The Gas Drag Effect in the Irregular Satellite Capture

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FAPESP

CNPq

Gravitational Capture Problem

Gravitational Capture Problem

- Heliocentric orbit to planetocentric orbit

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- Restricted Three-Body Problem

Gravitational Capture Problem

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  - Temporary Capture

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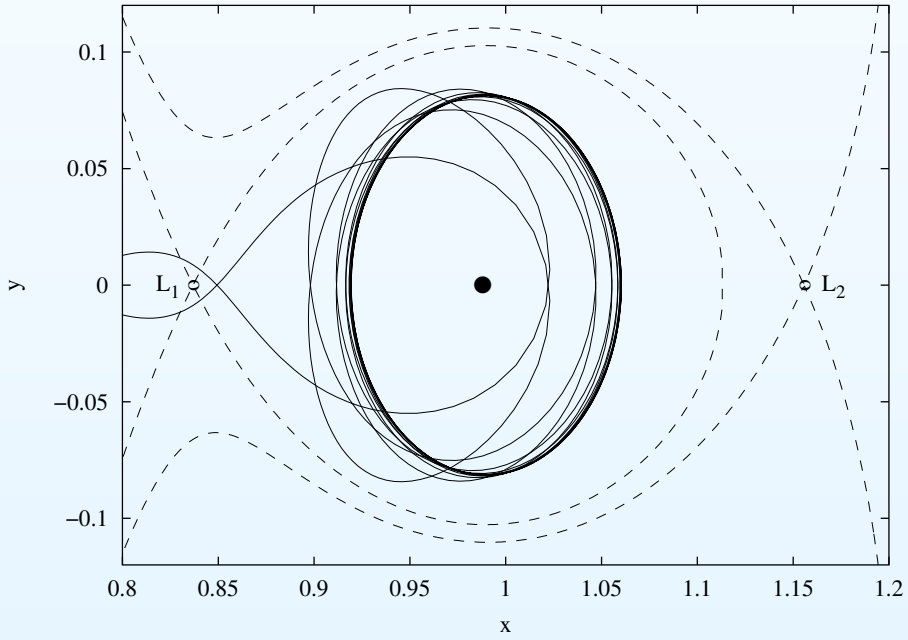

Capture Efetivation

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- Dissipative Process

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  - Mass Variation

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  - Planetary Migration

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Capture Efetivation

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  - Gas Drag

Planetary Formation

Planetary Formation

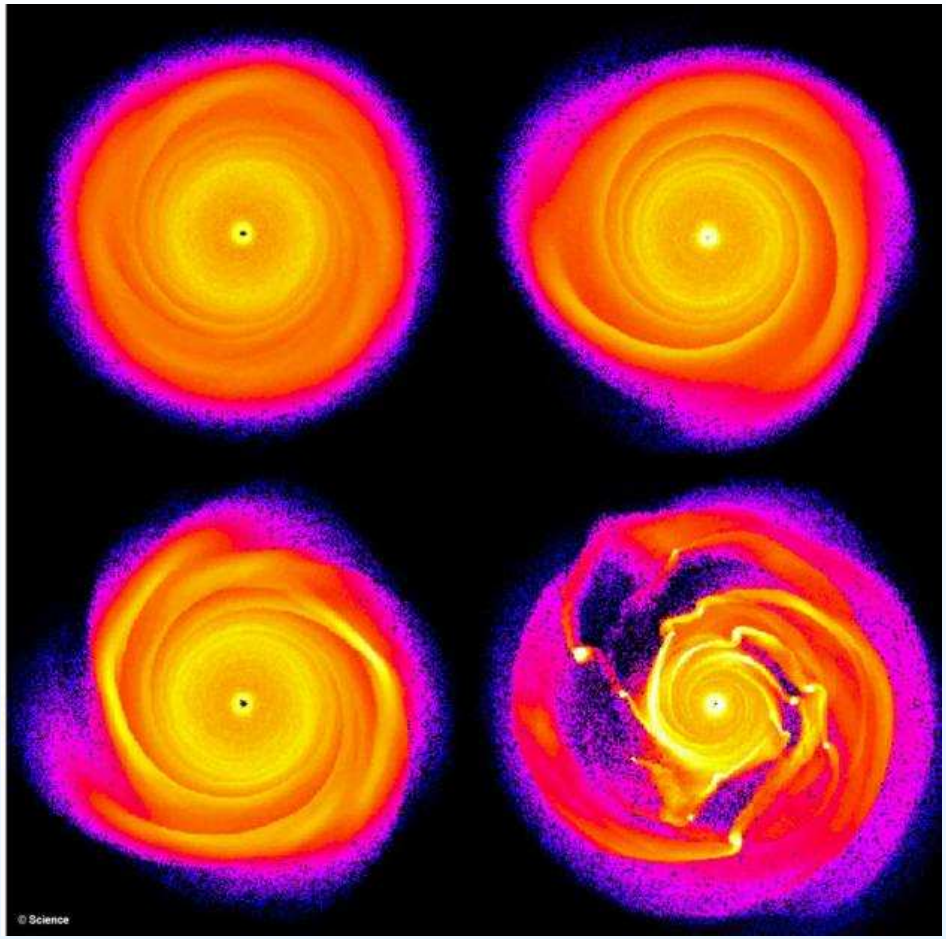
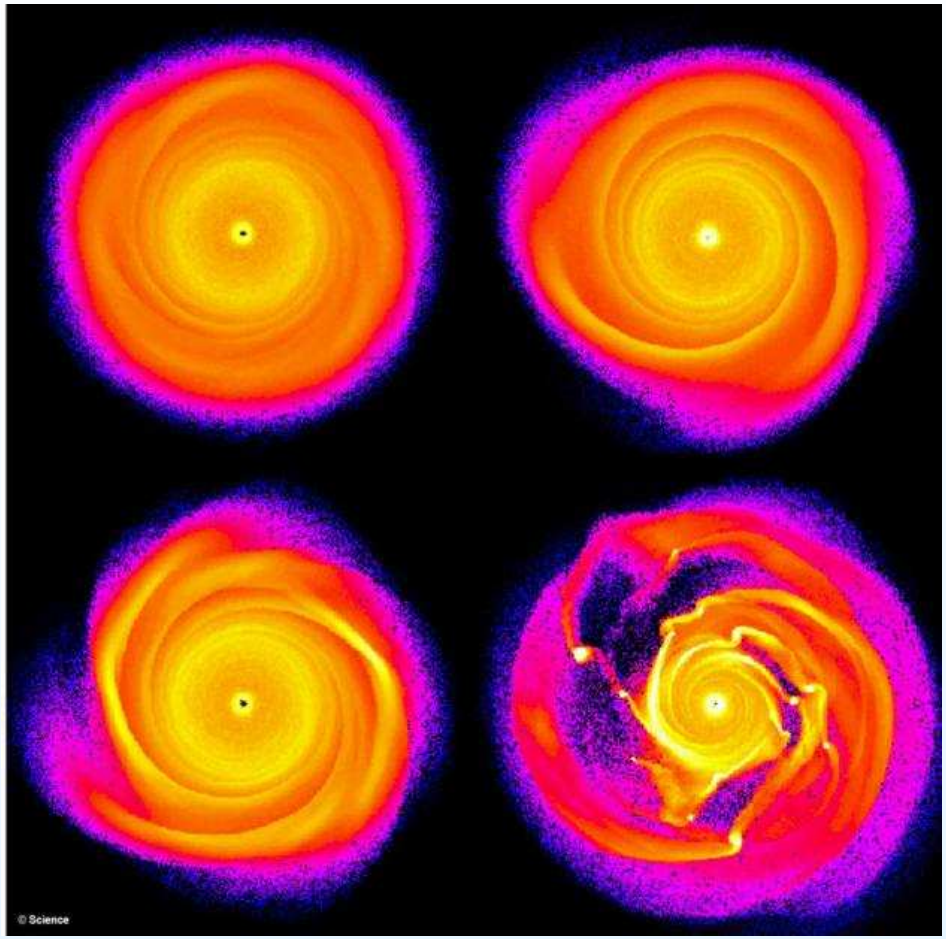


IMAGE: Science/Mayer et al.

Planetary Formation



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- Disk of material or gas

Planetary Formation

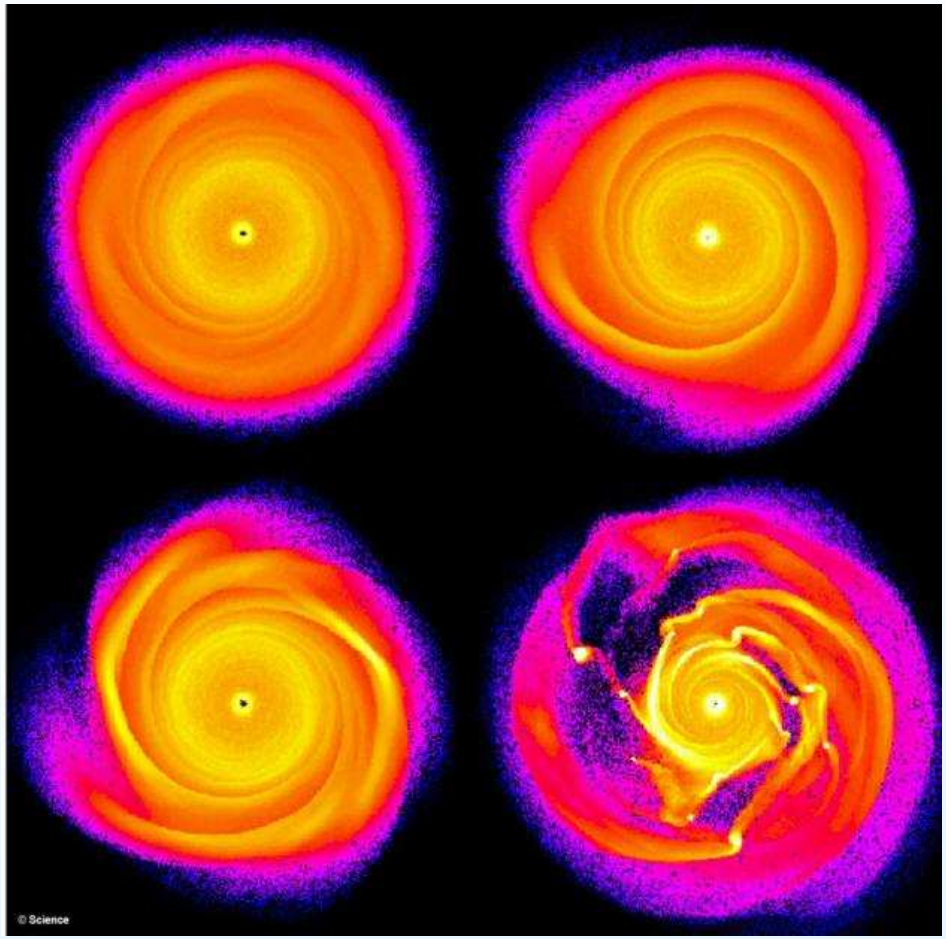

IMAGE: Science/Mayer et al.

- Disk of material or gas
- Nebula

Planetary Formation

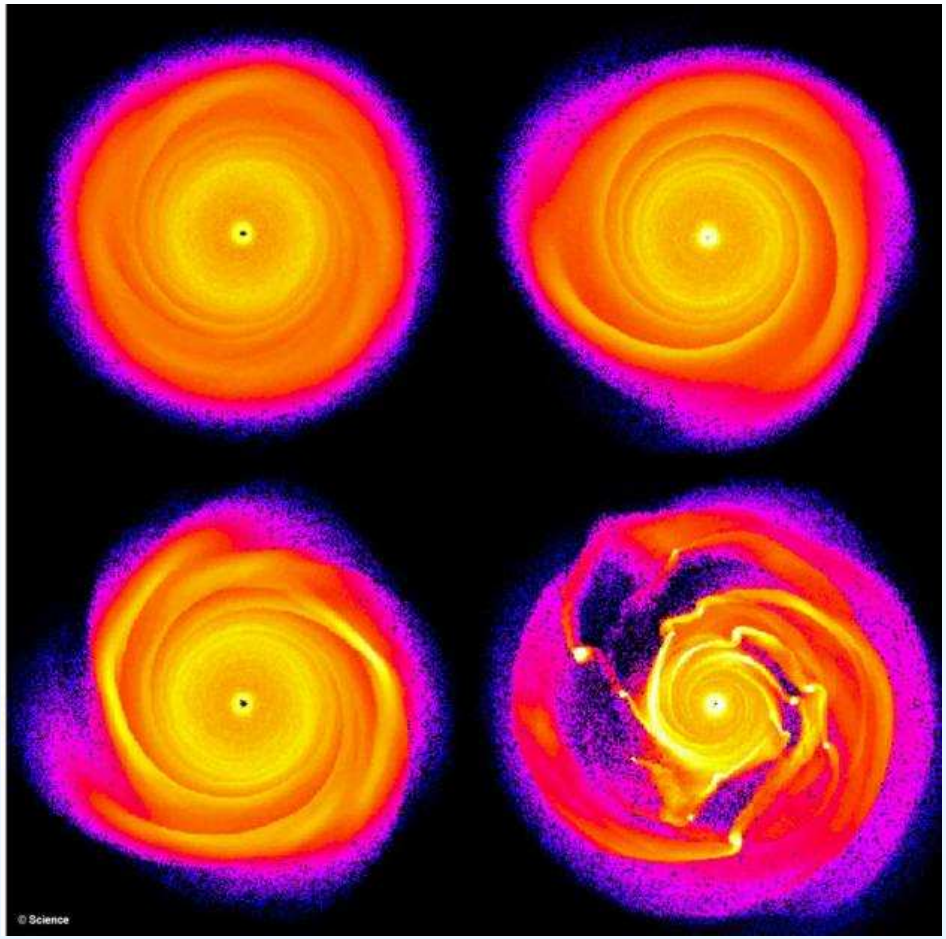

IMAGE: Science/Mayer et al.

- Disk of material or gas
- Nebula
- Colapse

Planetary Formation

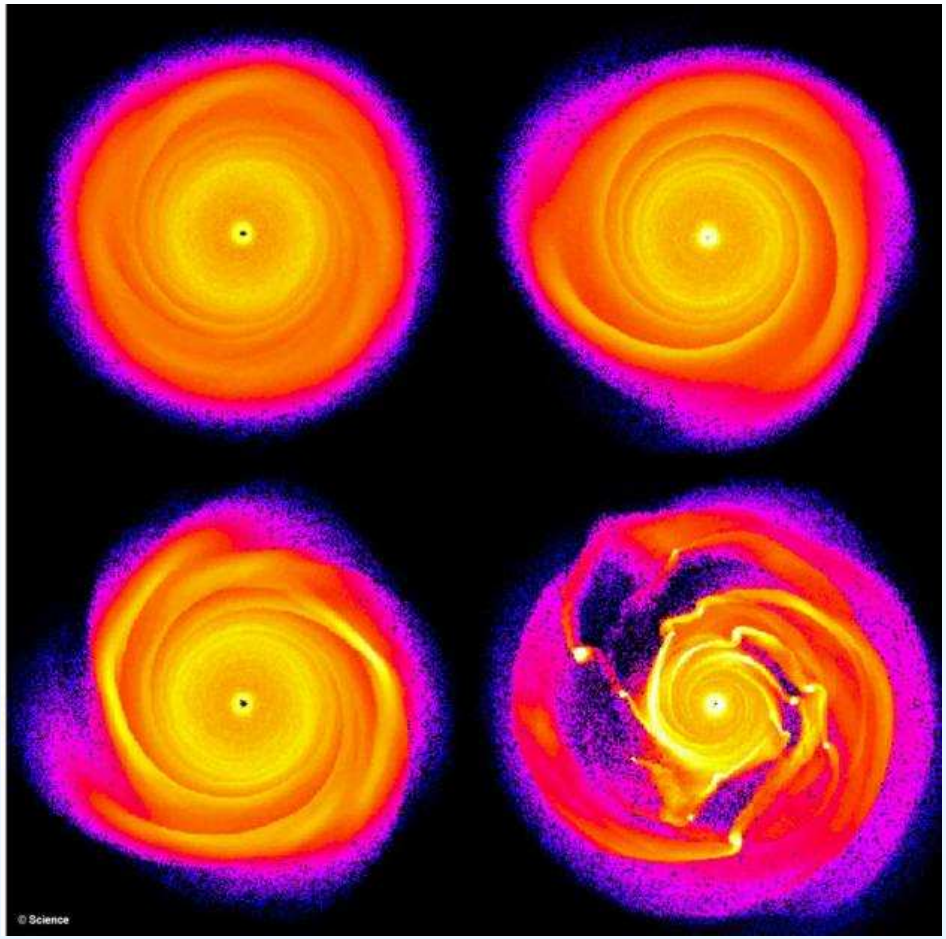

IMAGE: Science/Mayer et al.

- Disk of material or gas
- Nebula
- Colapse
- Subnebula around the planet

Gas Envelope

Gas Envelope

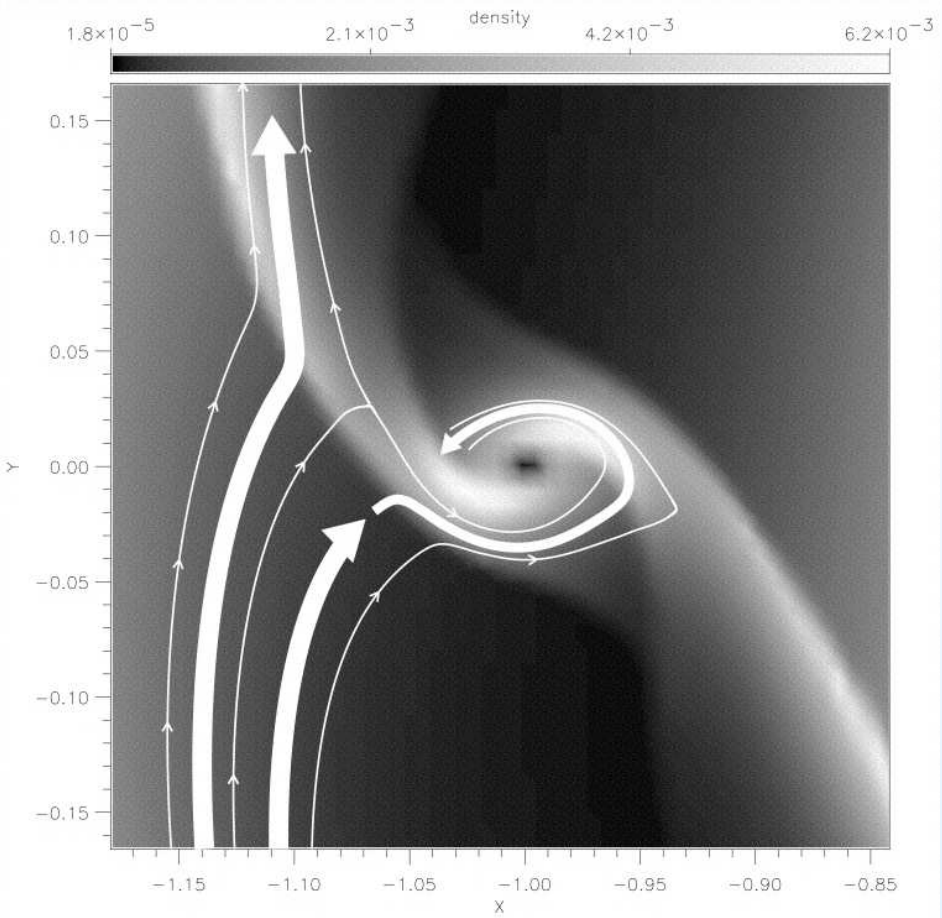

IMAGE: The Astrophysical Journal/Lubow et al.

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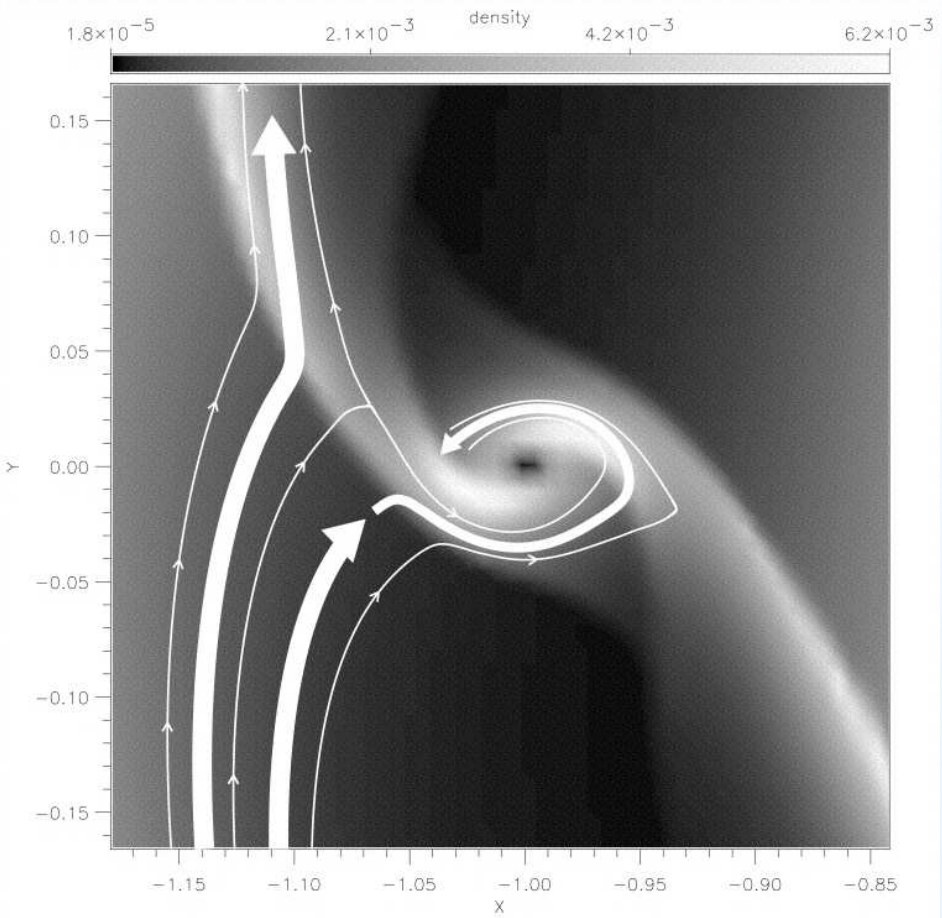

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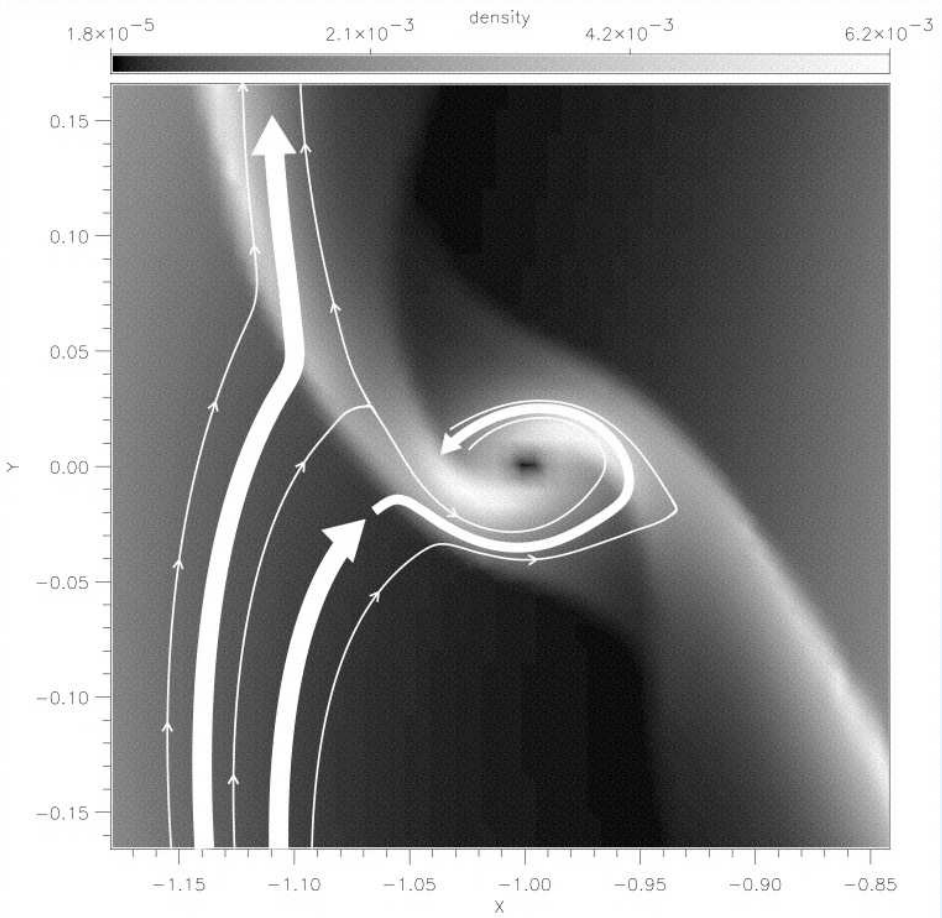
- Passage through the nebula

Gas Envelope



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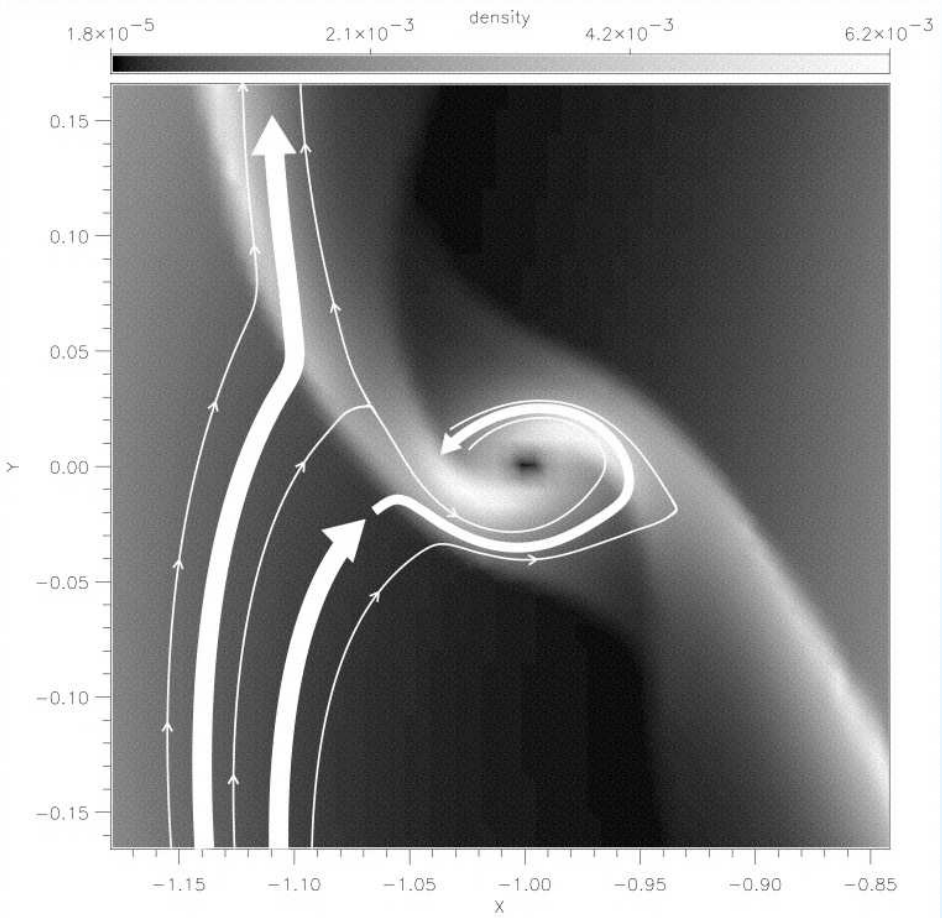
- Passage through the nebula
- Energy loss

Gas Envelope



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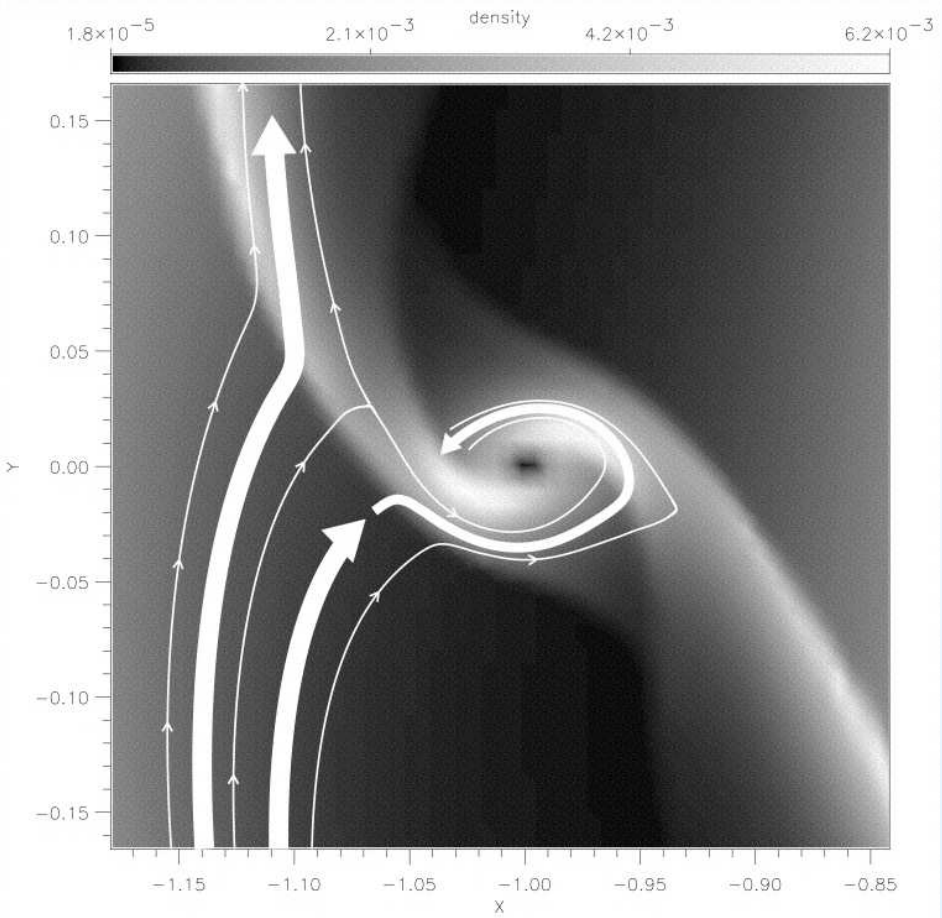
- Passage through the nebula
- Energy loss
- Semi-major axis reduction

Gas Envelope



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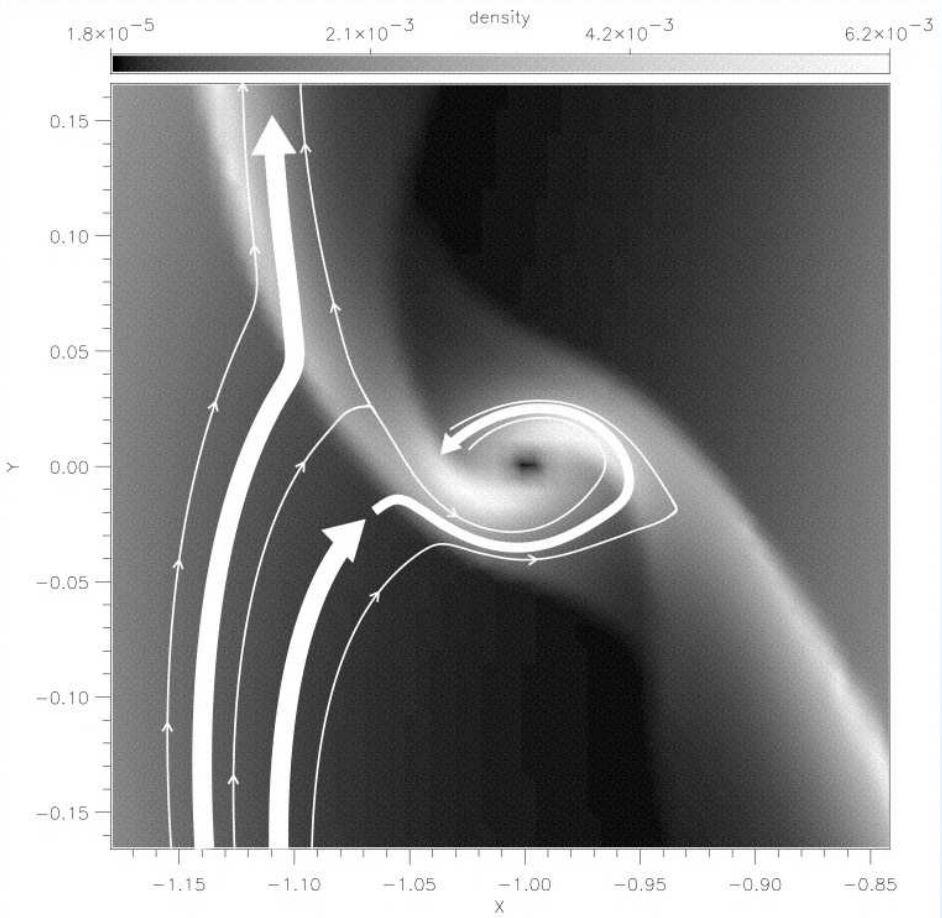
- Passage through the nebula
- Energy loss
- Semi-major axis reduction
- Capture

Gas Envelope



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- Energy loss
- Semi-major axis reduction
- Capture
- Collisions

Lubow Model

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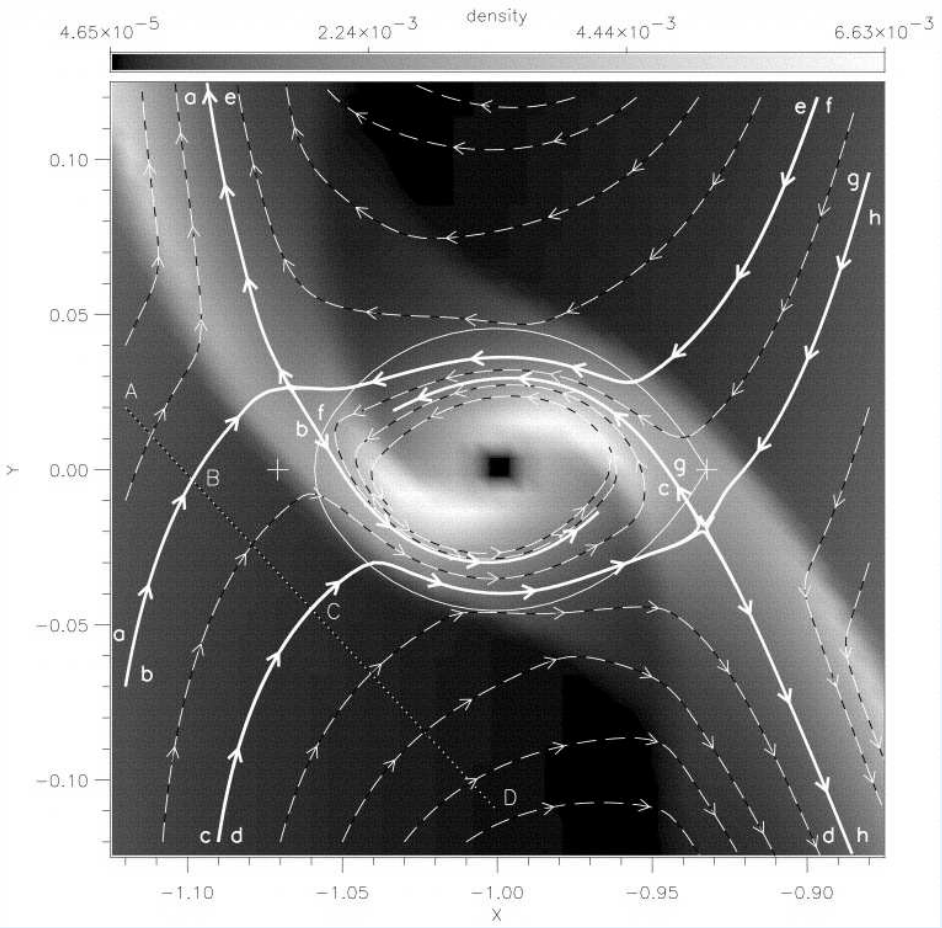

IMAGE: The Astrophysical Journal/Lubow et al.

Lubow Model

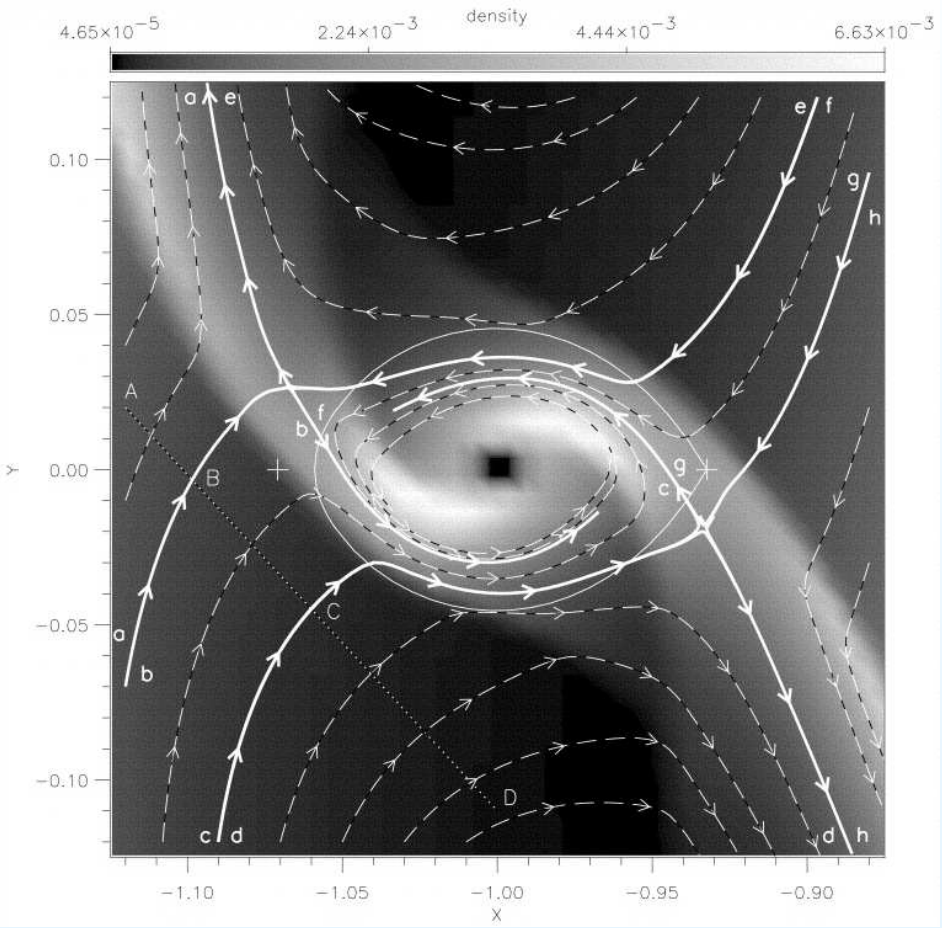

IMAGE: The Astrophysical Journal/Lubow et al.

- Edge

Lubow Model

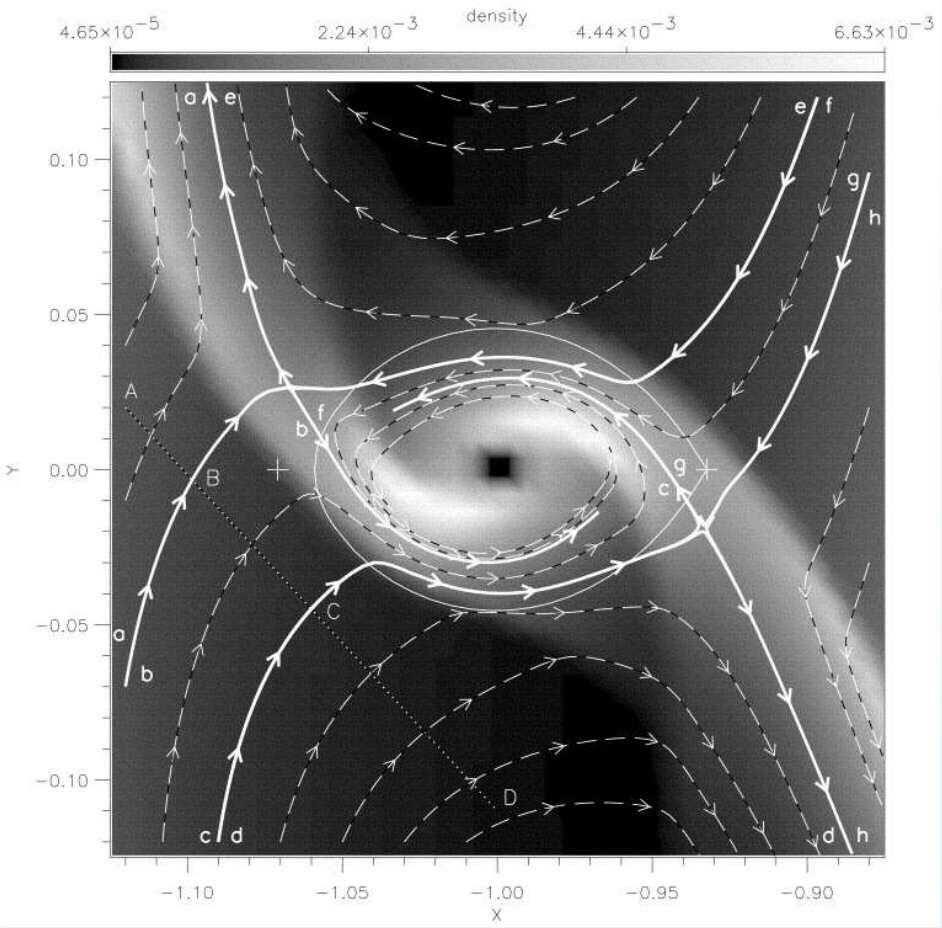

IMAGE: The Astrophysical Journal/Lubow et al.

- Edge
- Lower density out of the edge

Lubow Model

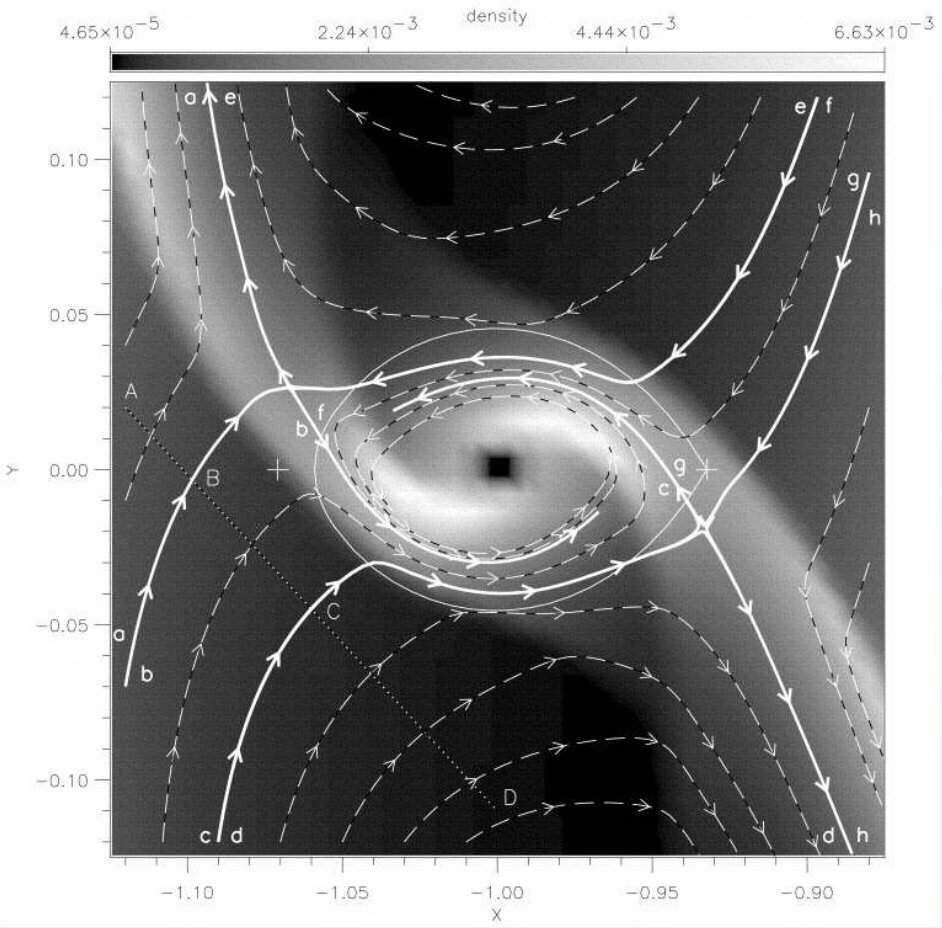

IMAGE: The Astrophysical Journal/Lubow et al.

- Edge
- Lower density out of the edge
- Interior to Hill's sphere

Gas Drag

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- Adachi et al. 1976

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  - Two-Body Problem with gas perturbation

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  - $f_D = \frac{1}{2} C_D \pi r_p^{-2} \rho v_r^2$

Gas Drag

- Adachi et al. 1976
  - Two-Body Problem with gas perturbation
  - Gas drag force
  - $f_D = \frac{1}{2} C_D \pi r_p^{-2} \rho v_r^2$
  - Spiral Orbits

Works on Satellite Capture

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- Pollack et al. 1979

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Our Simulations

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- Planar Case ($i = 0, i = 180$)

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- Grid

Our Simulations

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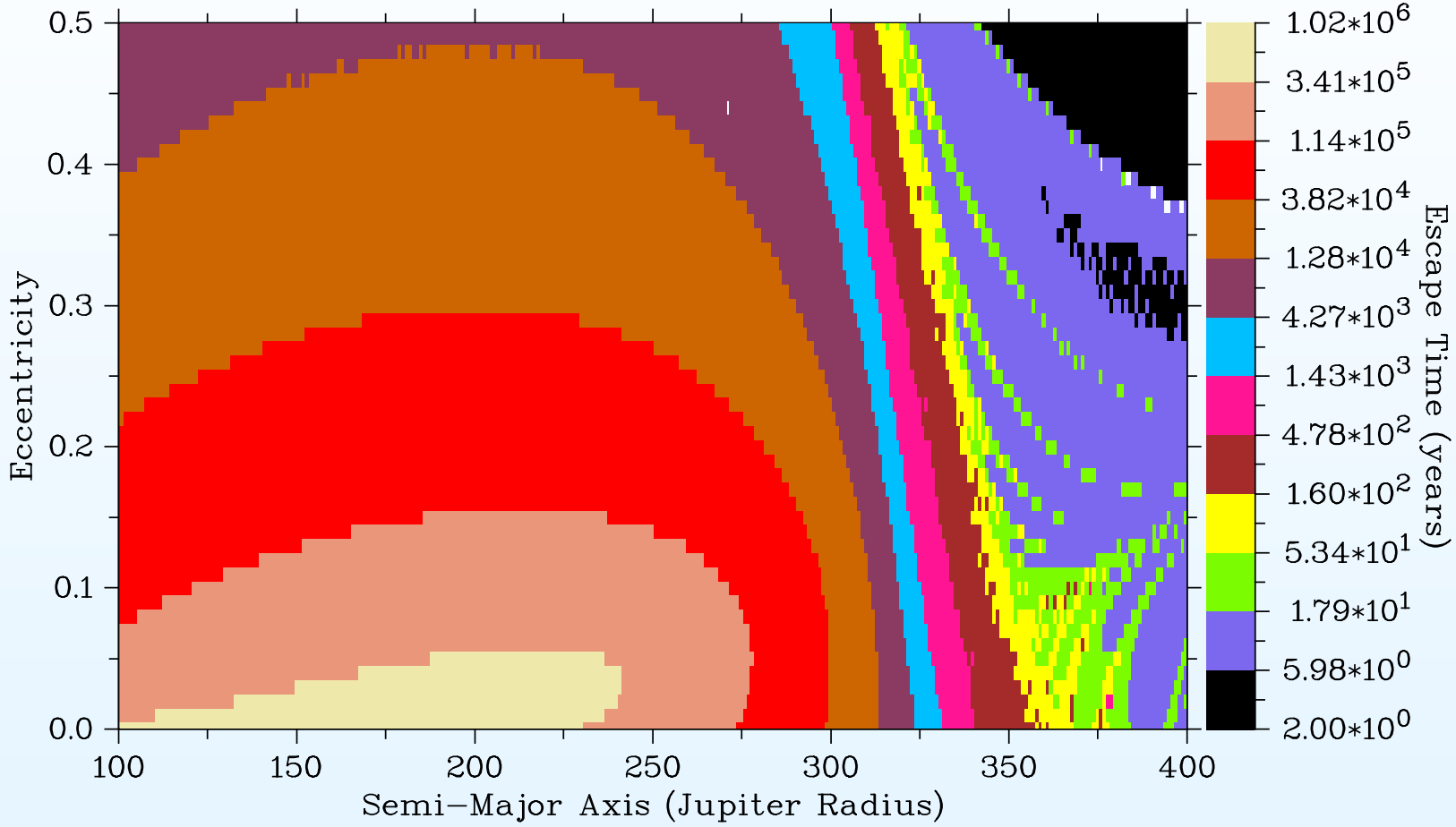
  - $a \times e$

Our Simulations

- Planar Case ($i = 0, i = 180$)
- Grid
  - $a \times e$
- Escape time

Prograde Case



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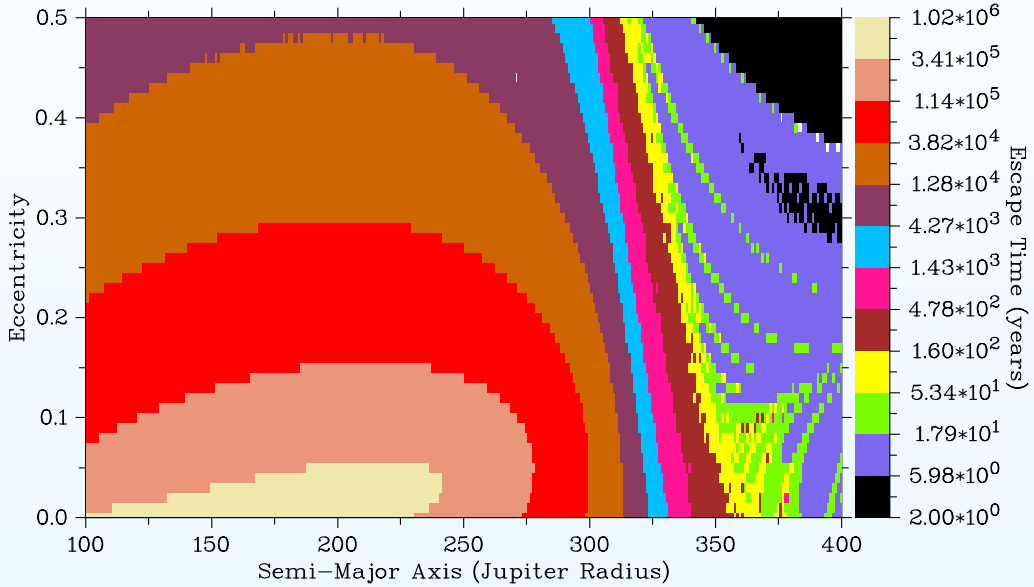

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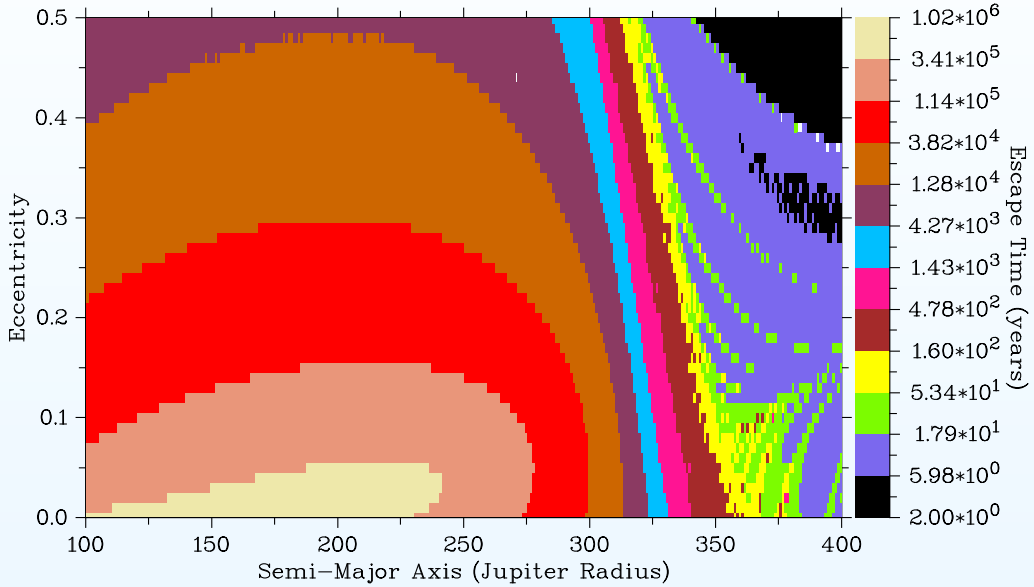
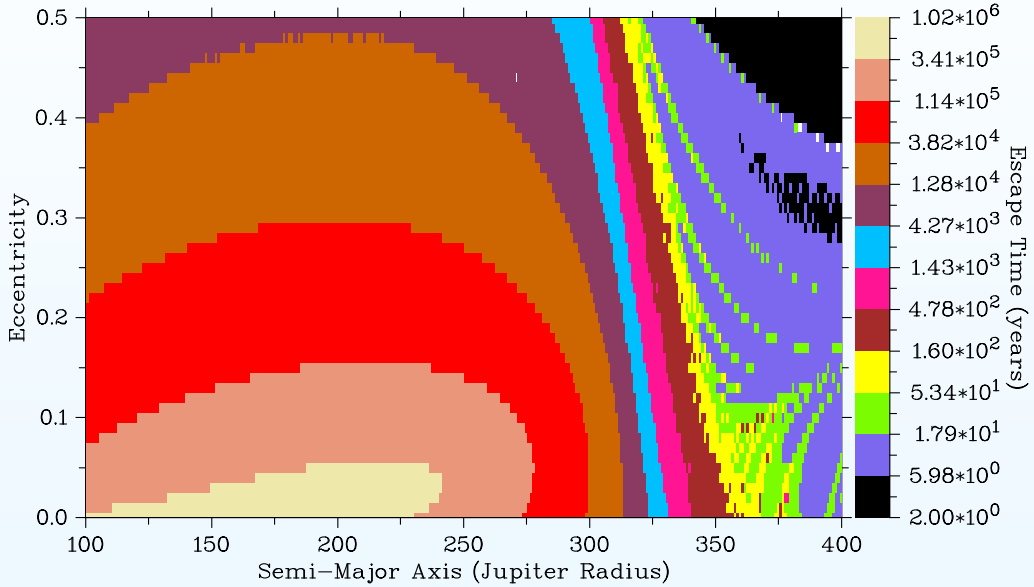


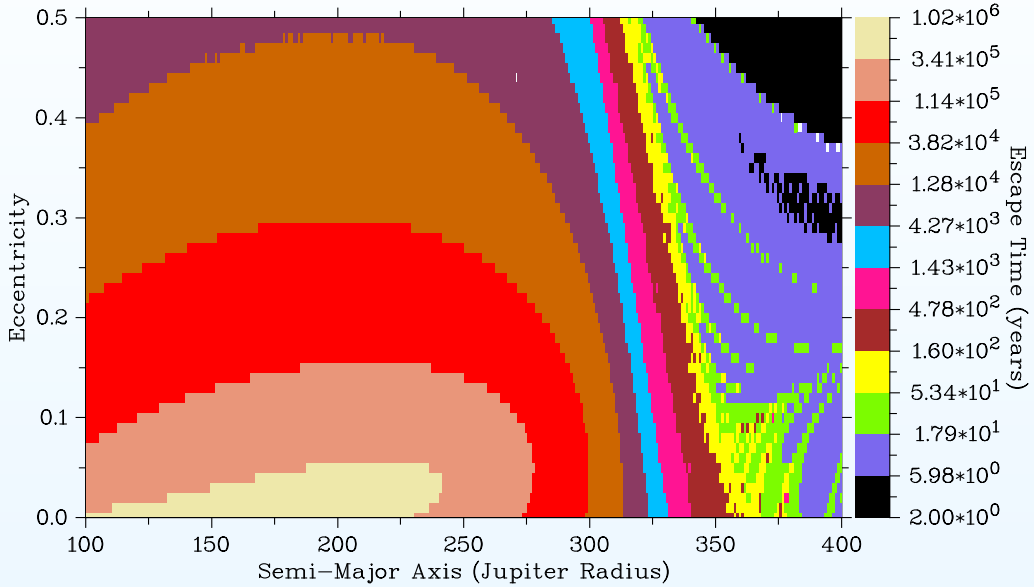
- Three distinct regions

Prograde Case



- Three distinct regions
- Layers of eccentricity

Prograde Case



- Three distinct regions
- Layers of eccentricity
  - Higher eccentricities
    $\longmapsto$ lower times

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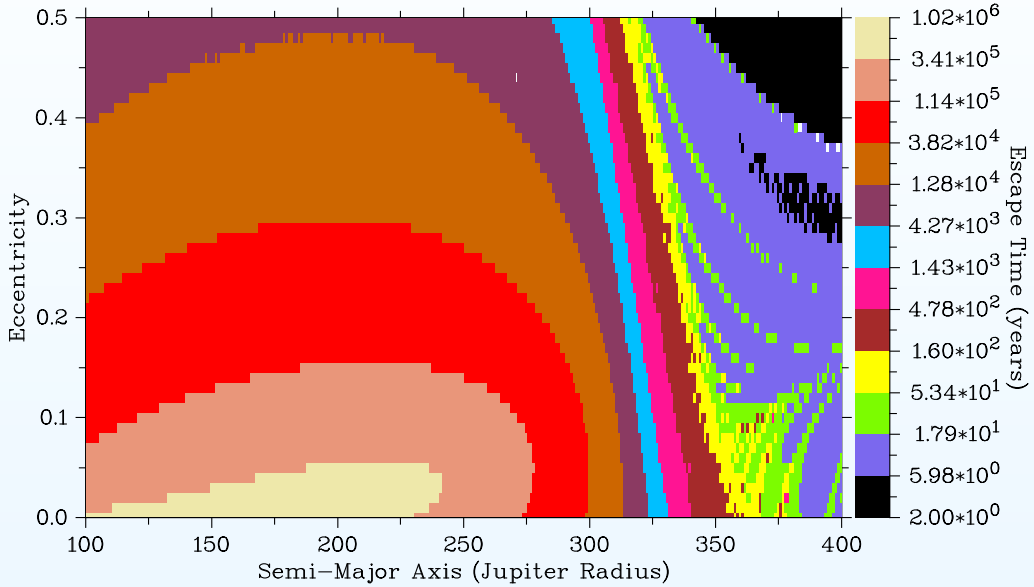

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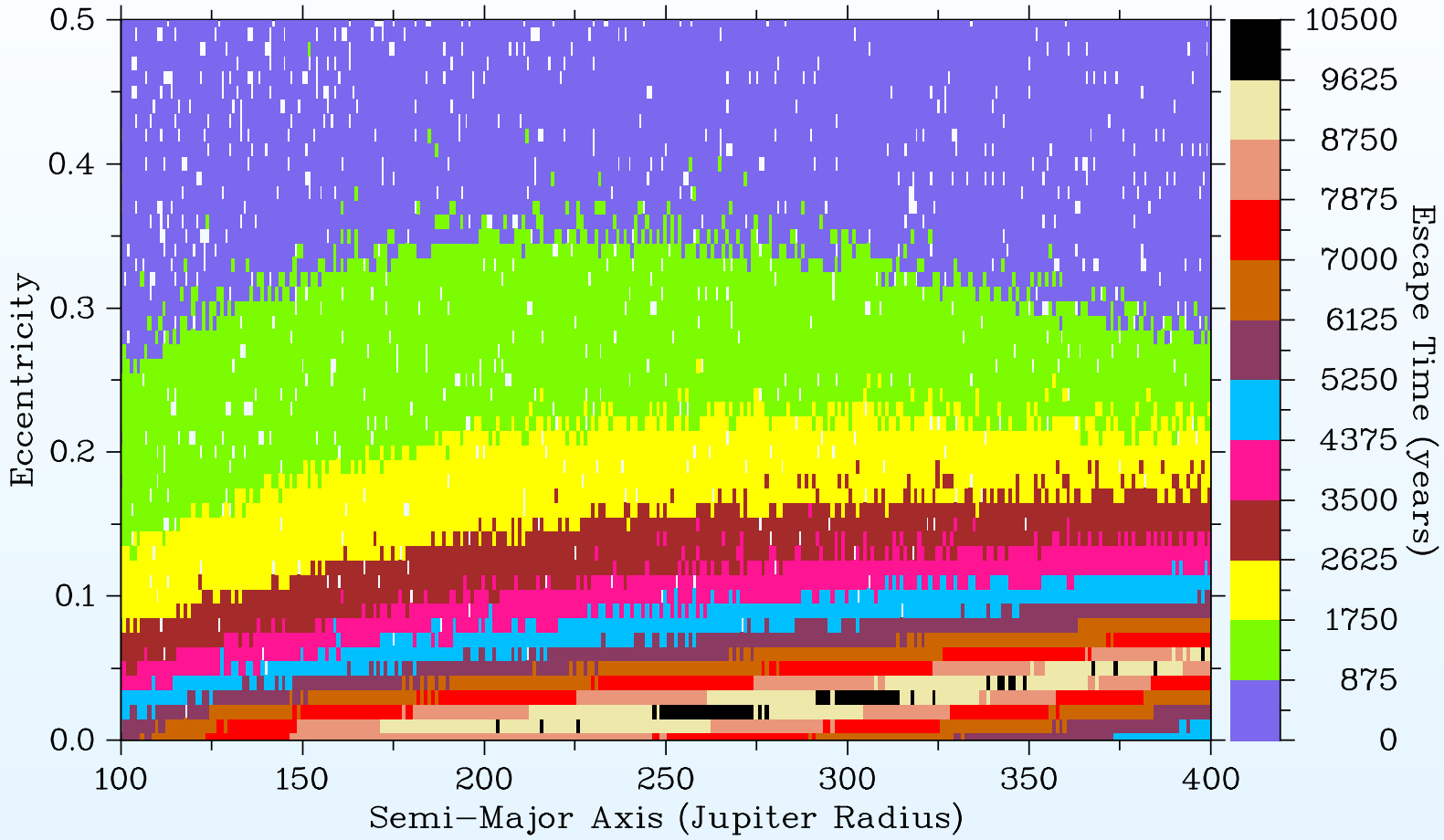
Retrograde Case



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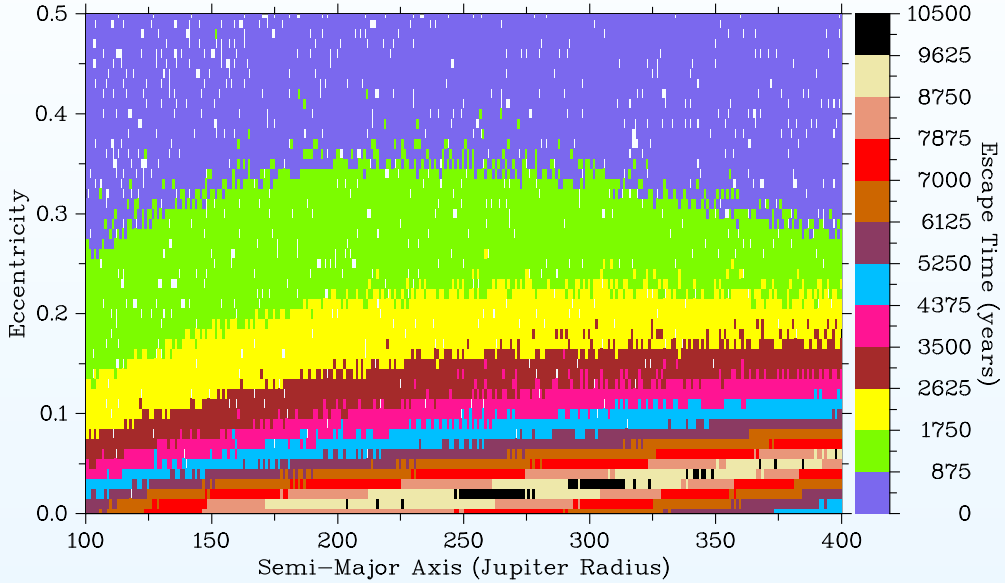

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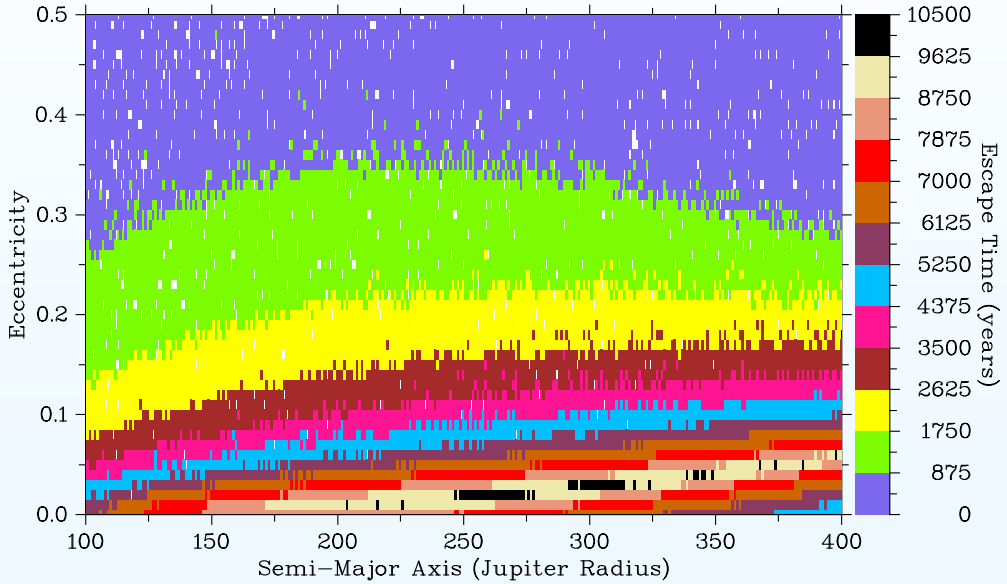
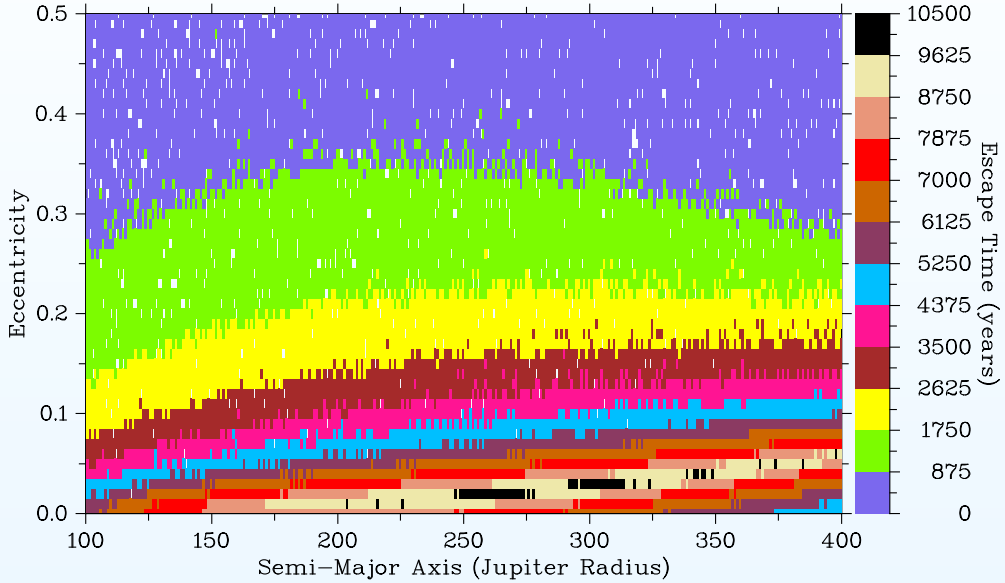


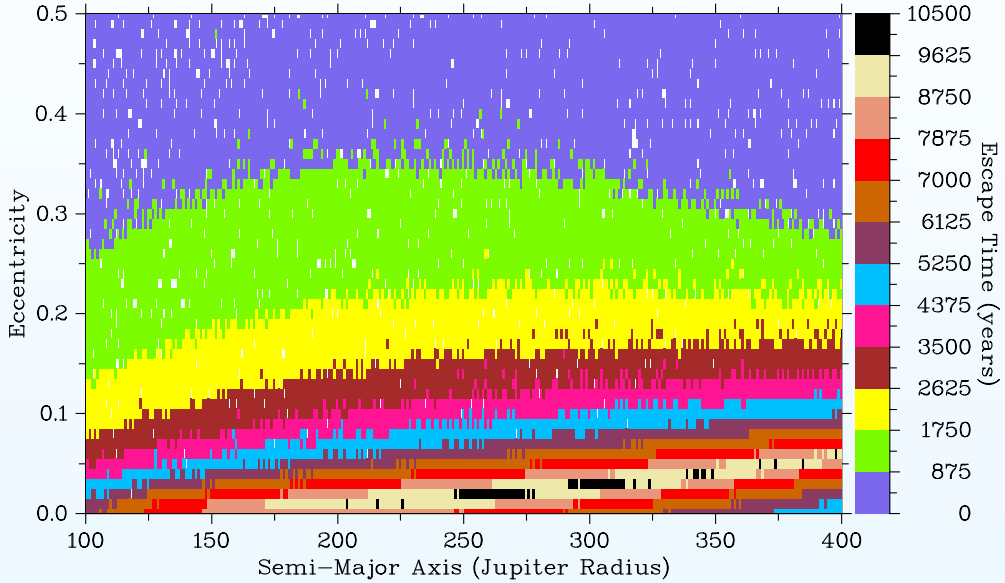
- Faster than the prograde

Retrograde Case



- Faster than the prograde
- layers of eccentricity

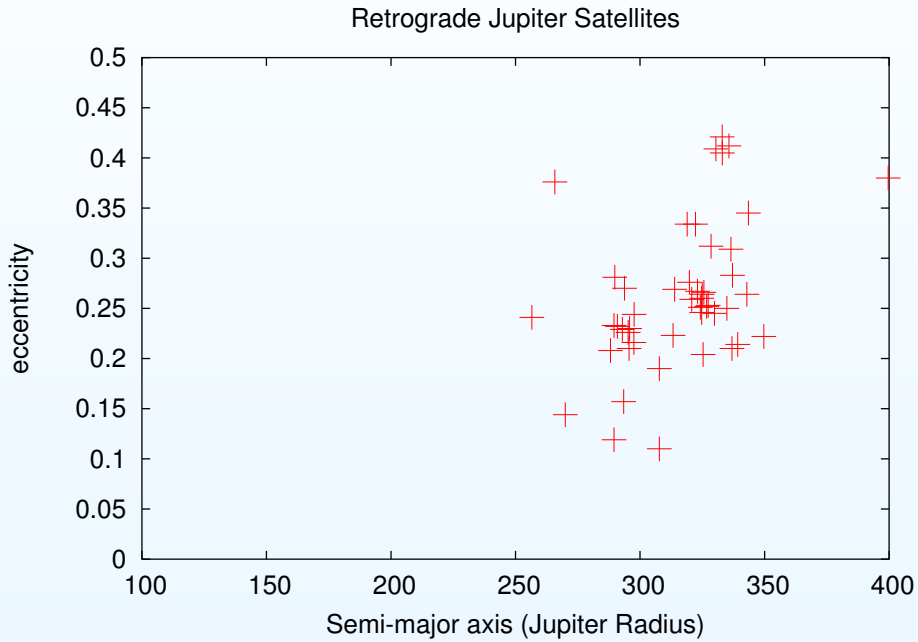
Retrograde Case



- Faster than the prograde
- layers of eccentricity
  - Greater times $\rightarrowtail$ low eccentricities

Real Case

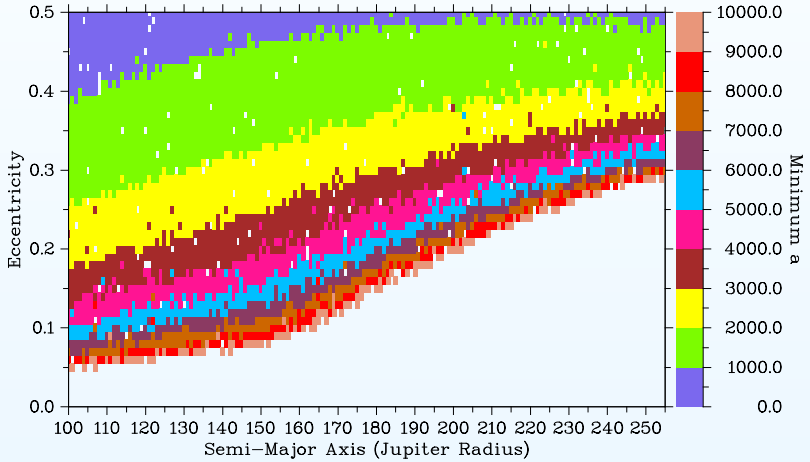
Real Case


Retrograde Jupiter Satellites
eccentricity
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
100
150
200
250
300
350
400
Semi-major axis (Jupiter Radius)

Edge Effect

Edge Effect

With Edge



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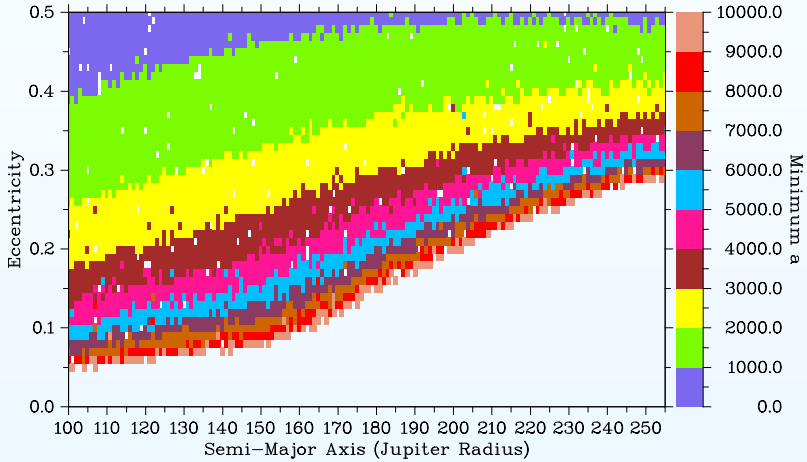

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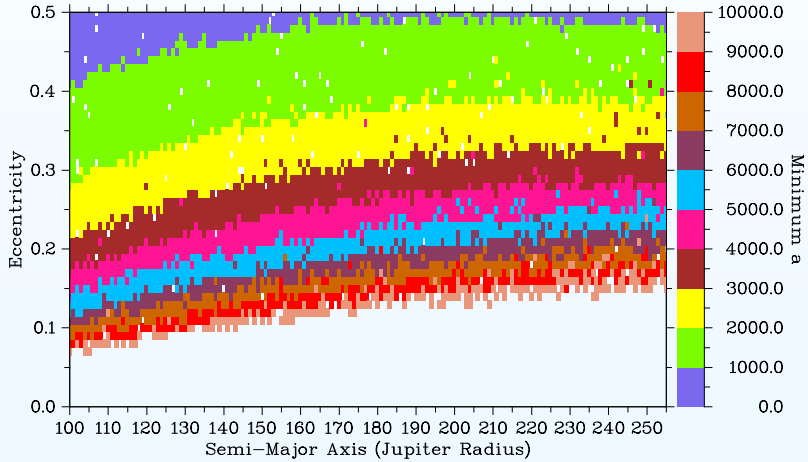

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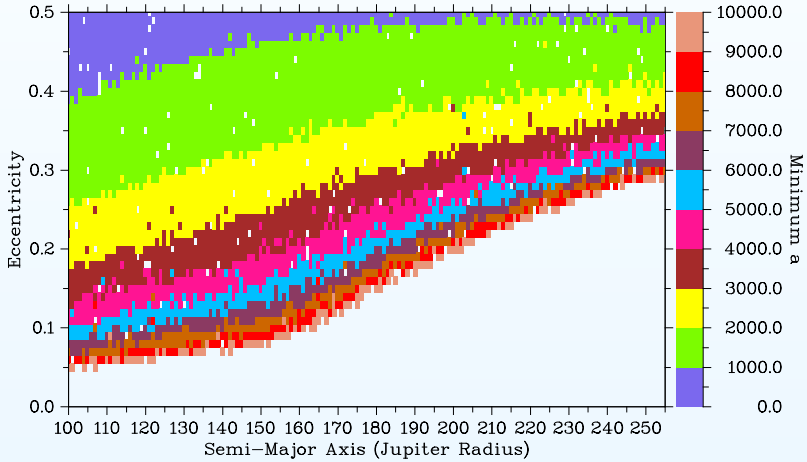

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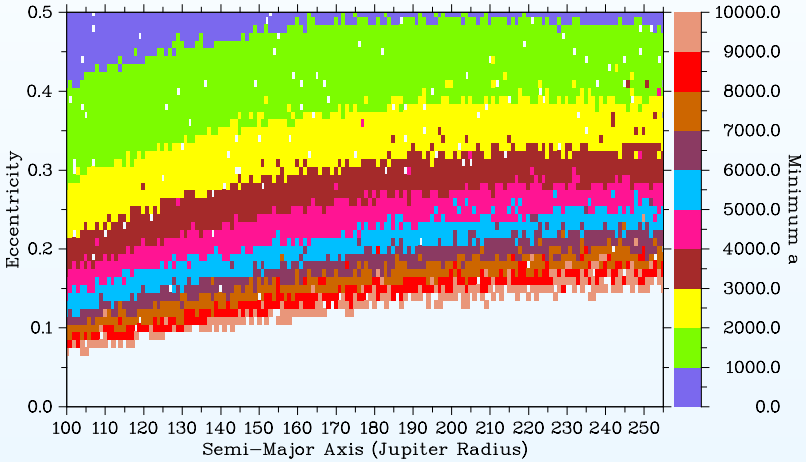

edge = 180 J_R, $i = 150$