Gravity Moments

Jupiter

Interior of Jupiter

Parameter	Value
G^a (global parameter)	$6.672598 \times 10^{-11} \pm 2 \times 10^{-17}$ m^{3}kg^{-1}s^{-2}
$G \times M_J{}^b$	$(126686533 \pm 2) \times 10^9$ m^{3}s^{-2}
M_J	1.89861×10^{27} kg
$R_{eq}{}^c$	71492 ± 4 km
$R_{polar}{}^c$	66854 ± 10 km
ω^d	$1.7585324 \times 10^{-4} \pm 6 \times 10^{-10}$ s^{-1}
$\bar{\rho}$	1326.5 kg m^{-3}
$m = 3\omega^2/4\pi G\bar{\rho}$	0.083408
$q = \omega^2 R_{eq}^3/GM_J$	0.0891954
$J_2 \times 10^{6\,e}$	14696.572 ± 0.014
$-J_4 \times 10^{6\,e}$	586.609 ± 0.004
$J_6 \times 10^{6\,e}$	34.198 ± 0.009
$-J_8 \times 10^{6\,e}$	2.426 ± 0.025
$J_{10} \times 10^{6\,e}$	0.172 ± 0.069

and I/(MR^2) = 0.276

Interior of Jupiter

A collision may have left Jupiter with a fuzzy core
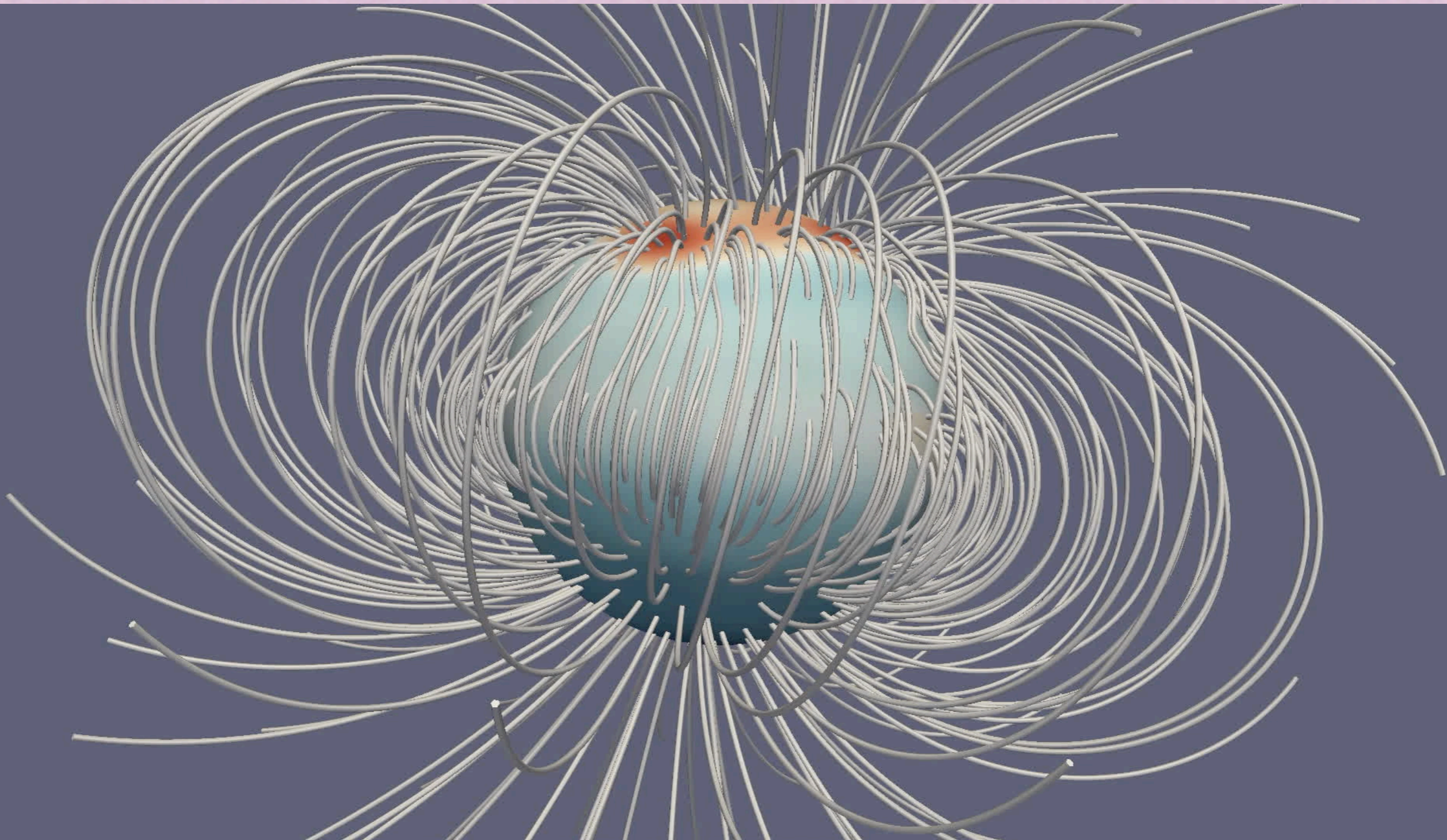
Before impact — Dense core — Envelope

Just after impact — Dilute core

Present day — Dilute core — Enriched envelope
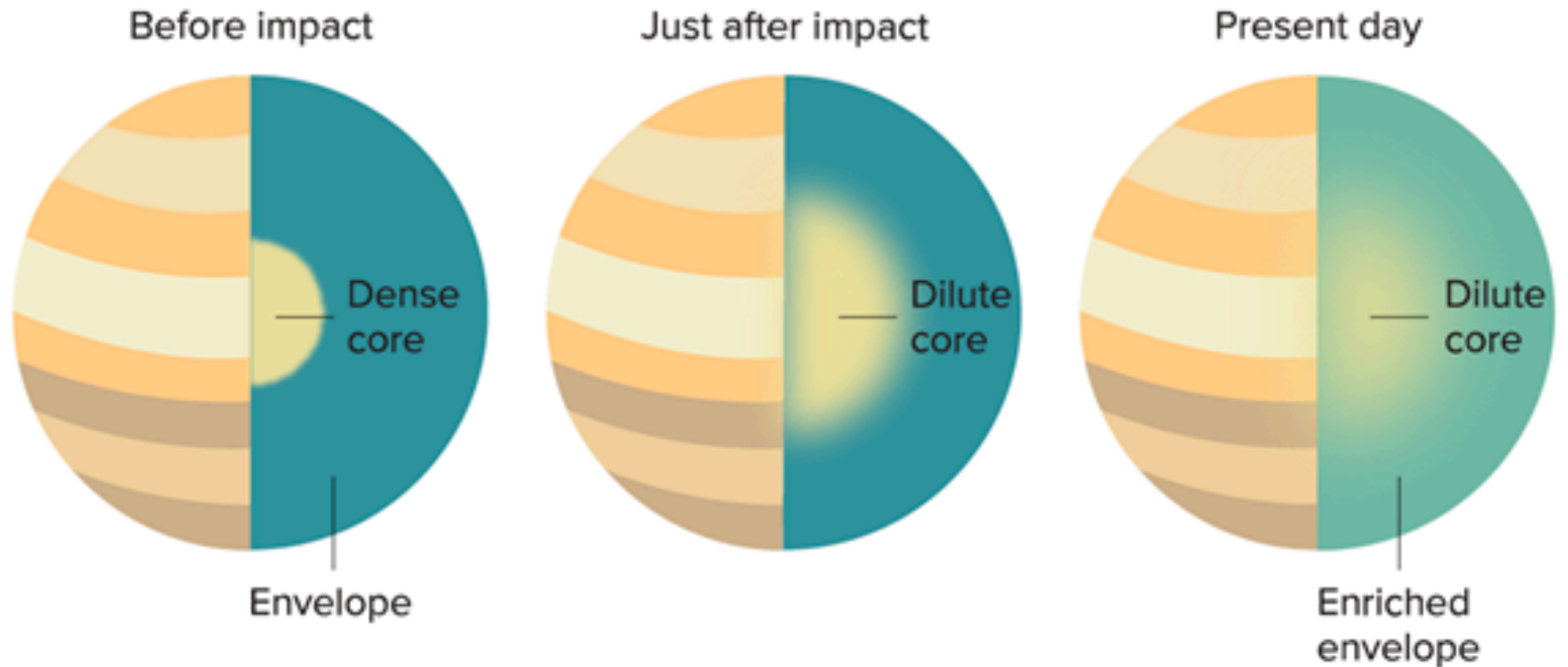
SOURCE: T. GUILLOT / *NATURE NEWS & VIEWS* 2019

Liu et al. (2020)

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Z_{ext} S_{ext} =7.11 k_B/proton

Y_{ext}

Composition change

$Y_2 \sim 0.28$

$Z_2 \sim 0.06$

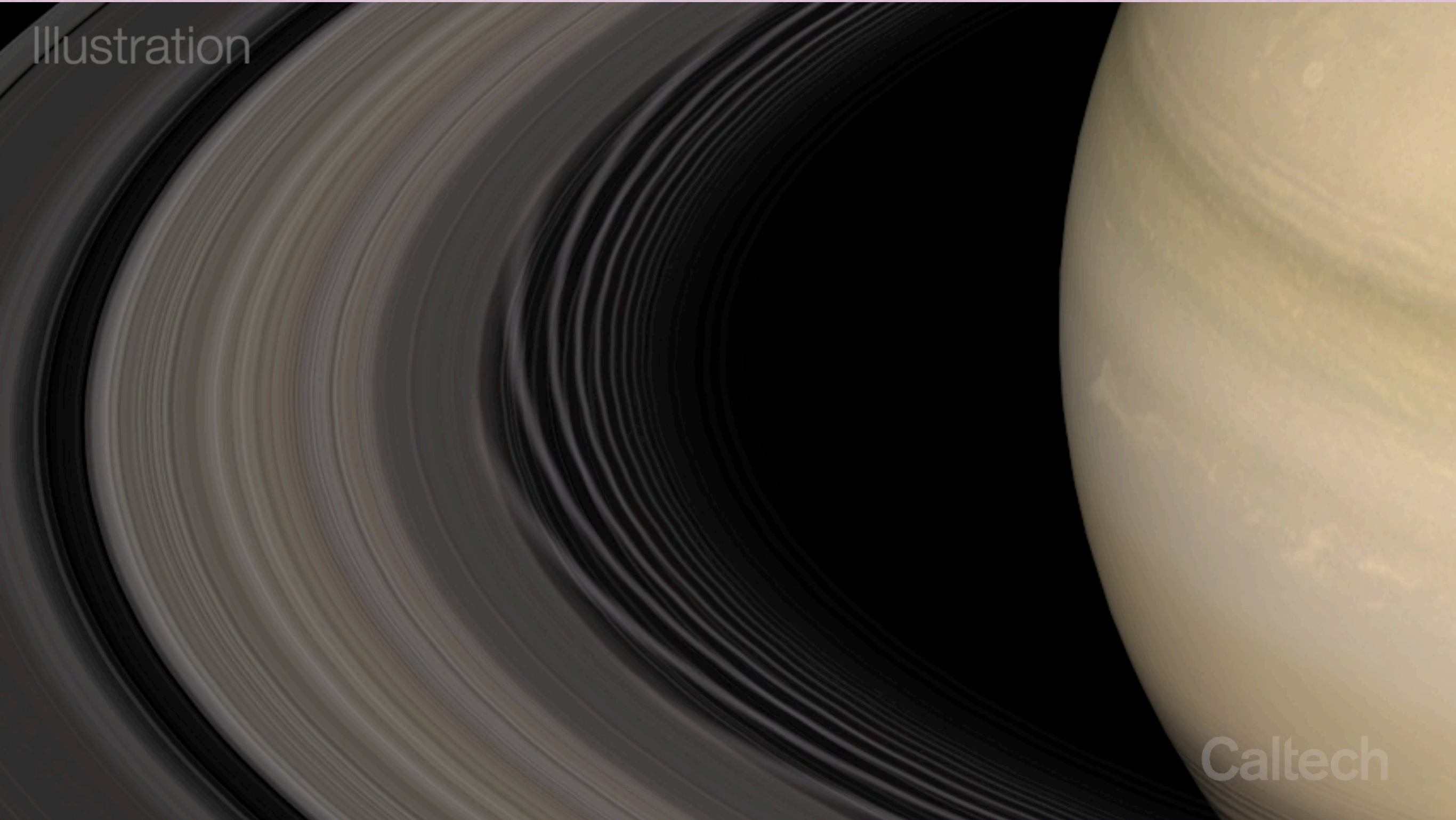$S_2 \sim 8.5$ k_B/proton

93% R_J

proton

R_J

bar - 3600K

Mass of the diffuse core is between 10 and 24 M_{Earth}

Magnetic Field of Jupiter

Interior of Saturn

Magnetic Field of Saturn
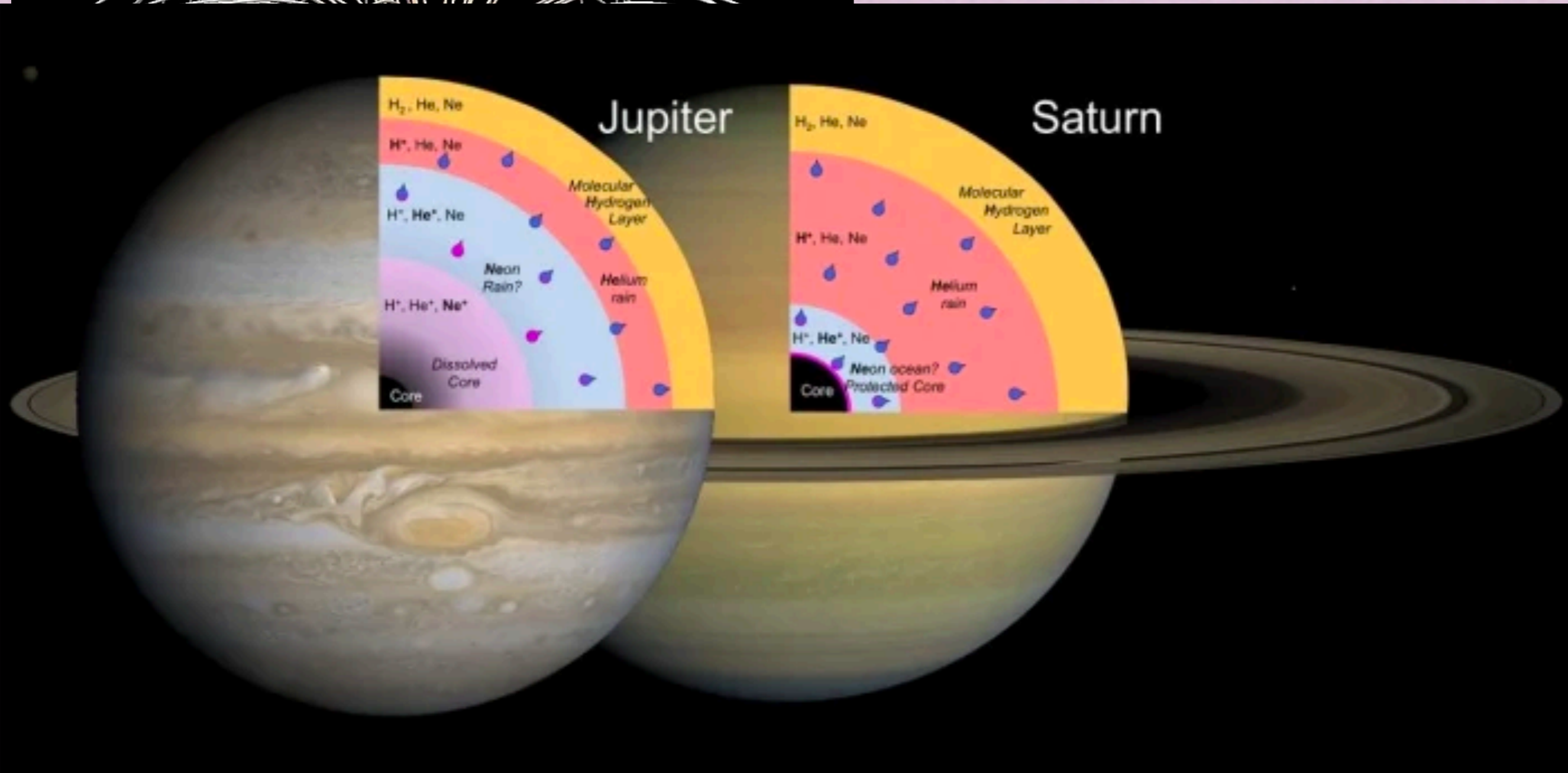
Interior and Magnetic Field of Uranus

Outer Atmosphere, the upper cloud layer

Atmosphere (hydrogen, helium, methane gases)

Mantle (water, ammonia, methane ices)

Core (silicate/Fe-Ni rock)
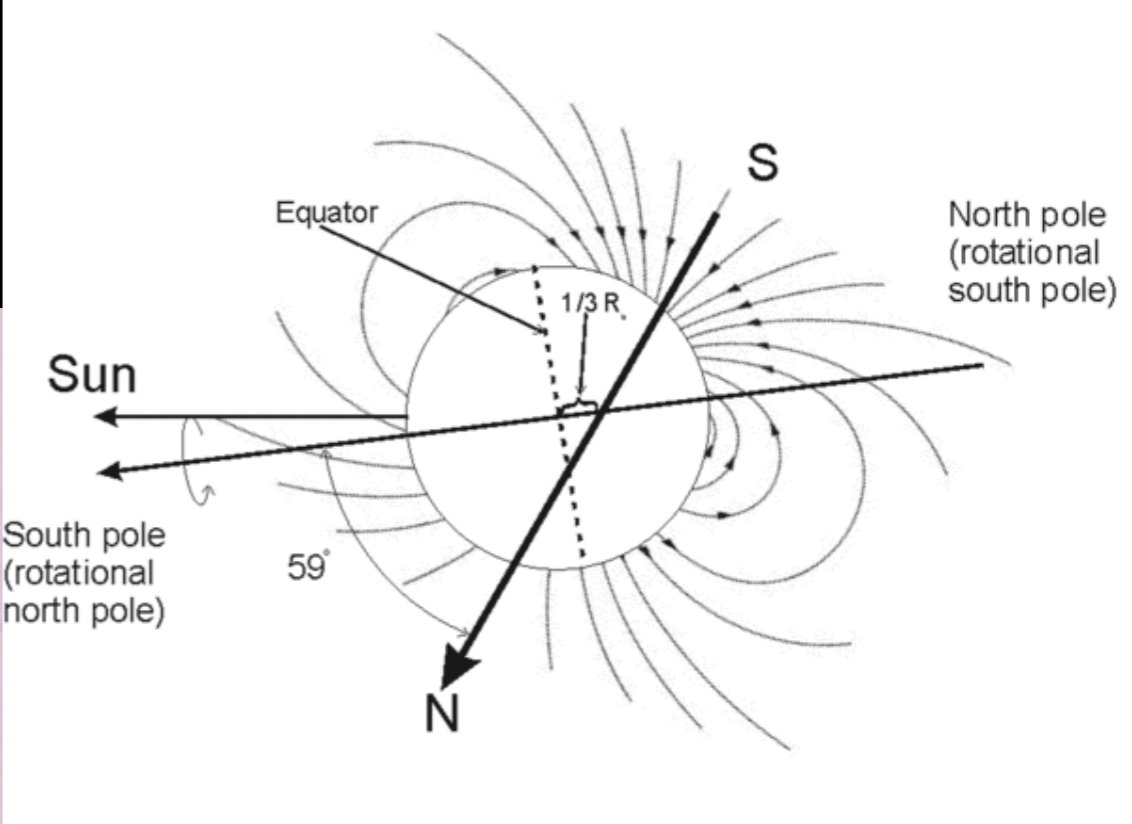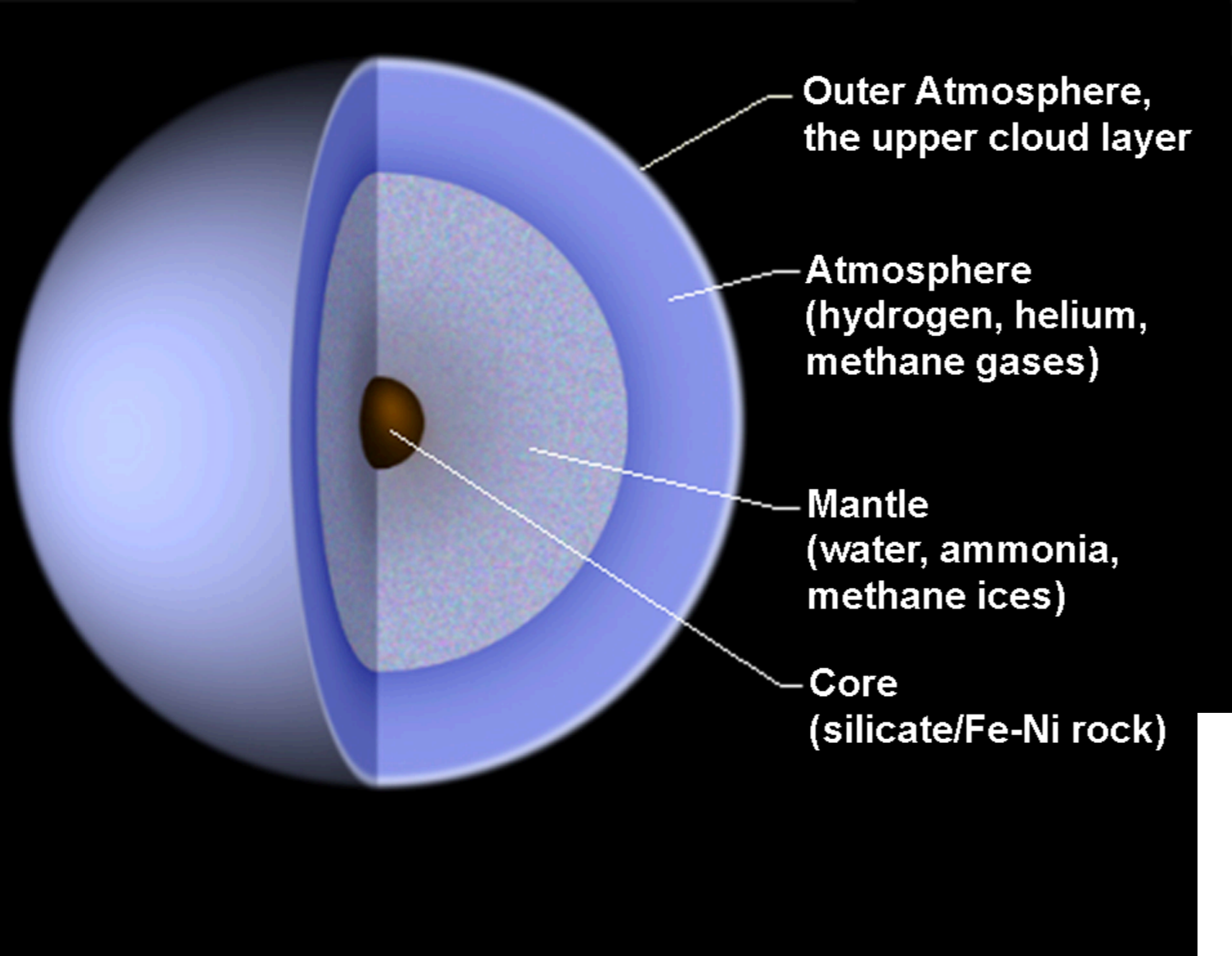
Interior and Magnetic Field of Neptune
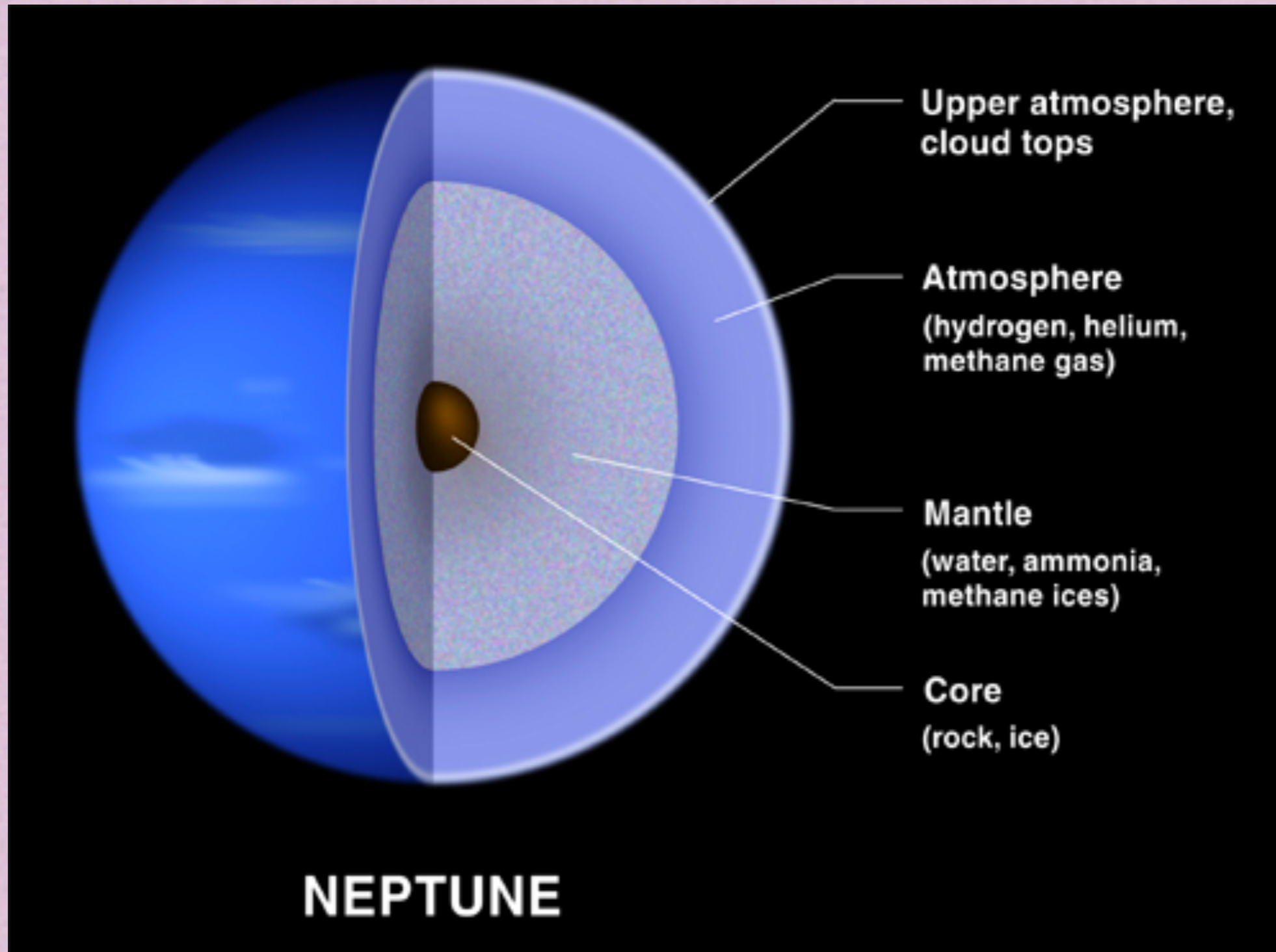
| Body	J_2 (×10⁻⁶)	J_3 (×10⁻⁶)	J_4 (×10⁻⁶)	J_6 (×10⁻⁶)	q_r	Λ_2	I/MR^2	C_{22} (×10⁻⁶)	Refs.
Mercury	60 ± 20				1.0×10^{-6}	60	0.33		1
Venus	4.46 ± 0.03	-1.93 ± 0.02	-2.38 ± 0.02		6.1×10^{-8}	73	0.33		1
Earth	$1\,082.627$	-2.532 ± 0.002	-1.620 ± 0.003	-0.21	3.45×10^{-3}	0.314	0.331		1
Moon	203.43 ± 0.09				7.6×10^{-6}	26.8	0.393	22.395	1, 2
Mars	$1\,960.5 \pm 0.2$	31.5 ± 0.5	-15.5 ± 0.7		4.57×10^{-3}	0.429	0.365		1
Jupiter	$14\,696.4 \pm 0.2$		-587 ± 2	34 ± 5	0.089		0.165	0.254	1
Saturn	$16\,290.7 \pm 0.3$		-936 ± 3	86 ± 9	0.151		0.108	0.210	4
Uranus	$3\,343.5 \pm 0.1$		-28.9 ± 0.2		0.029		0.114	0.23	1
Neptune	$3\,410 \pm 9$		-35 ± 10		0.026		0.136	0.23	1
Io	$1\,860 \pm 3$				1.7×10^{-3}	1.08	0.378	558.8	3
Europa	436 ± 8				5.02×10^{-4}	0.87	0.346	131.5	3
Ganymede	128 ± 3				1.91×10^{-4}	0.67	0.312	38.3	3
Callisto	33 ± 1				3.67×10^{-5}	0.90	0.355	10.2	3

Size Distribution
Small Planets Are Common
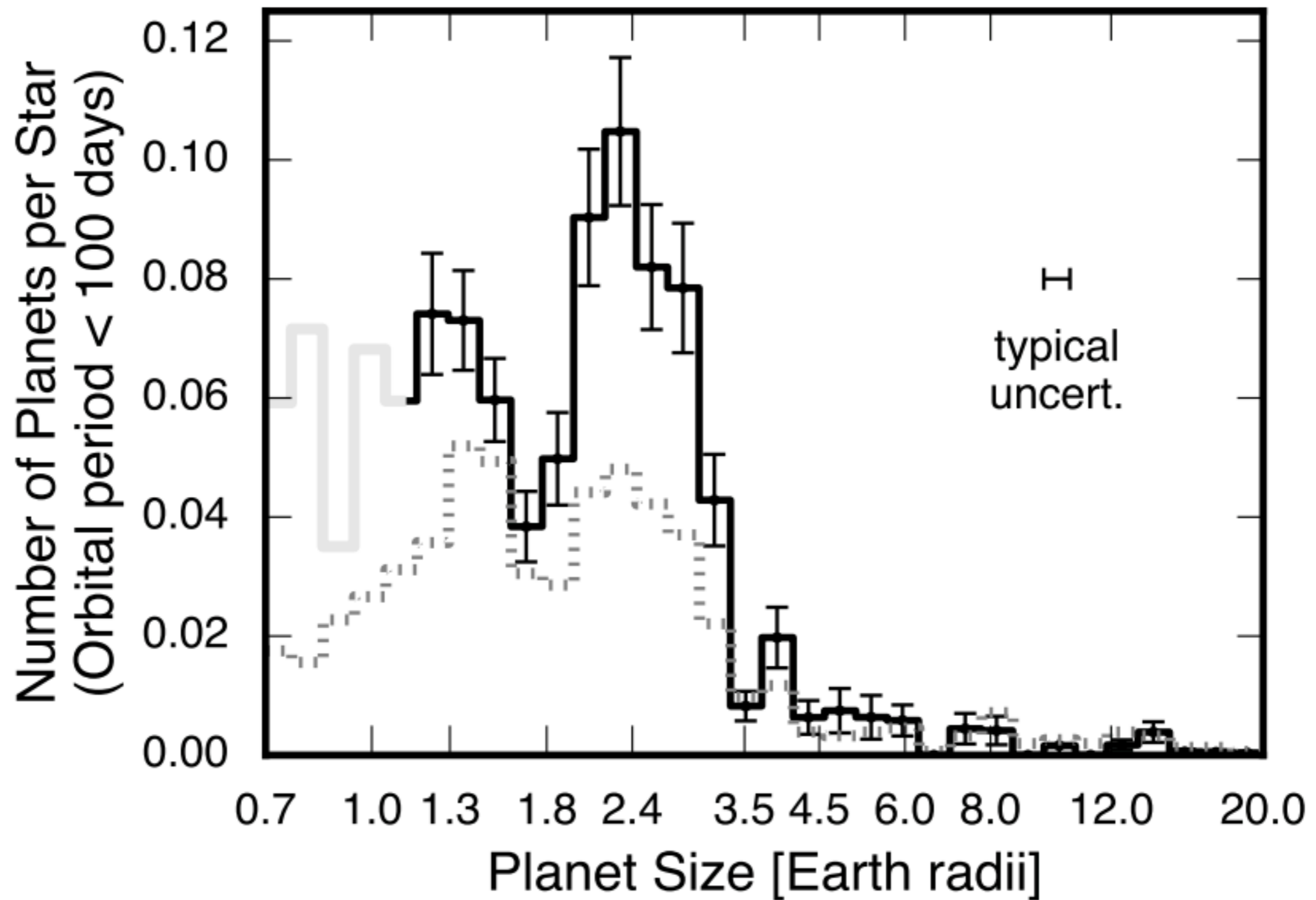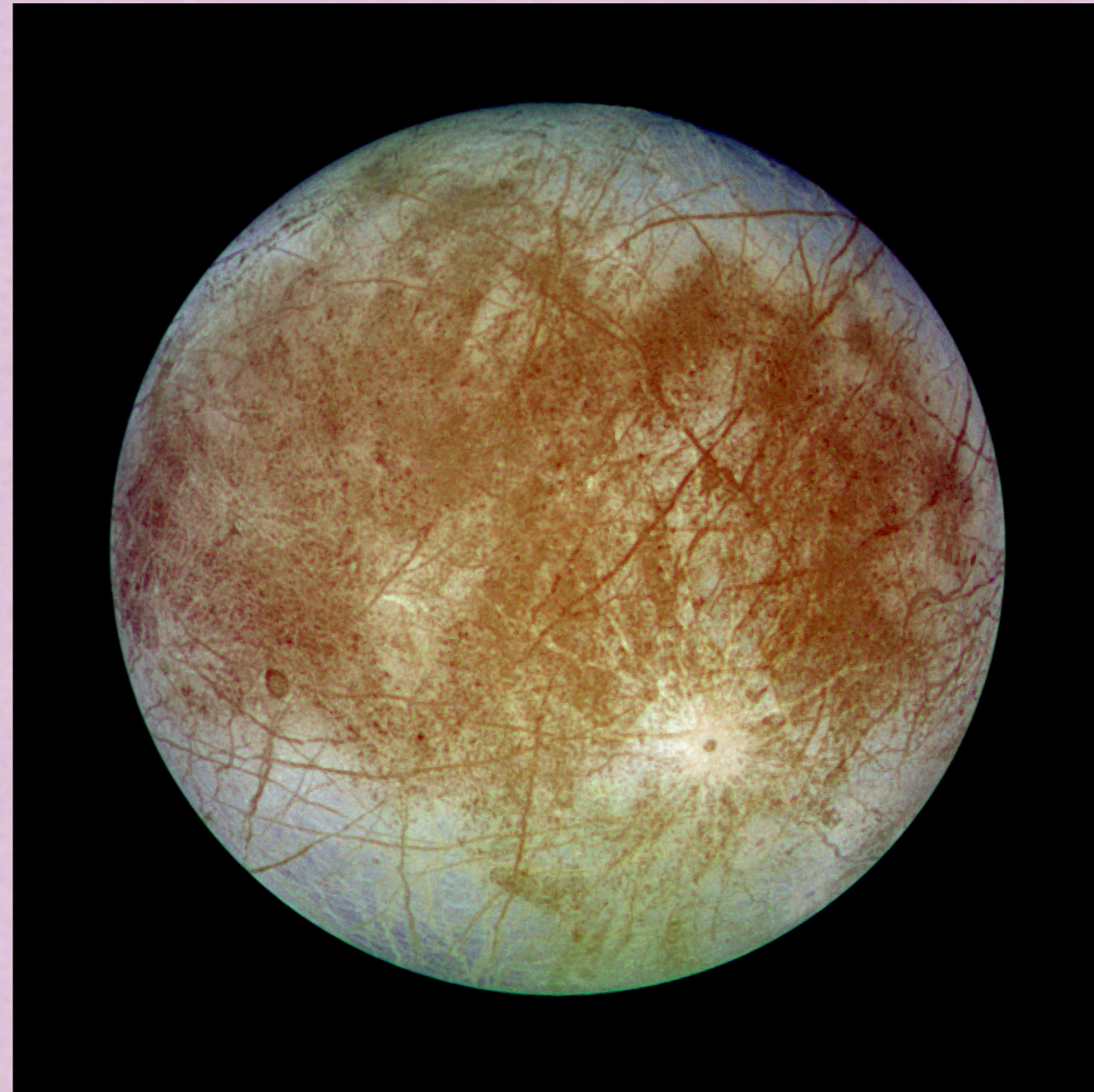

Fulton & Petigura (2018)
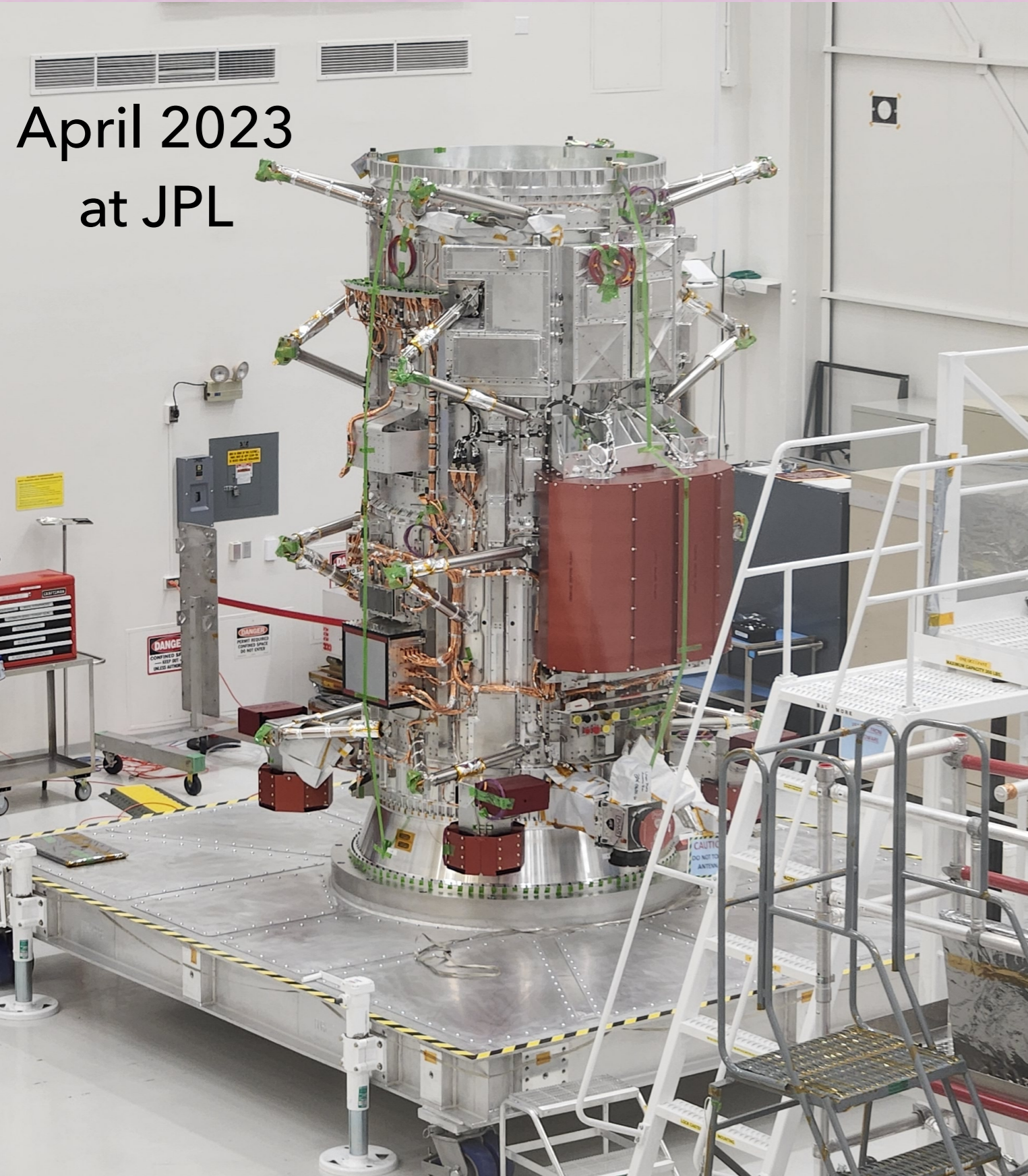
Exoplanet Mass-Radius Diagram
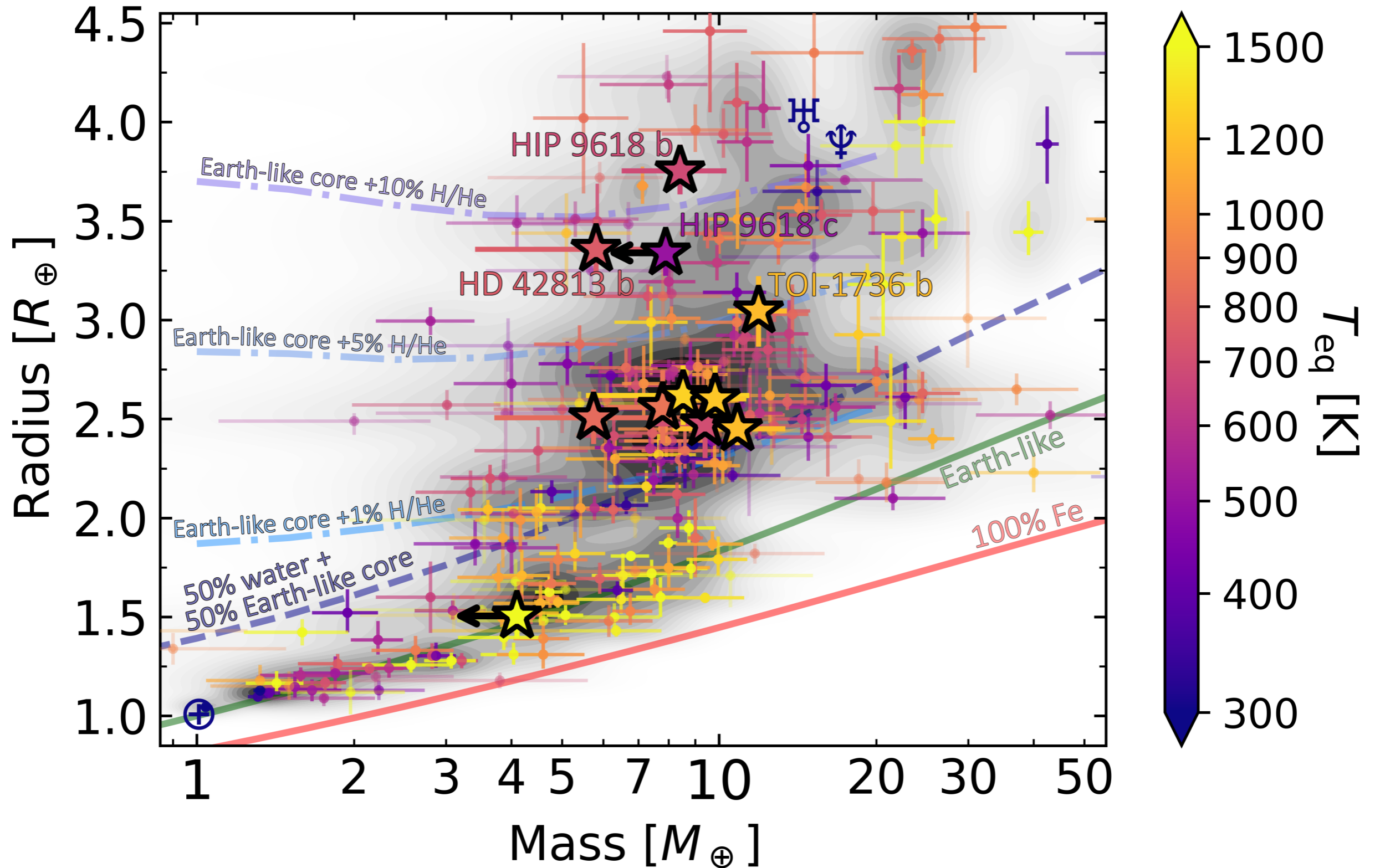
Europa

Europa has the smoothest surface of any known solid object in the Solar System
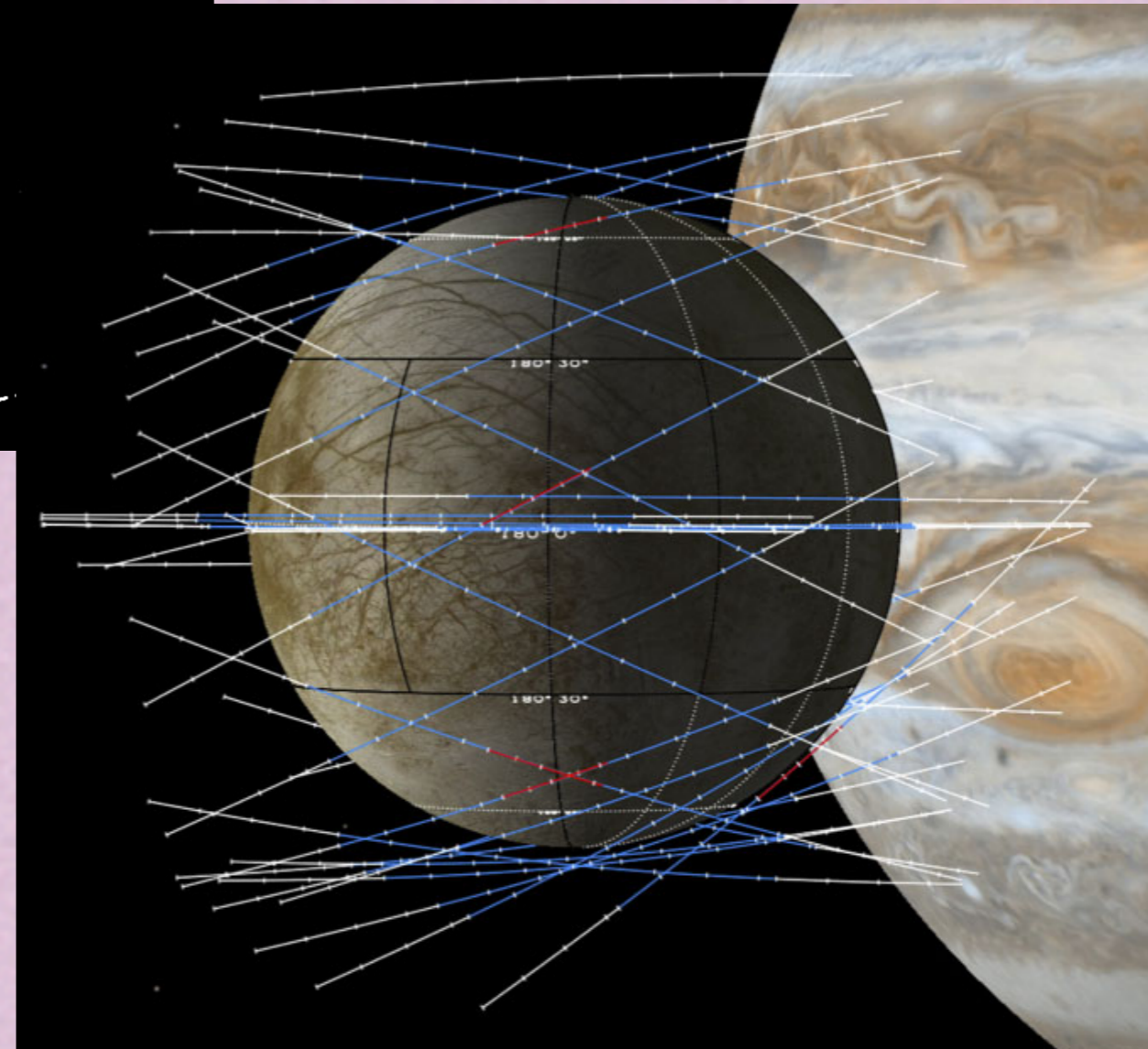
water-ice surface + oxygen atmosphere
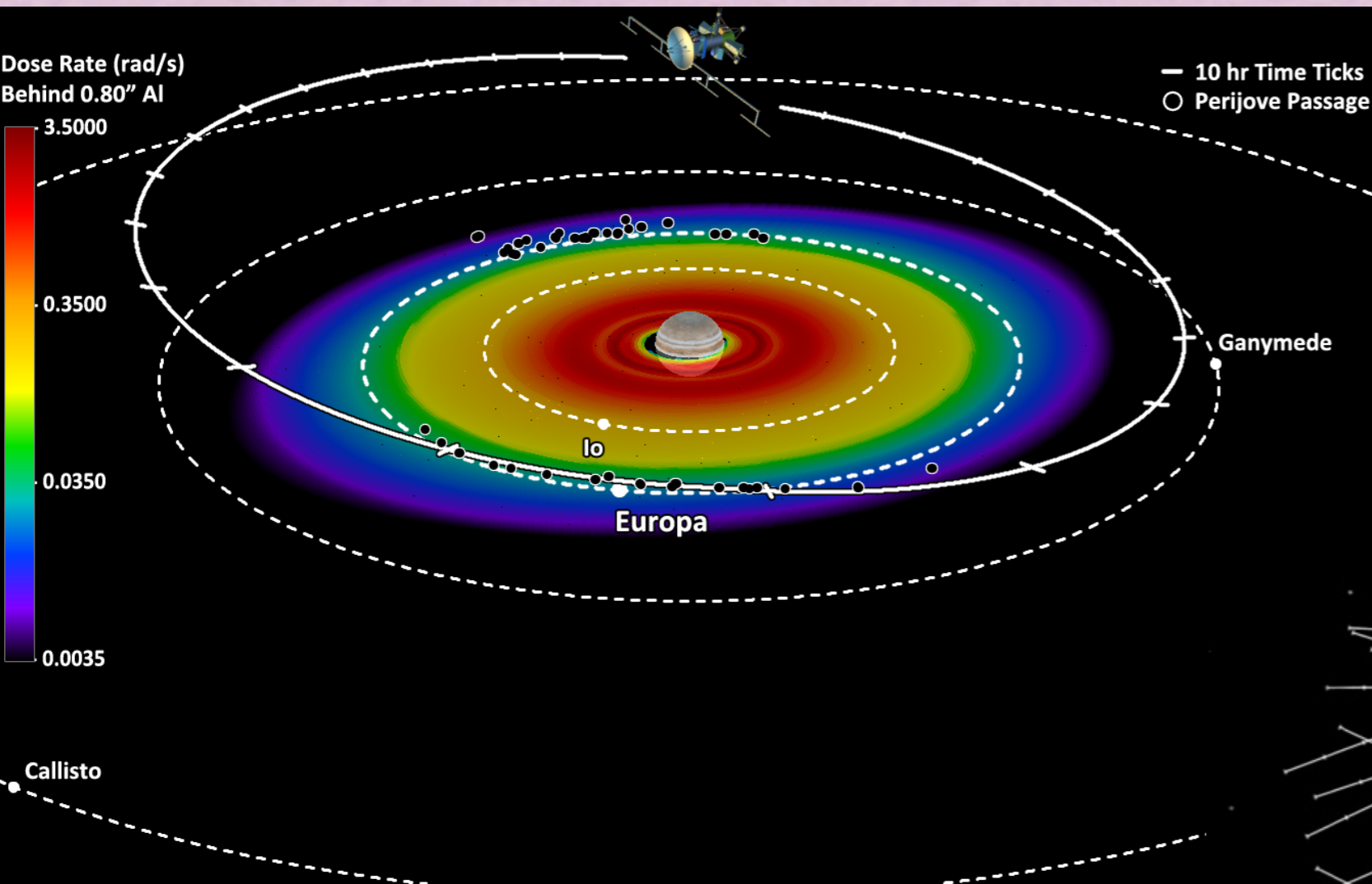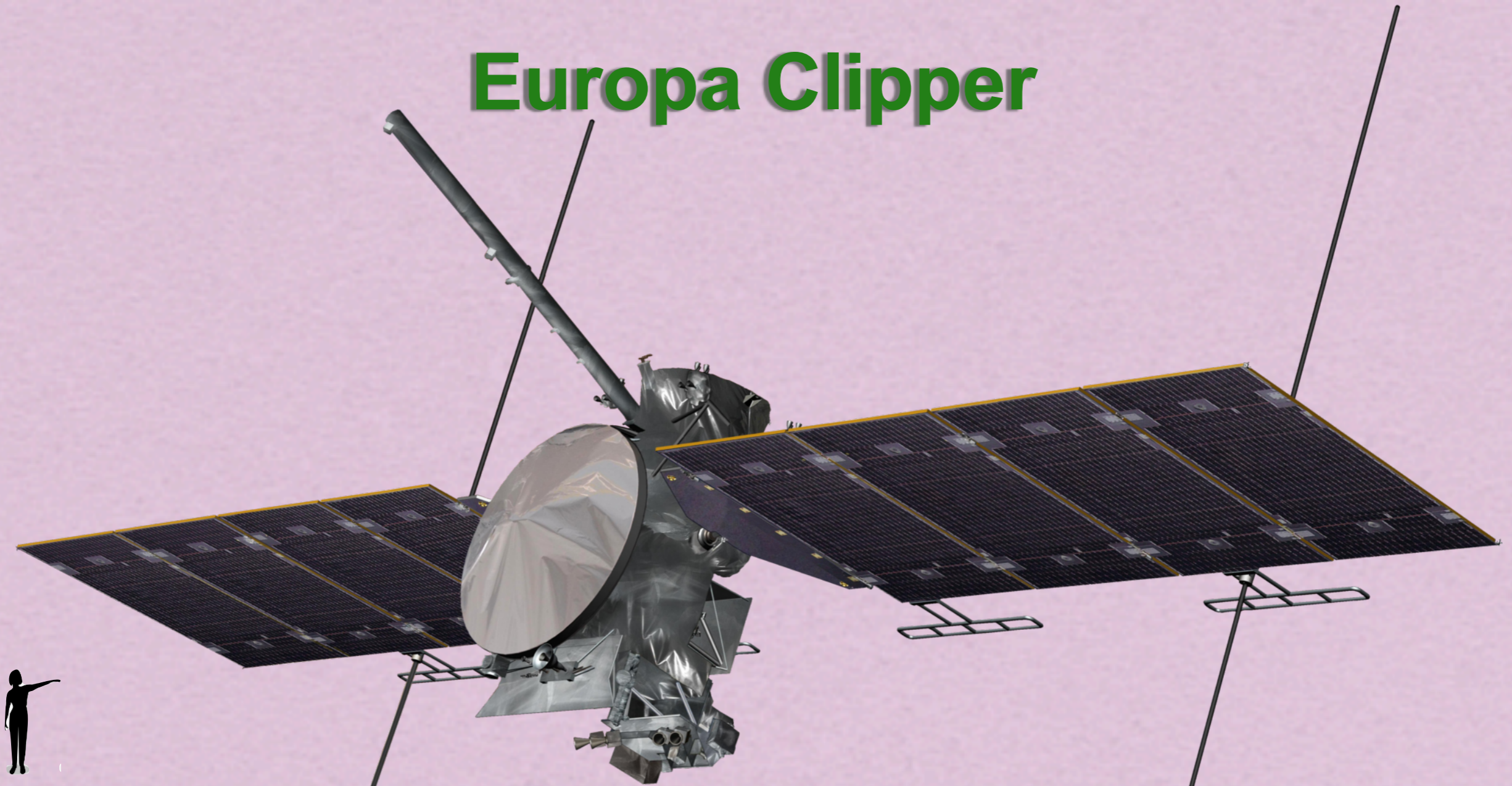
Europa Clipper

April 2023
at JPL

September 2024
at KSC

Europa Clipper

Europa Clipper

Instruments: IR imager, visible light imager, near-IR spectrograph, UV spectrograph, radar, magnetometer, magnetic sounding instrument, mass spectrometer, surface dust analyzer, radio antenna for gravity measurements