

Origin of the Different Architectures of the Jovian and Saturnian Satellite Systems

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Jovian System v.s. Saturnian System

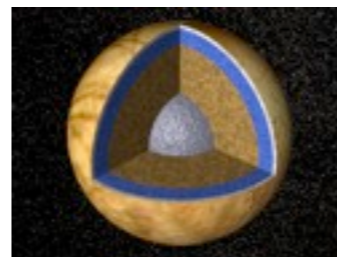


rocky



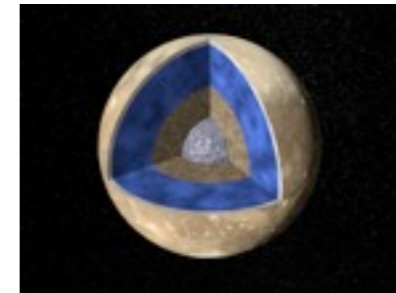
Io

rocky



Europa

icy



Ganymede

icy, undiff.



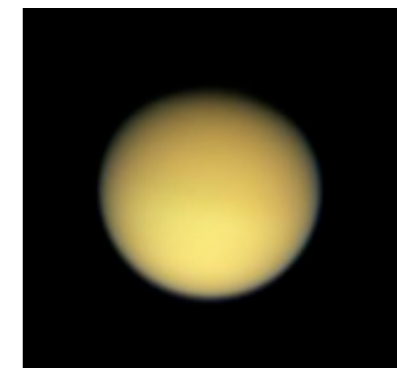
Callisto

|
|
|
mutual mean motion resonances (MMR)



only one big body

icy



Titan

Overview of this study

Circum-Planetary Disk

Canup & Ward, 2002, 2006

Satellites formed in c.-p. disk

Actively-supplied accretion disk

Supplied from circum-stellar disk

→ Analytical solution for T , Σ

Satellite Formation

Ida & Lin, 2004, 2008, in prep.

Analytical solution for

accretion timescale

type I migration timescale

trapping condition in MMR

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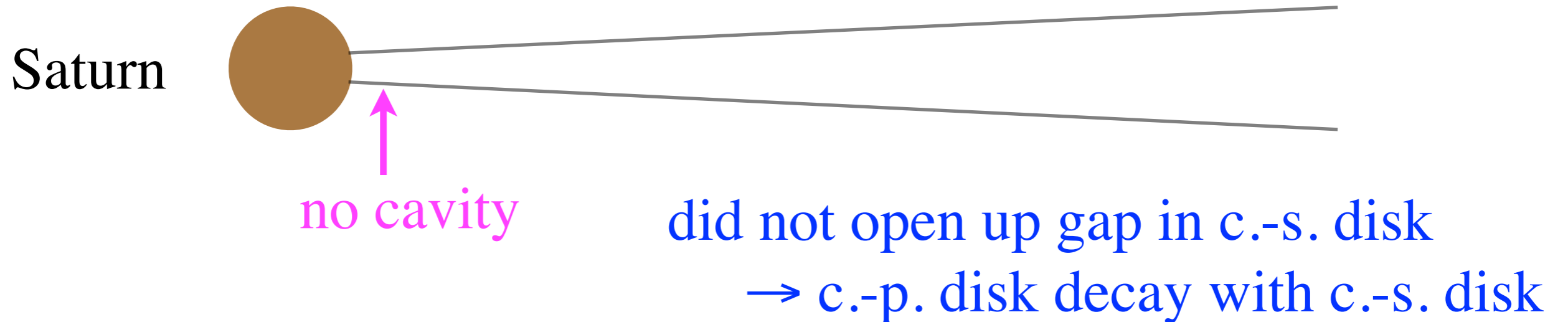
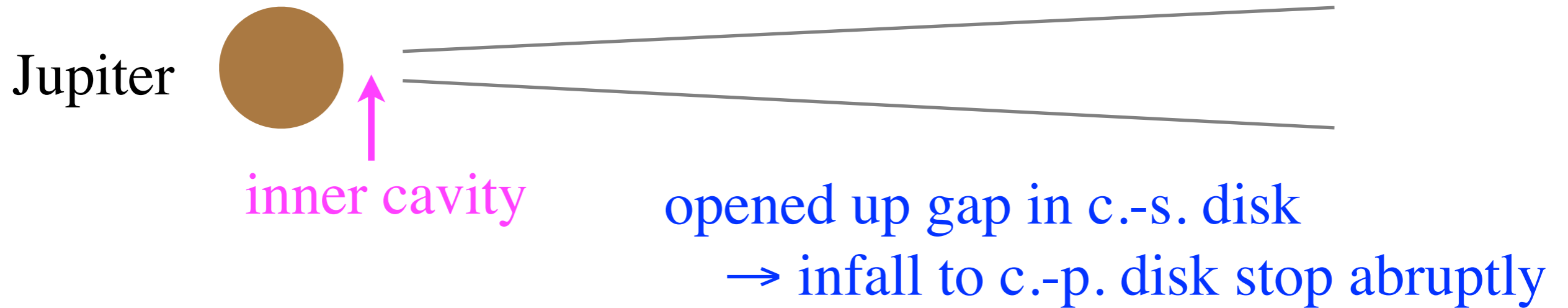
trapping condition in MMR

Adding New Ideas

Disk boundary conditions

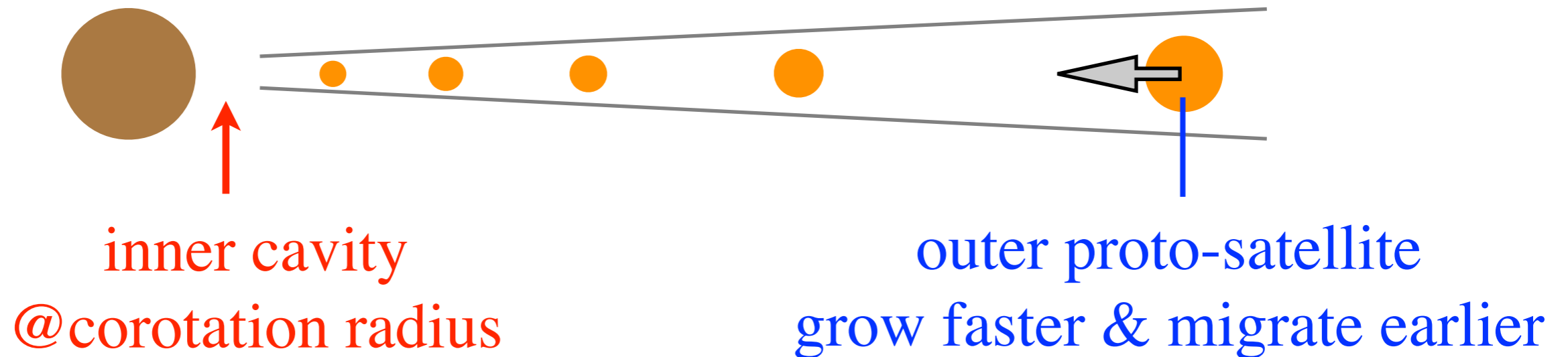
Difference of Jovian/Saturnian systems is naturally reproduced?

The Ideas



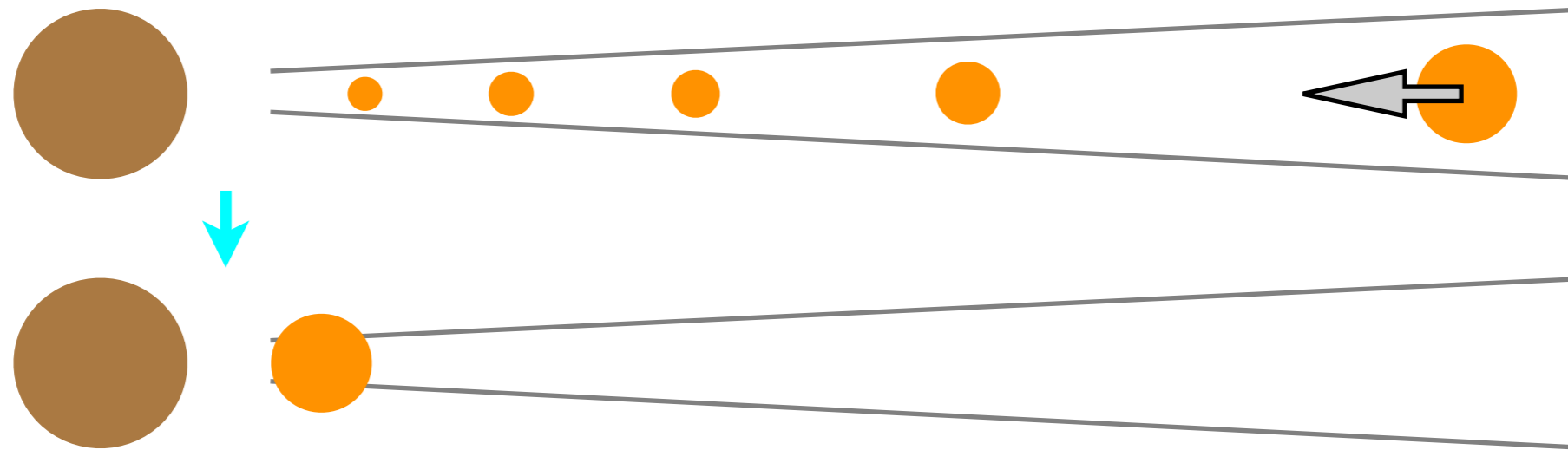
Difference of “inner cavity” is from Königl (1991) and Stevenson (1974)
Difference of gap conditions is from Ida & Lin (2004)

Jovian System



Because the infall mass flux per unit area is constant,
the total mass flux to satellite feeding zones is larger in outer regions.

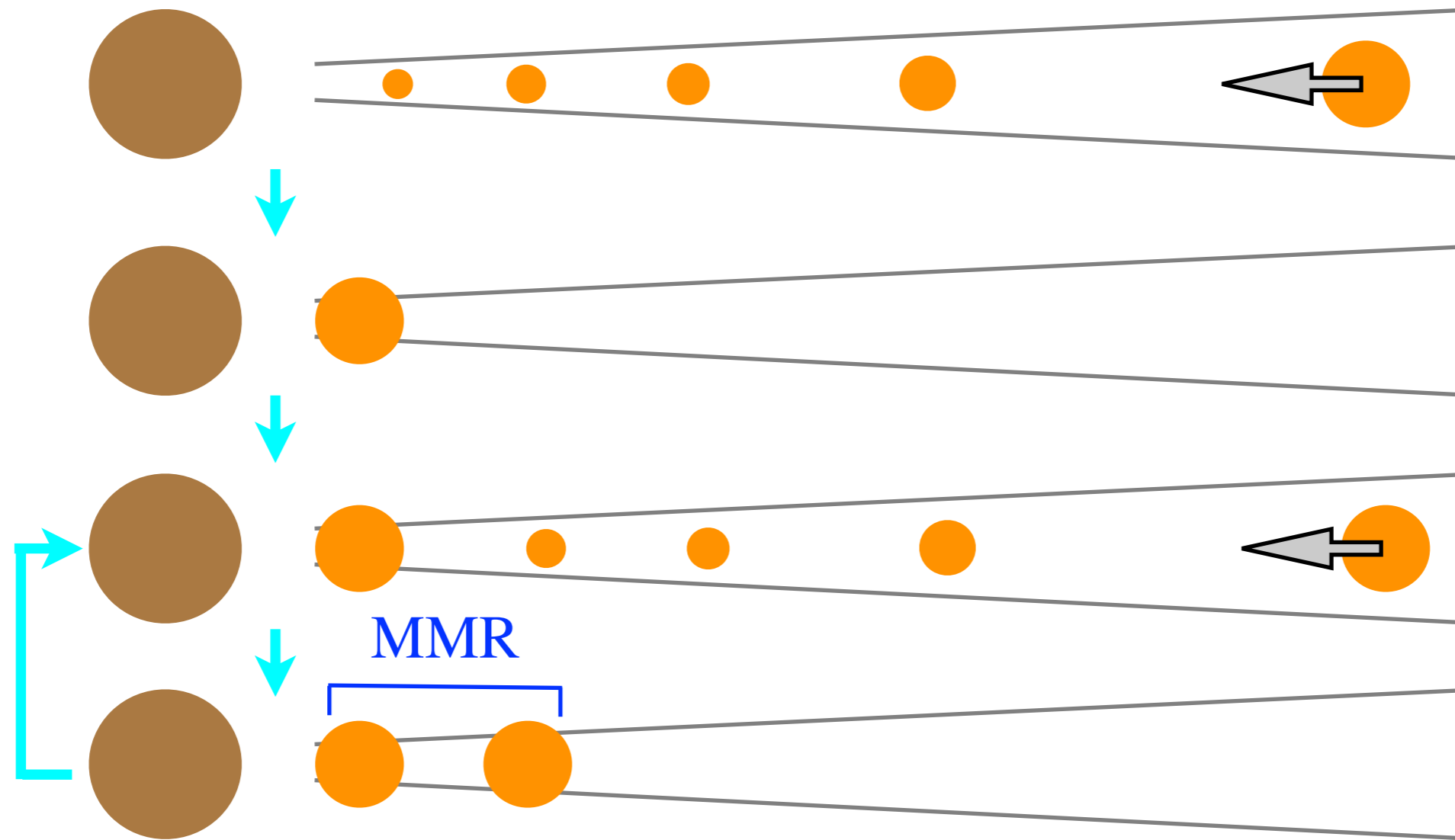
Jovian System



Type I migration is
halted near the inner edge

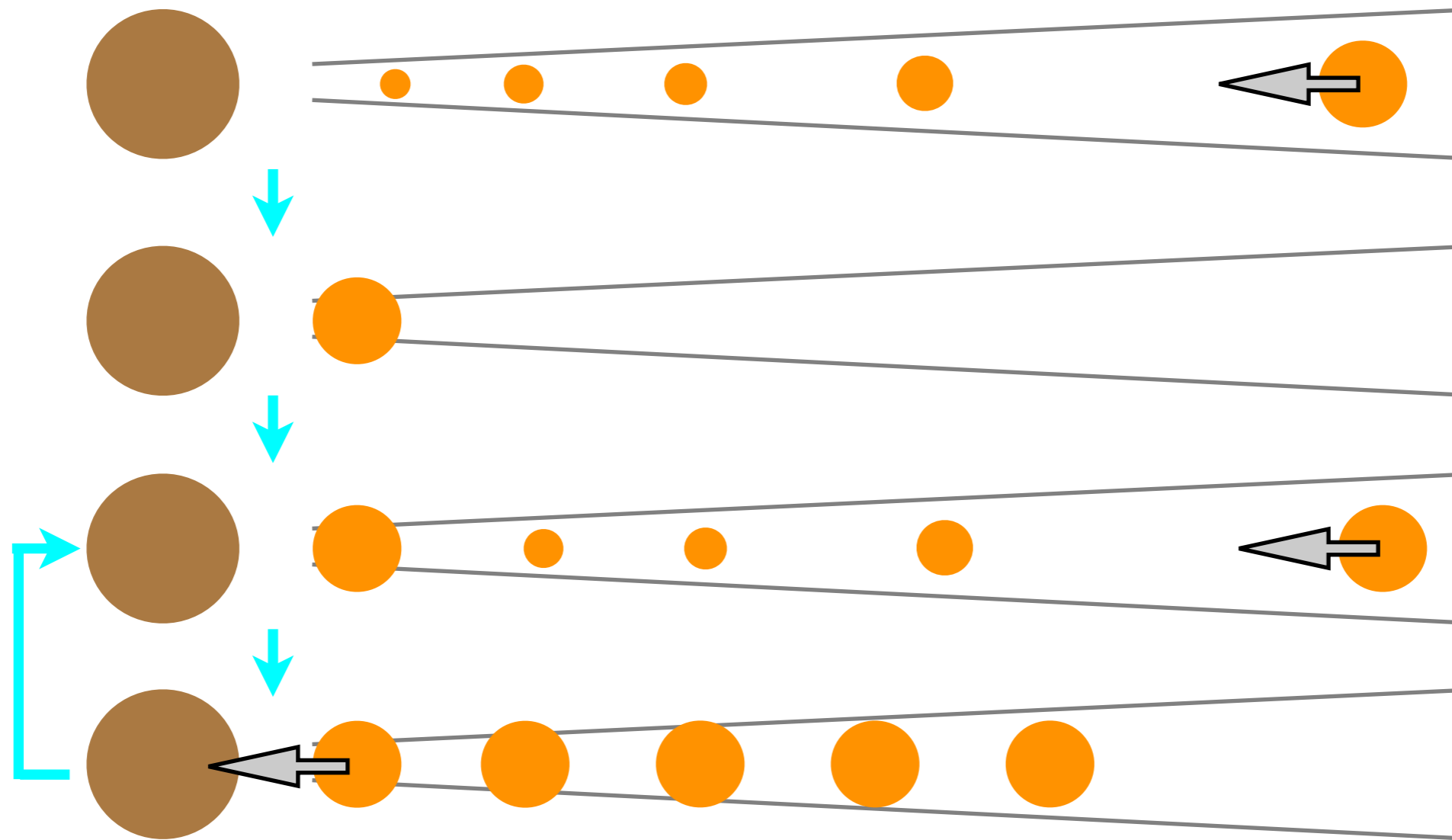
The outer most satellite migrates and sweeps up
the inner small satellites.

Jovian System



Proto-satellites grow & migrate repeatedly
They are trapped in MMR with the innermost satellite

Jovian System

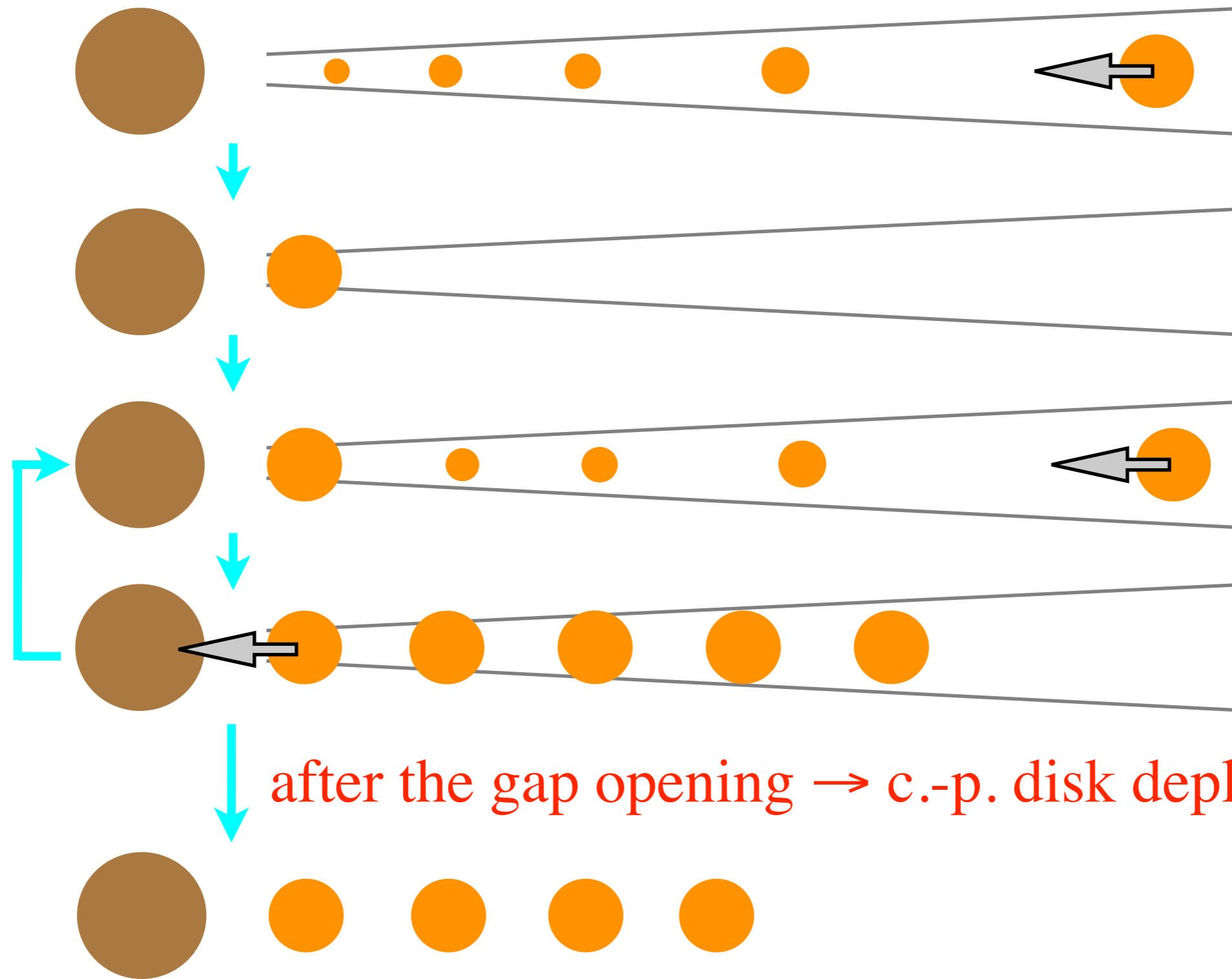


Total mass of the trapped satellites $>$ Disk mass

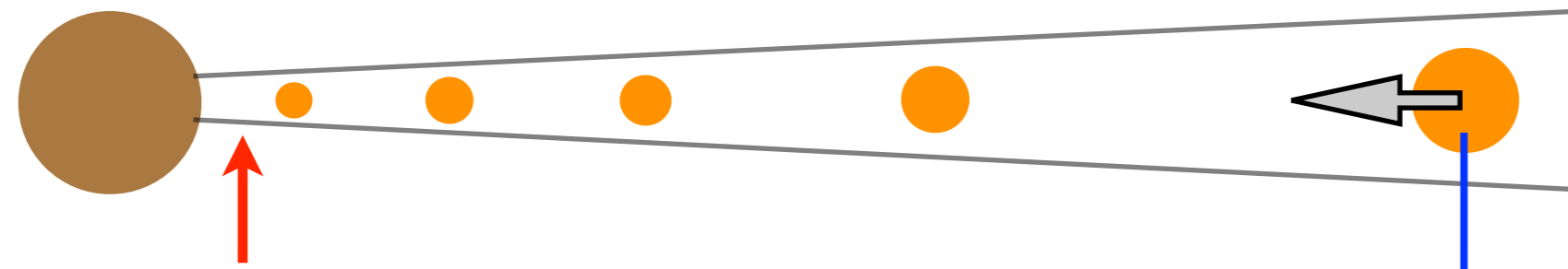
→ the halting mechanism is not effective

→ Innermost satellite is released to the host planet

Jovian System



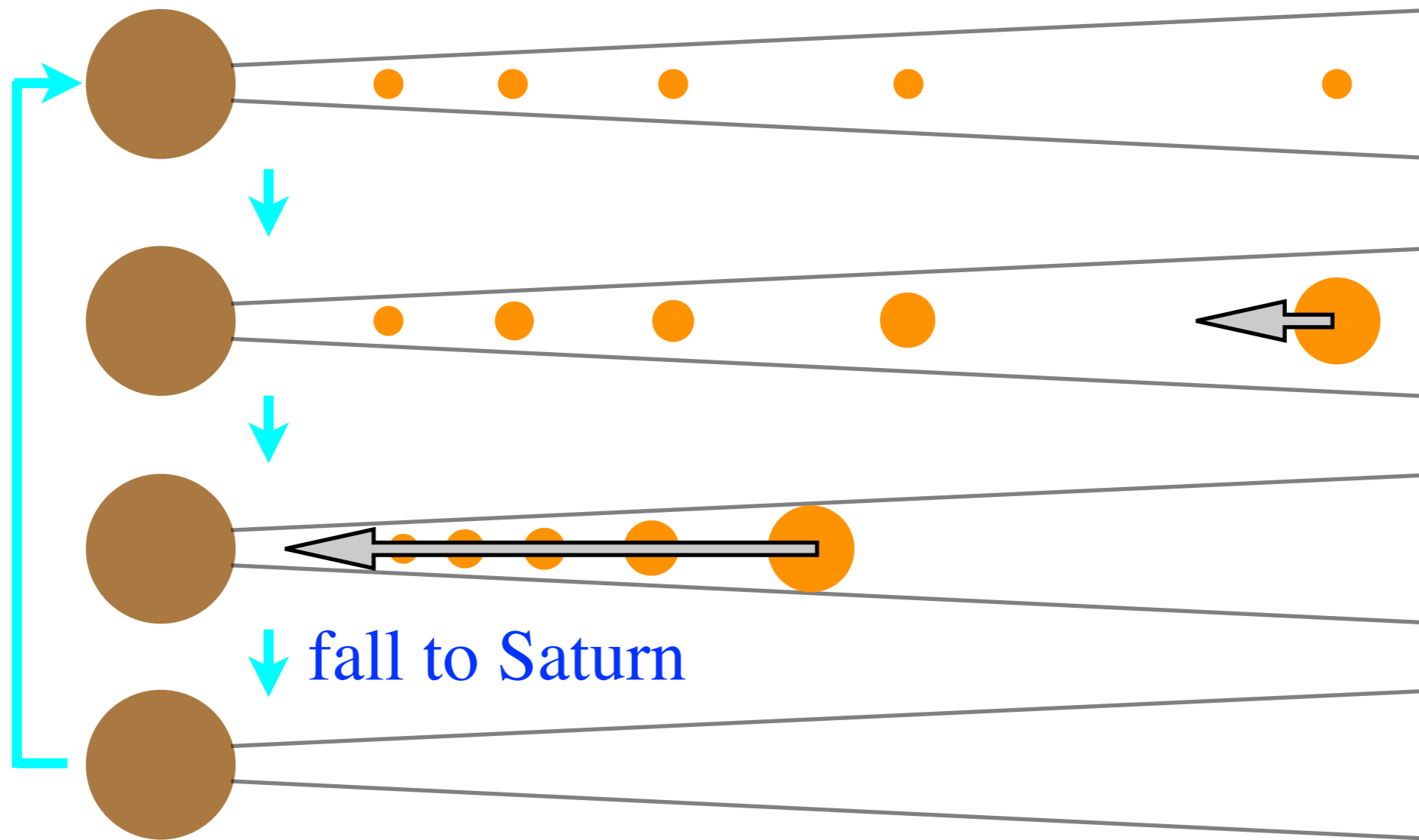
Saturnian System



No inner cavity

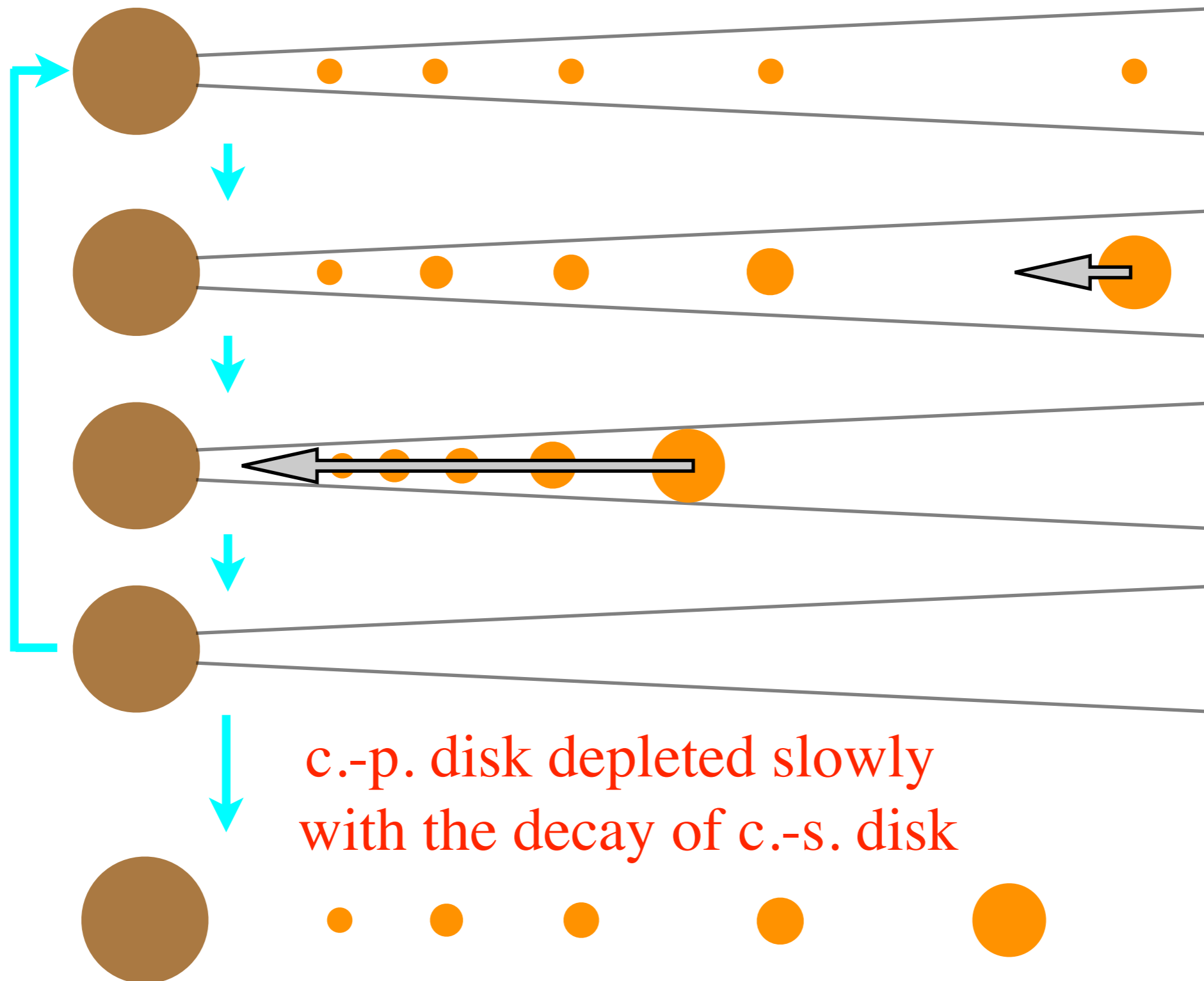
outer proto-satellite
grow faster & migrate earlier

Saturnian System



Large proto-satellites migrate from the outer regions and fall to the host planet with inner smaller satellites

Saturnian System



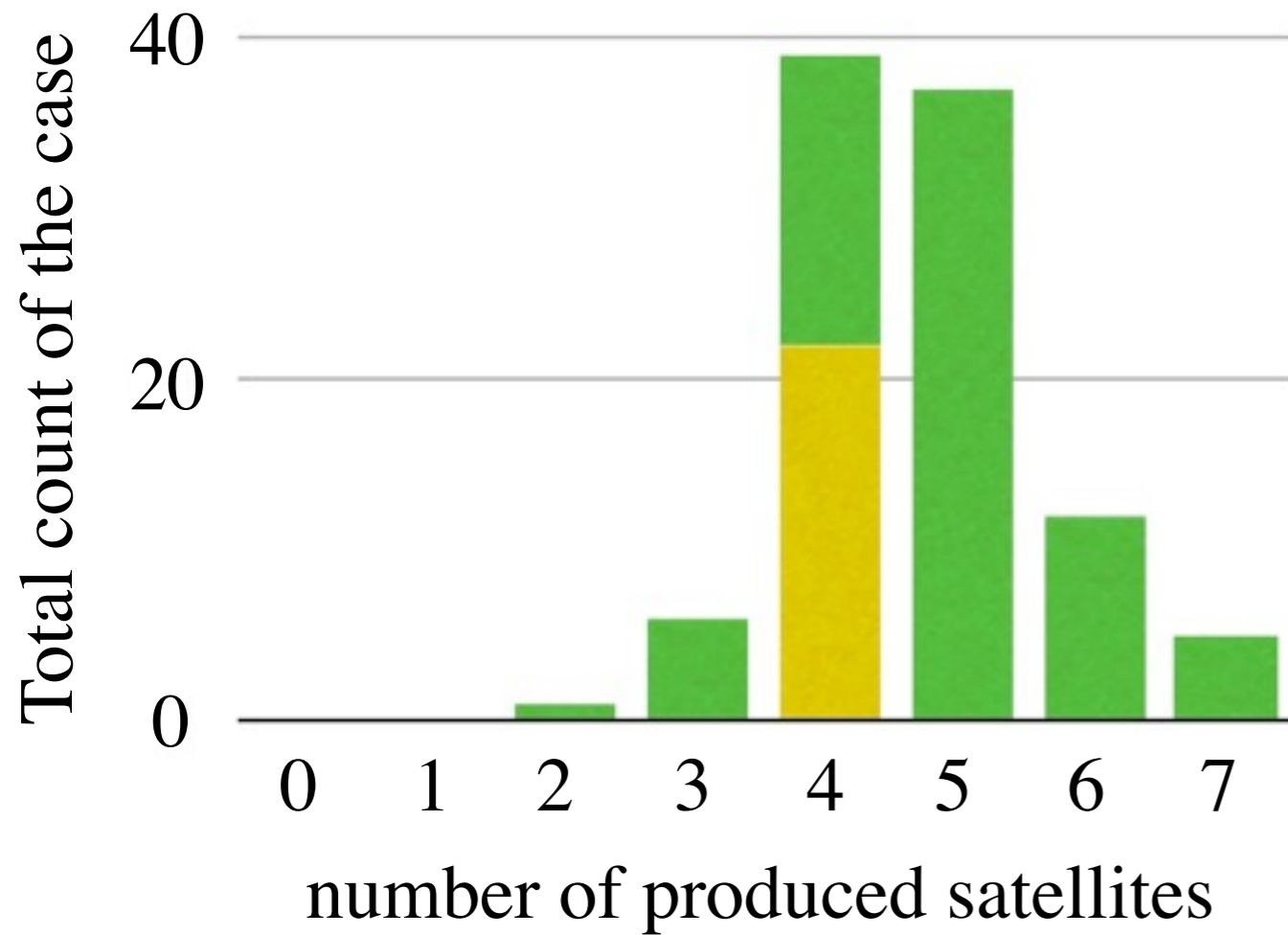
Monte Carlo Simulation (n=100)

Parameters:

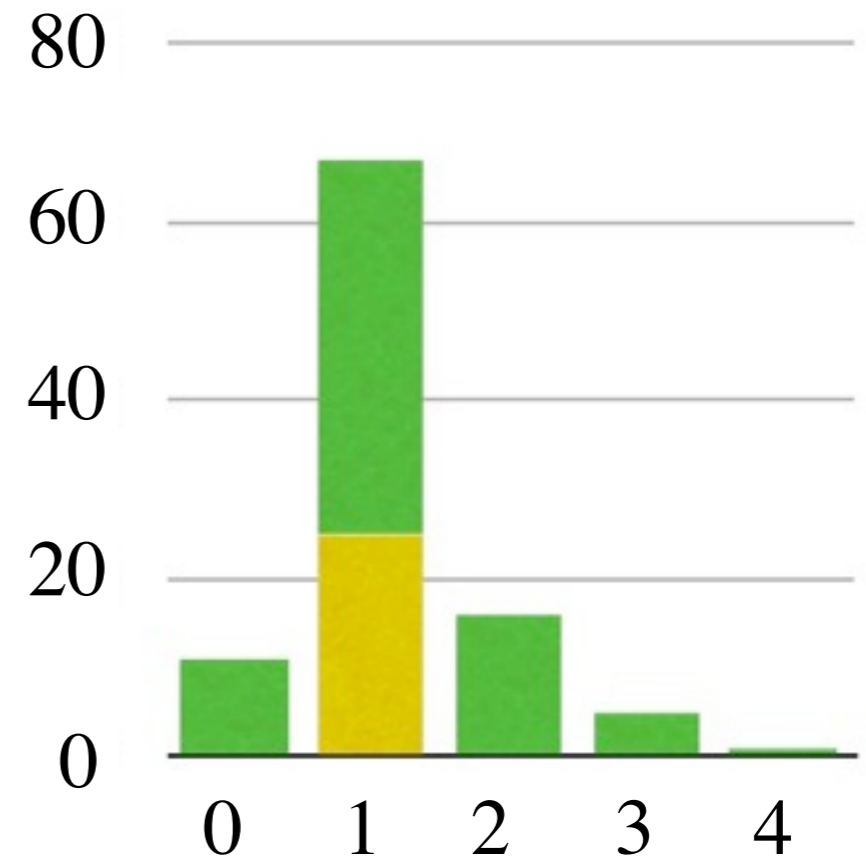
Disk viscosity (α model)	$\alpha = 10^{-3} - 10^{-2}$
Disk decay timescale	$\tau_{in} = 3 \times 10^6 - 5 \times 10^6 \text{ yr}$
Number of “satellite seeds”	$N = 10 - 20$

Results: Distribution of the number of large satellites

Jovian

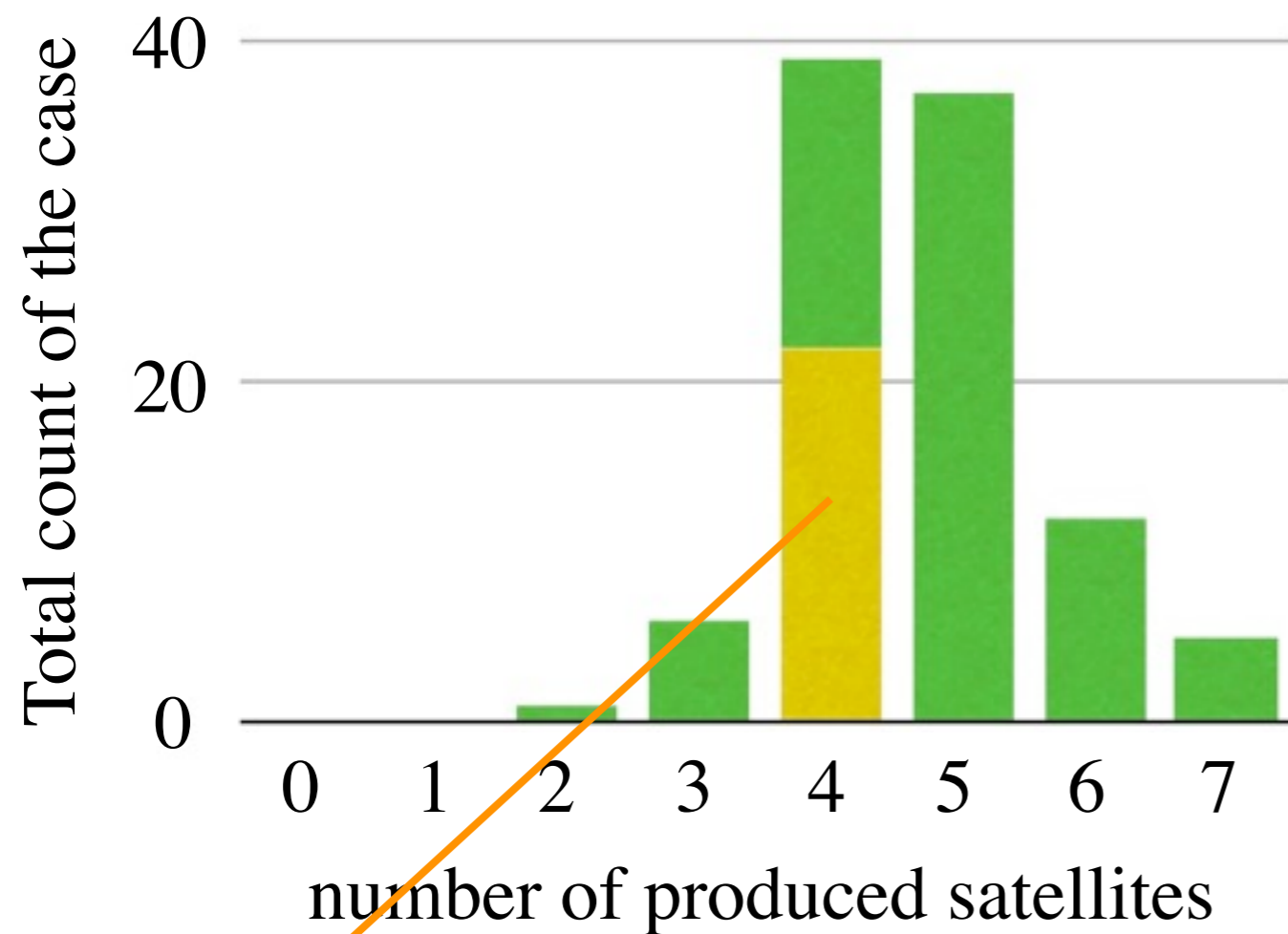


Saturnian



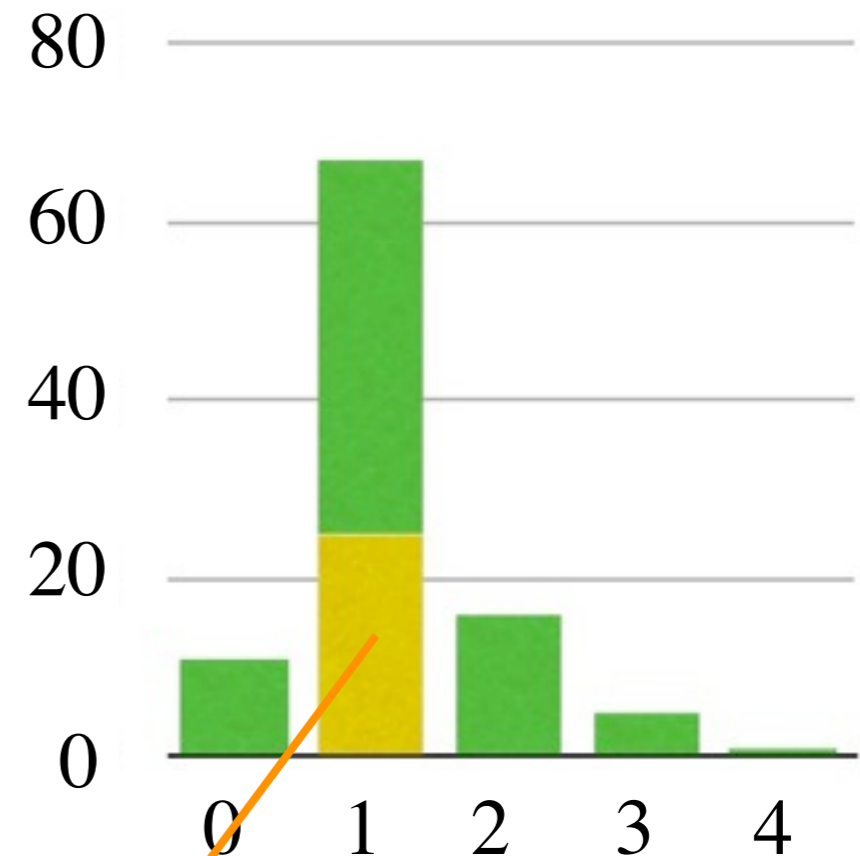
Results: Distribution of the number of large satellites

Jovian



inner two bodies: rocky
& outer two bodies: icy

Saturnian

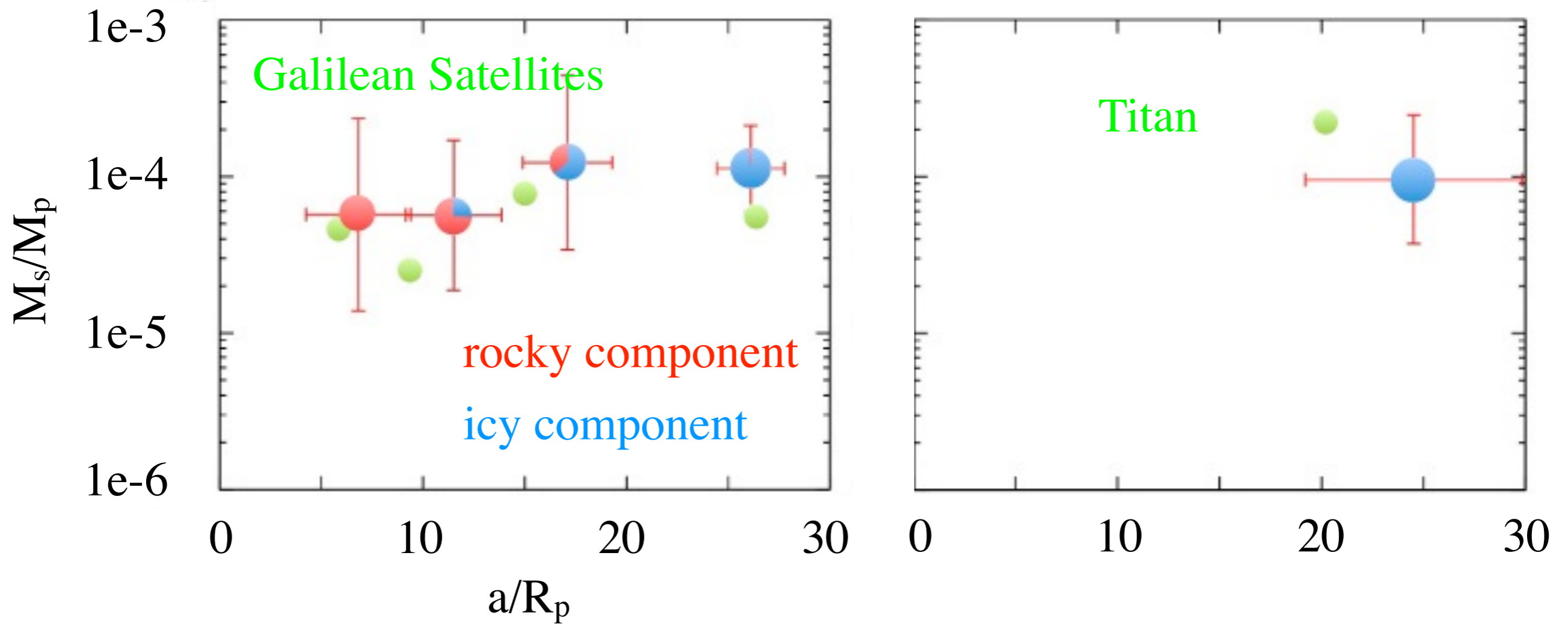


icy satellite
& large enough ($\sim M_{\text{Titan}}$)

Results: Properties of produced satellite systems

Jovian

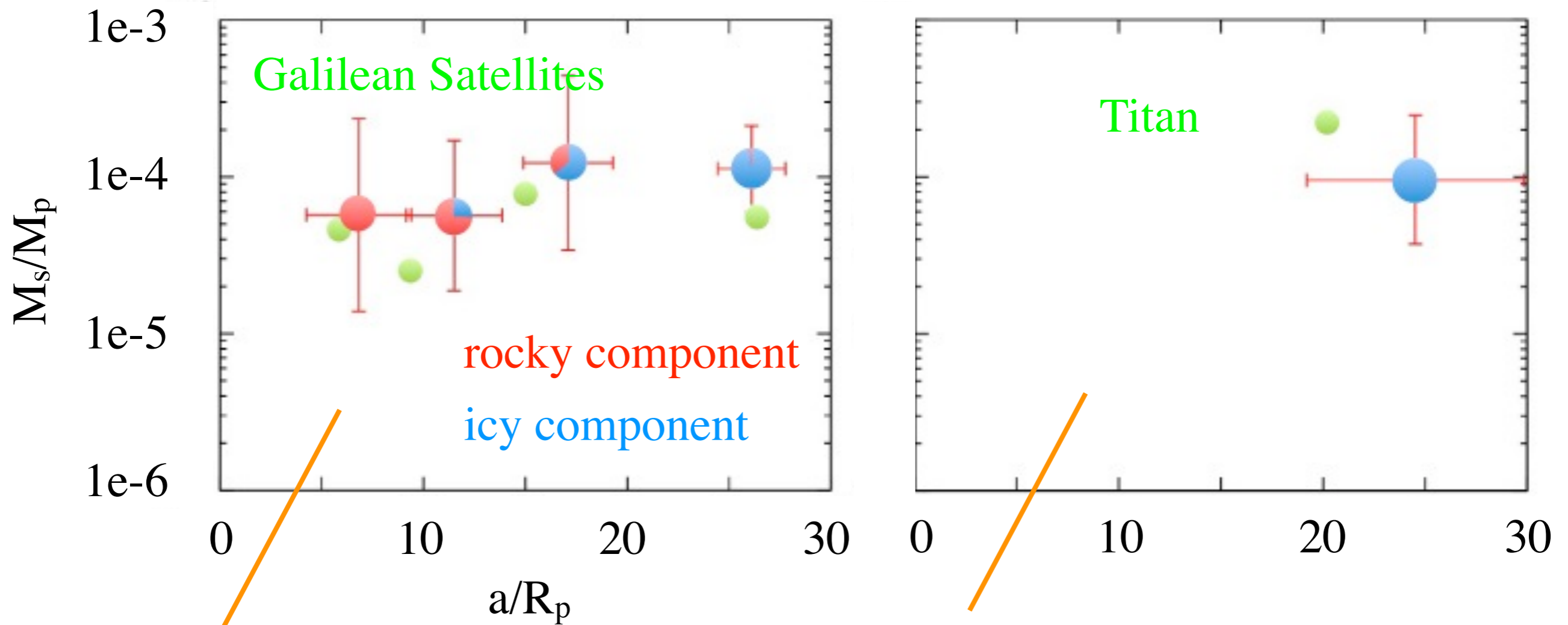
Saturnian



Results: Properties of produced satellite systems

Jovian

Saturnian



inner three bodies
are trapped in MMR

the largest satellite
has ~90% of total satellite mass

Summary

- **Jovian Satellite System v.s. Saturnian Satellite System**
Difference of size, number, location, and compositions
- **Satellite Accretion/Migration in Circum-Planetary Disk**
Canup & Ward (2002, 2006) + Ida & Lin (2004, 2008, in prep.)
- **The Ideas of Disk Boundary Conditions**
Difference of inner cavity opening and gap opening conditions
- **Monte Carlo Simulations**
Difference of Jovian/Saturnian system are naturally reproduced