

# Orbital History of Mimas and Enceladus



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SETI

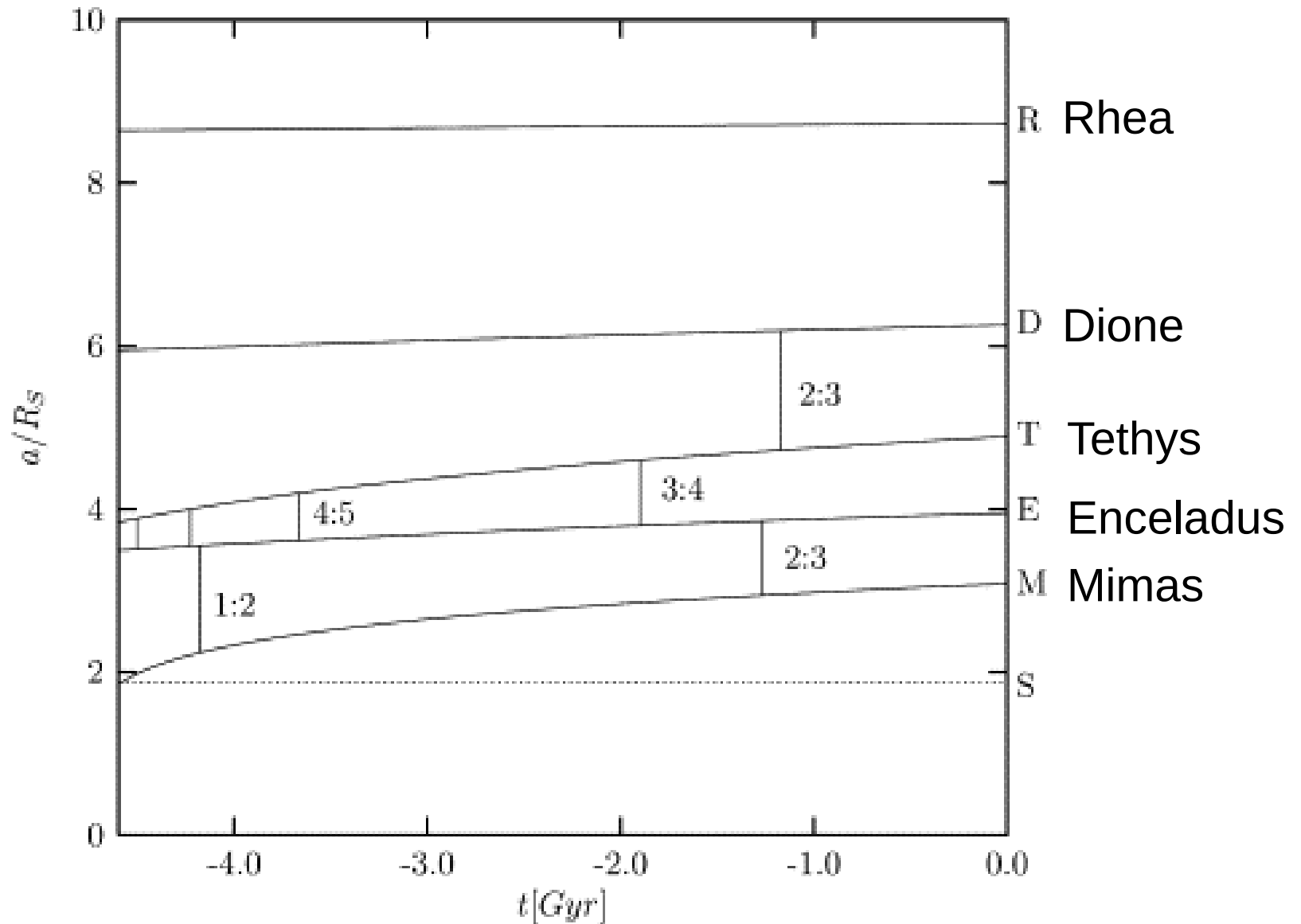
**Maryame El Moutamid**

Cornell

**Matthew Tiscareno**

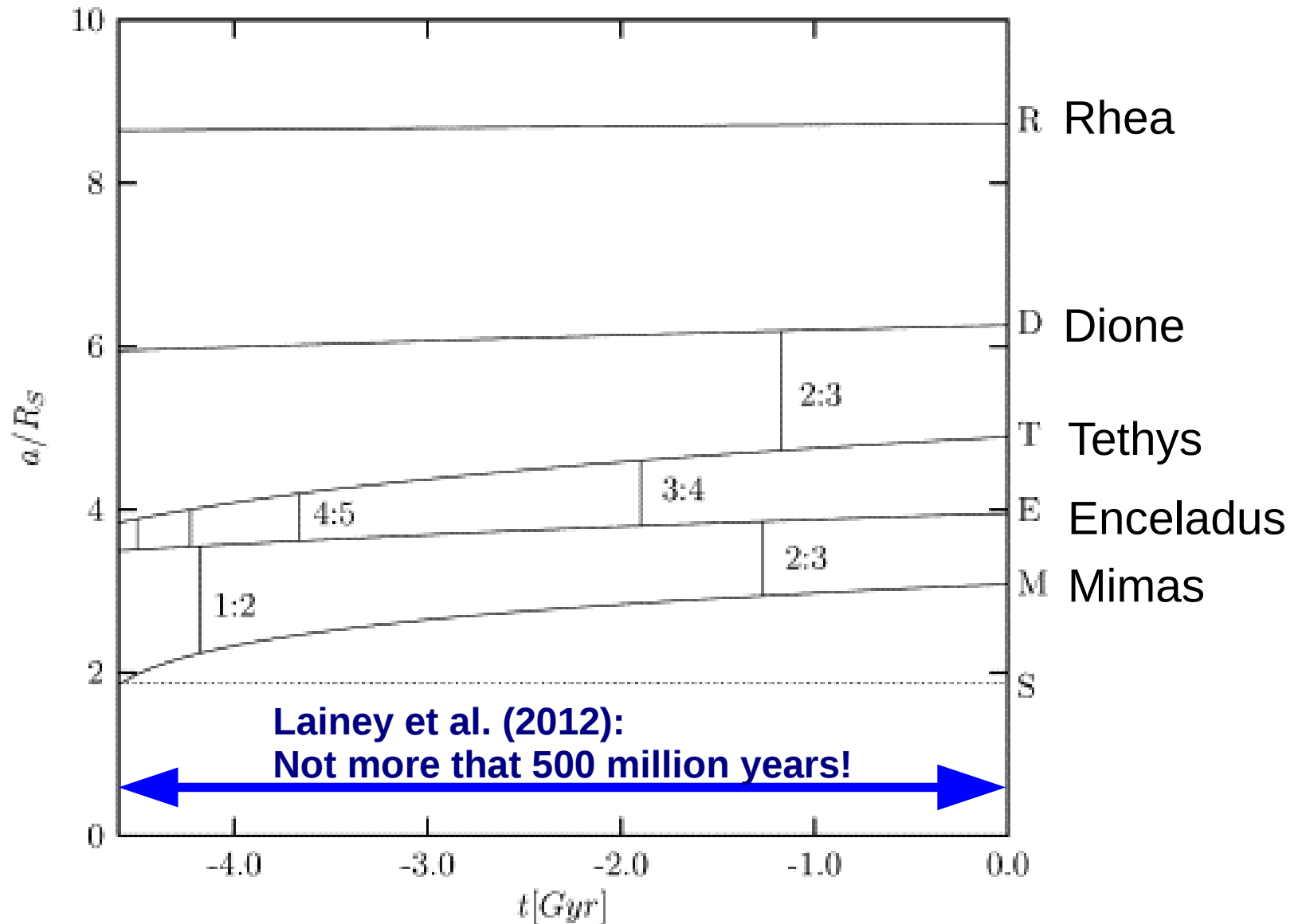
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# The Past of the Saturnian Moons



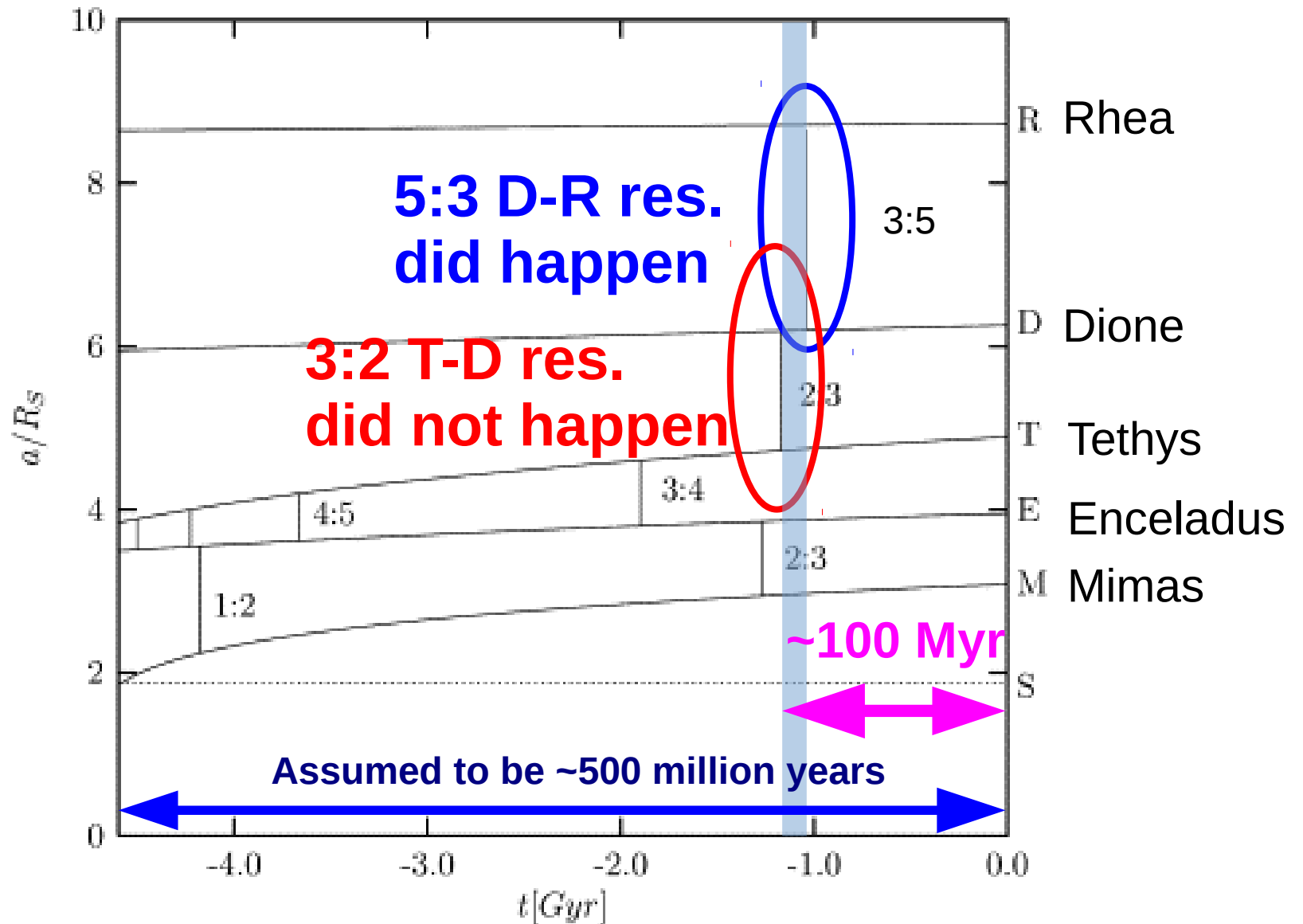
Past resonances among Saturn's Moons  
(Meyer and Wisdom 2007)

# The Past of the Saturnian Moons



Past resonances among Saturn's Moons  
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# The Past of the Saturnian System



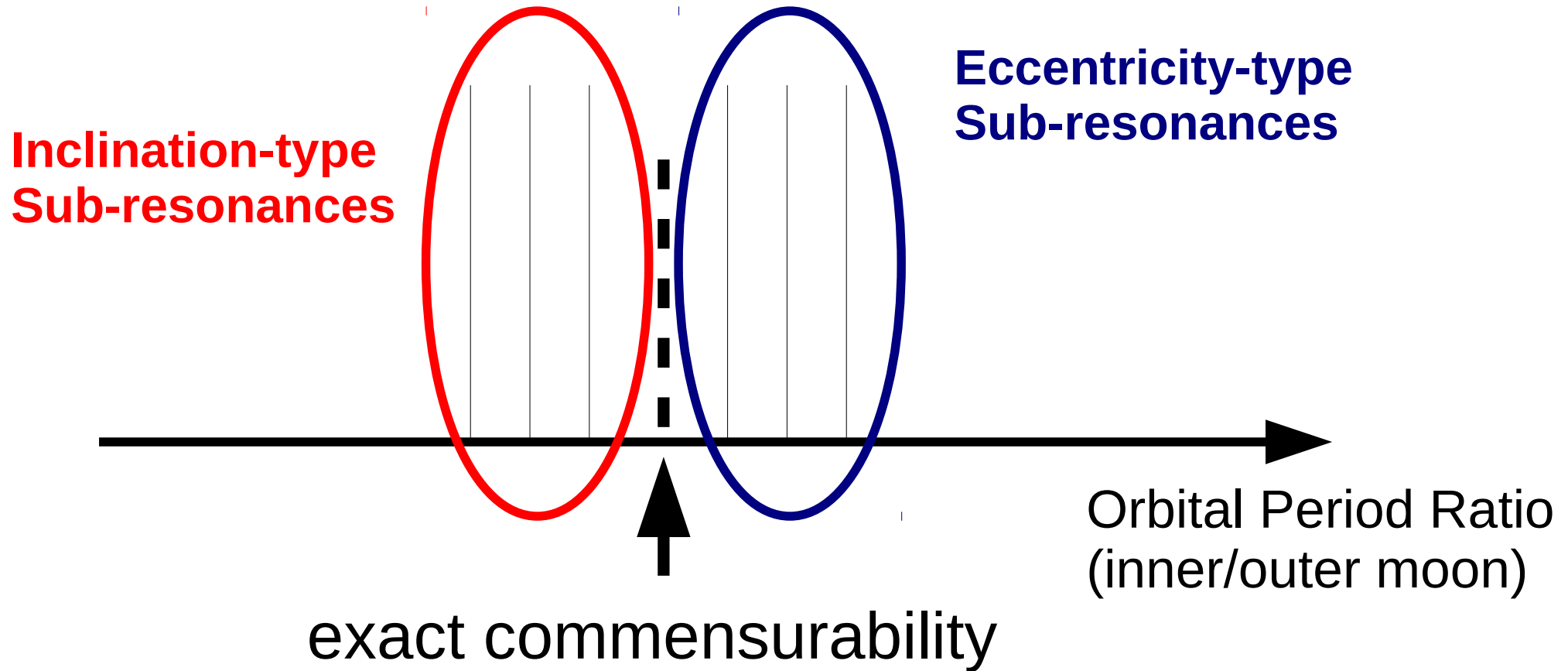
Ćuk et al. (2016): the moons are about **100 Myr** old  
(plot from Meyer and Wisdom 2007, assumes constant Q tides)

# How about Mimas and Enceladus?

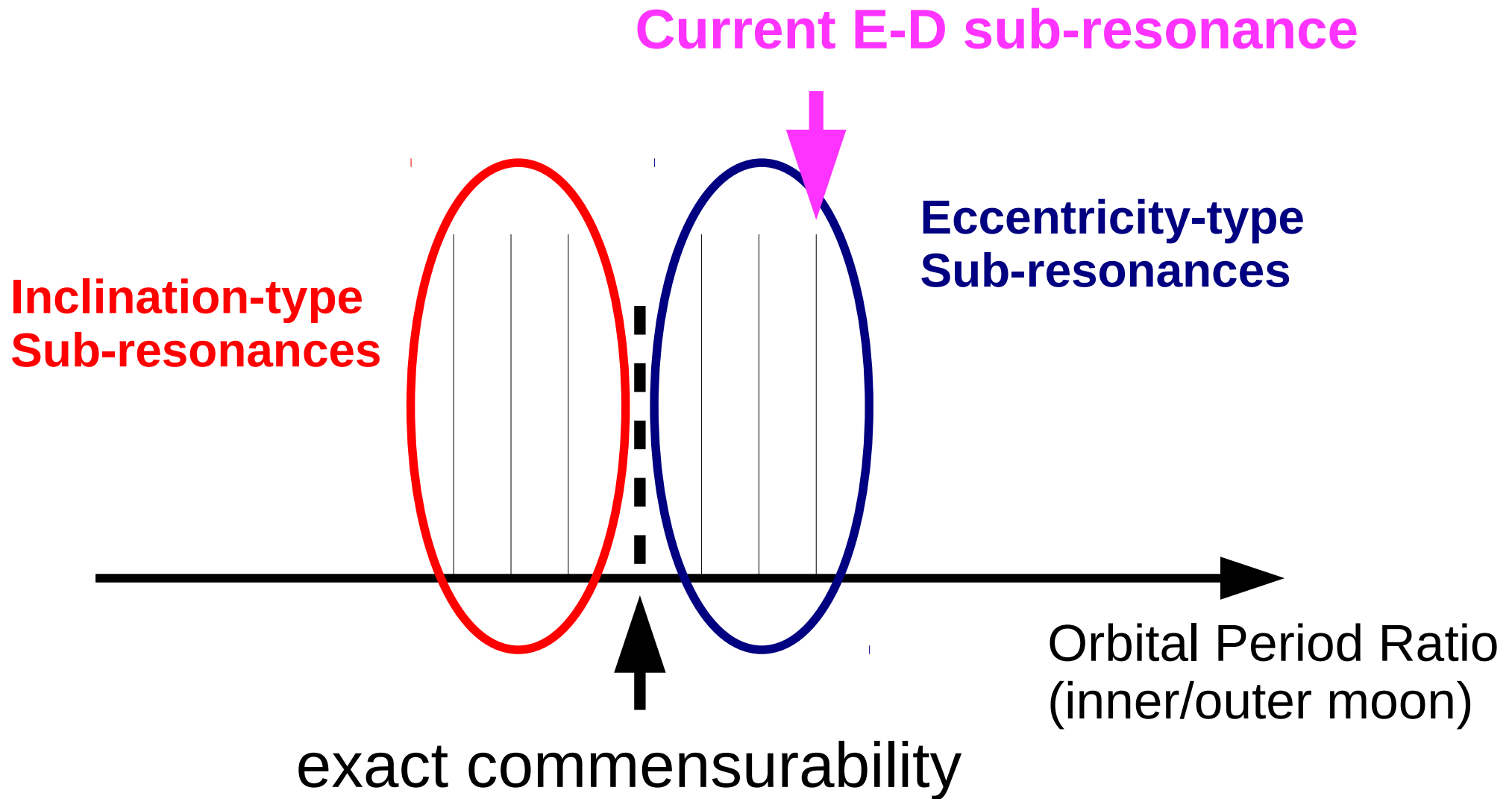
- **Mimas** is in 4:2 inclination resonance with Tethys
- Has free  $e=0.02$
- Likely solid?
- **How did it get into this resonance?**
- Source of free  $e$ ?

- **Enceladus** is in 2:1 eccentricity resonance with Dione
- Has no free  $e$
- Has a global ocean?
- **How did it get into this resonance?**
- When did it melt?

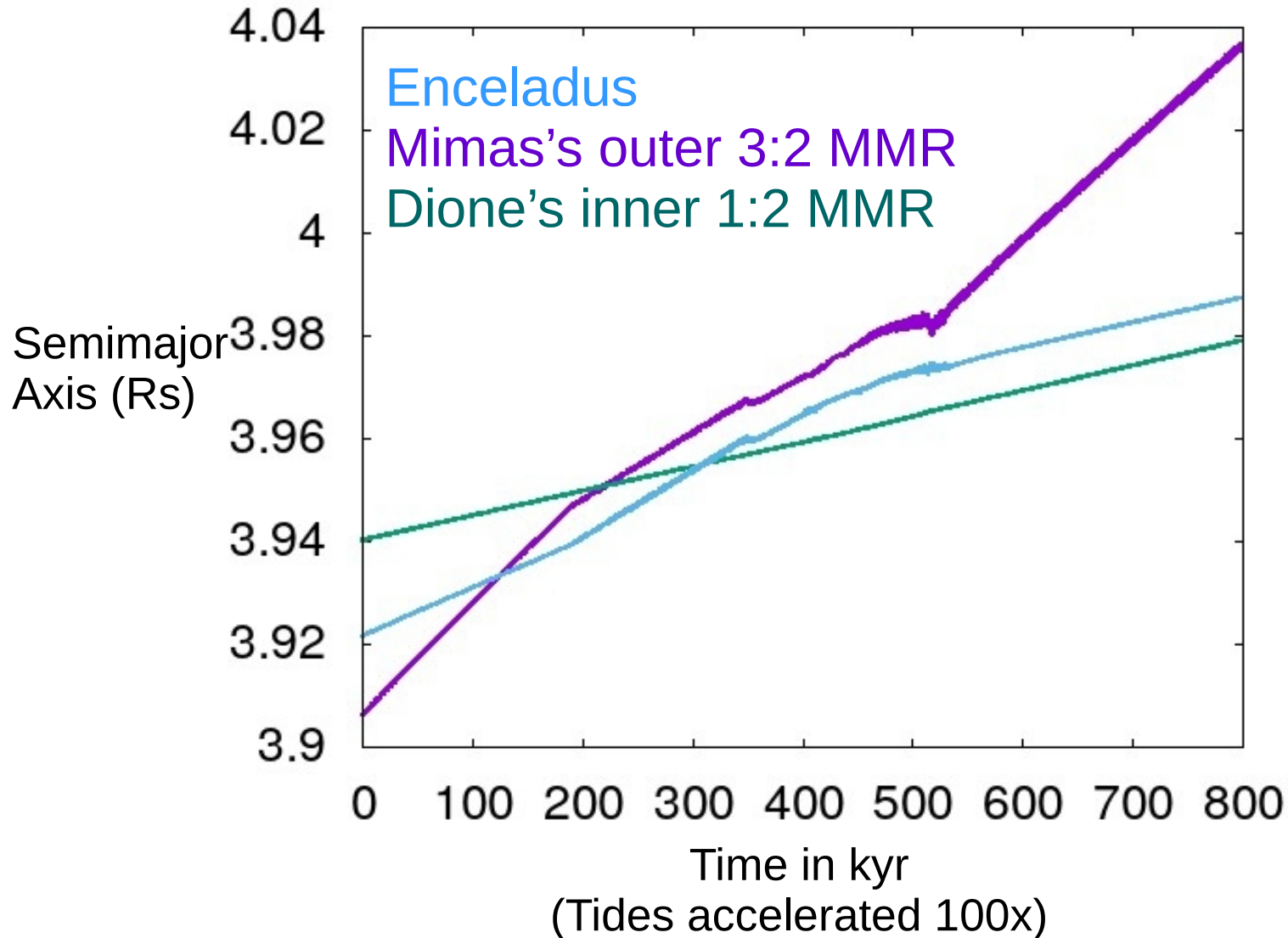
# Enceladus-Dione Resonance



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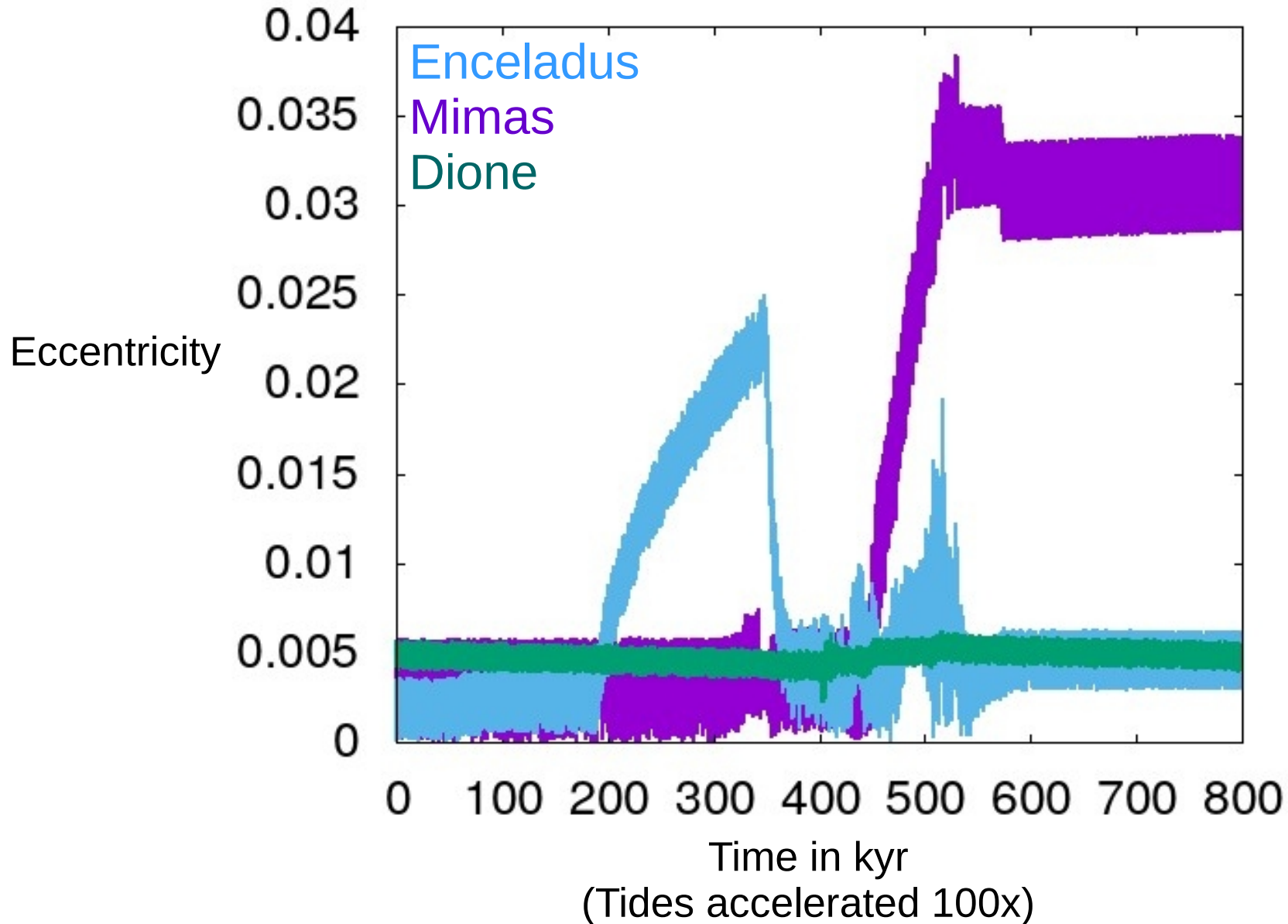


# Enceladus-Dione Resonance: Help From Mimas?

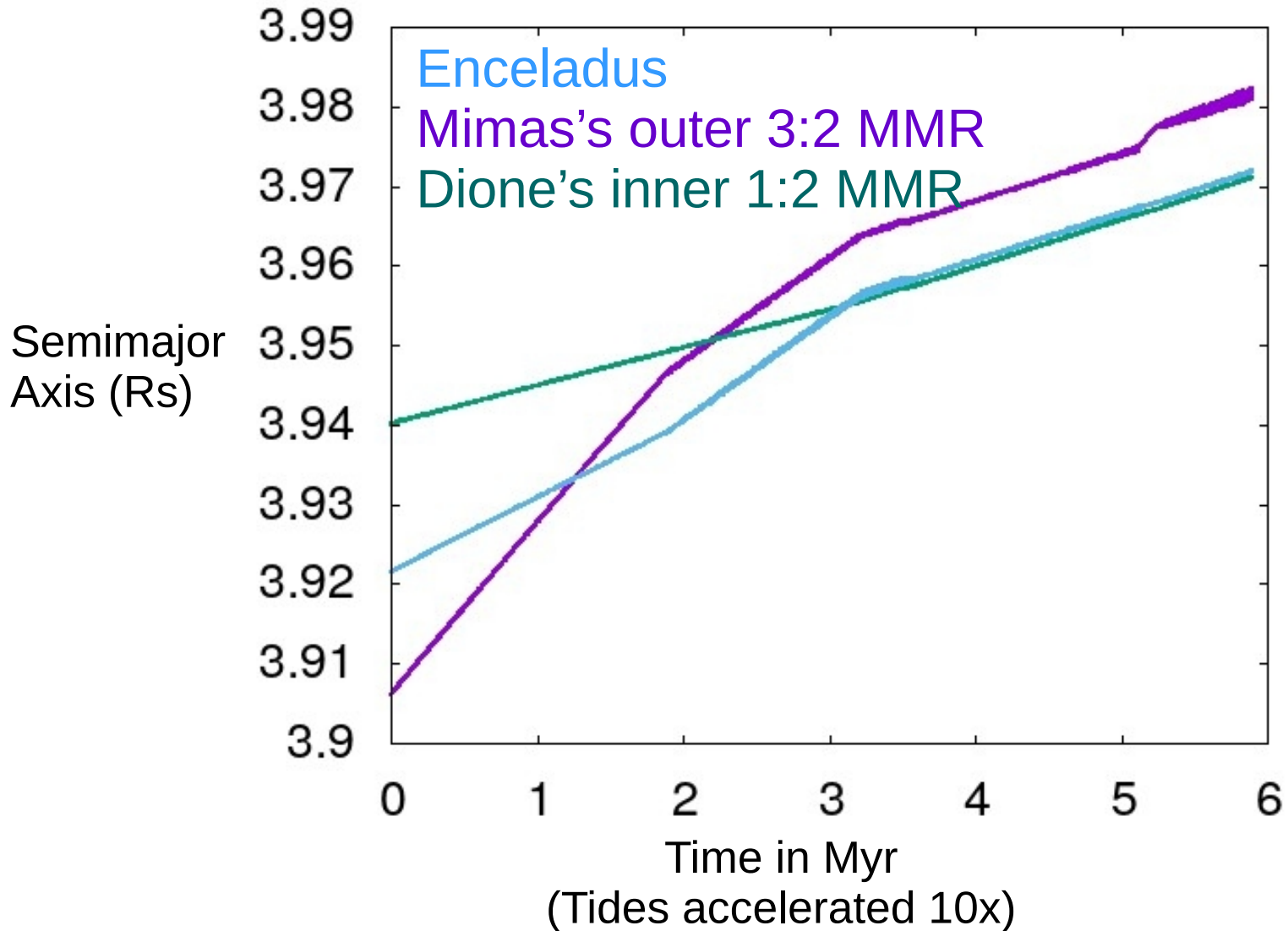




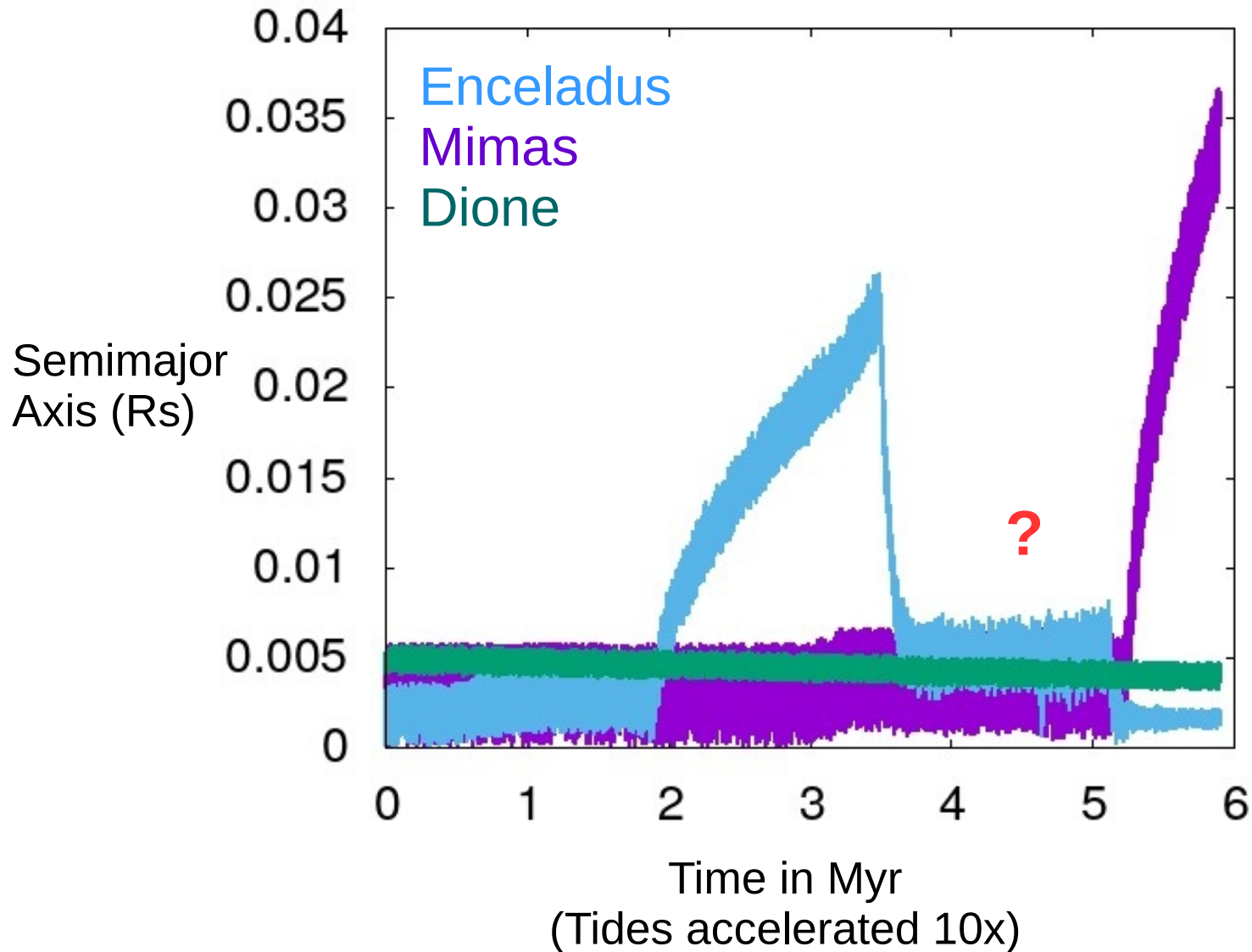
# Enceladus-Dione Resonance: Help From Mimas?



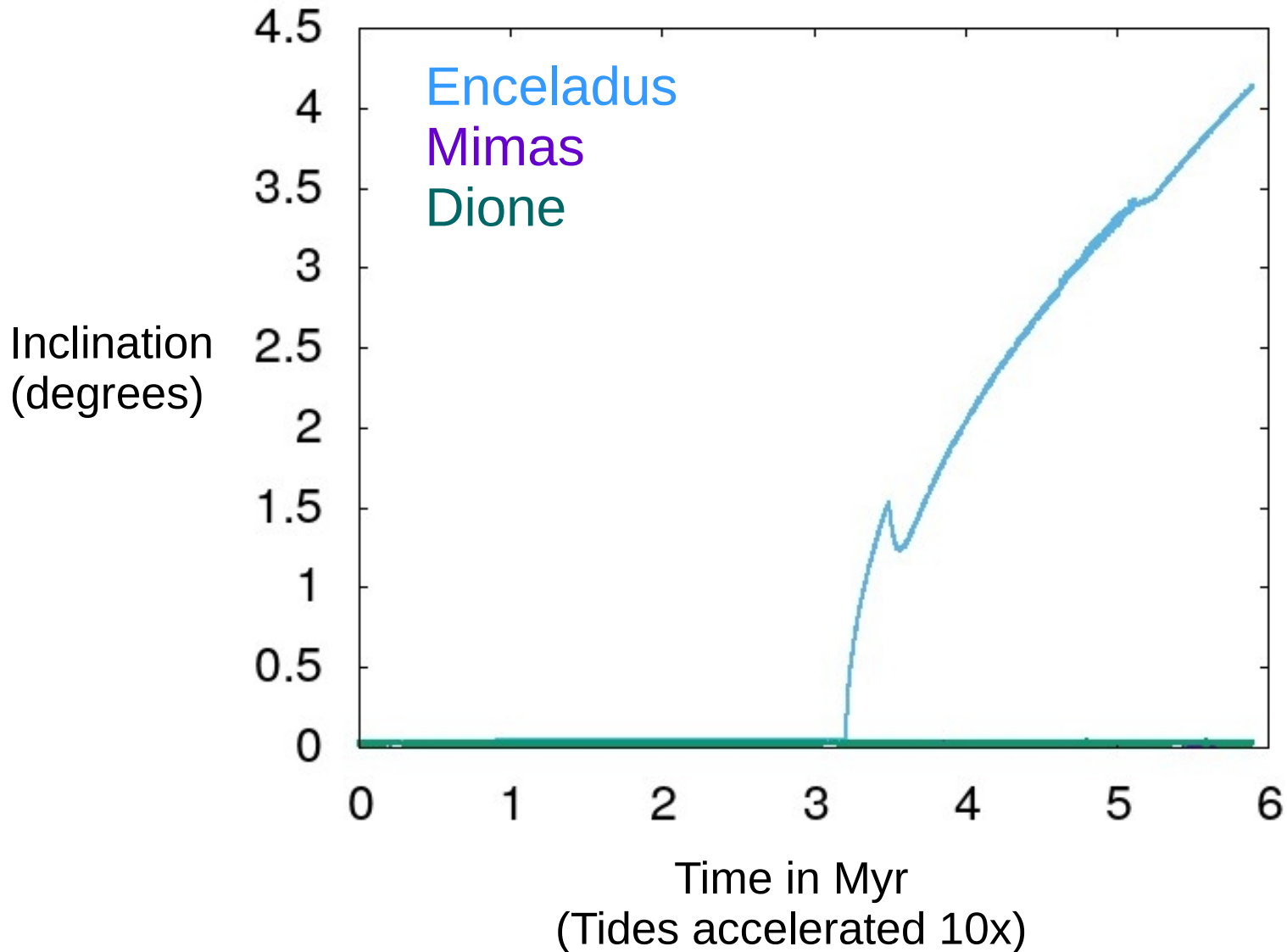
# Mimas-Enceladus-Dione Mess Slower Evolution



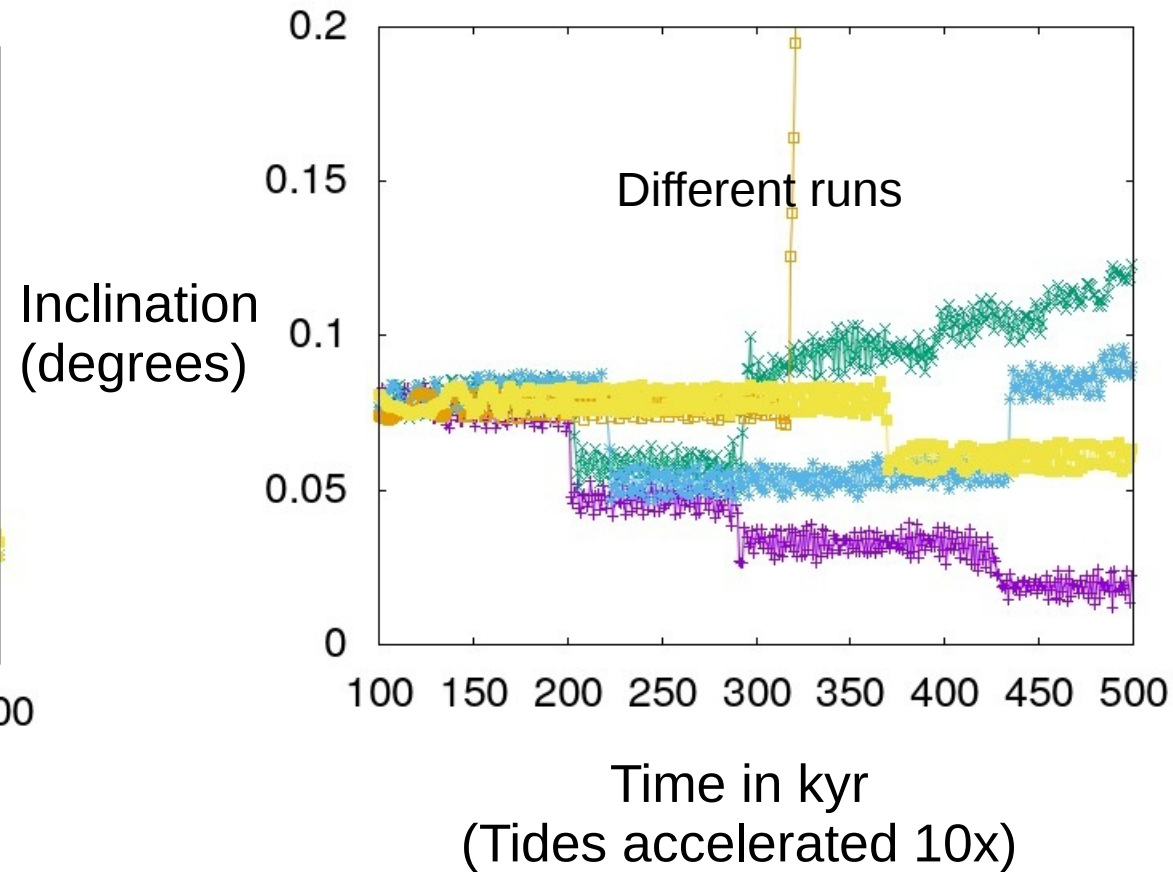
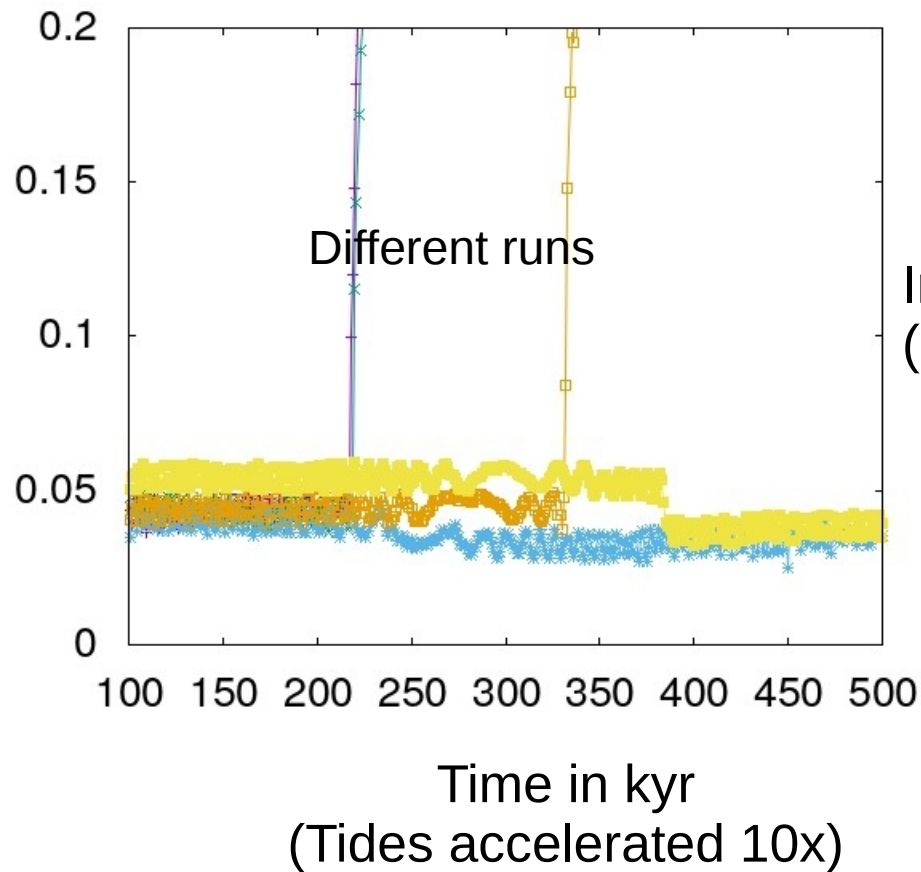
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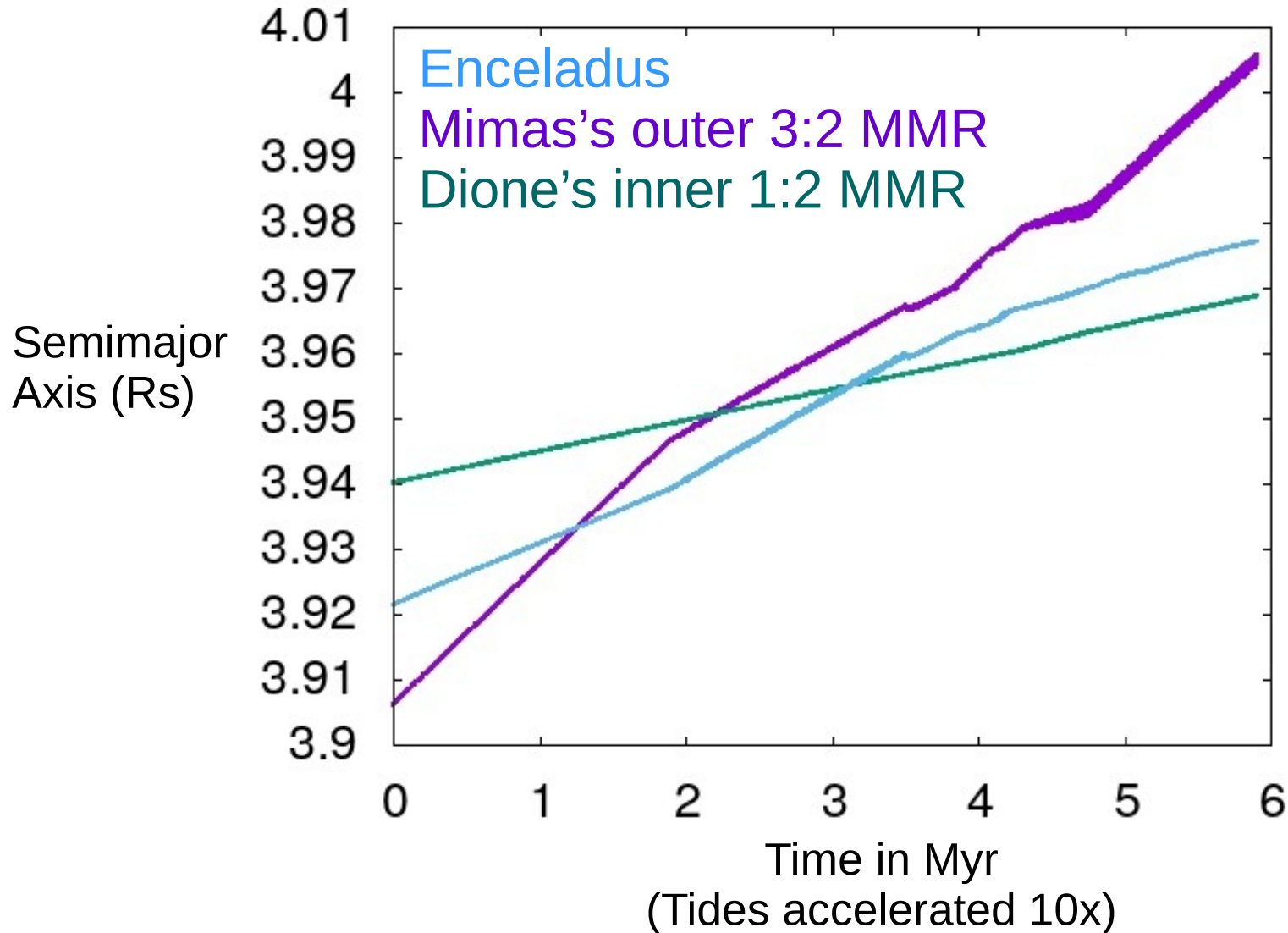
# Mimas-Enceladus-Dione Mess Slower Evolution



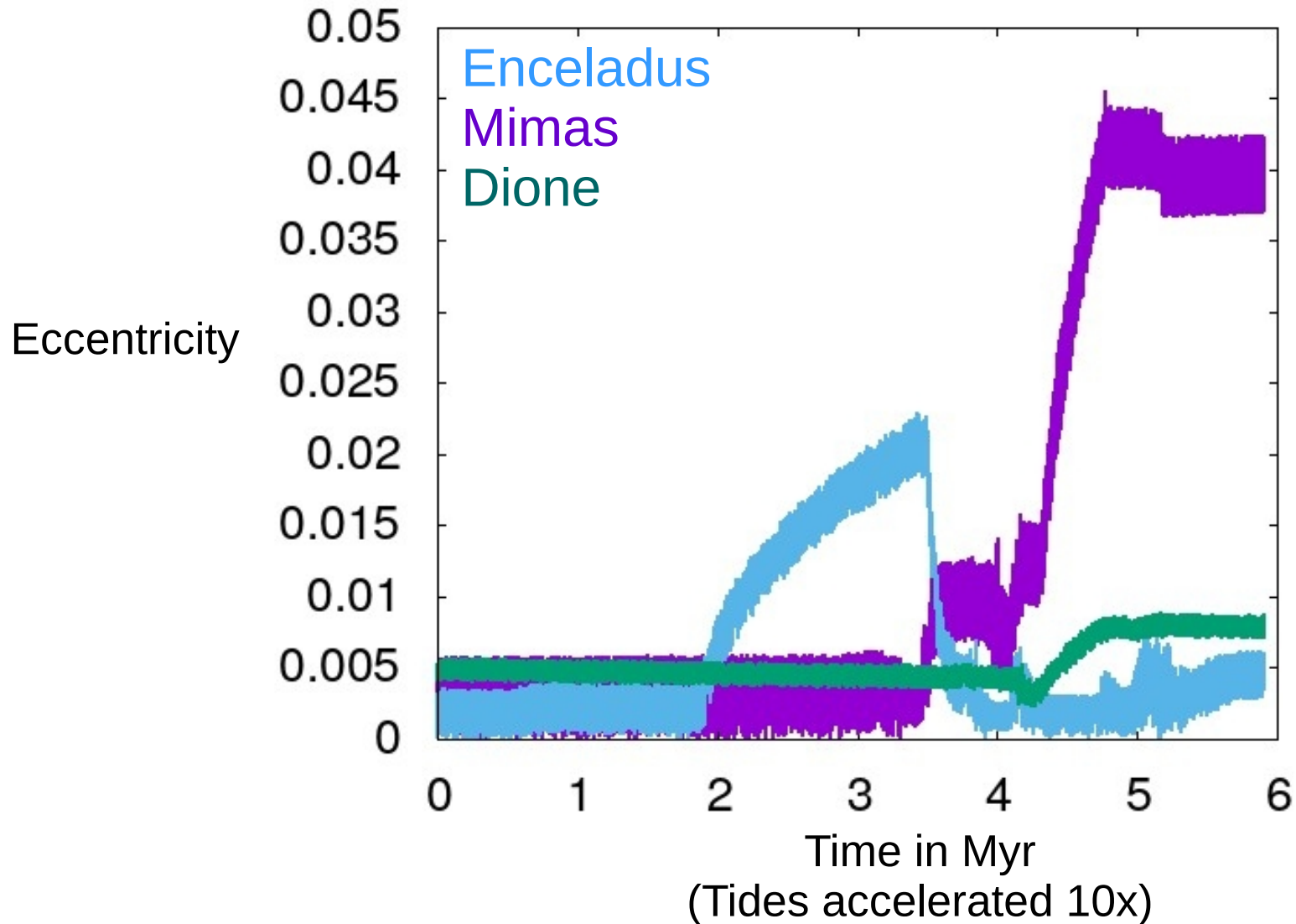
# Capture into Inclination-type Enceladus-Dione 4:2 MMR



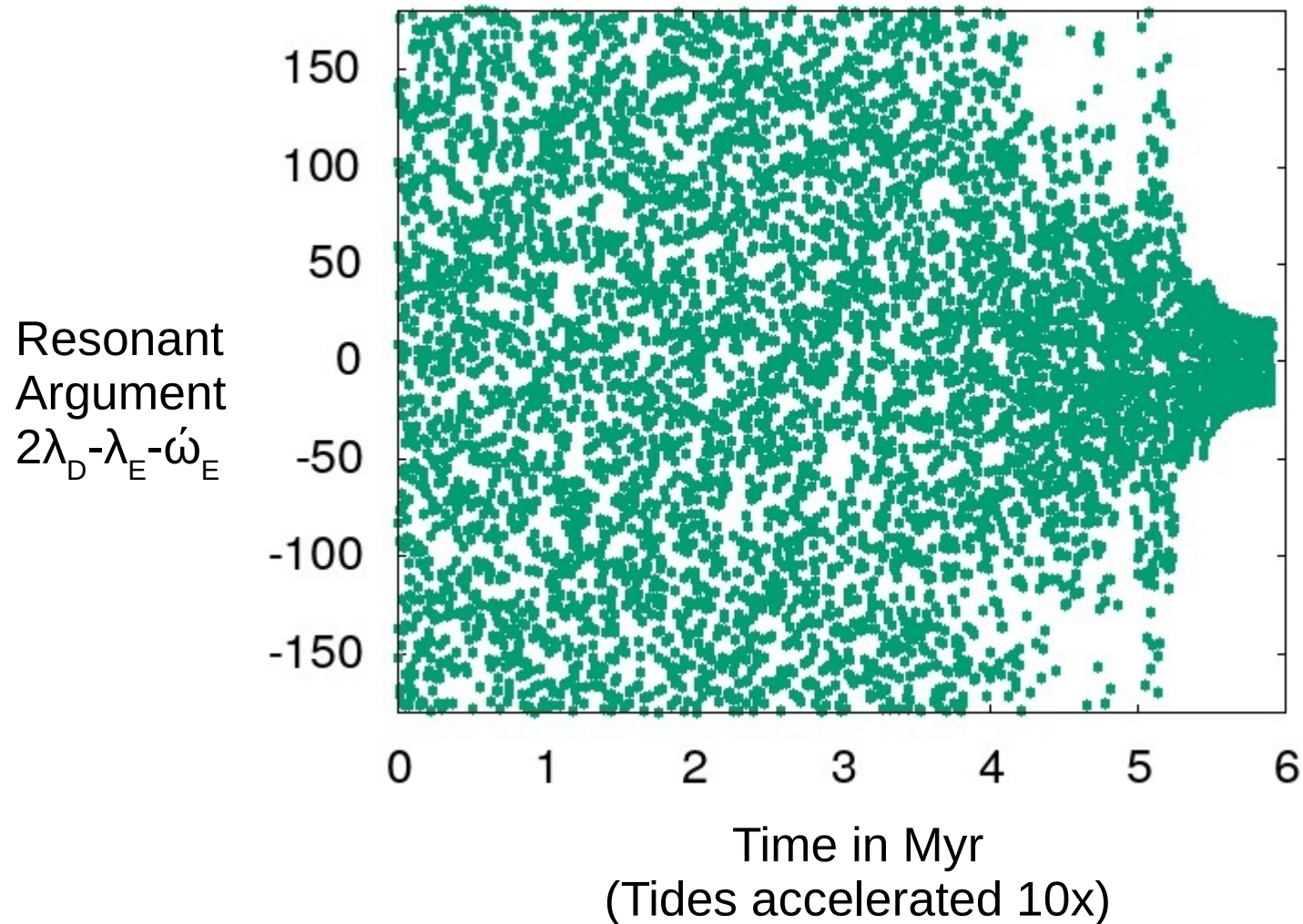
# Mimas-Enceladus-Dione Mess Slower Evolution (no 4:2 $i_E^2$ MMR)



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# Mimas-Enceladus-Dione Mess Slower Evolution (no 4:2 $i_E^2$ MMR)





# Summary

- Direct numerical simulations of past orbits of Saturn's inner moons are possible if the system is young (but interior properties are unknown)
- Strange properties of Mimas and Enceladus may be explained a past M-E resonance, followed by triple M-E-D resonant encounter
- Outcomes are chaotic, with a triple-resonance, no resonance, and D-E resonance all possible
- Realistic-rate simulations may suggest that Enceladus had a small but non-zero inclination
- Preliminary work: may or may not be funded by NASA Solar System Workings Program