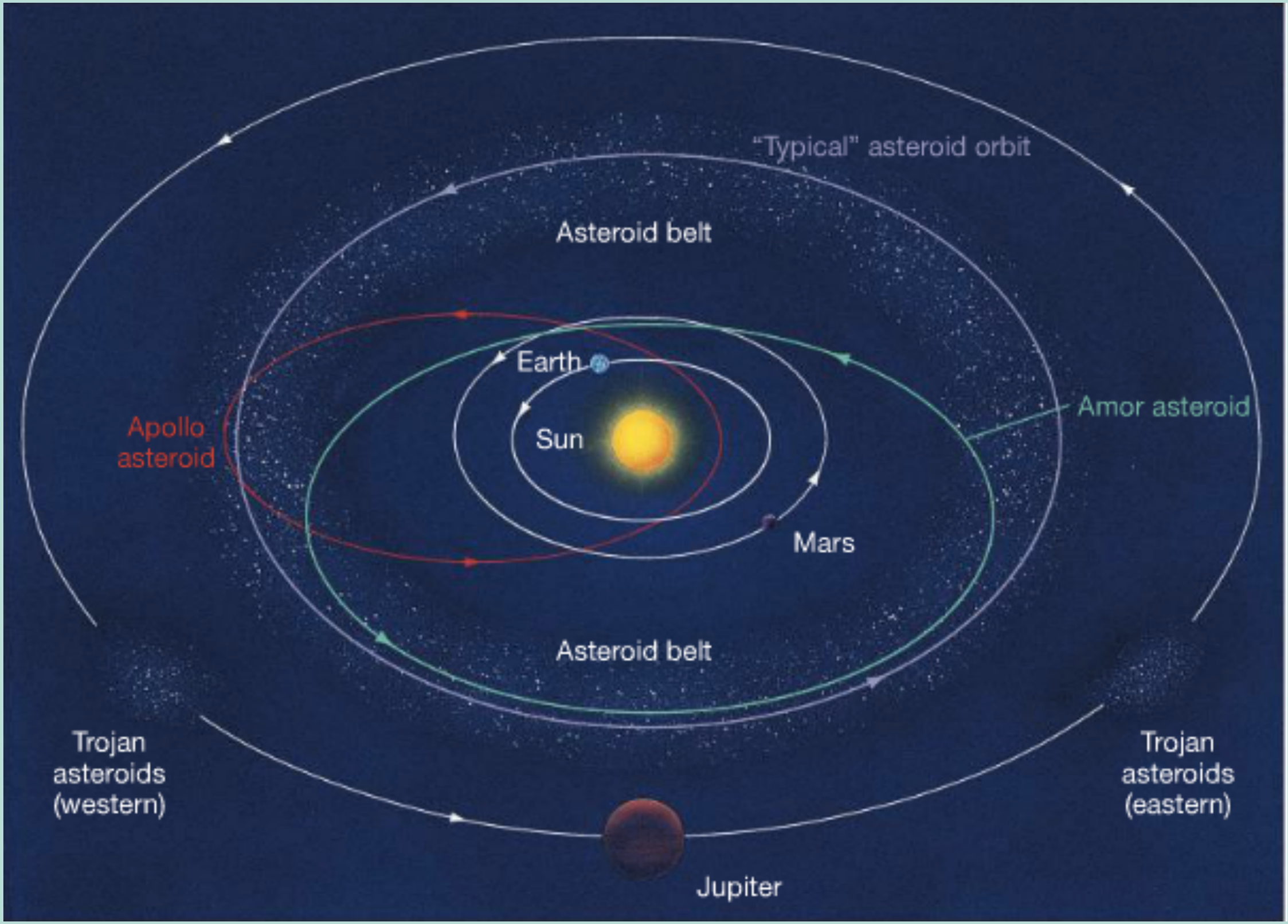
with your host:

Lecture 13:
Cosmic Debris

Coop

Cosmic Debris: Ch 16

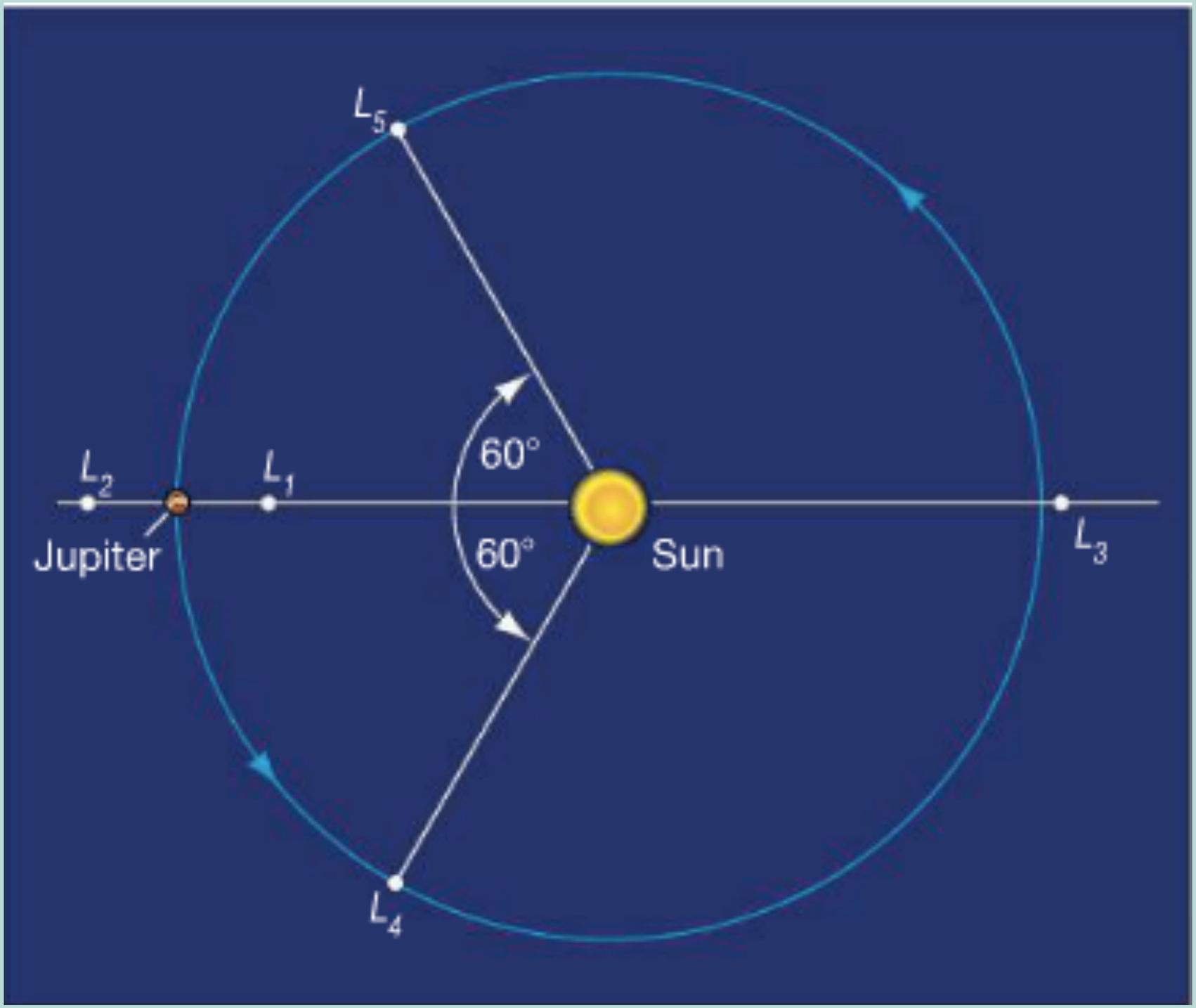


Cosmic Debris: Ch 16

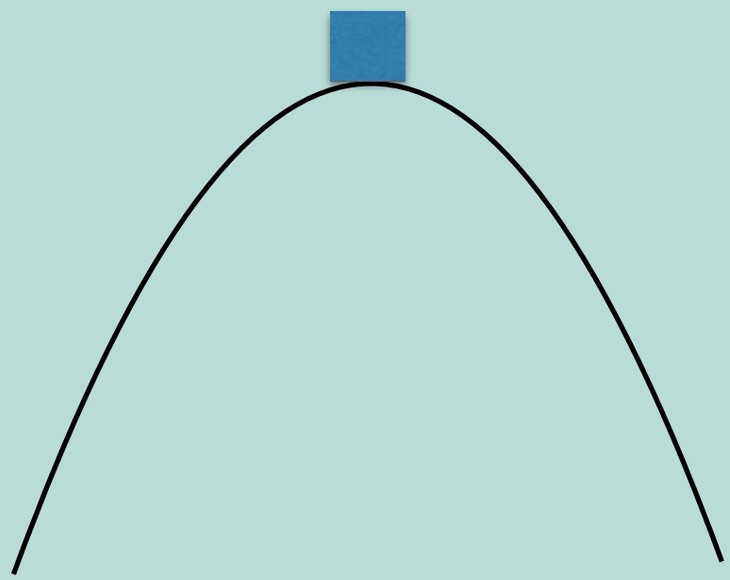
- ~ 3 AU
- 4% the mass of the moon
- Very few more than 300km across (mid size moon)
- Jupiter prevents larger objects from forming

Cosmic Debris: Ch 16

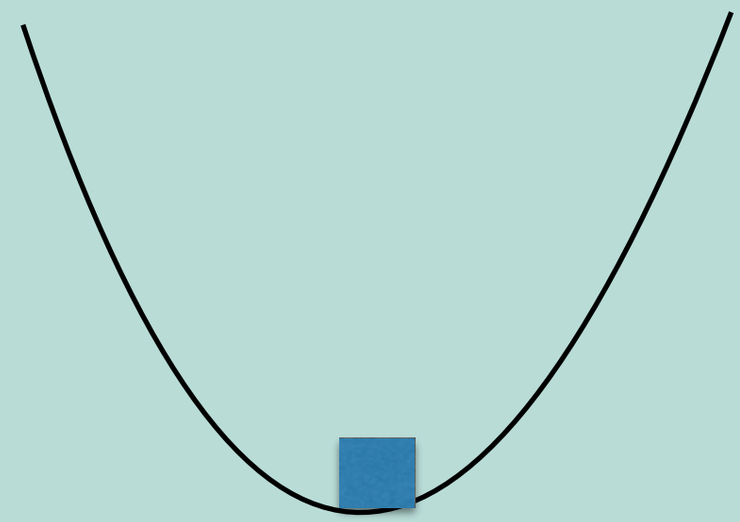
Lagrange Points Revisited



Cosmic Debris: Ch 16

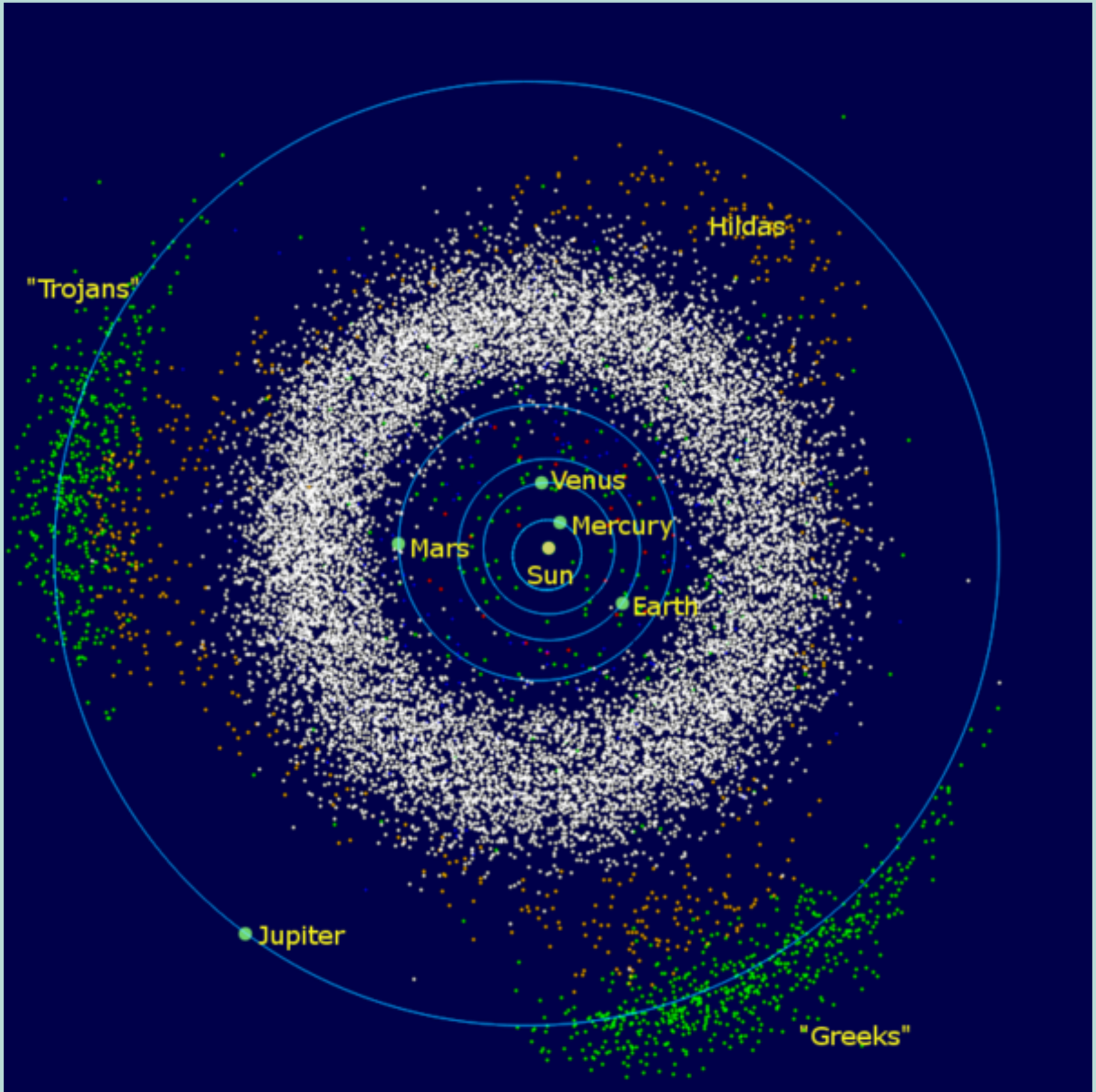


L1, L2, L3



L4, L5

Cosmic Debris: Ch 16



Cosmic Debris: Ch 16

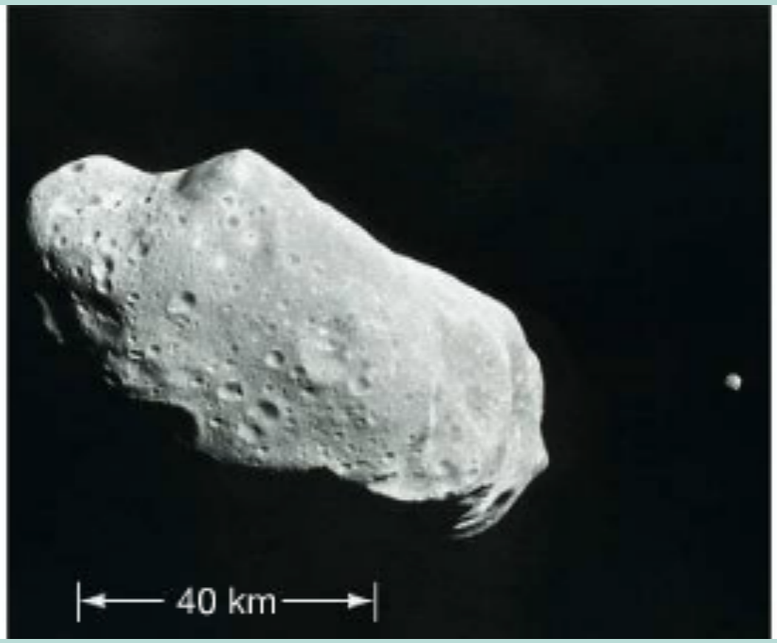
C-type: Carbonaceous, darkest (75%)

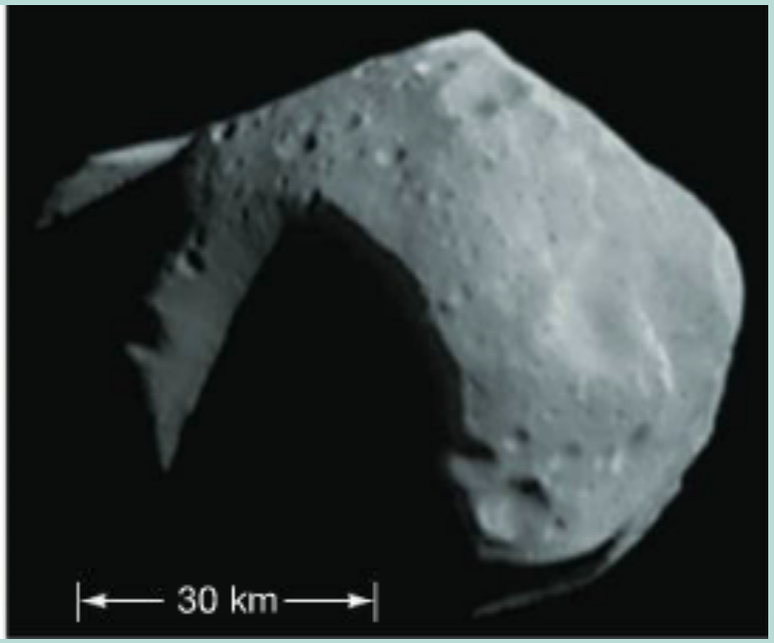
S-type: Silicate, More reflective, rocky (15%)

M-type: Nickel and Iron (10%)

Cosmic Debris: Ch 16

Dactyl!





S-type: Gaspara (Galileo)

S-type: Ida (Galileo)

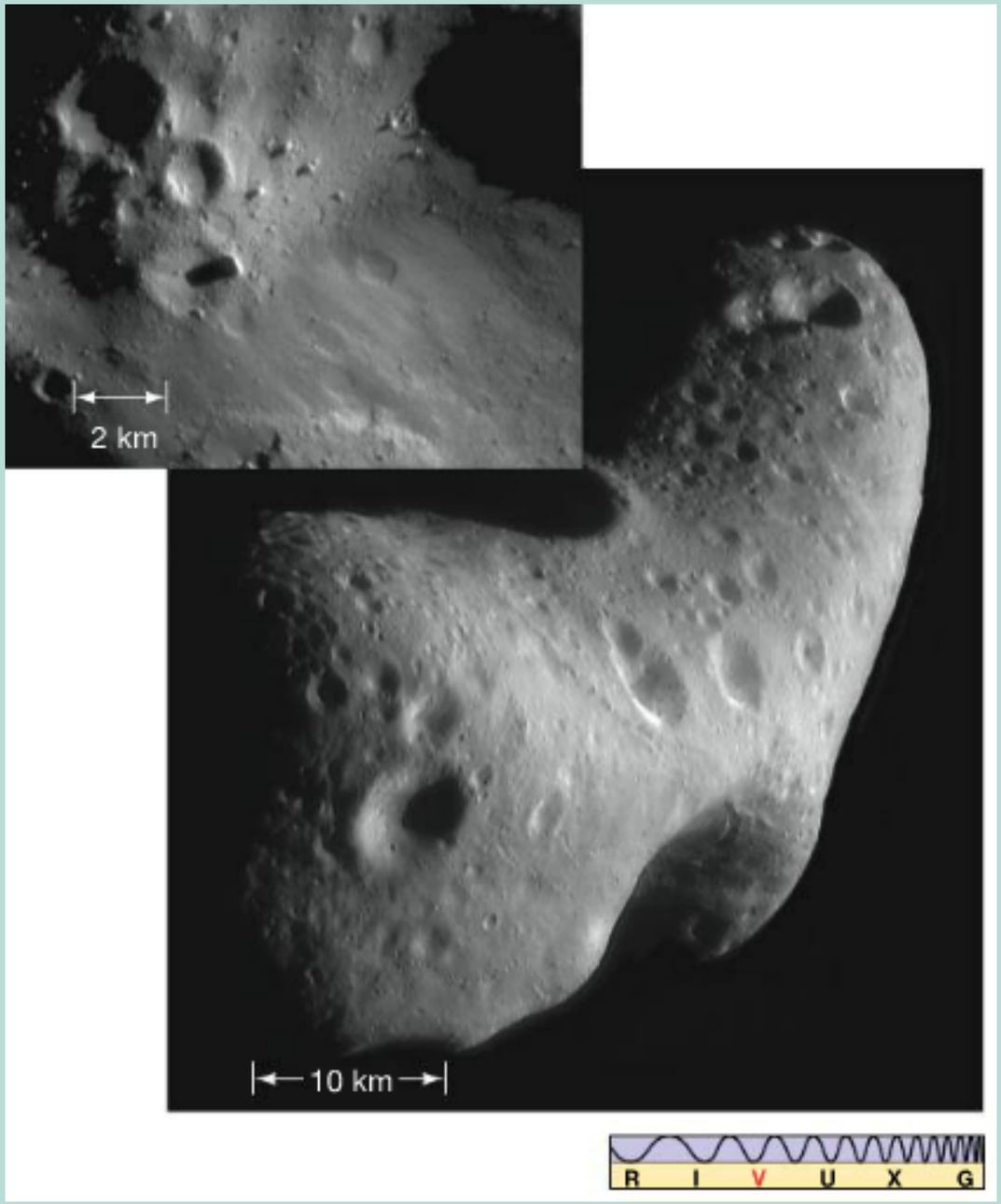
C-type: Mathilda (NEAR)

m~ 10^16, 10^17 kg

Near Earth Asteroid Rendezvous (NEAR)
1997

Cosmic Debris: Ch 16

Eros (NEAR)



Cosmic Debris: Ch 16

DAWN

Cosmic Debris: Ch 16

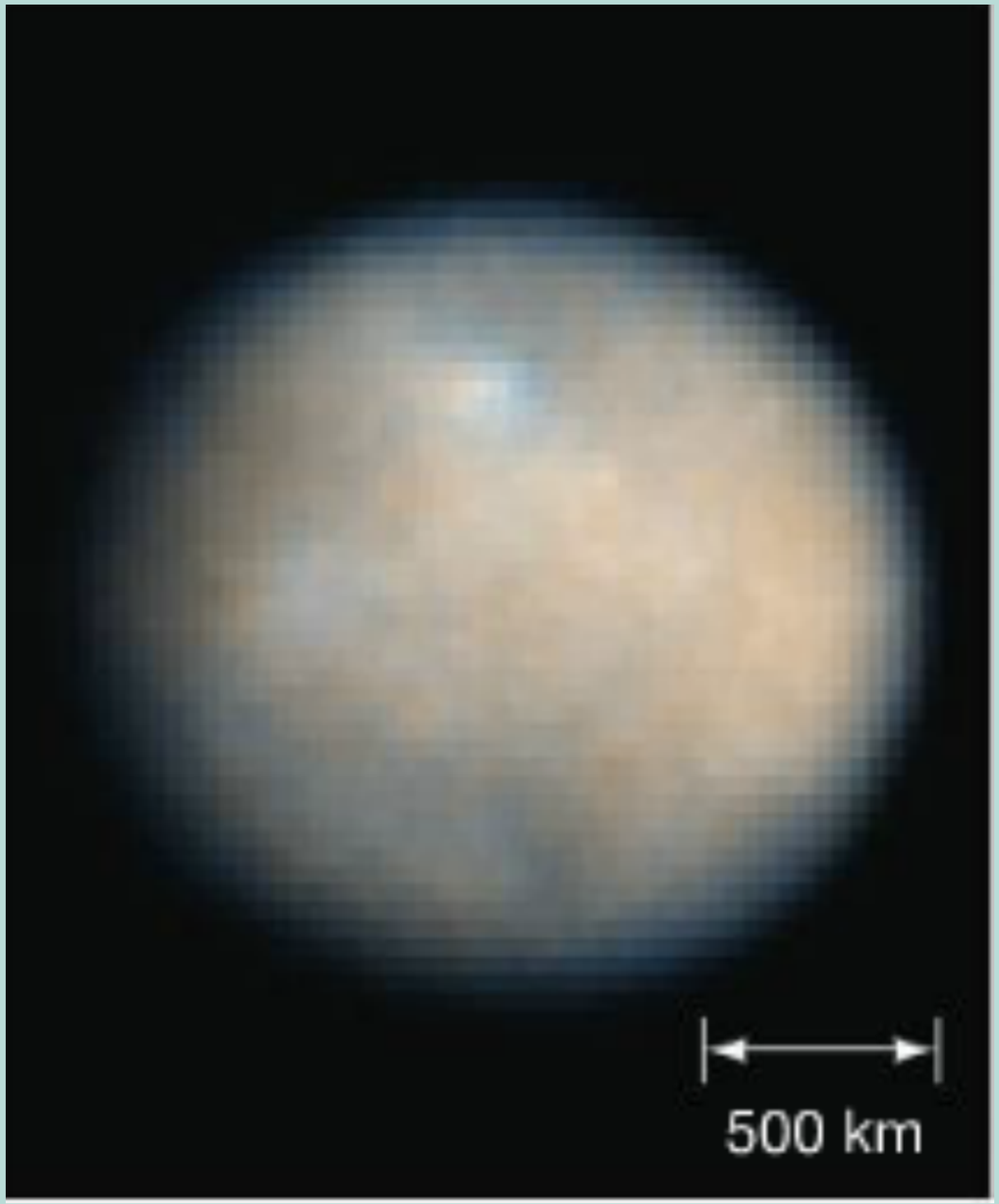
Vesta

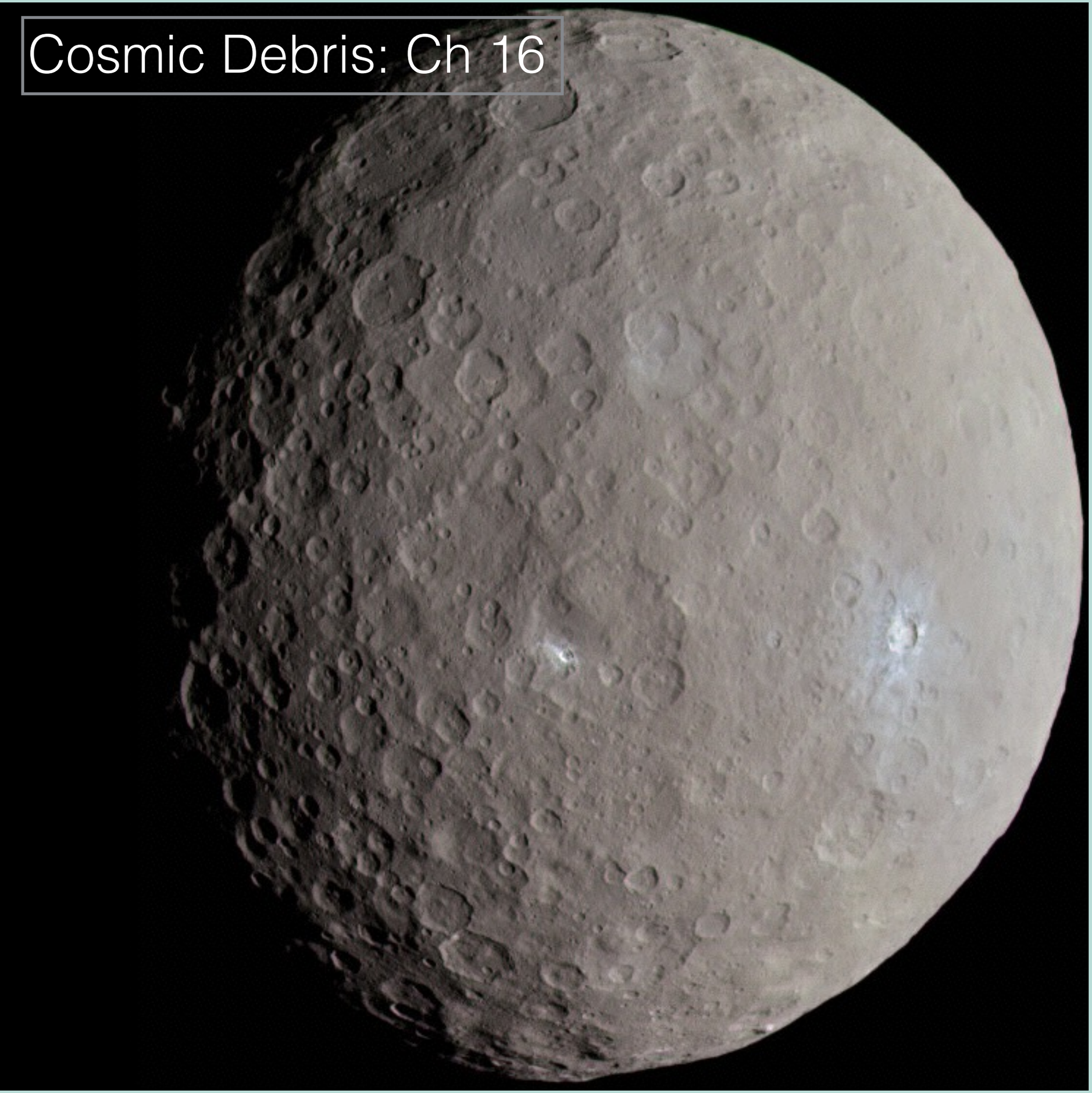
- Past Volcanism!
- m ~ 10^20 kg
- mountain in left image: 2 X the height of Everest!

Cosmic Debris: Ch 16

Better angle

Ceres Pre-Dawn





Ceres

m ~ 9.5e22 kg
~ 1.5e-4 m_e

r ~ 475 km
~ .075 r_e

(5 lbs)

d ~ 2.75 AU

density ~
2000 kg/m^3

Cosmic Debris: Ch 16

Relative Sizes

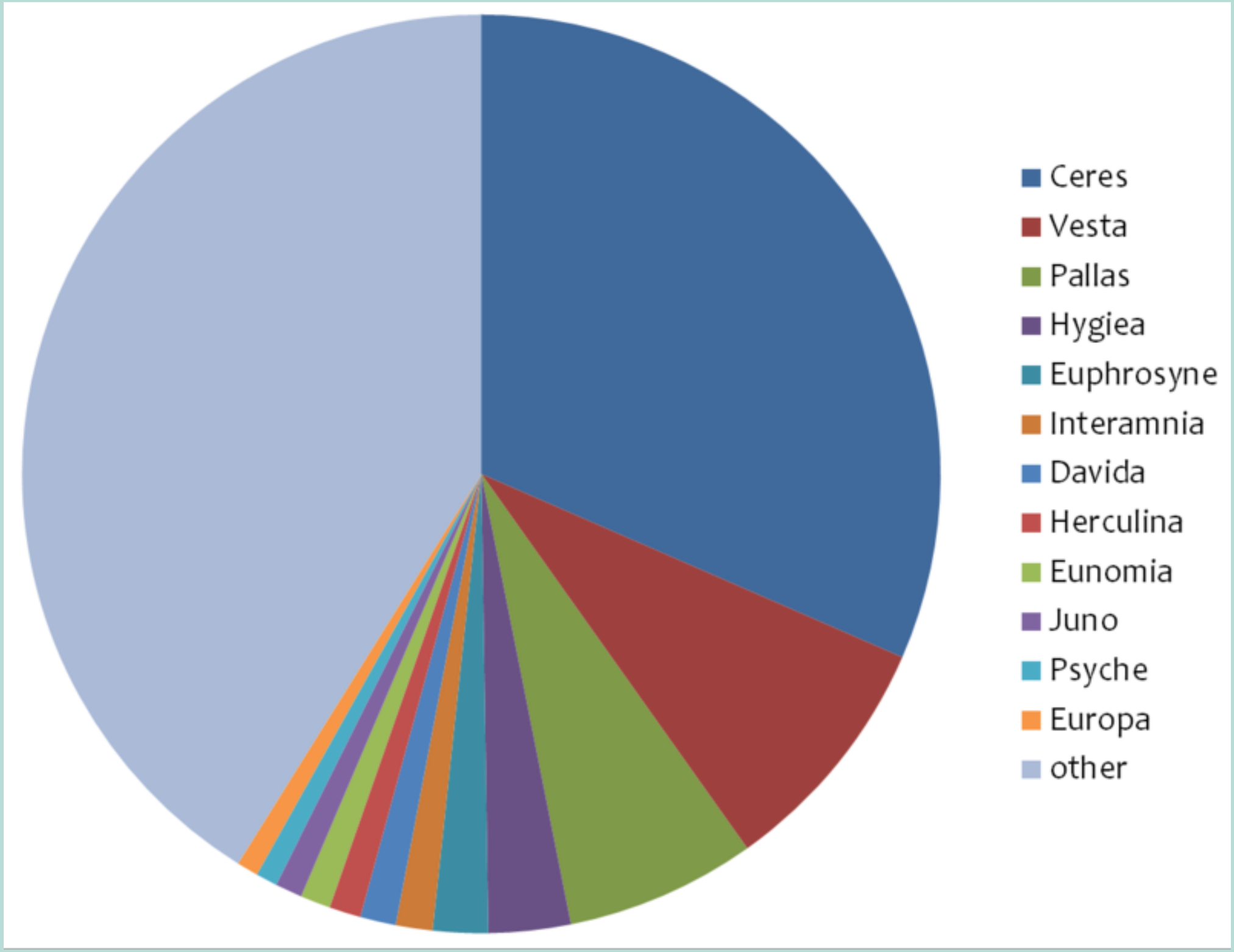
Cosmic Debris: Ch 16

Bode's Law

$$a = 0.4 + 0.3 \times 2^n$$

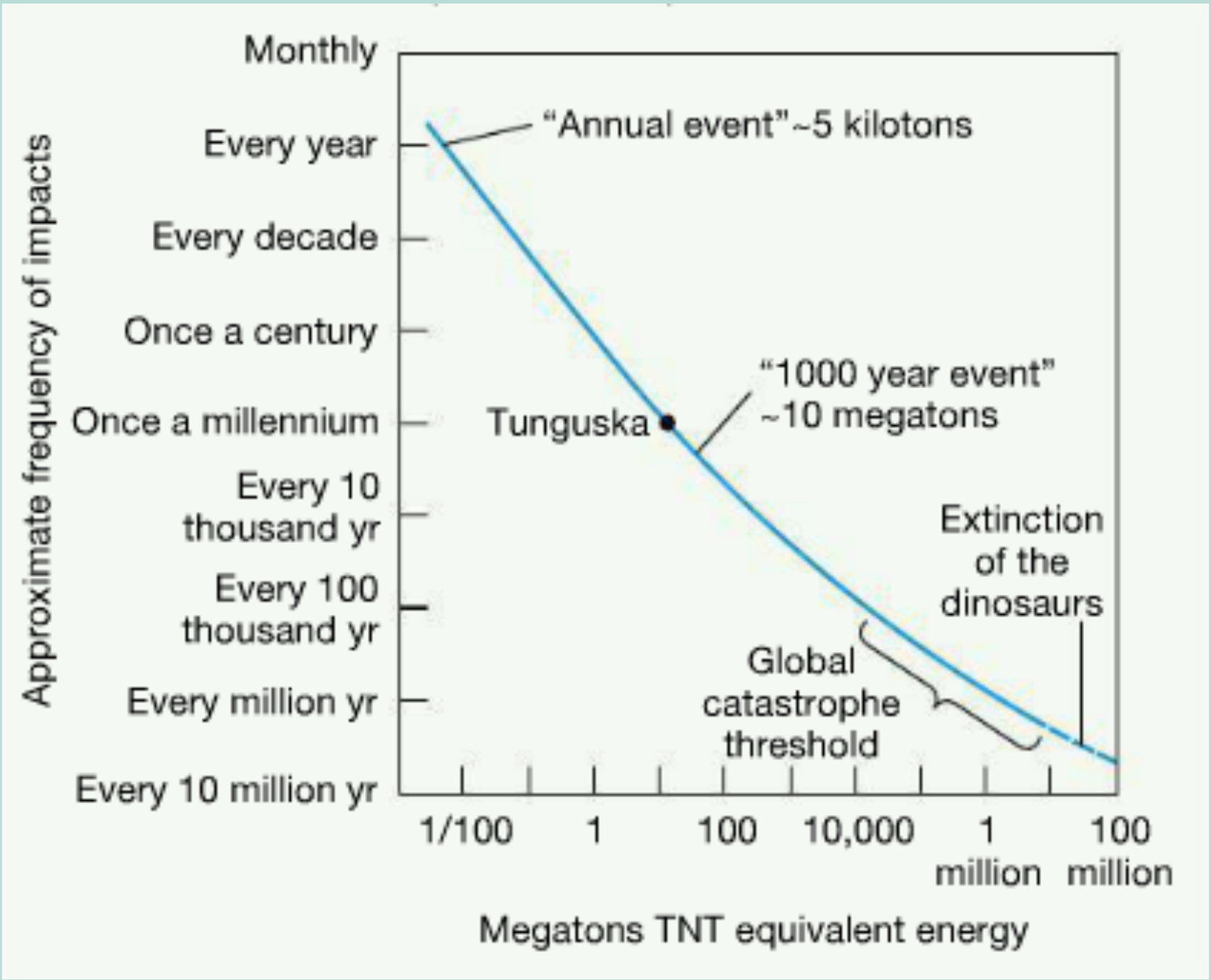
Uranus and Ceres were the gaps!

Cosmic Debris: Ch 16



Cosmic Debris: Ch 16

Doomsday Clock

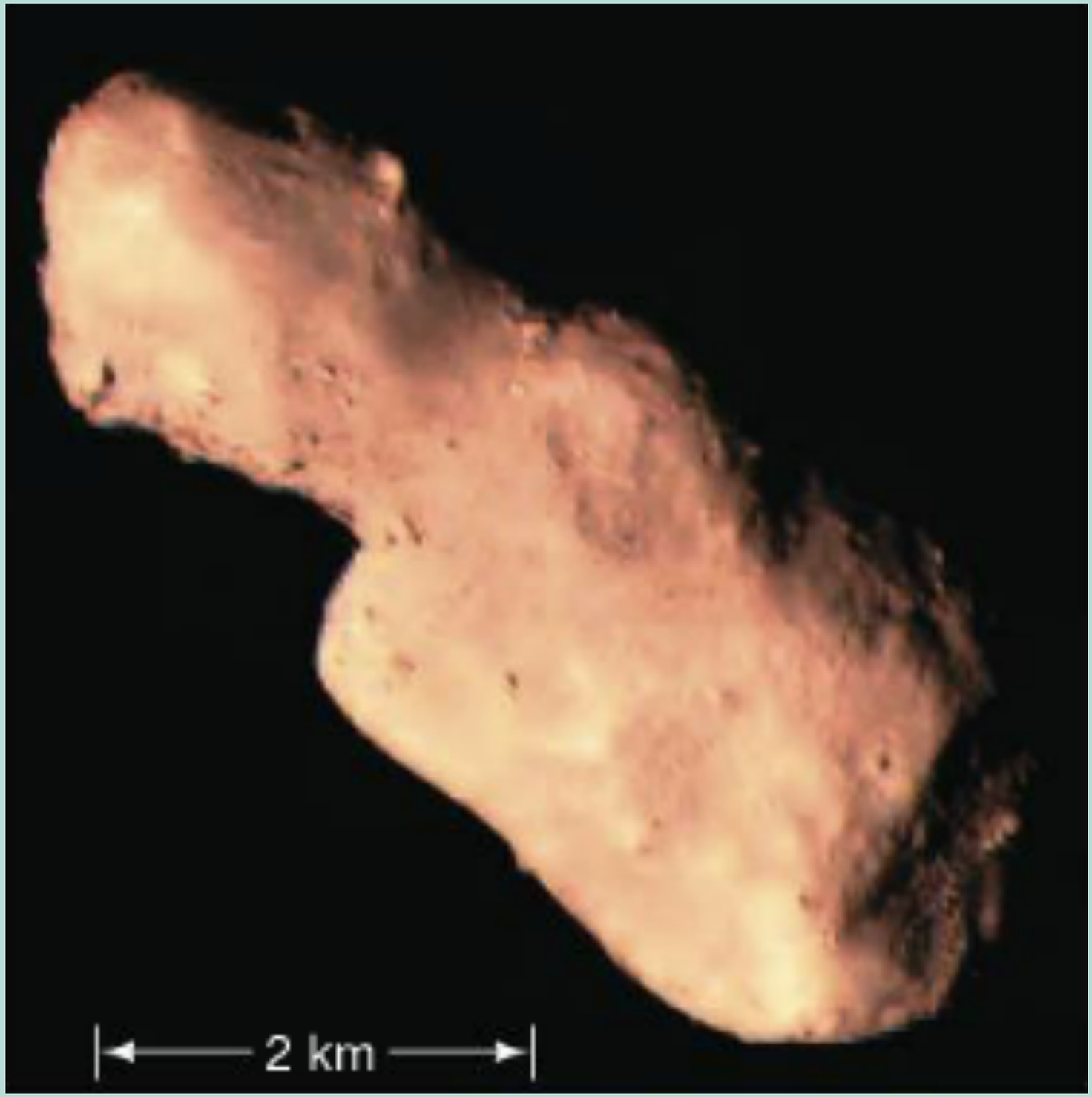


Cosmic Debris: Ch 16

Just a 1 km asteroid could devastate an area of some 100 km in diameter (NYC metro) with as much energy as 1 million 1-megaton nukes (100 times to total human arsenal)

Cosmic Debris: Ch 16

Toutatis



missed us by 1.5e6 km.

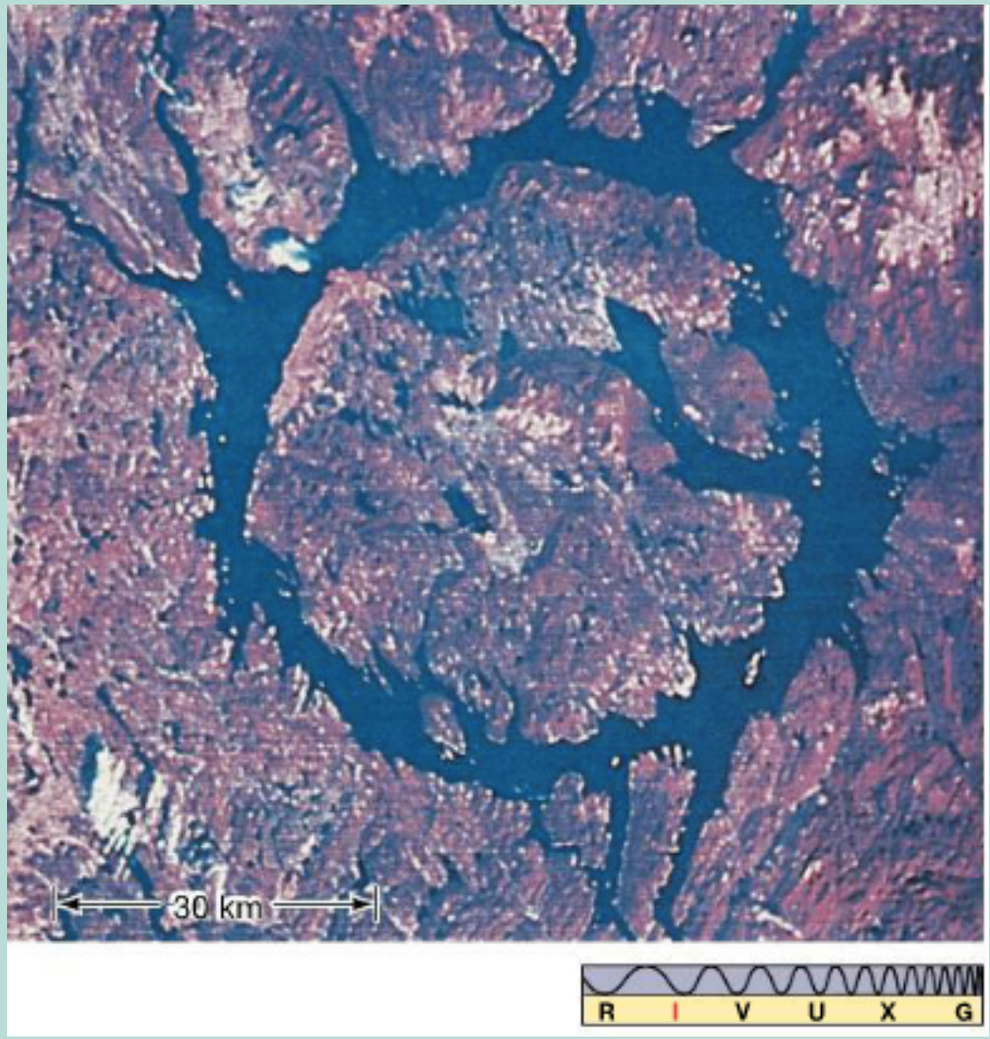
Cosmic Debris: Ch 16

1908

Cosmic Debris: Ch 16

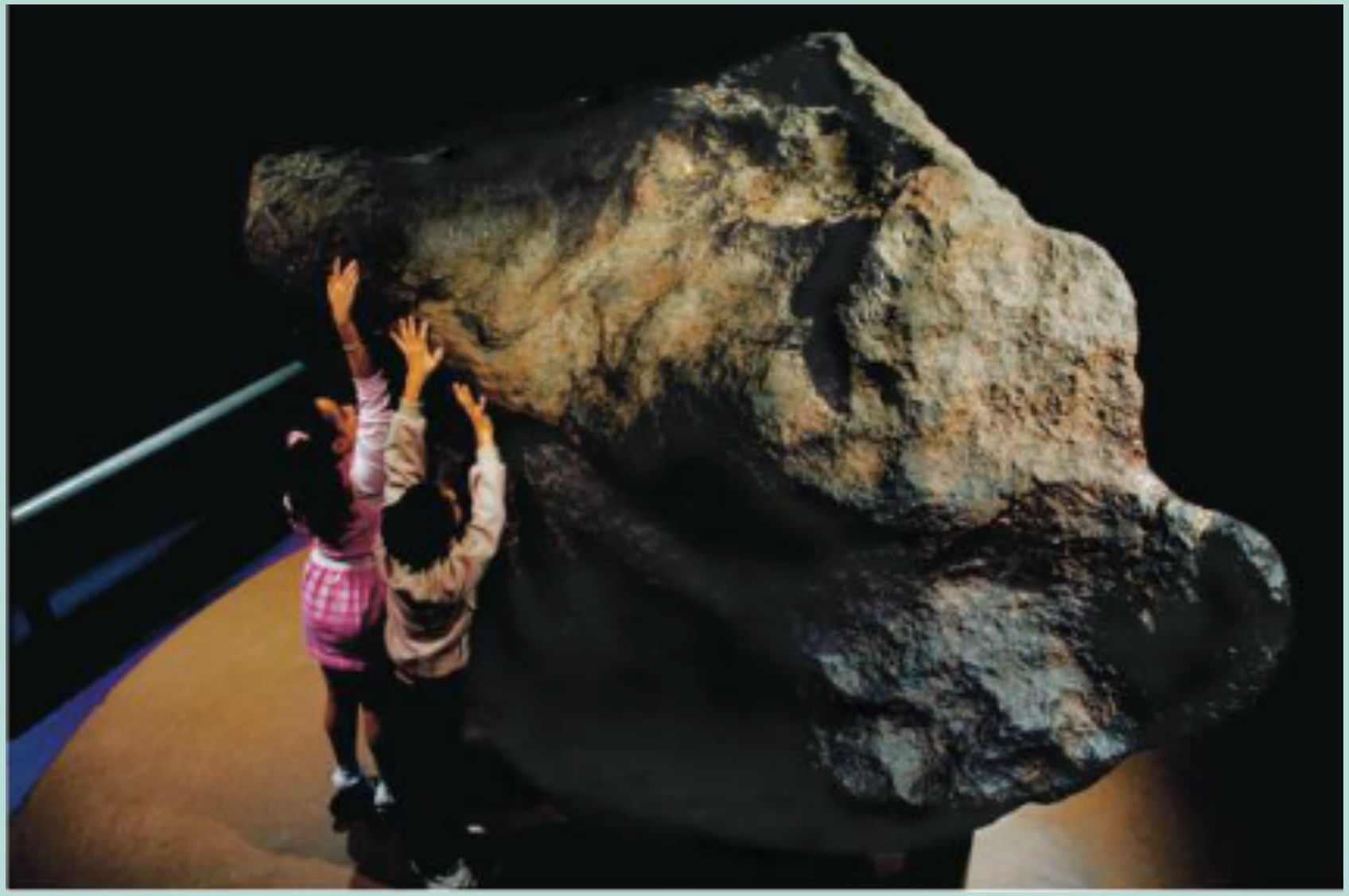
Cosmic Debris: Ch 16

Manicouagan Reservoir



Cosmic Debris: Ch 16

Museum of Natural History, NYC



34 ton

Cosmic Debris: Ch 16

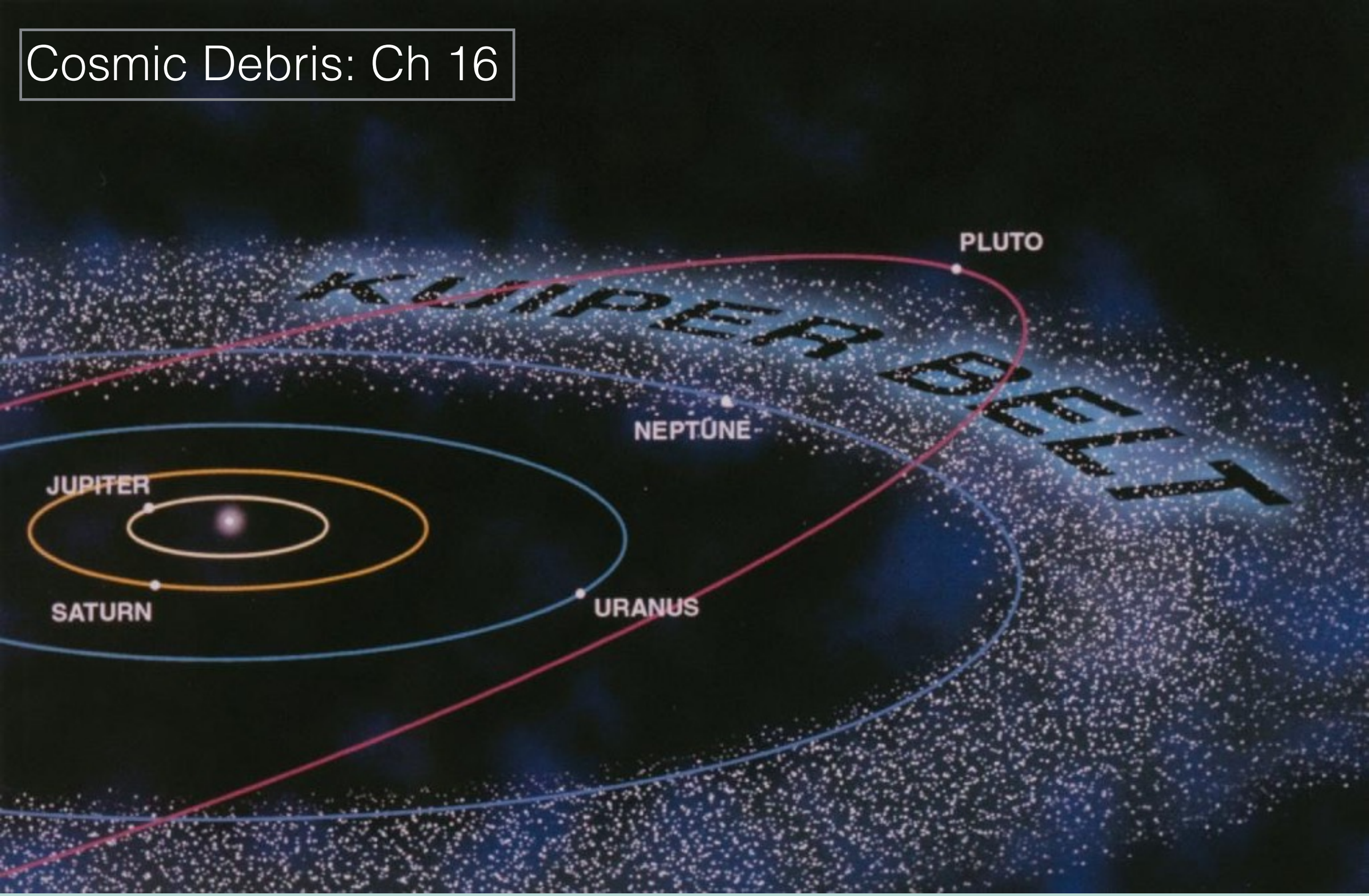
Wabar Meteorite in the Arabian Desert

Cosmic Debris: Ch 16

Meteorites

~4.4-4.6 billion years old

Cosmic Debris: Ch 16



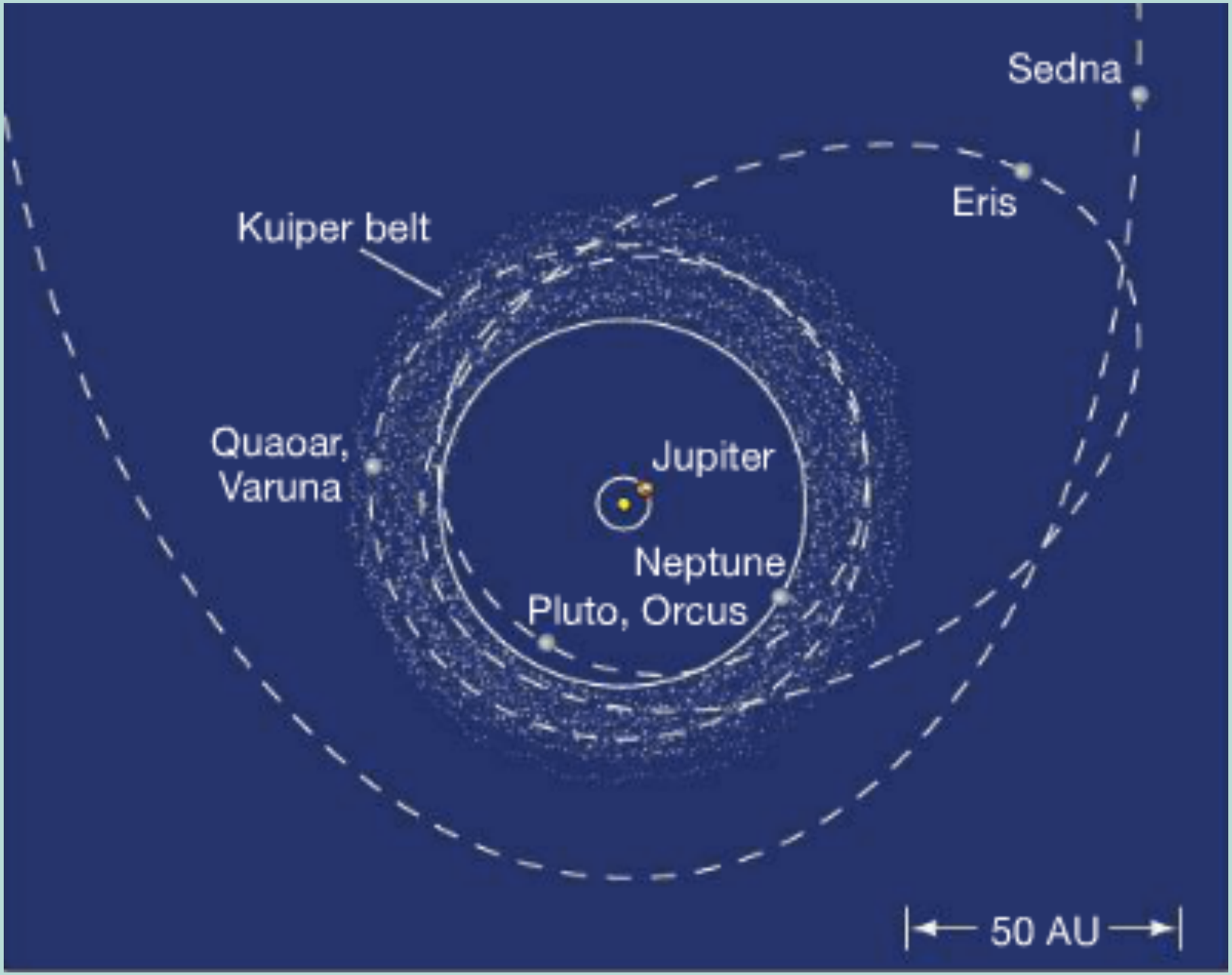
30-50 AU

Cosmic Debris: Ch 16

DISCUSSION

Cosmic Debris: Ch 16

Orbits of Various Kuiper Belt Objects

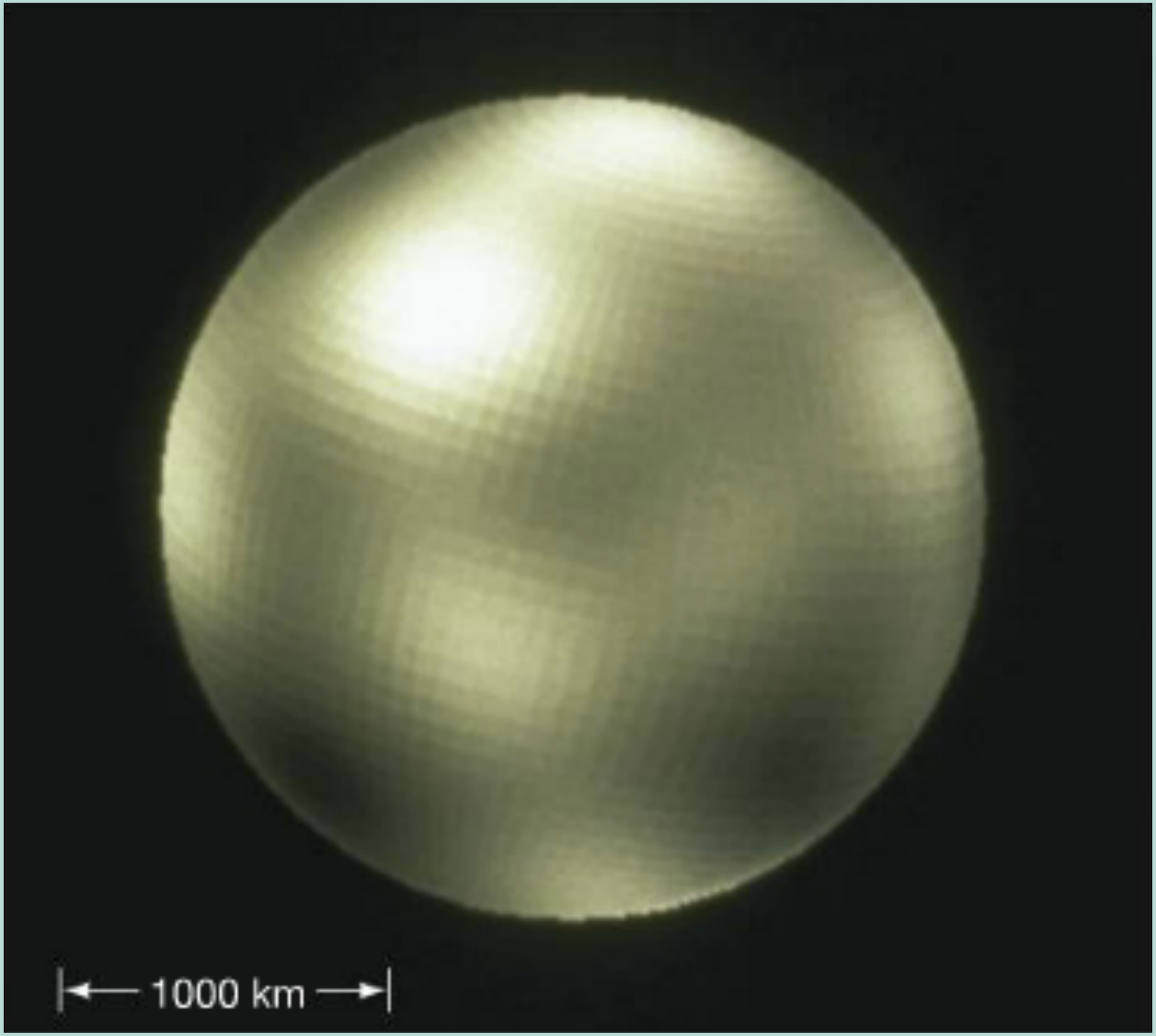


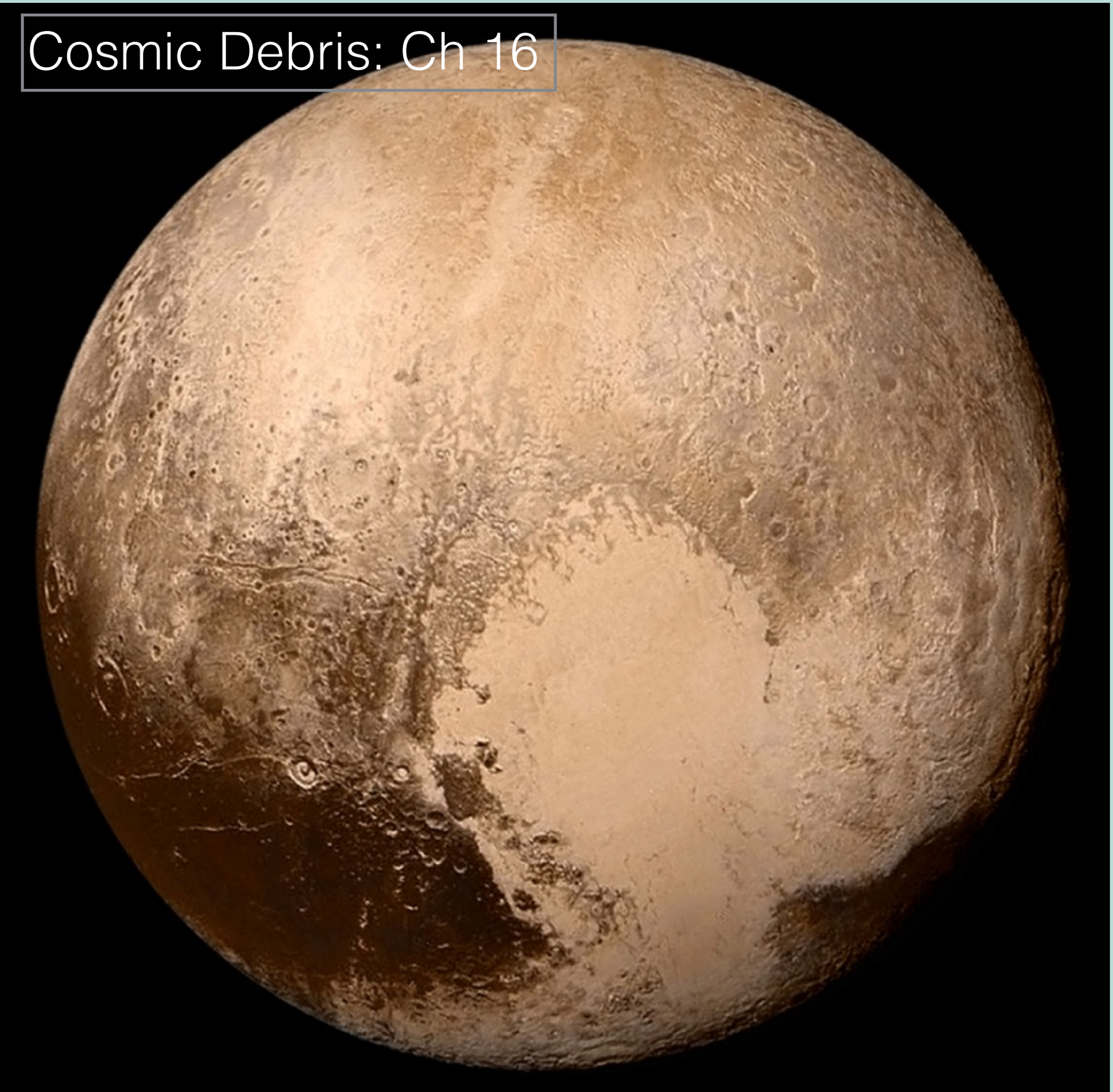
Cosmic Debris: Ch 16

False.

Cosmic Debris: Ch 16

Why?





Pluto

m~ 1.3e22 kg
~ .002 m_e

r~ 1.1e3 km
~ .186 r_e

(11 lbs)

d~ 40 AU

density ~
2000 kg/m^3

Cosmic Debris: Ch 16

Sun

Mercury

Venus

Earth

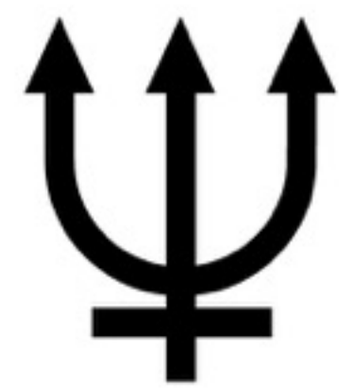
Moon

Mars

Jupiter

Saturn

Uranus



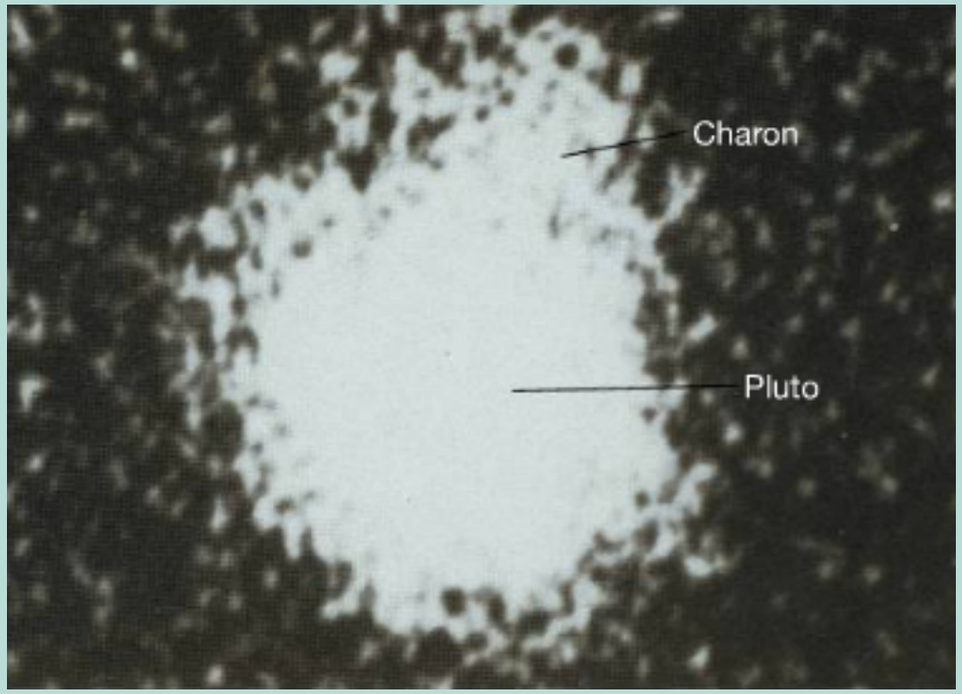
Neptune

Pluto

Cosmic Debris: Ch 16

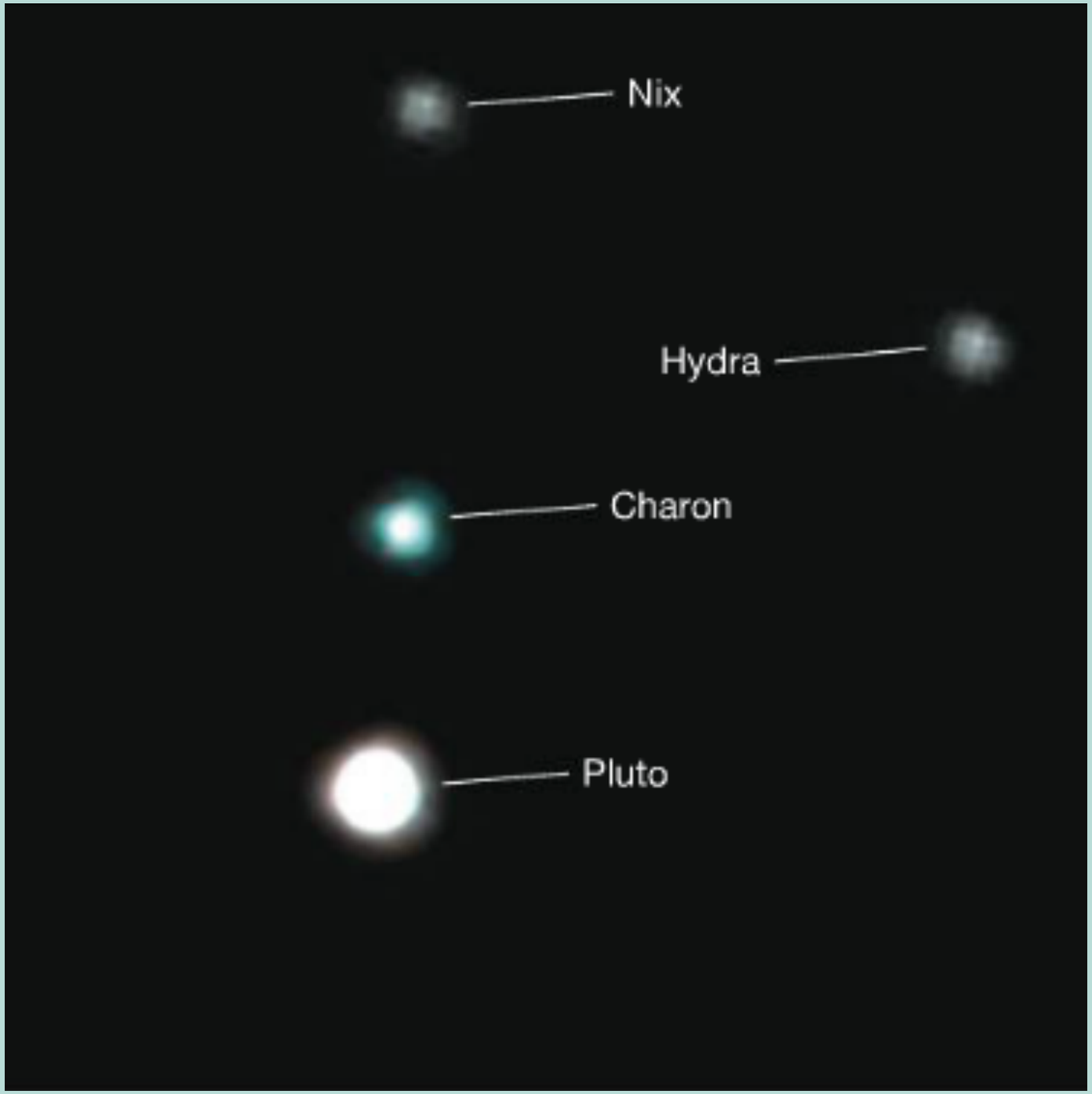
Cosmic Debris: Ch 16

Eureka!



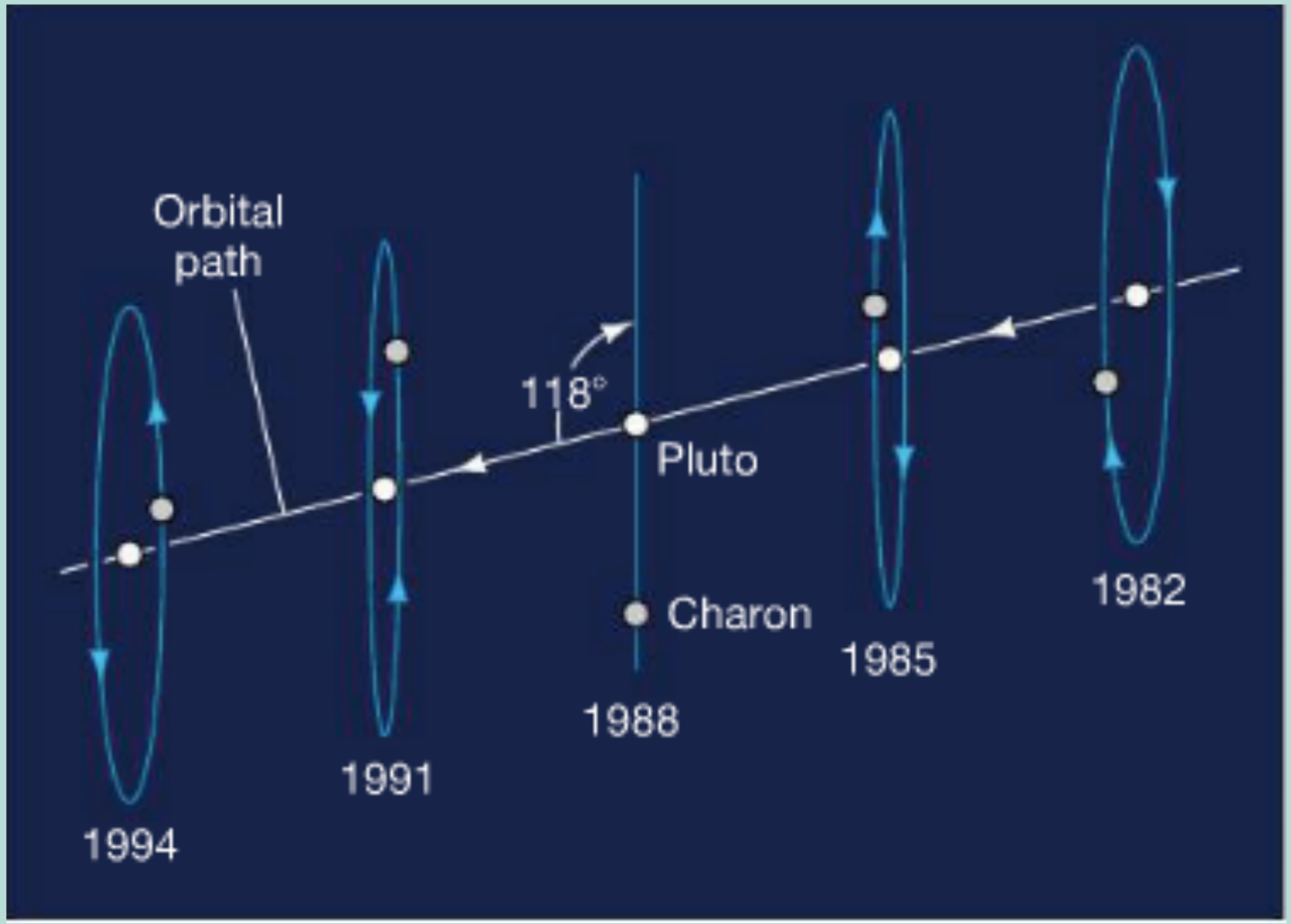
Cosmic Debris: Ch 16

Pluto and its moons



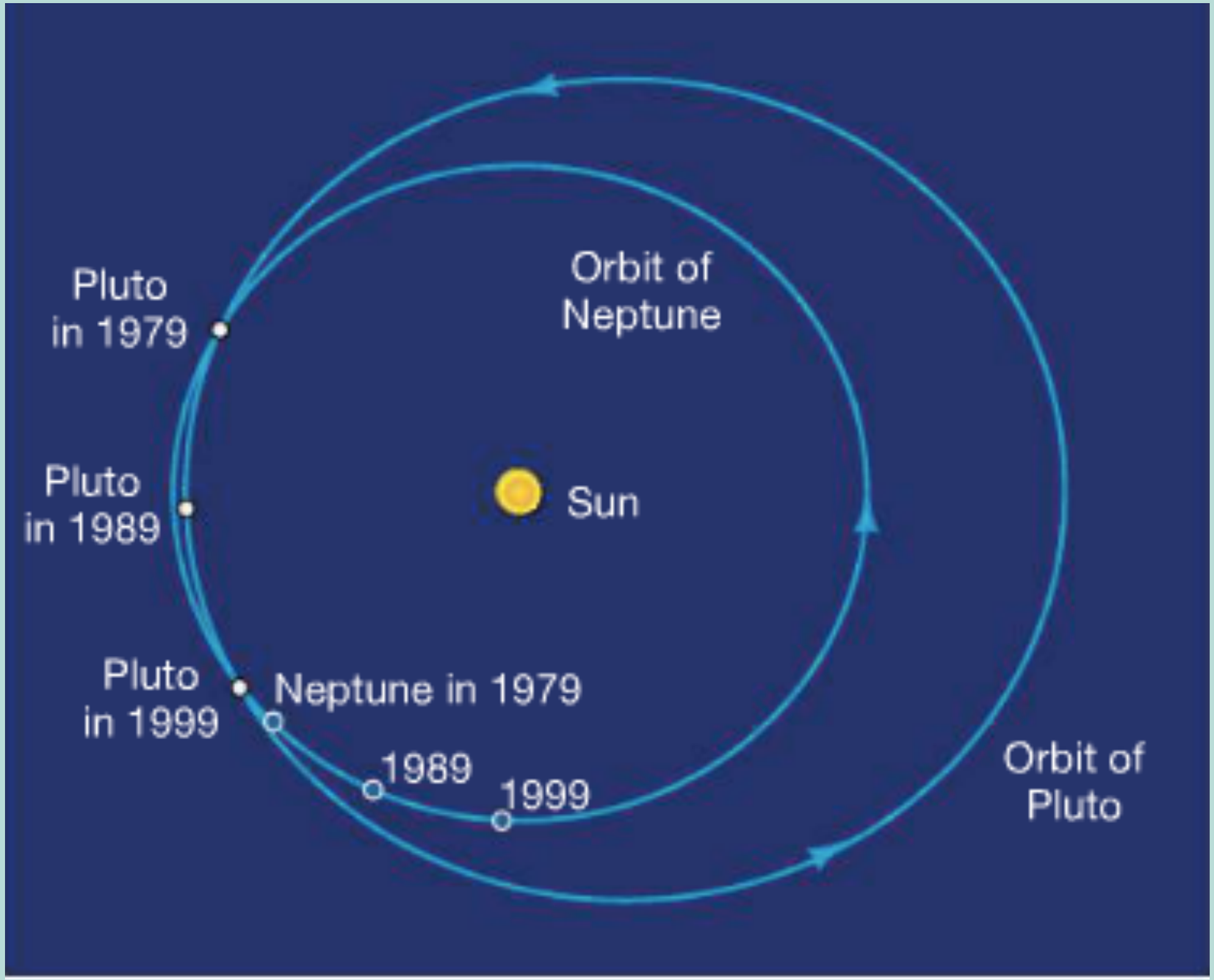
Cosmic Debris: Ch 16

A fortuitous event



Cosmic Debris: Ch 16

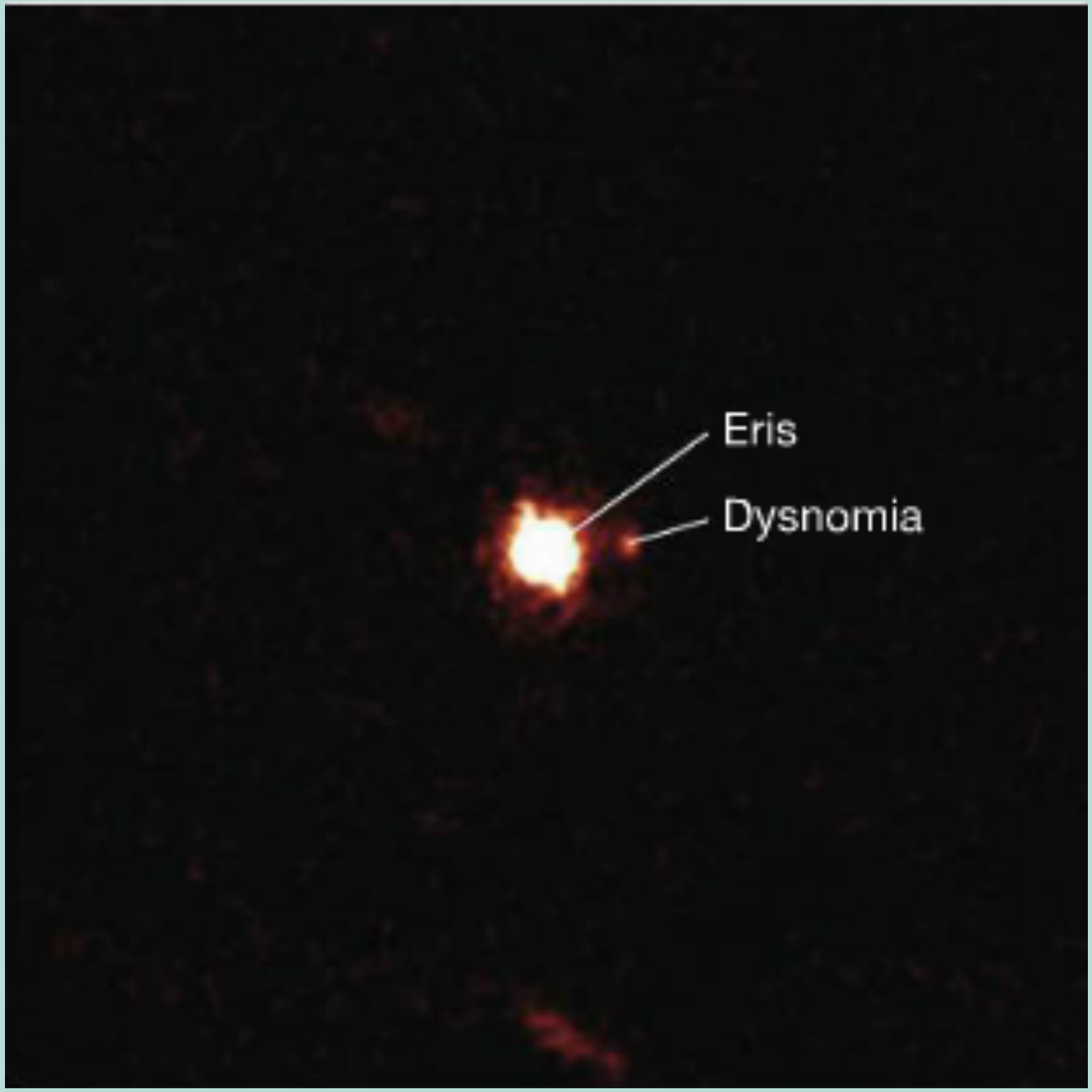
My Childhood was Confusing



e-pluto ~ .25

e-neptune ~ .0085

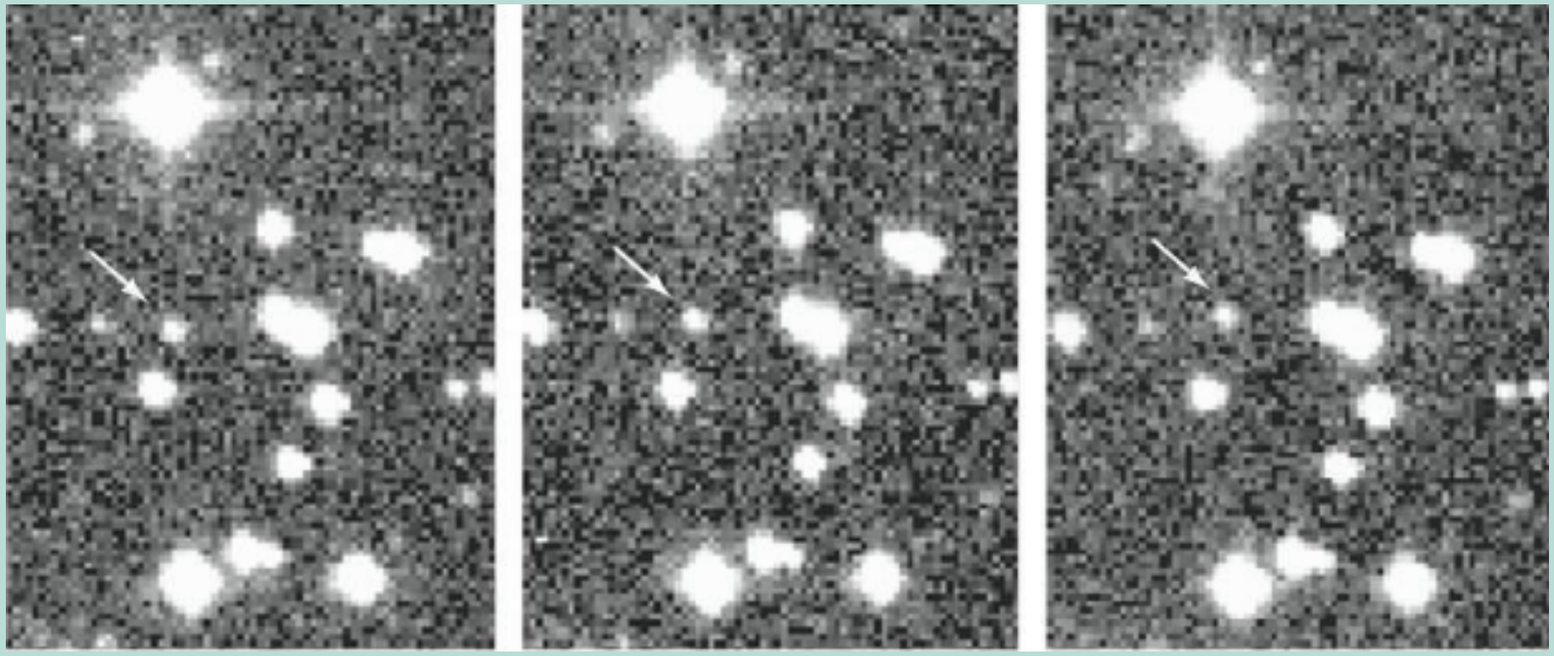
Cosmic Debris: Ch 16



(~70 AU)

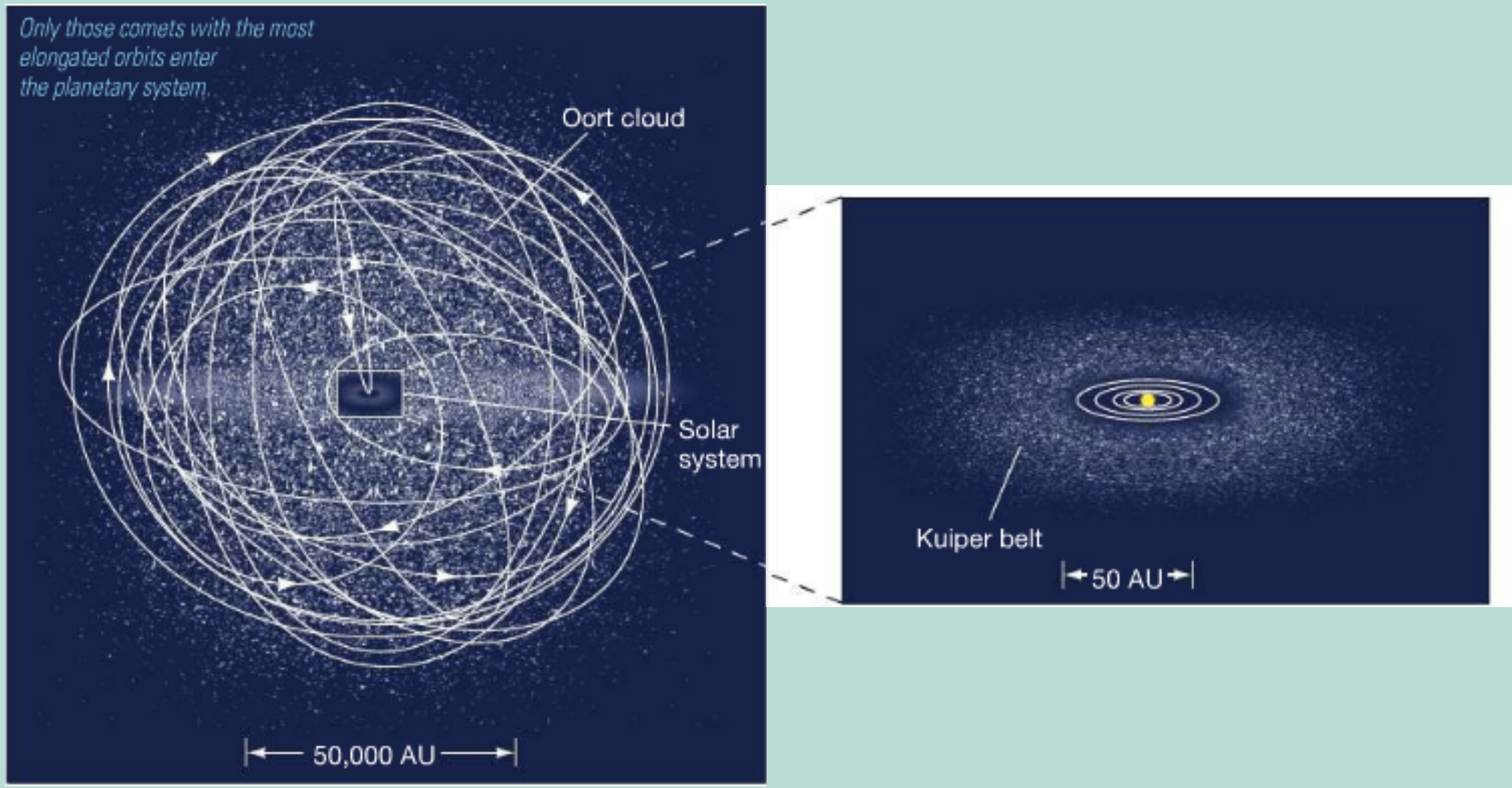
Cosmic Debris: Ch 16

Pholus



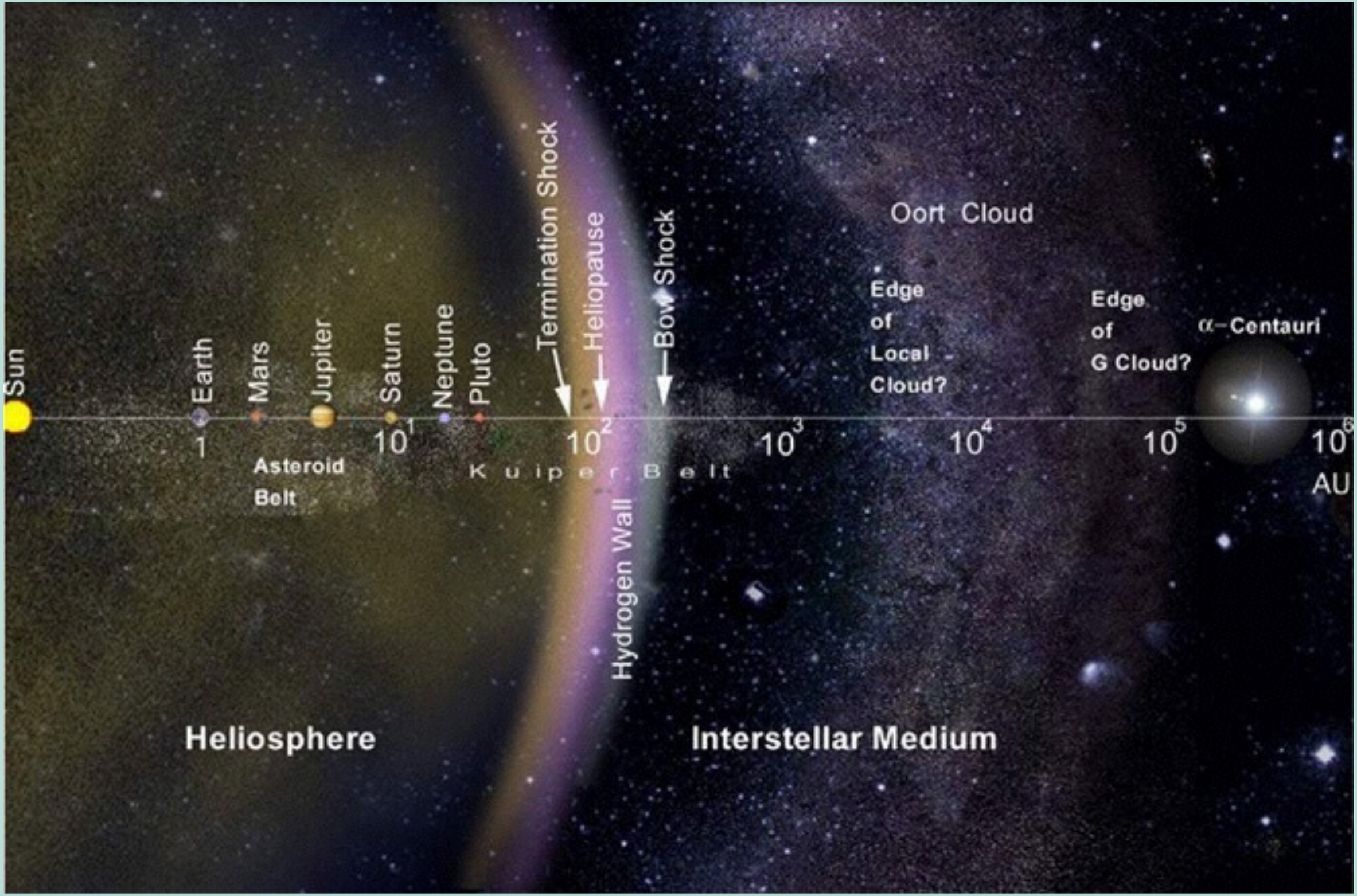
Cosmic Debris: Ch 16

The Ort Cloud

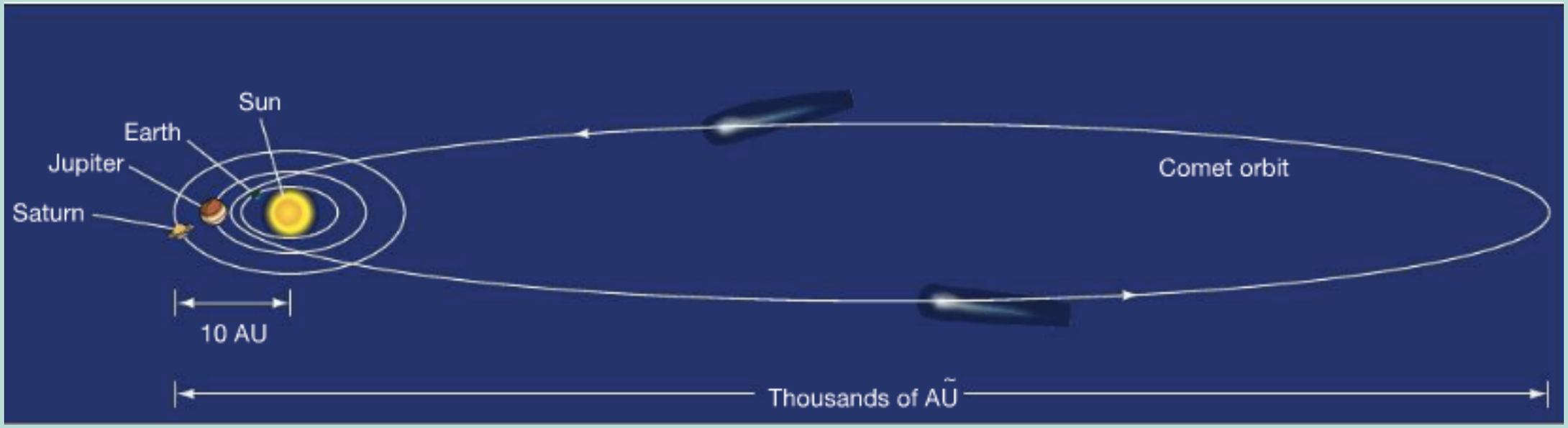


Cosmic Debris: Ch 16

Log Plot (careful!)



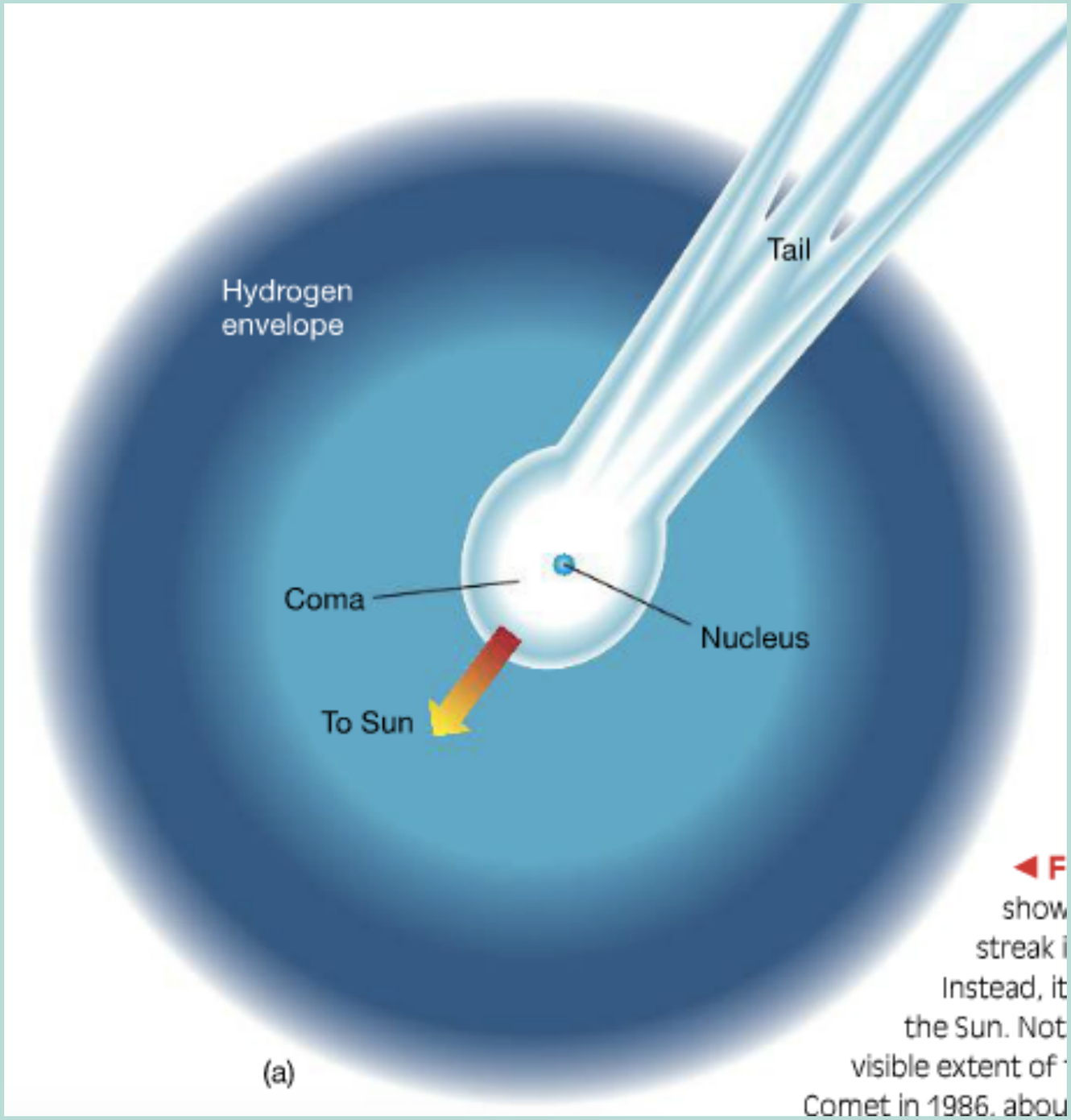
Cosmic Debris: Ch 16



"Thousands of A$\widetilde{u}$"

Cosmic Debris: Ch 16

Comet Anatomy



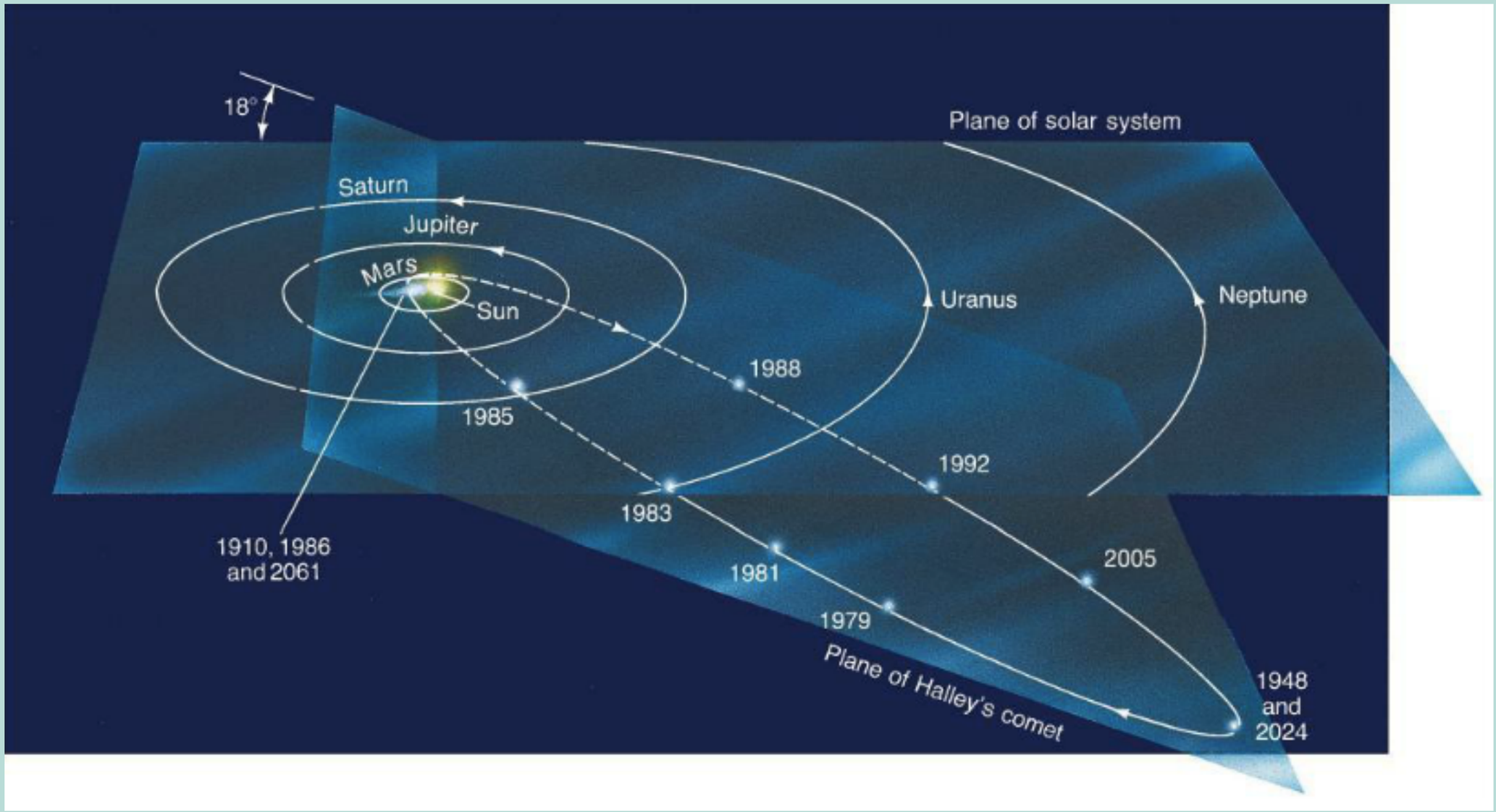
◀ F
show
streak i
Instead, it
the Sun. Not
visible extent of
Comet in 1986, abou

Cosmic Debris: Ch 16

- Icy nucleus obtains a coma due to sublimation near sun
- Sublimation rates reach 10^30 molecules / second (30 tons of material!)
- Coma can be up to the size of saturn
- Tails span as much as an AU! (2000 R_J)

Cosmic Debris: Ch 16

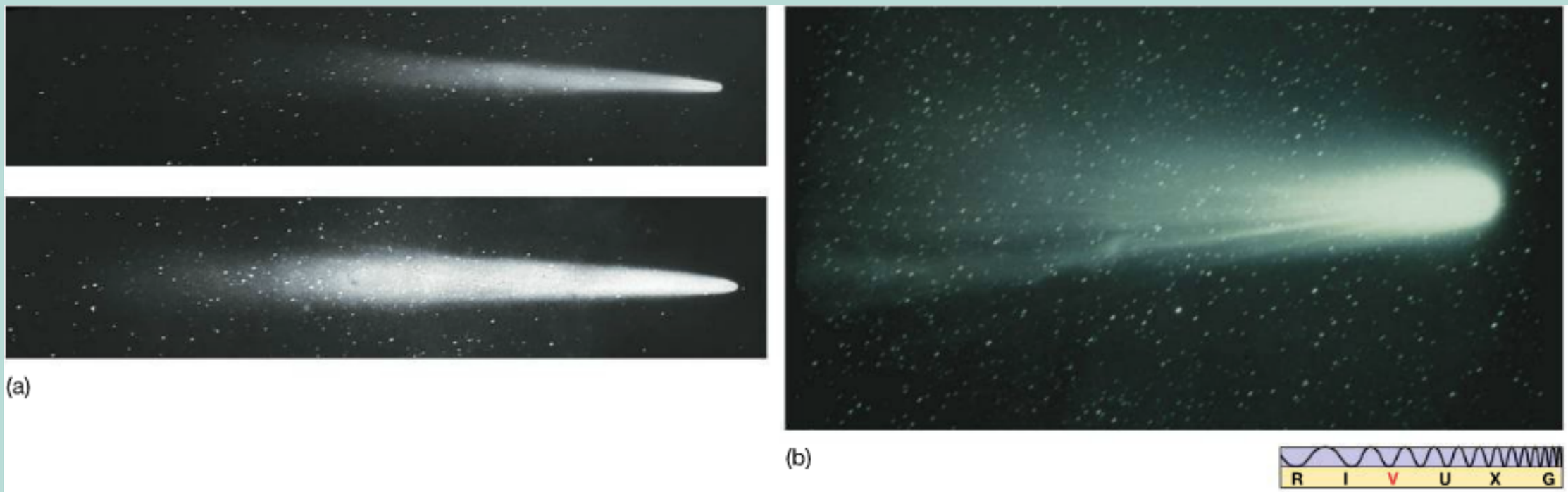
Halley's Comet



- 76 year period (1986 last sighting)
- Sightings go back to 240 BC

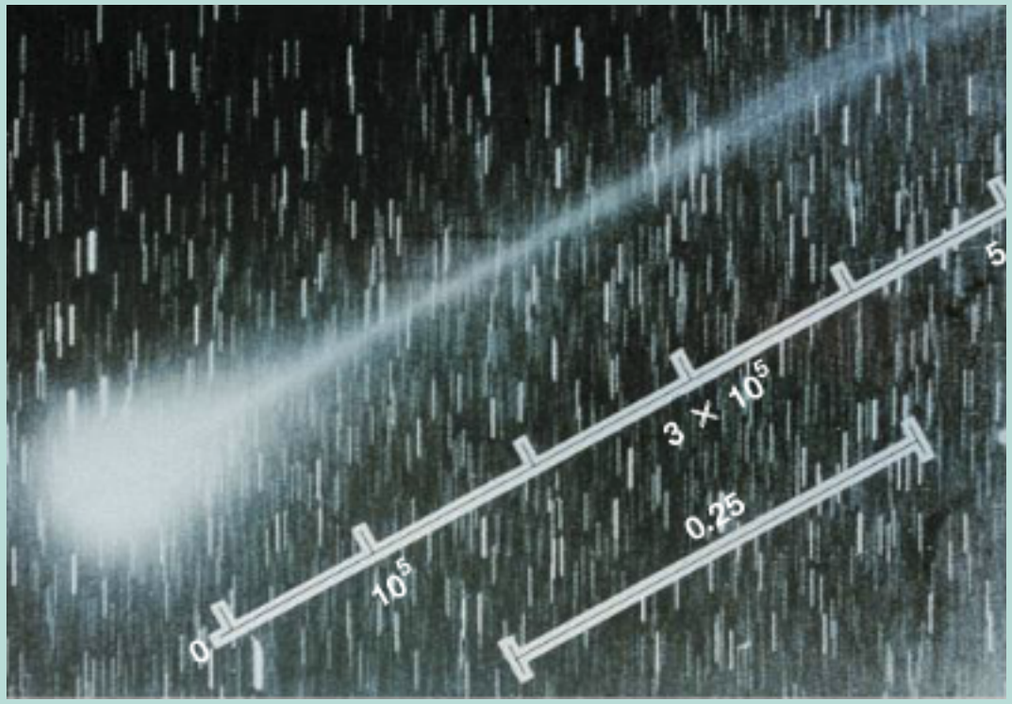
Cosmic Debris: Ch 16

Halley Comet tails



Cosmic Debris: Ch 16

Giocobini Zinner Ion Tail

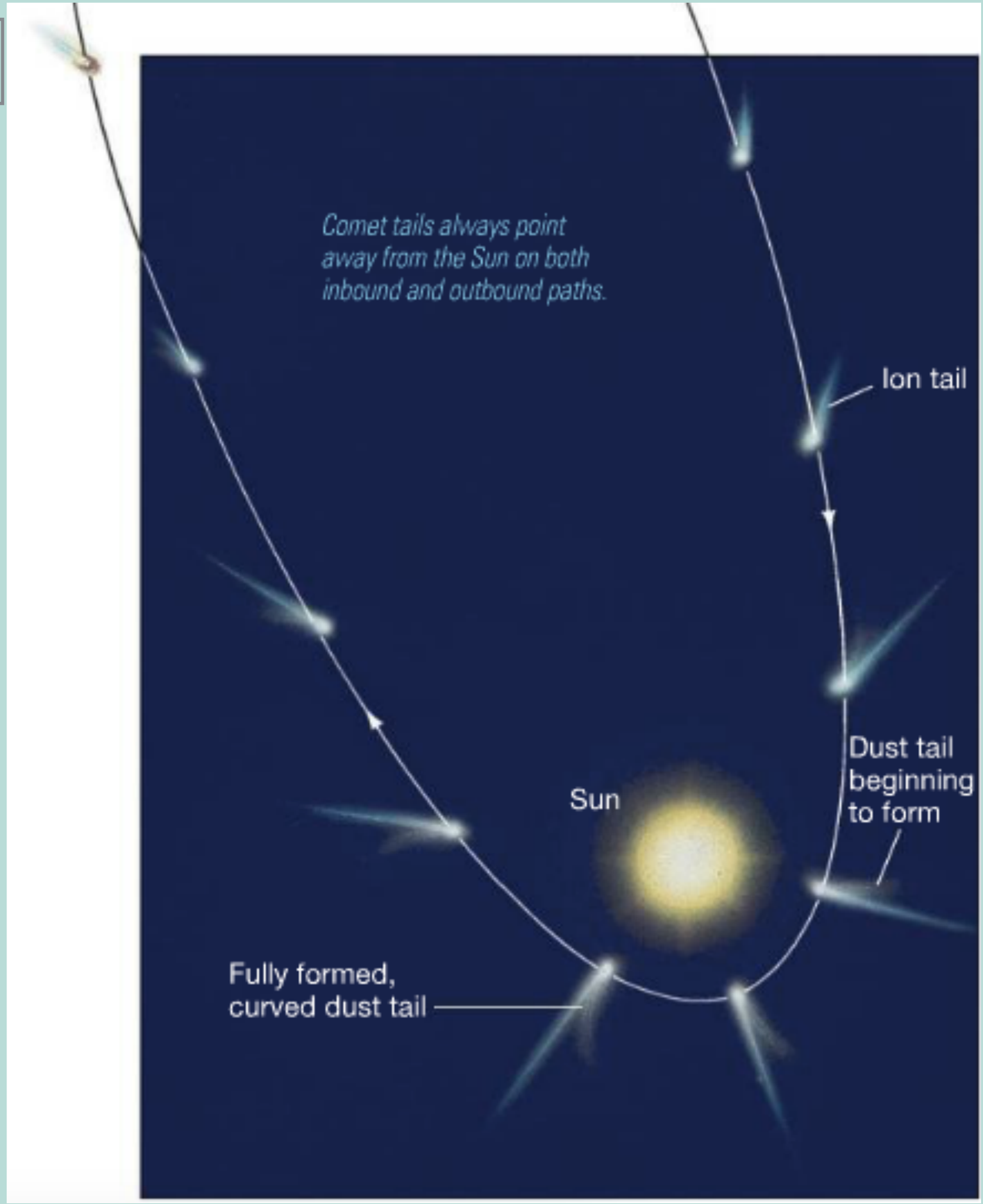


Cosmic Debris: Ch 16

Halley Ion Tail

Cosmic Debris: Ch 16

Comet Tails point towards the sun



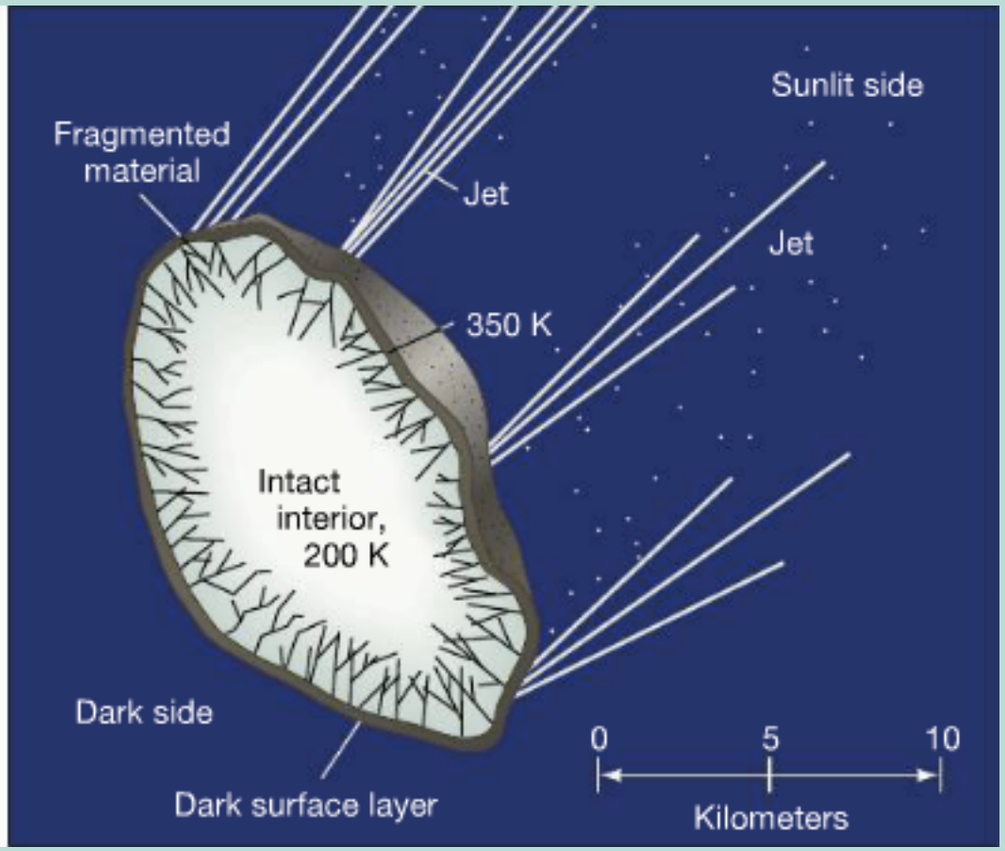
Cosmic Debris: Ch 16

Giotto (ESA)

(named after 1301 Italian artist)

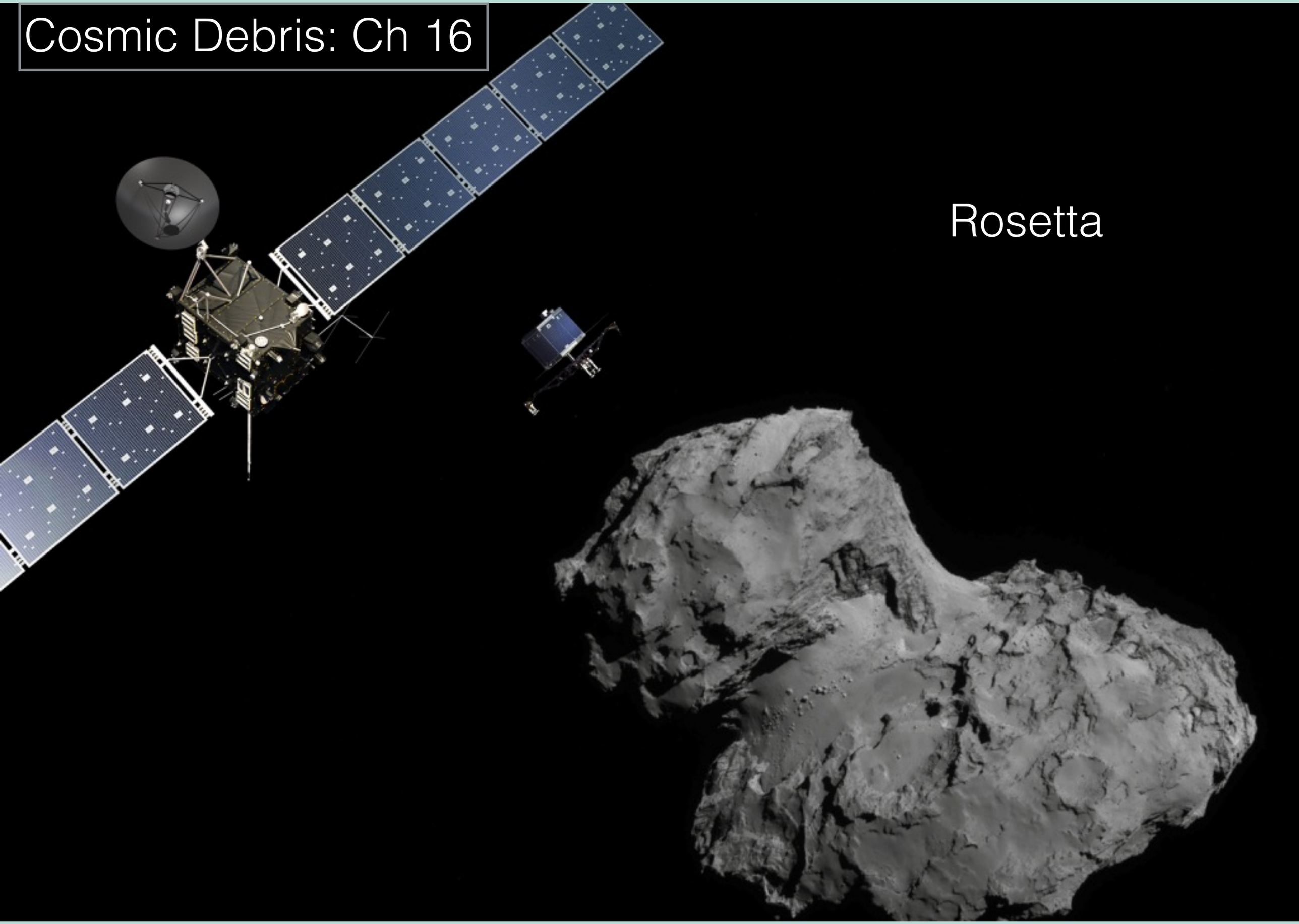
Cosmic Debris: Ch 16

Halley's Nucleus

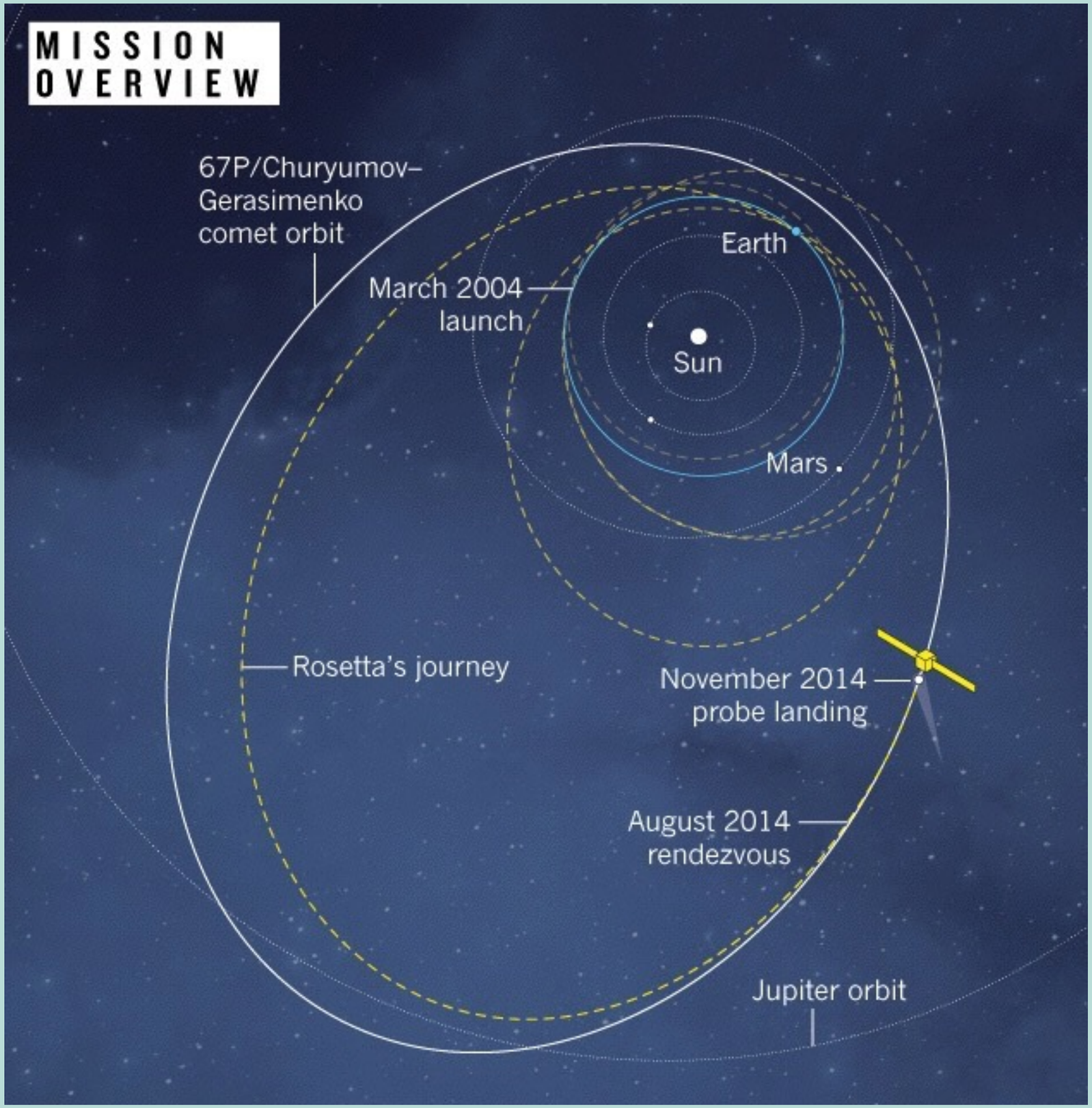


Sublimation jets cause comet to rotate

Cosmic Debris: Ch 16



Cosmic Debris: Ch 16



Cosmic Debris: Ch 16

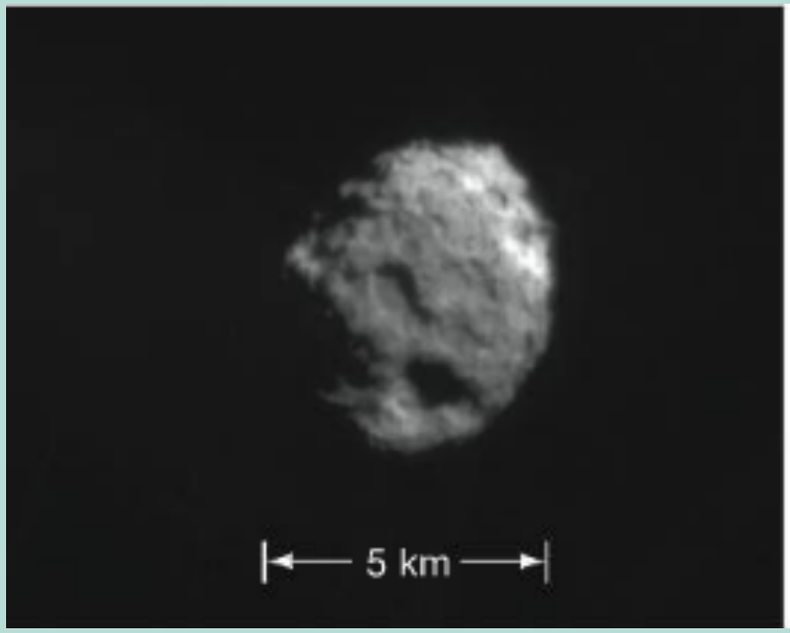
67P/ Churyumov-Gerasimenko

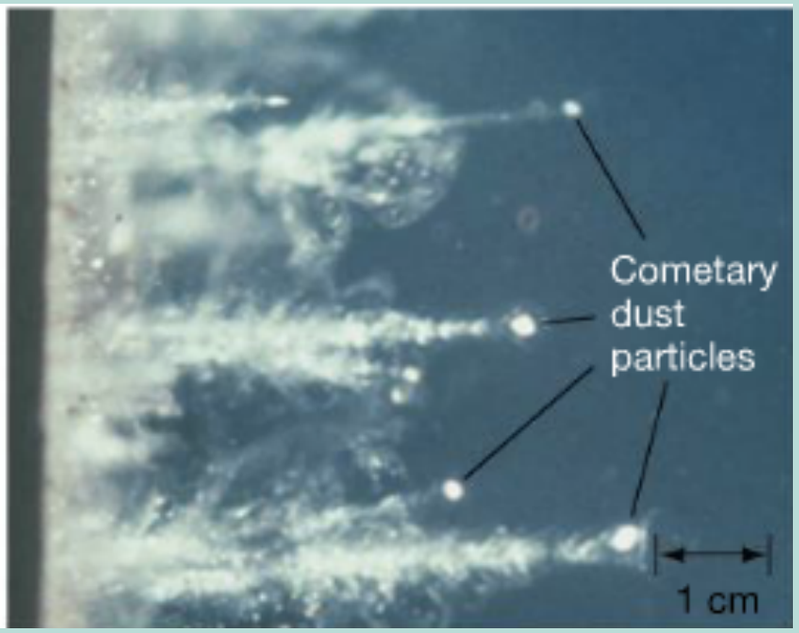
Cosmic Debris: Ch 16

Hale-Bopp (97)

Cosmic Debris: Ch 16

NASA Stardust Mission

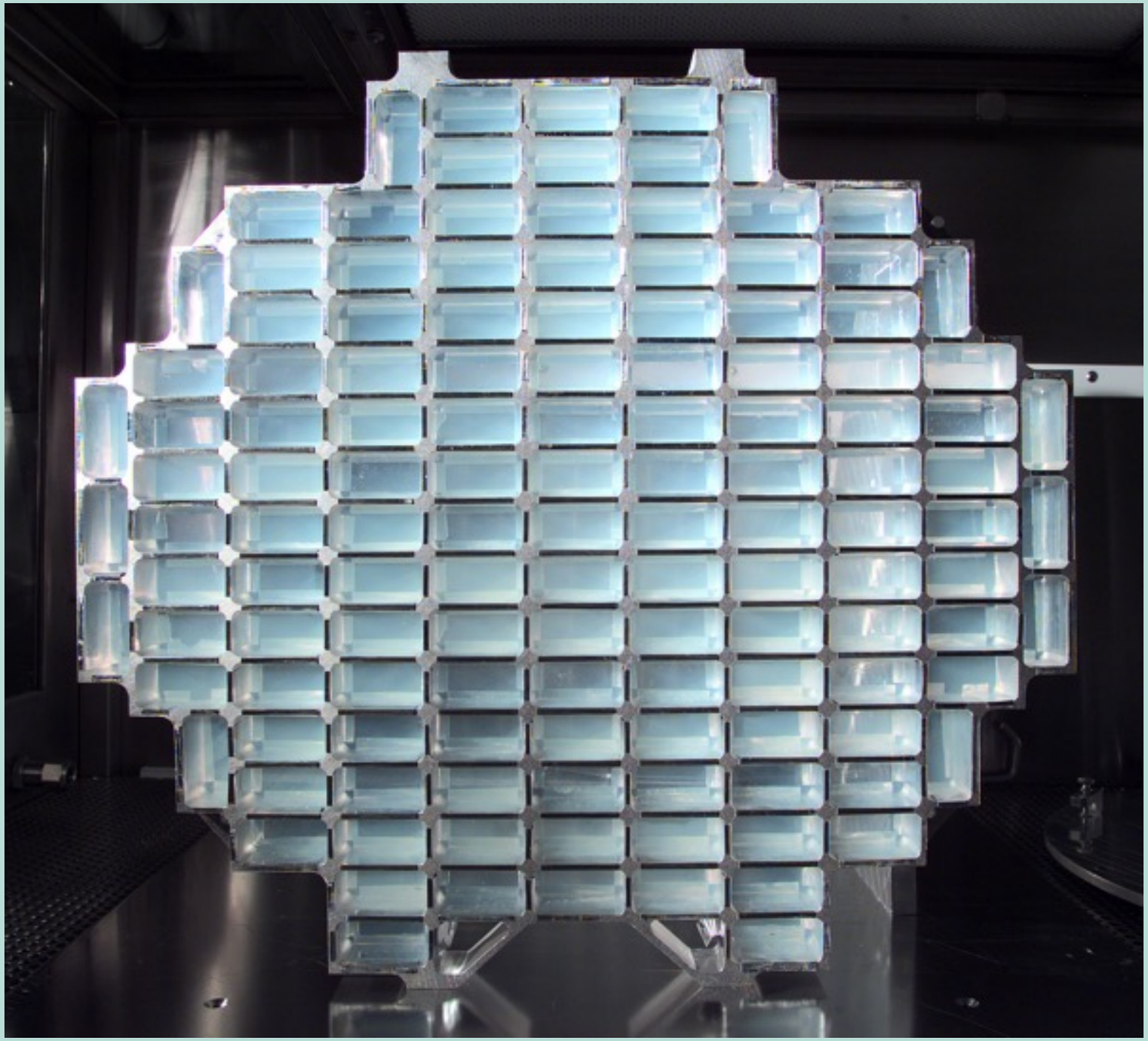




Wild-2

Cosmic Debris: Ch 16

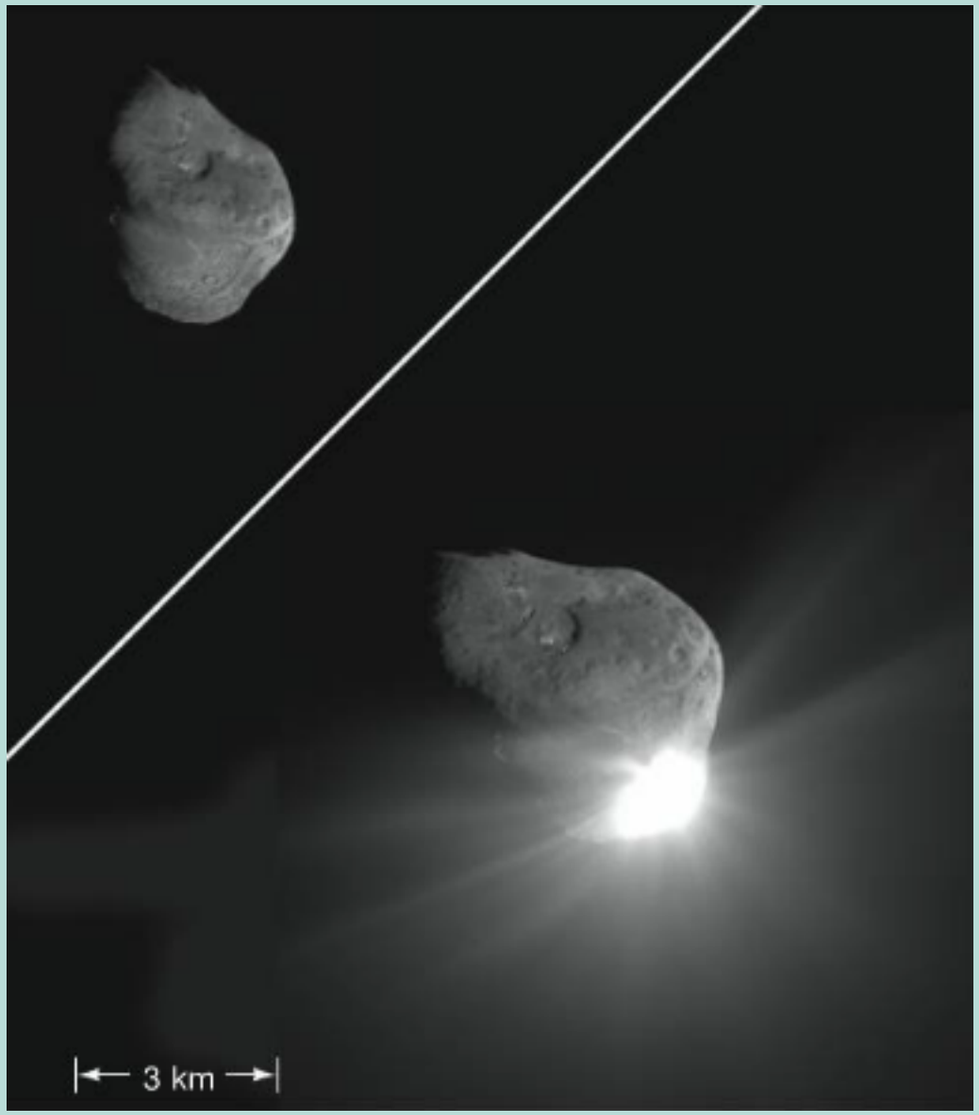
Stardust Collector



Cosmic Debris: Ch 16

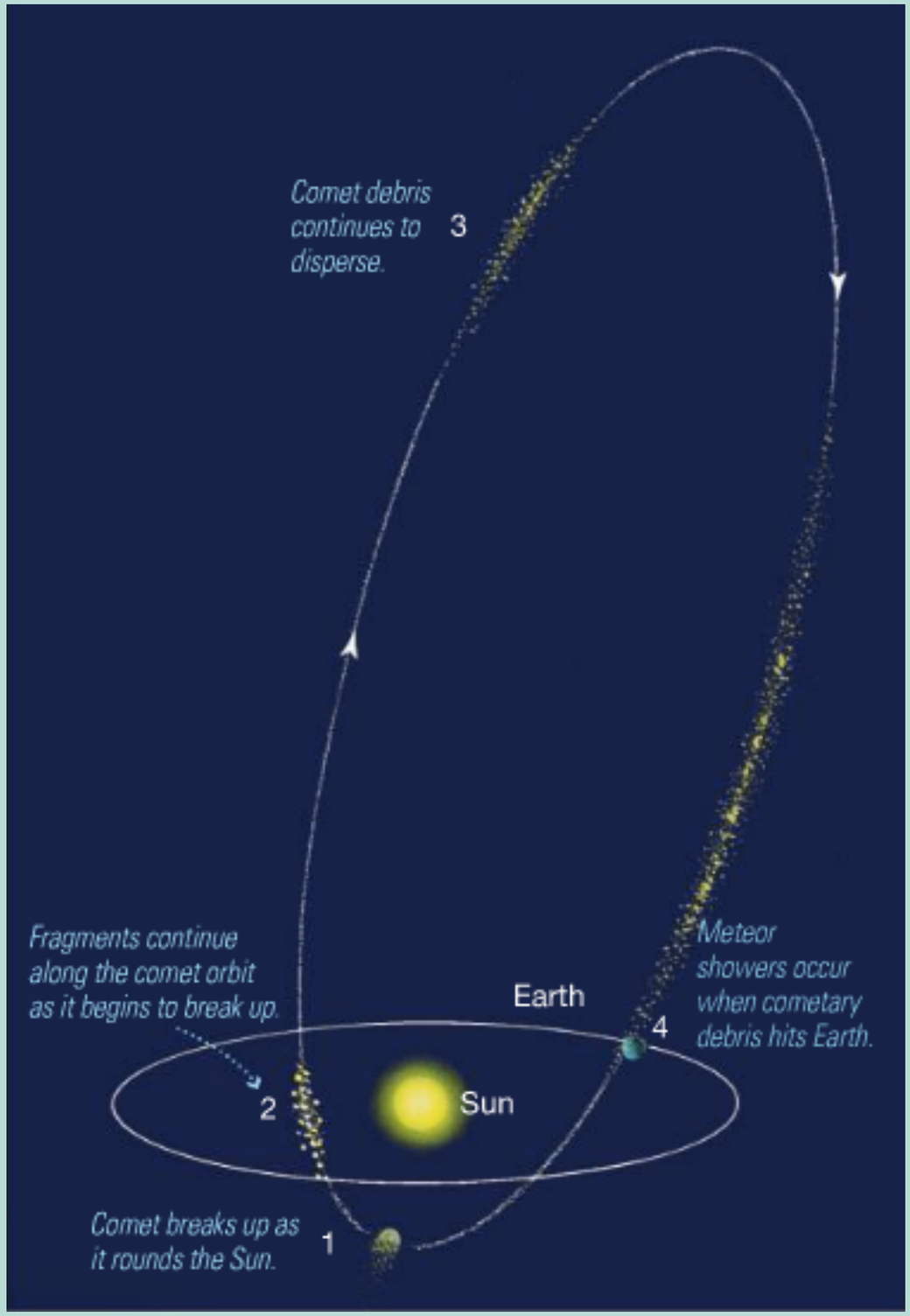
Cosmic Debris: Ch 16

Deep Impact



“Smash and Observe” from particle physics to jupiter to comets

Cosmic Debris: Ch 16

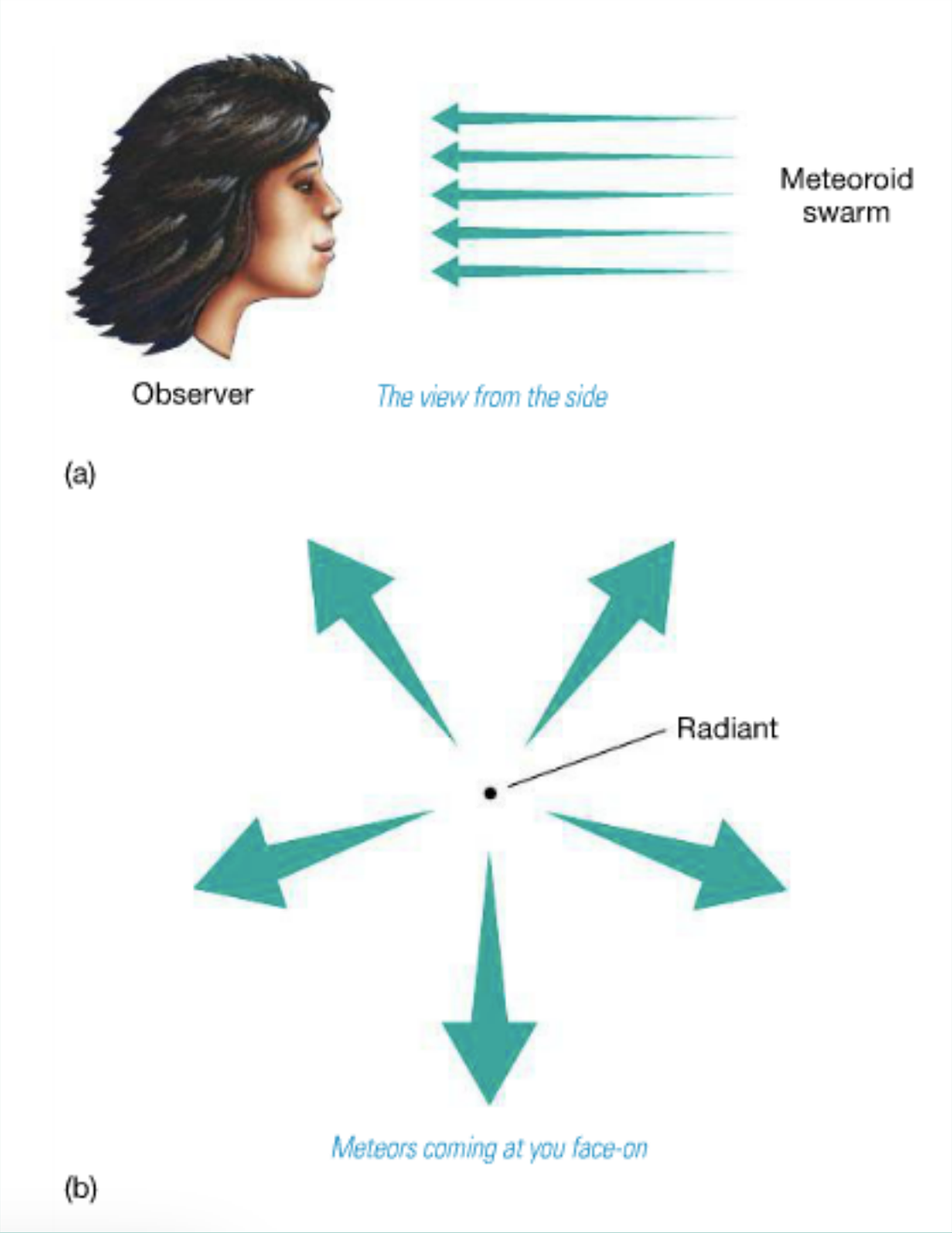


Meteor Rain

Cosmic Debris: Ch 16

Meteors

Cosmic Debris: Ch 16



Cosmic Debris: Ch 16

TABLE 14.1 Some Prominent Meteor Showers

Morning of Maximum Activity	Name of Shower	Rough Hourly Count	Parent Comet
Jan. 3	Quadrantid	40	—
Apr. 21	Lyrid	10	1861I (Thatcher)
May 4	Eta Aquarid	20	Halley
June 30	Beta Taurid	25‡	Encke
July 30	Delta Aquarid	20	—
Aug. 11	Perseid	50	1862III (Swift-Tuttle)
Oct. 9	Draconid	up to 500	Giacobini-Zinner
Oct. 20	Orionid	30	Halley
Nov. 7	Taurid	10	Encke
Nov. 16	Leonid	12*	1866I (Tuttle)
Dec. 13	Geminid	50	3200 (Phaeton)†