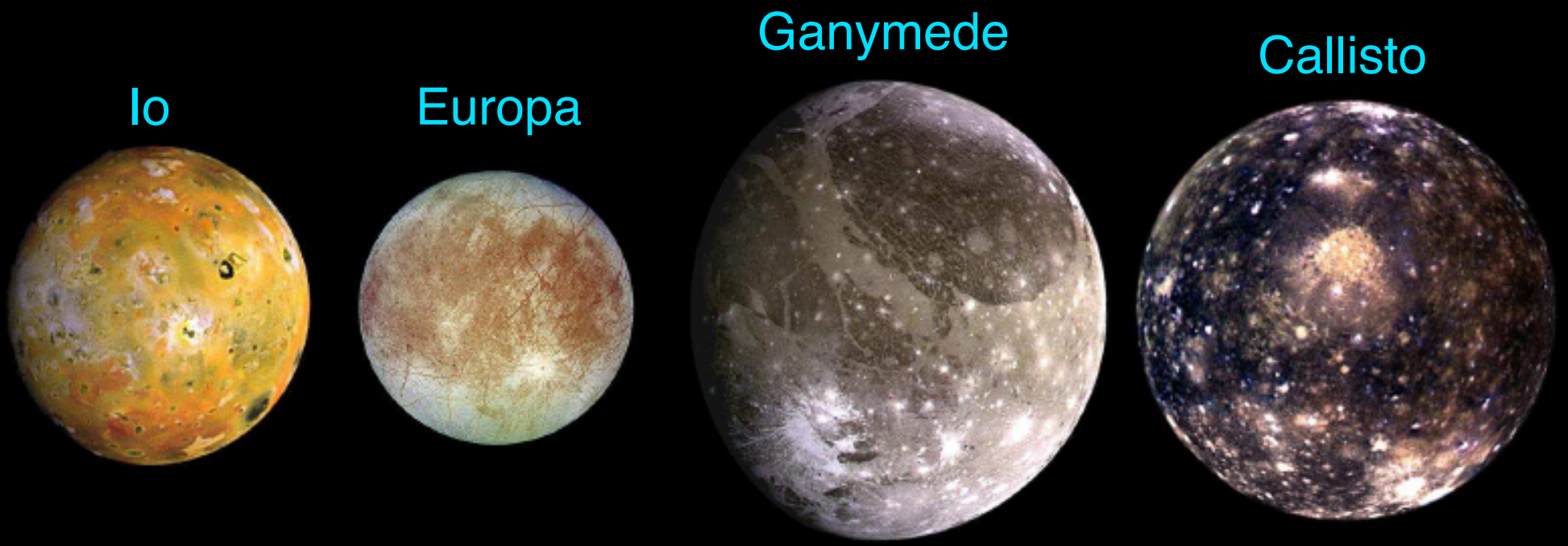
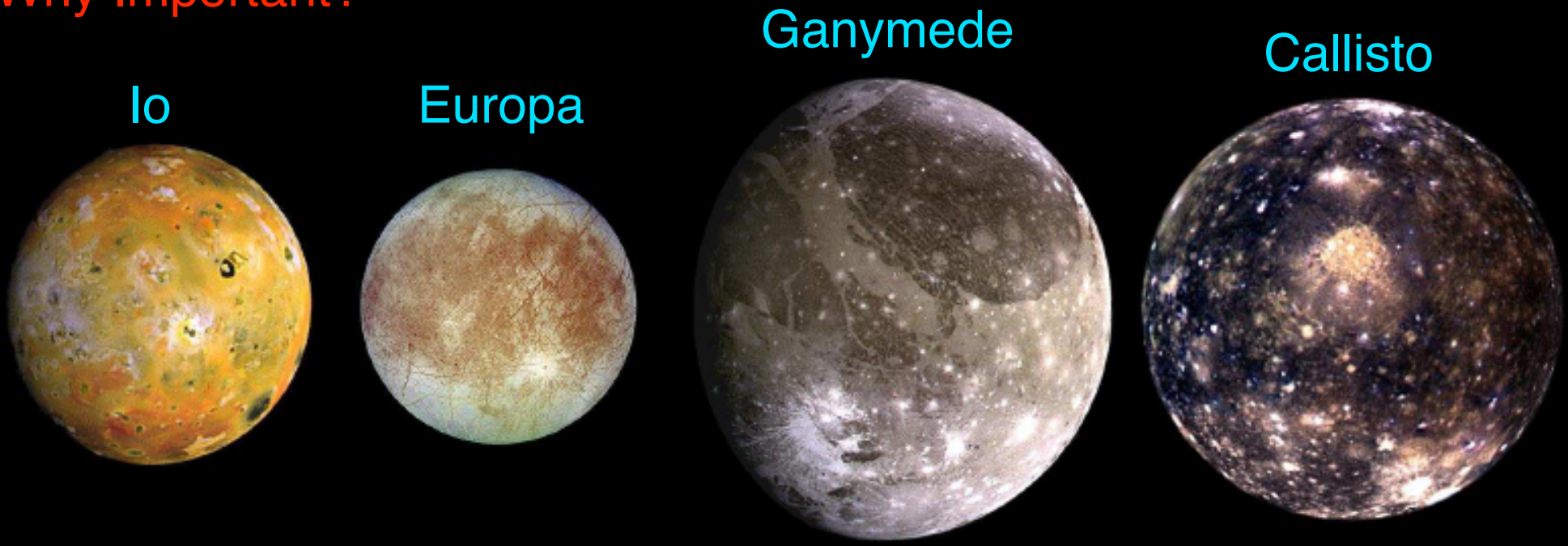
Formation of Satellite and Ring Systems



Research with Doug Hamilton

Where did the Galilean Satellites Form?

Why Important?



Where did the Galilean Satellites Form?

Why Important?

Geophysics

Has Io always had volcanoes?

How long has Europa had liquid water?

Why did rock separate from ice more fully at Ganymede than at Callisto?

Where did the Galilean Satellites Form?

Why Important?

Planetary Formation

Satellite Systems of the giant planets are local analogs to Planetary Systems

Four Things to Know About Satellite Dynamics

1. Tides move Satellites Radially Outward; damp eccentricities, but not inclinations

2. Diverging Orbits lead to Resonant Kicks; Converging Orbits lead to Resonant Trapping

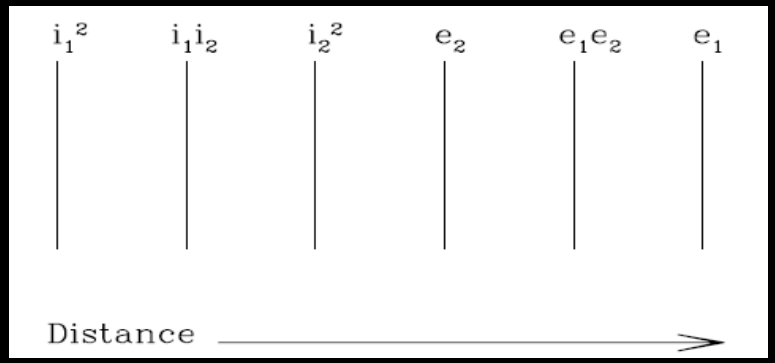
3. Resonant Strengths depend on e,i

4. Precession Splits Resonances

Diverging Orbits: Io & Amalthea

Jupiter

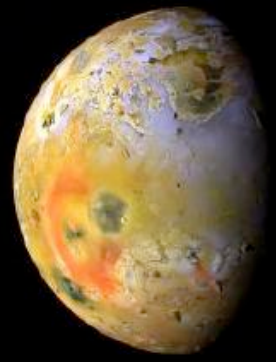
2:1 Io Resonances



resonances move with Io & are much closer than depicted!

Amalthea

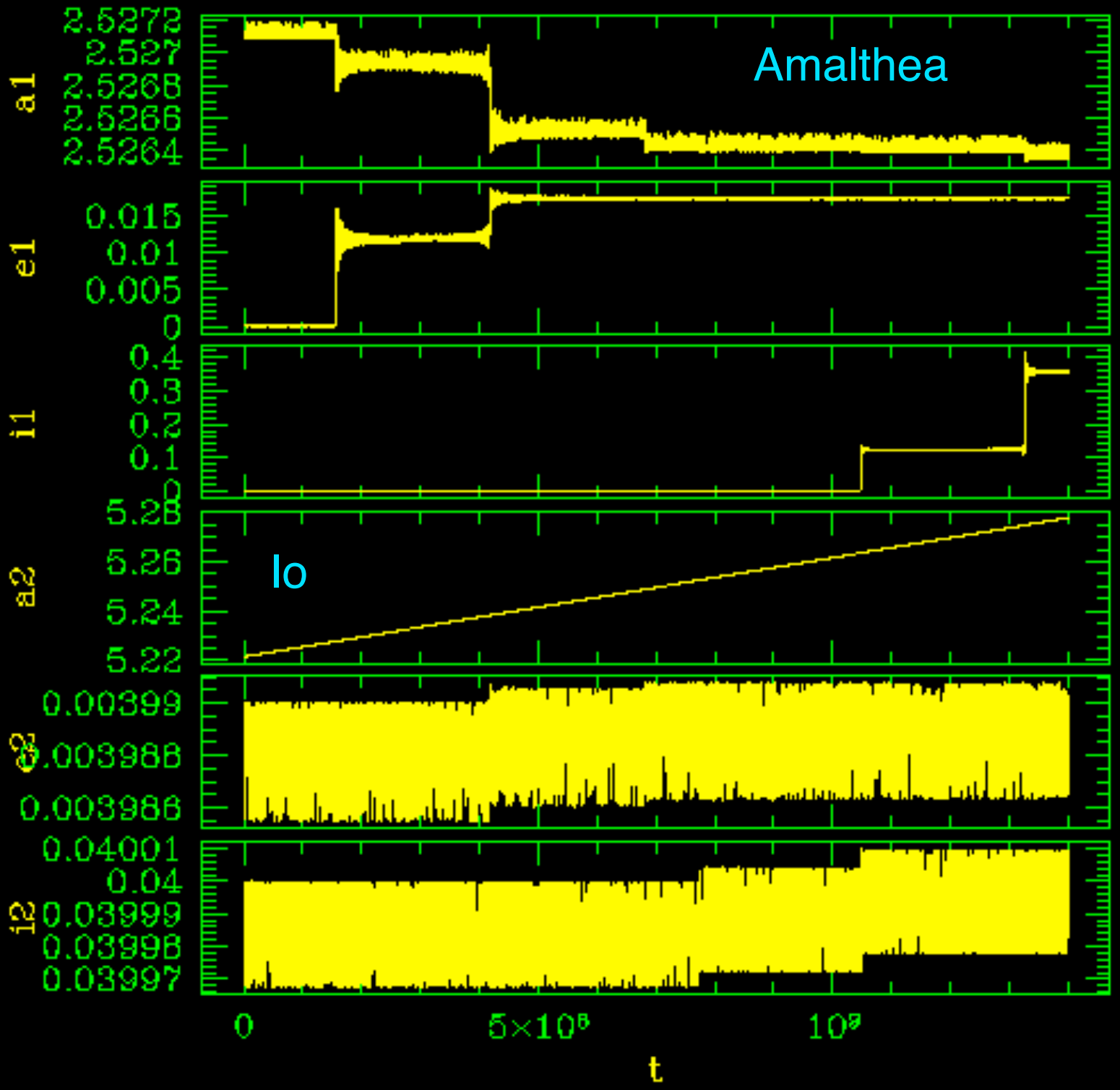
Io



Tides push Io outward

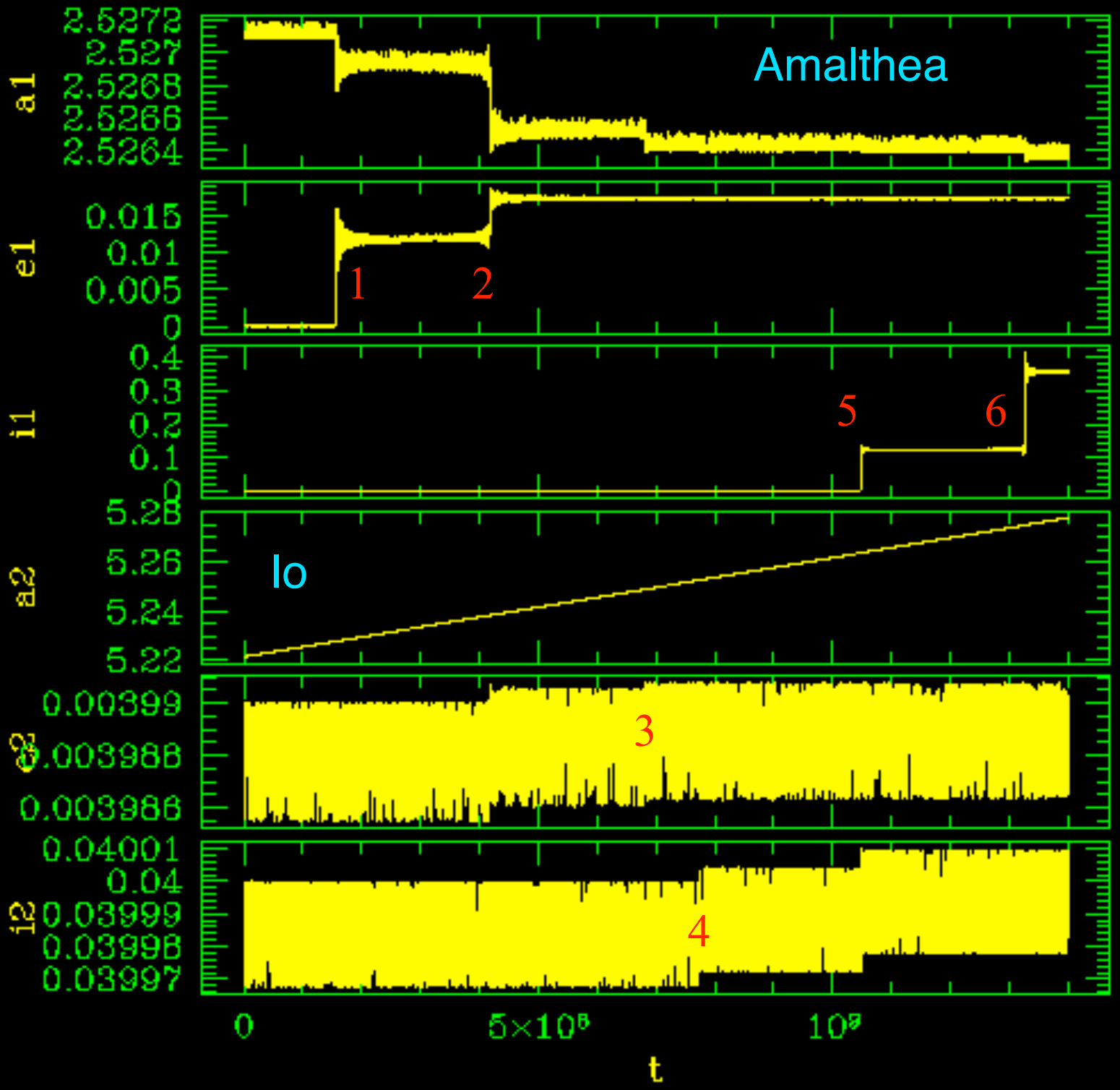
2 satellites

Numerical Simulations
with hnbody/hndrag



Io-Amalthea 3:1,
diverging

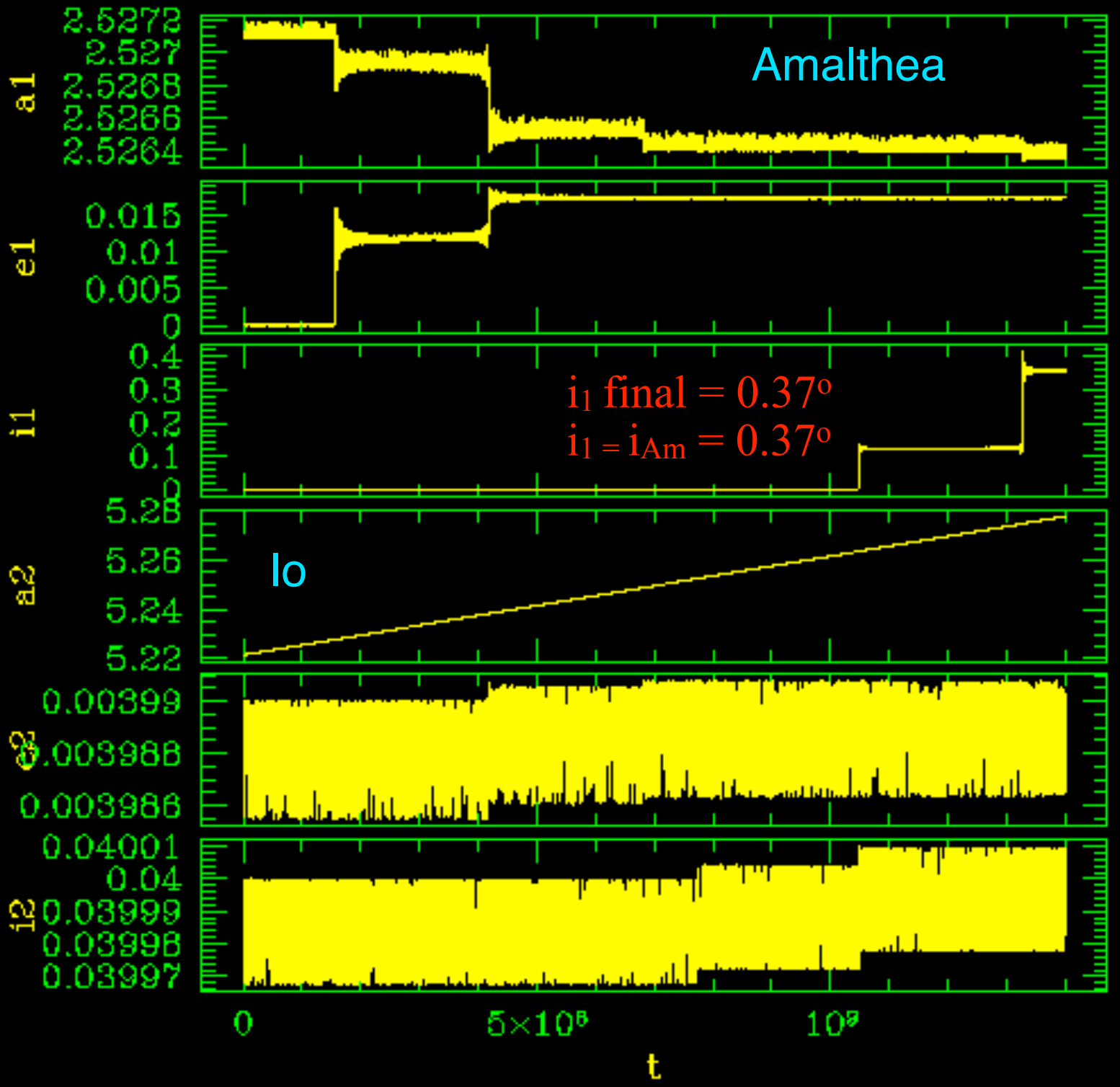
2 satellites



6 resonant kicks

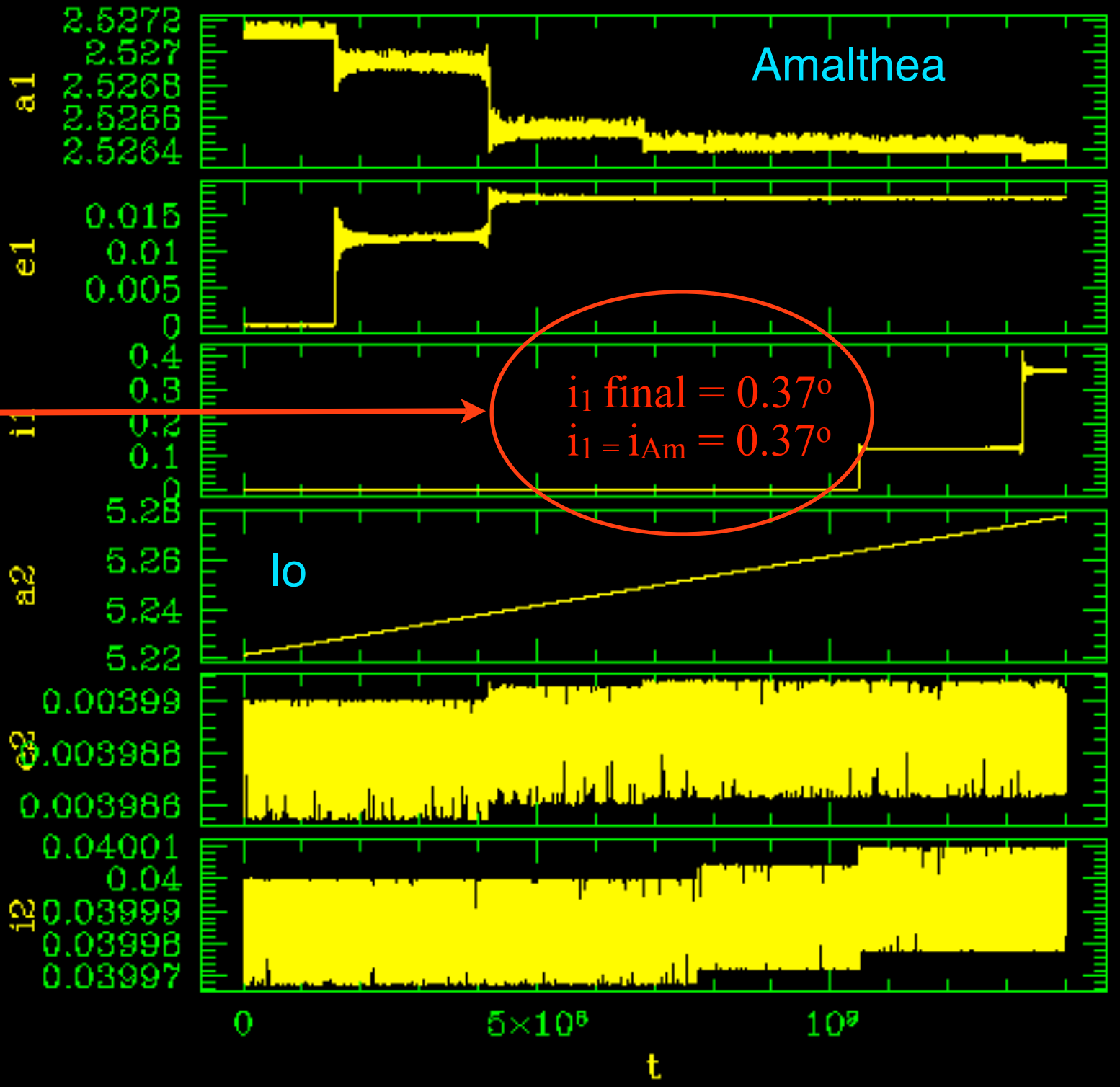
Io-Amalthea 3:1, diverging

2 satellites



Io-Amalthea 3:1, diverging

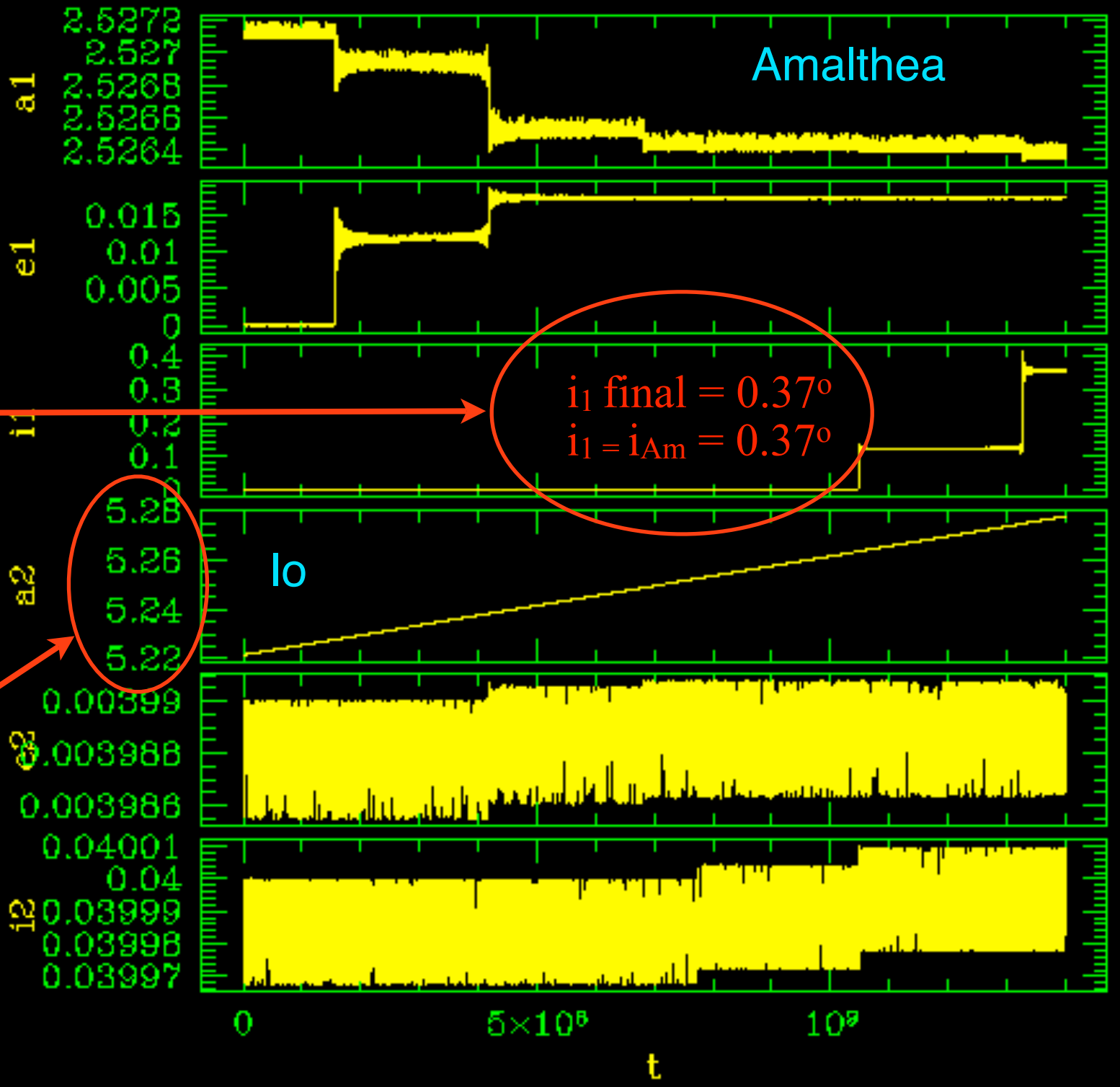
2 satellites



Io gives Amalthea the correct inclination!

Io-Amalthea 3:1, diverging

2 satellites



Io gives Amalthea the correct inclination!

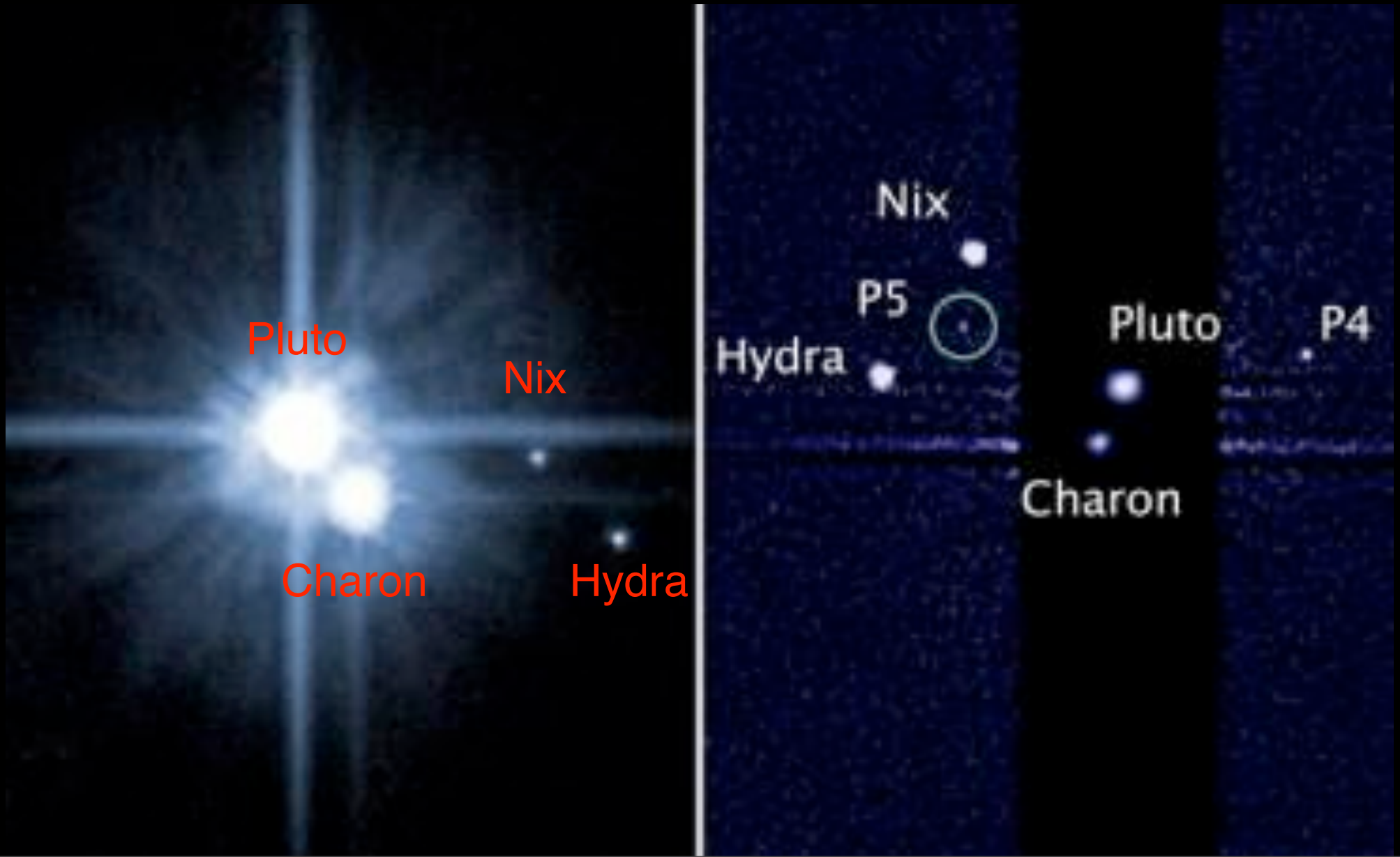
i_1 final = 0.37°

$i_1 = i_{Am} = 0.37°$

So Io must have once been here

Io-Amalthea 3:1, diverging

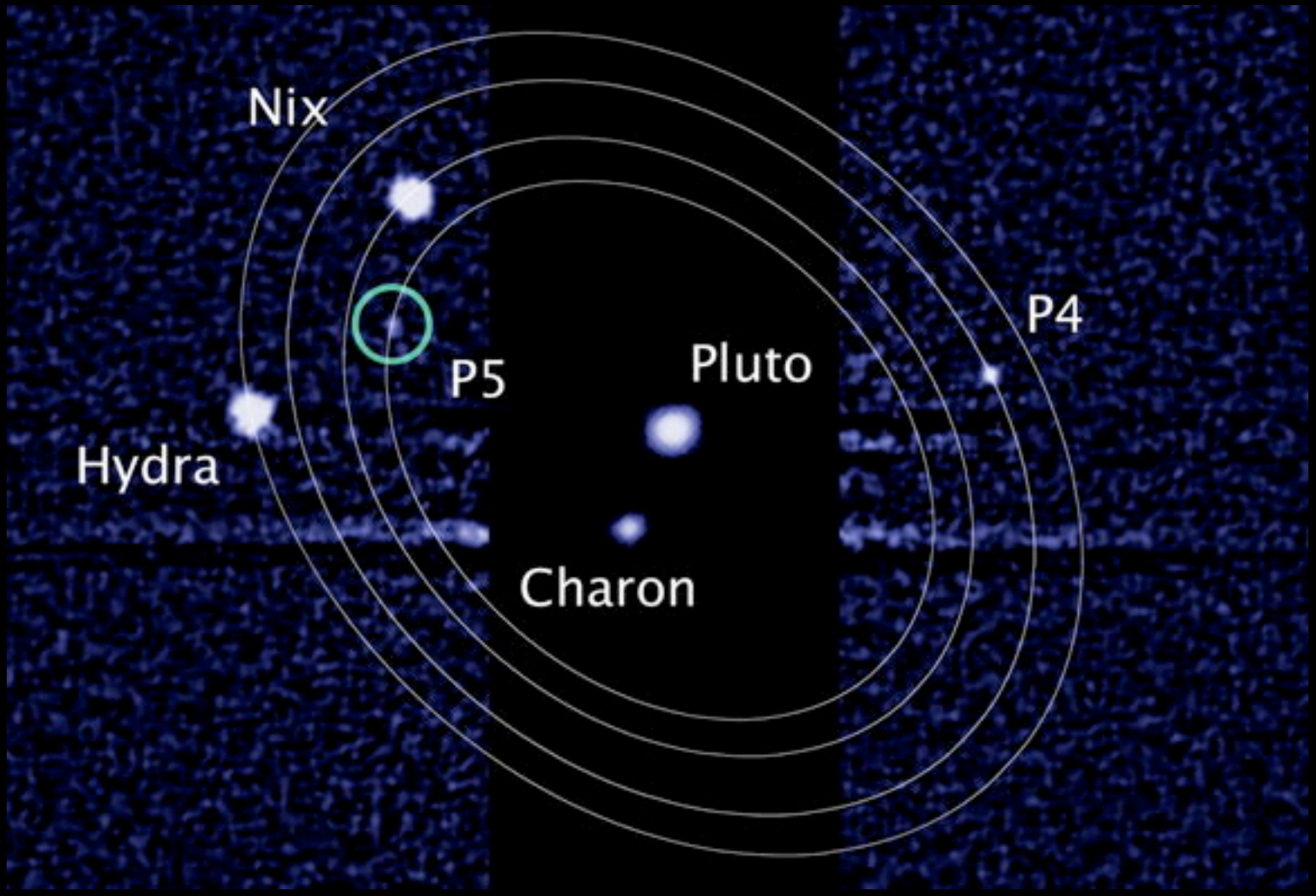
New Moons P4 and P5 just Discovered Orbiting Pluto!



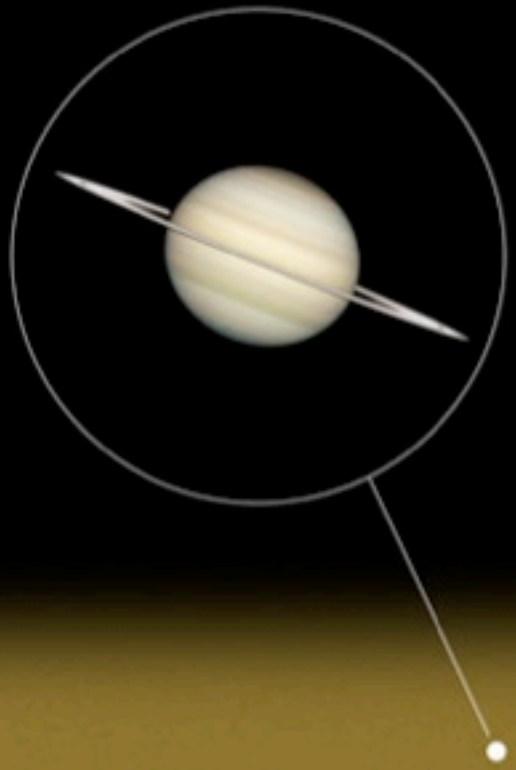
The 4 small moons are evenly spaced

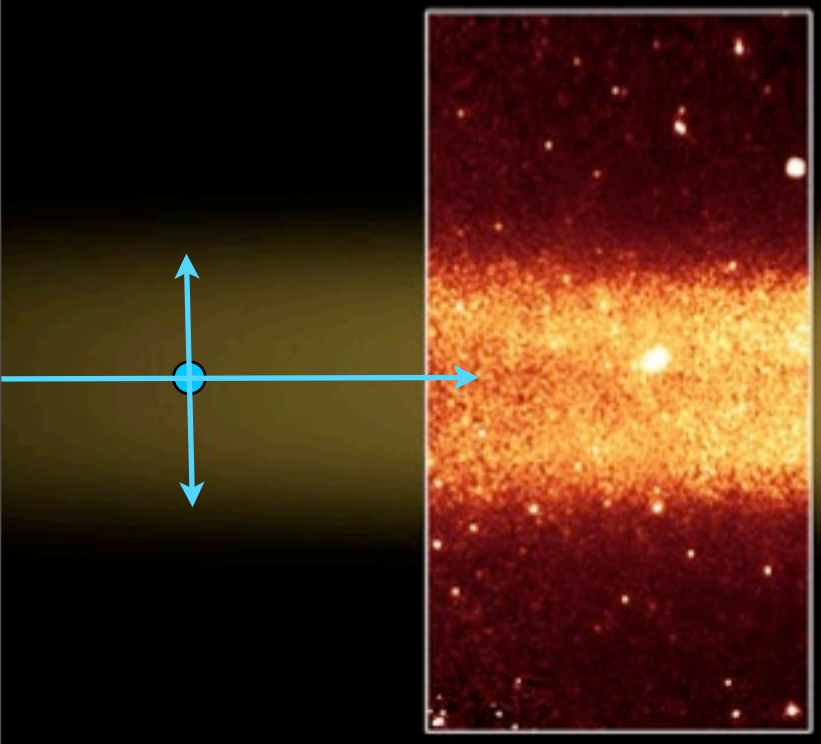
P5 is near Charon's 1:3 resonance
Nix is near 1:4
P4 is near 1:5
Hydra is near 1:6

These resonances hint at how the system formed.



Saturn's Phoebe Ring Discovered in 2009

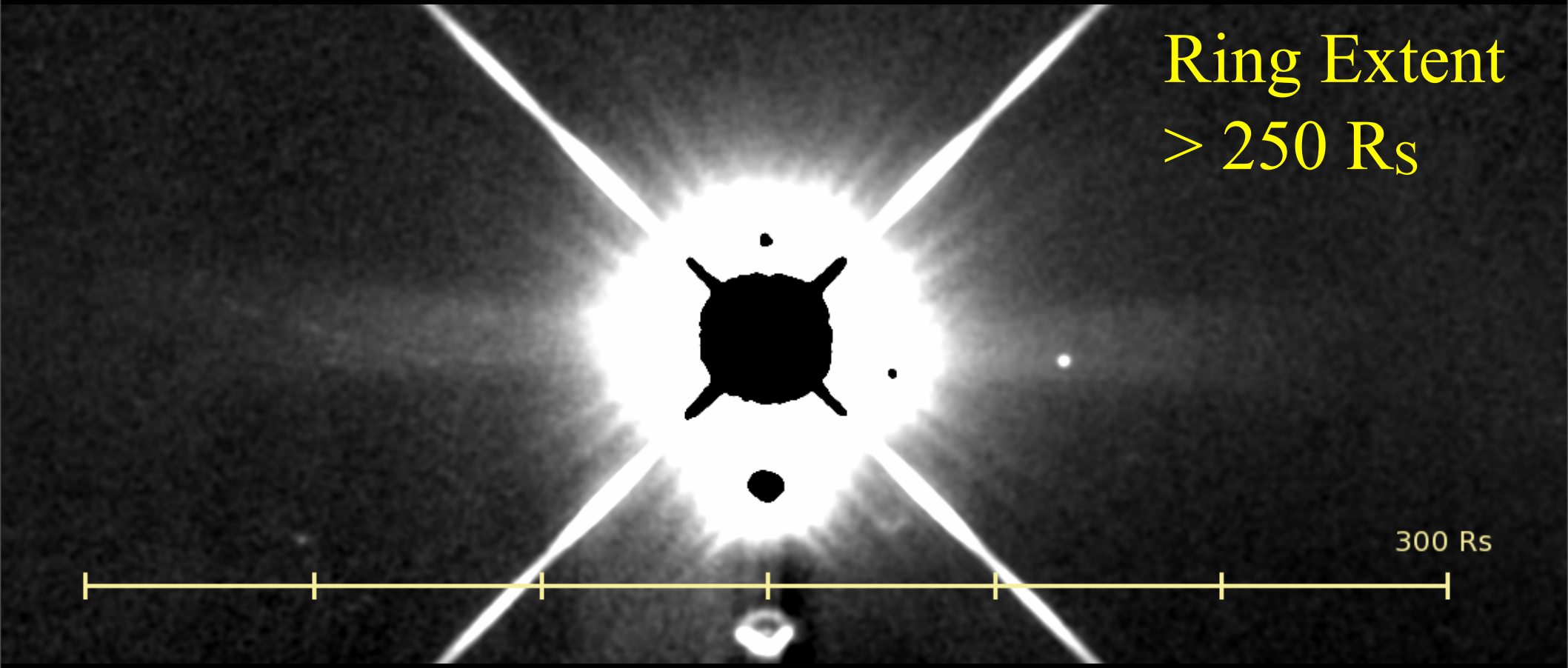




Spitzer, 24 microns

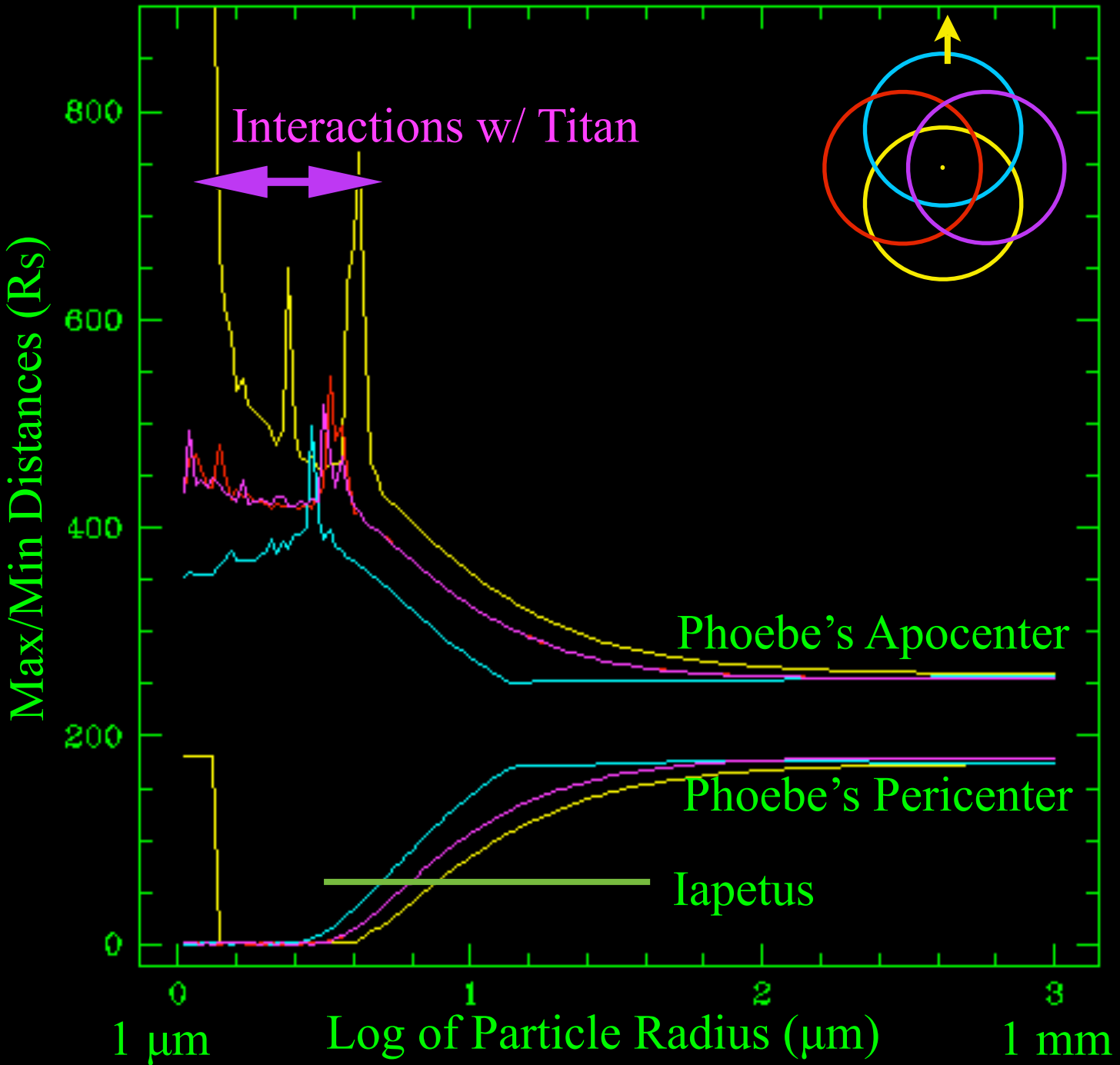
Dust Ring

Verbiscer, Skrutskie, Hamilton 2009. Saturn's Largest Ring, Nature.

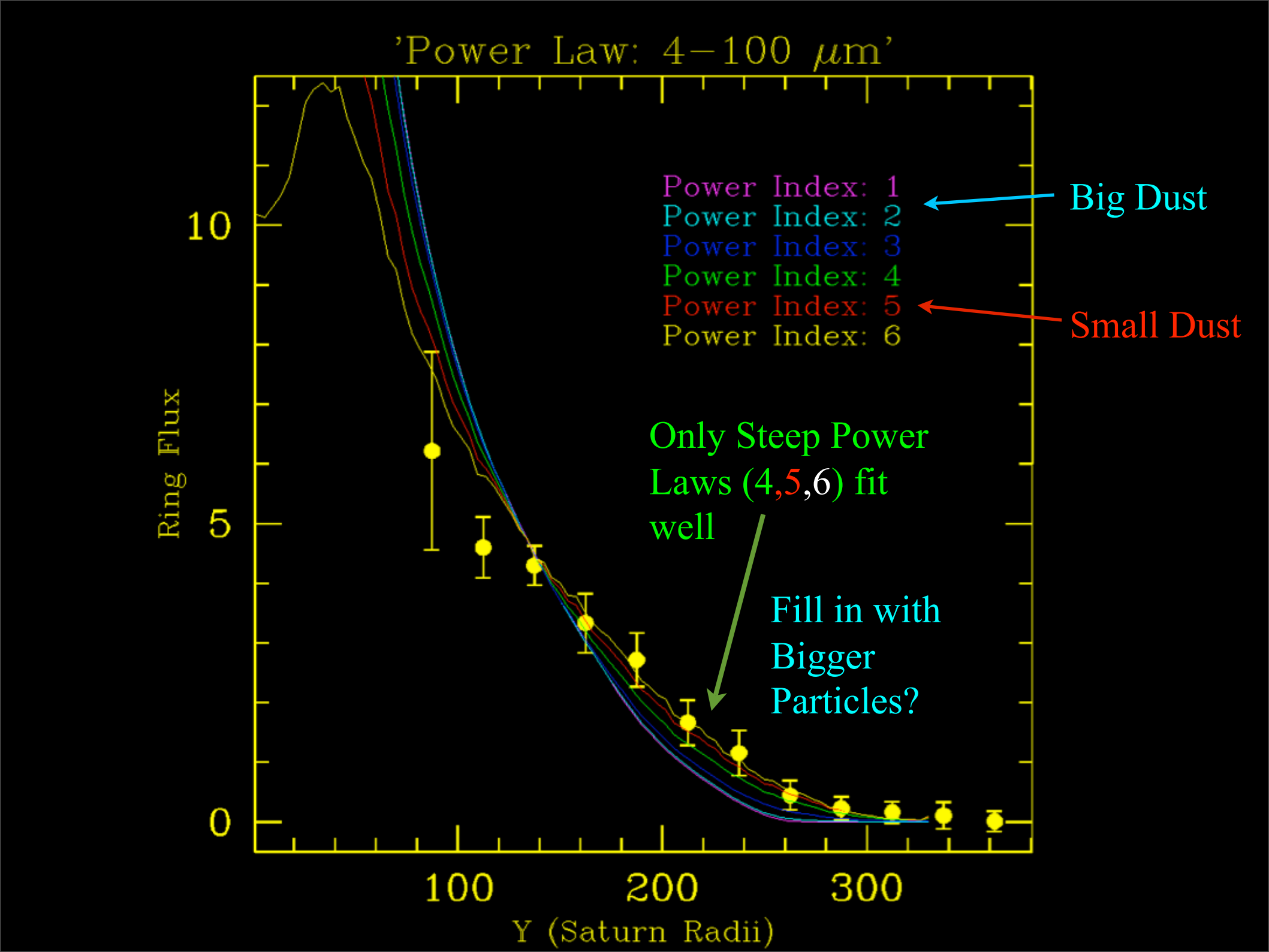


Raw WISE Image, 22 microns

Radial Structure of the Phoebe Ring



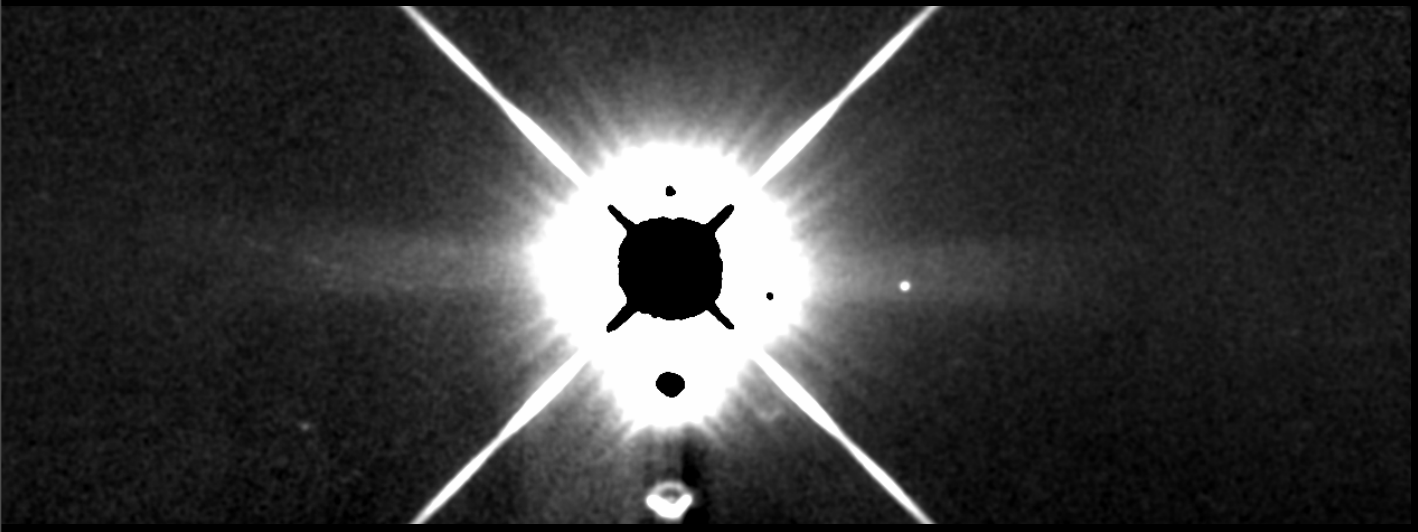
Now add Poynting-Robertson Drag


'Power Law: 4−100 μm'
Power Index: 1
Power Index: 2
Power Index: 3
Power Index: 4
Power Index: 5
Power Index: 6
Big Dust
Small Dust
Only Steep Power Laws (4,5,6) fit well
Fill in with Bigger Particles?
Ring Flux
10
5
0
100
200
300
Y (Saturn Radii)

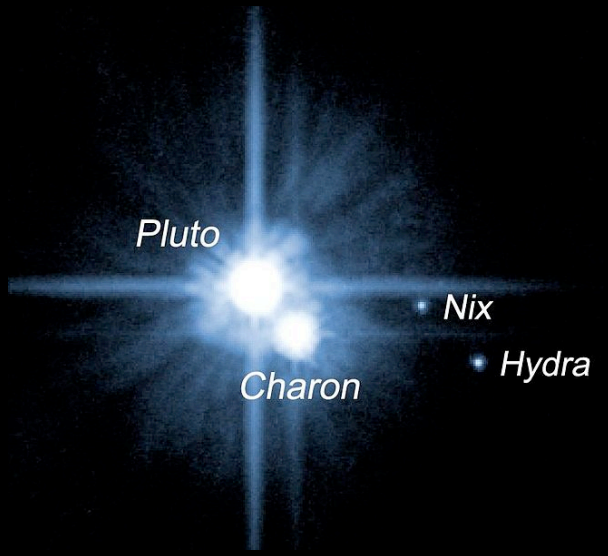
2nd-Year Projects

Galilean Satellites
(Dr. Katie Philpott)

Phoebe Ring

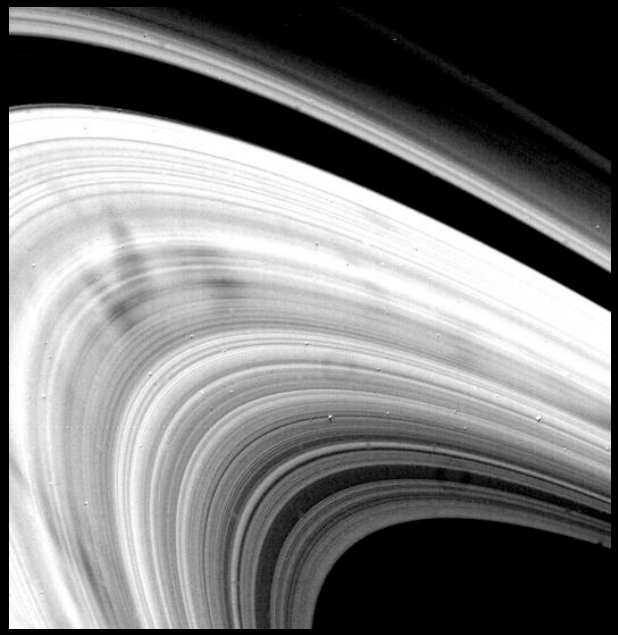


Pluto
(Kate Krivjanik)



2nd-Year Projects, continued

Planetary Rings
(Dr. Daniel Jontof-Hutter)



Uranian Satellites