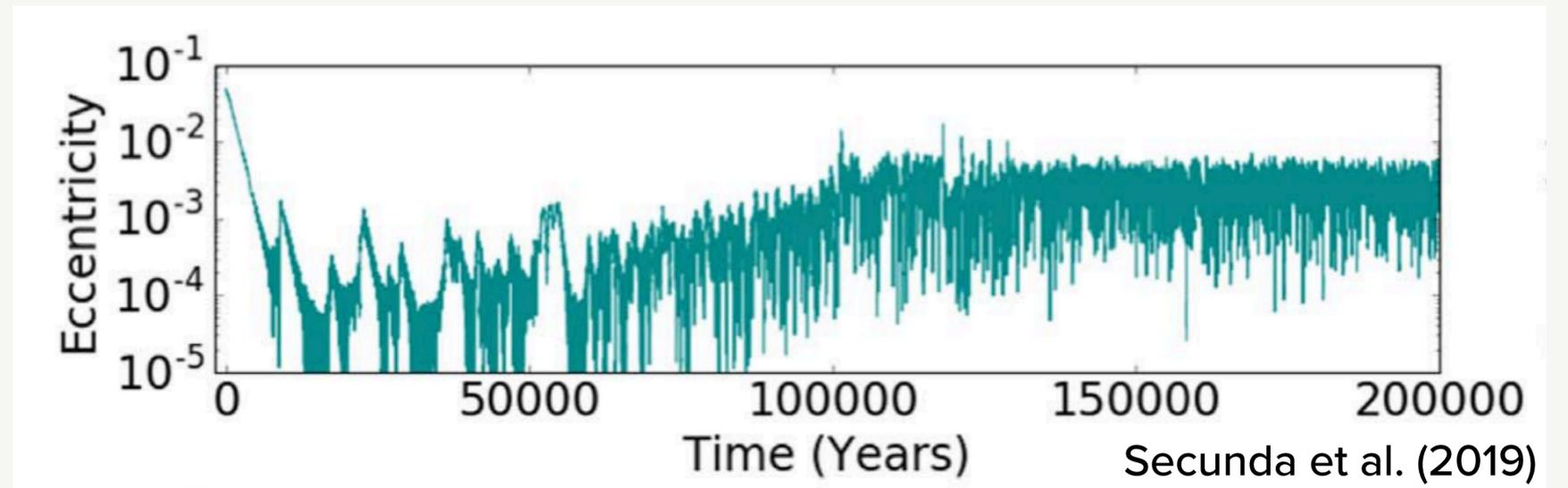


How to Form Binaries in AGN Disks

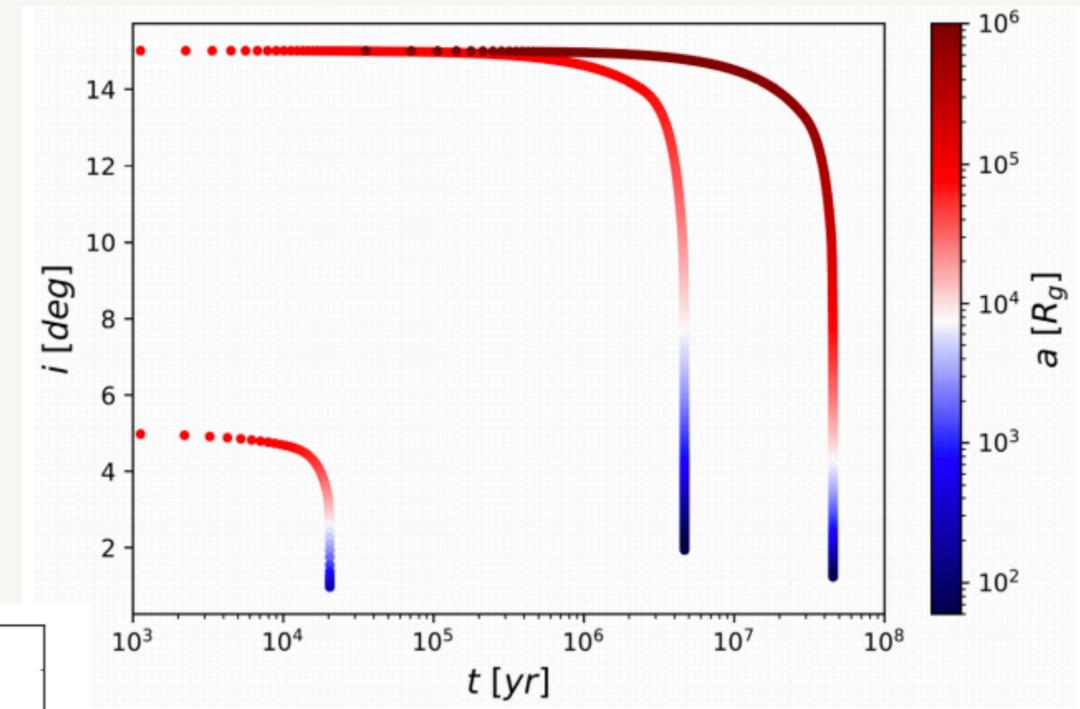
Amy Secunda¹

Betsy Hernandez¹, Jeremy Goodman¹, Nathan Leigh², Barry McKernan^{3,4,5}, Saavik Ford^{3,4,5}, Jose I. Adorno⁶, Mordecai-Mark Mac Low^{4,5},
Jillian Bellovary³, Katherine Gonglewski^{4,7}

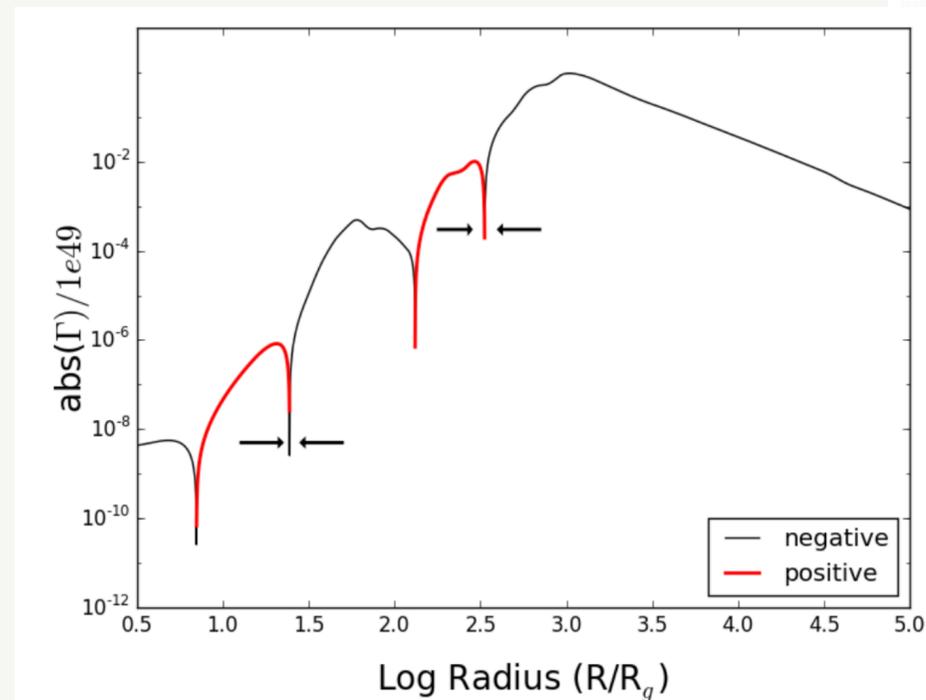
- Small relative velocities



- BHs are ground down into alignment with the orbital plane



- Migration torques



Bellovary et al. (2016)

Simulation Set up - Forces

- N-body interactions
- Migration force (Paardekooper et al. 2010)
- Eccentricity and Inclination Damping (Cresswell & Nelson 2008)
- MRI turbulence (Ogihara et al. 2017)

Simulation Set up - “Mergers”

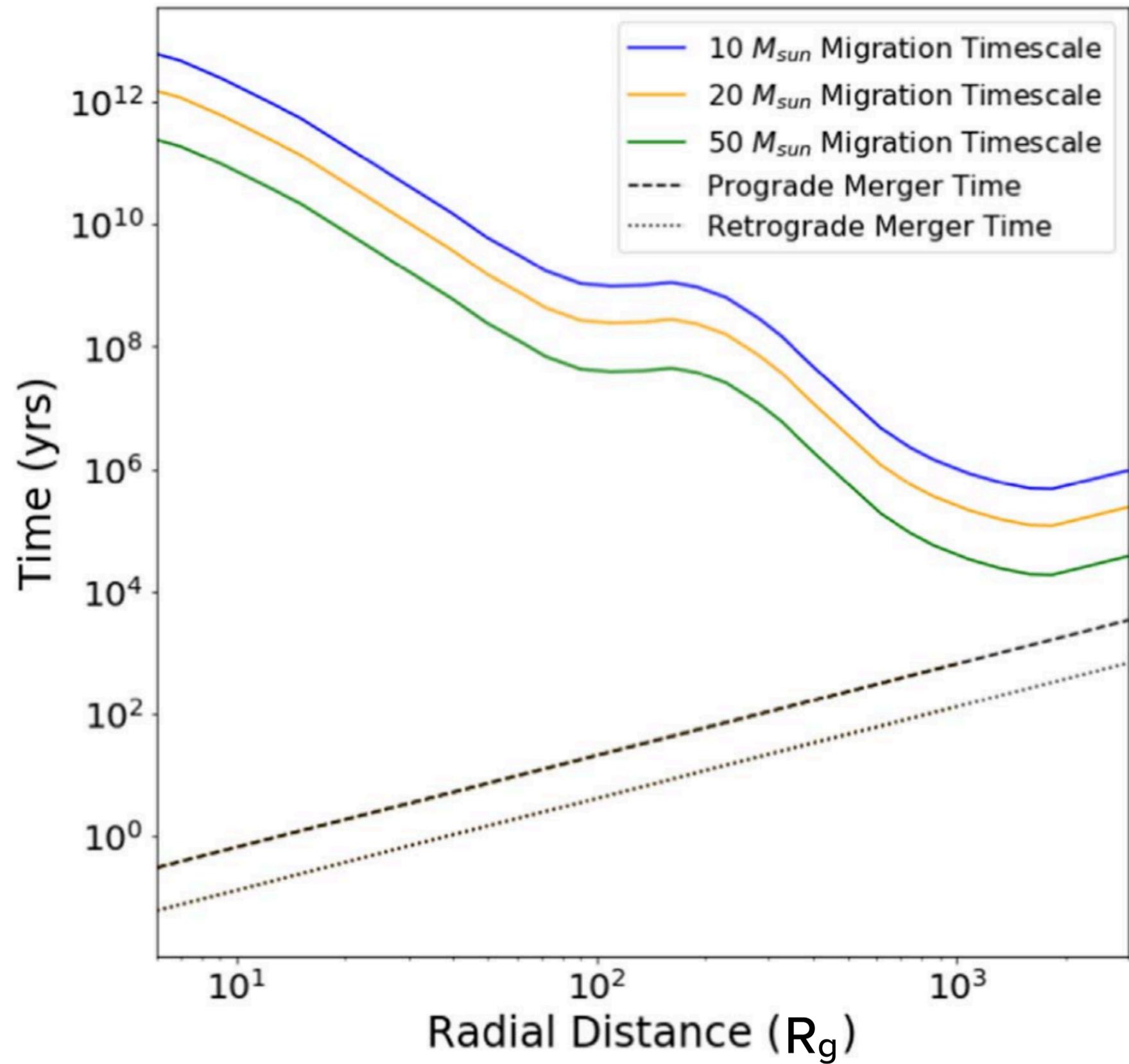
- A BBH is formed once two BHs are:

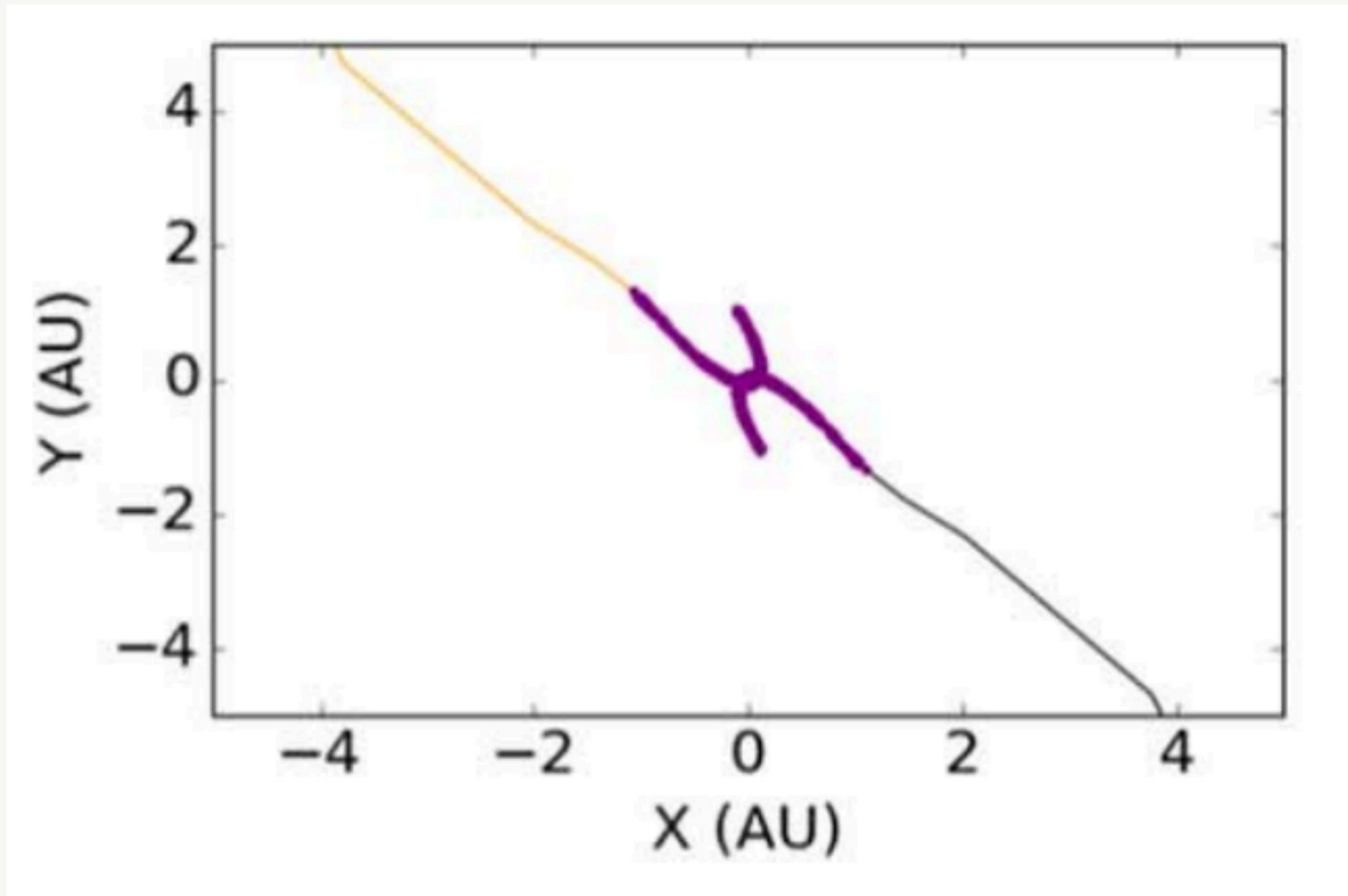
- Within one Hill Radius

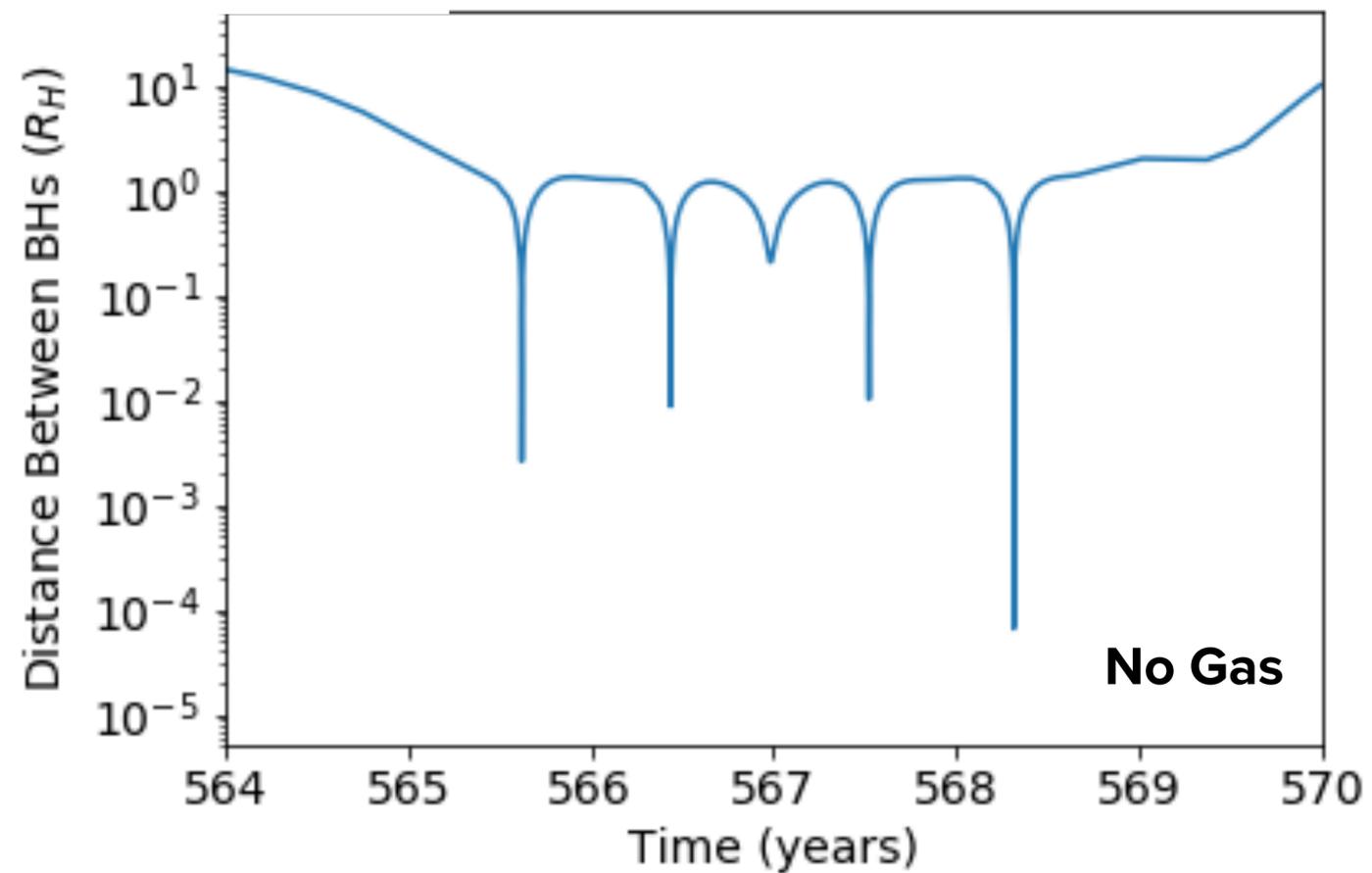
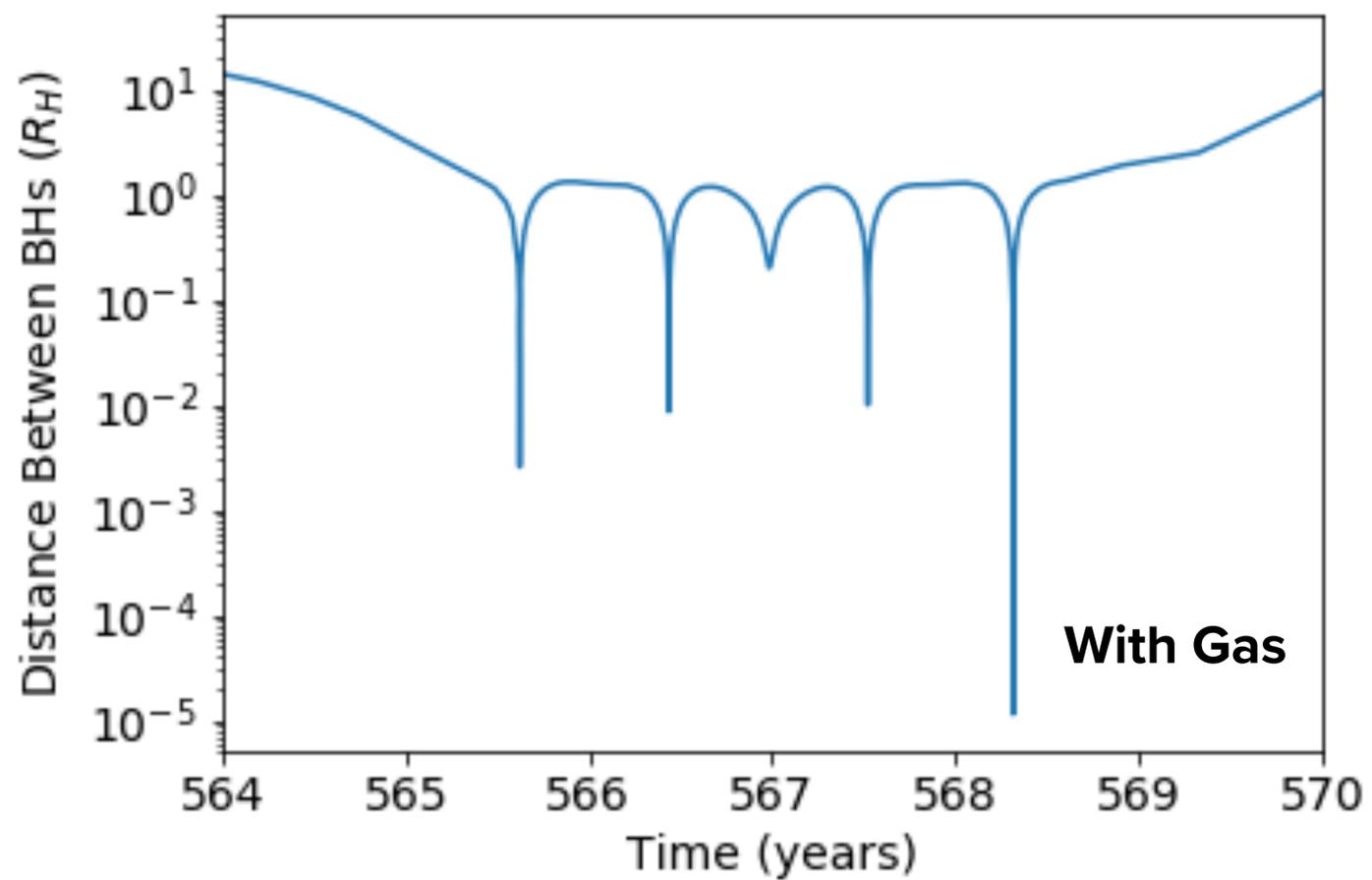
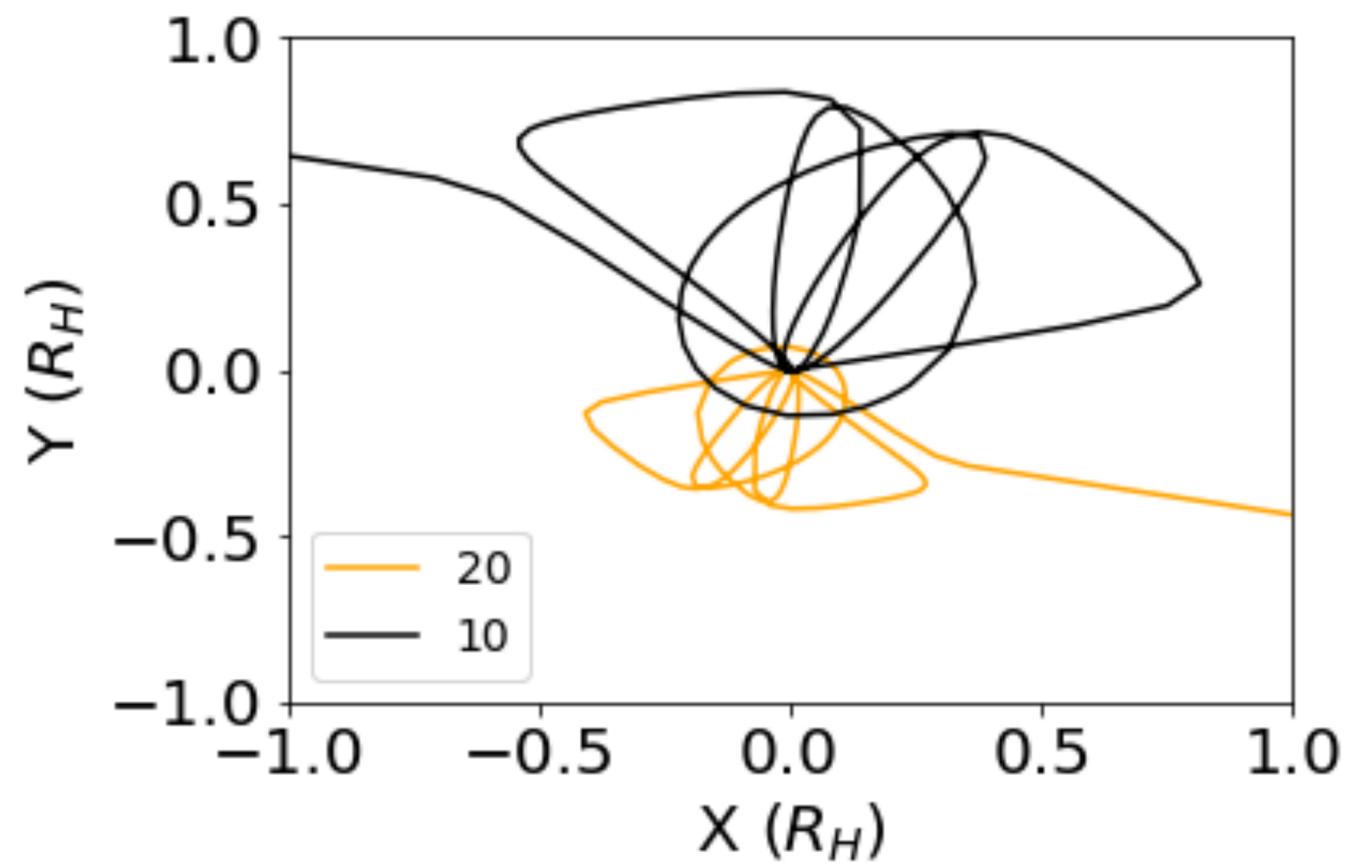
$$R_{mH} = \left(\frac{m_i + m_j}{3M_\star} \right)^{1/3} \left(\frac{r_i + r_j}{2} \right)$$

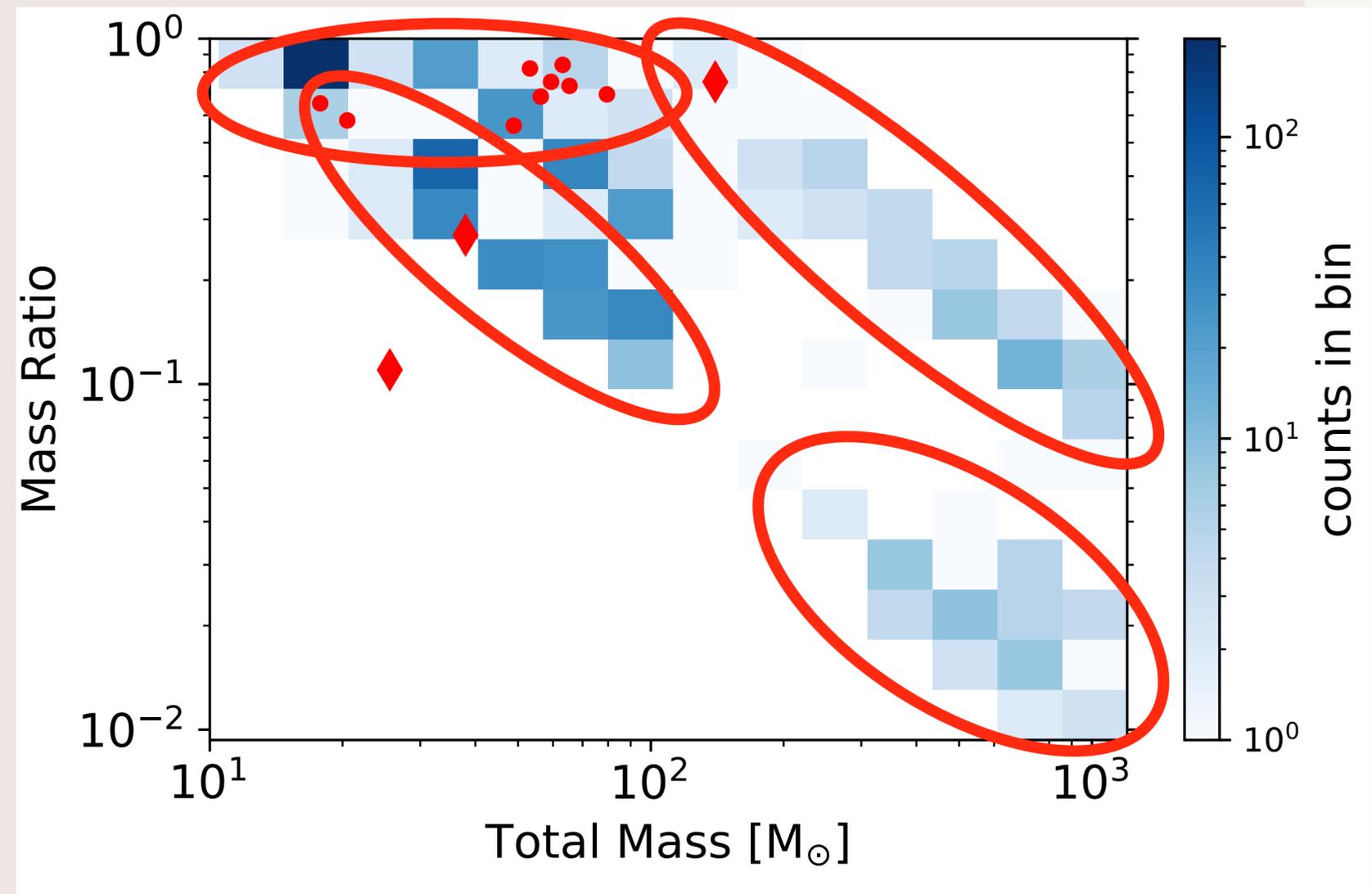
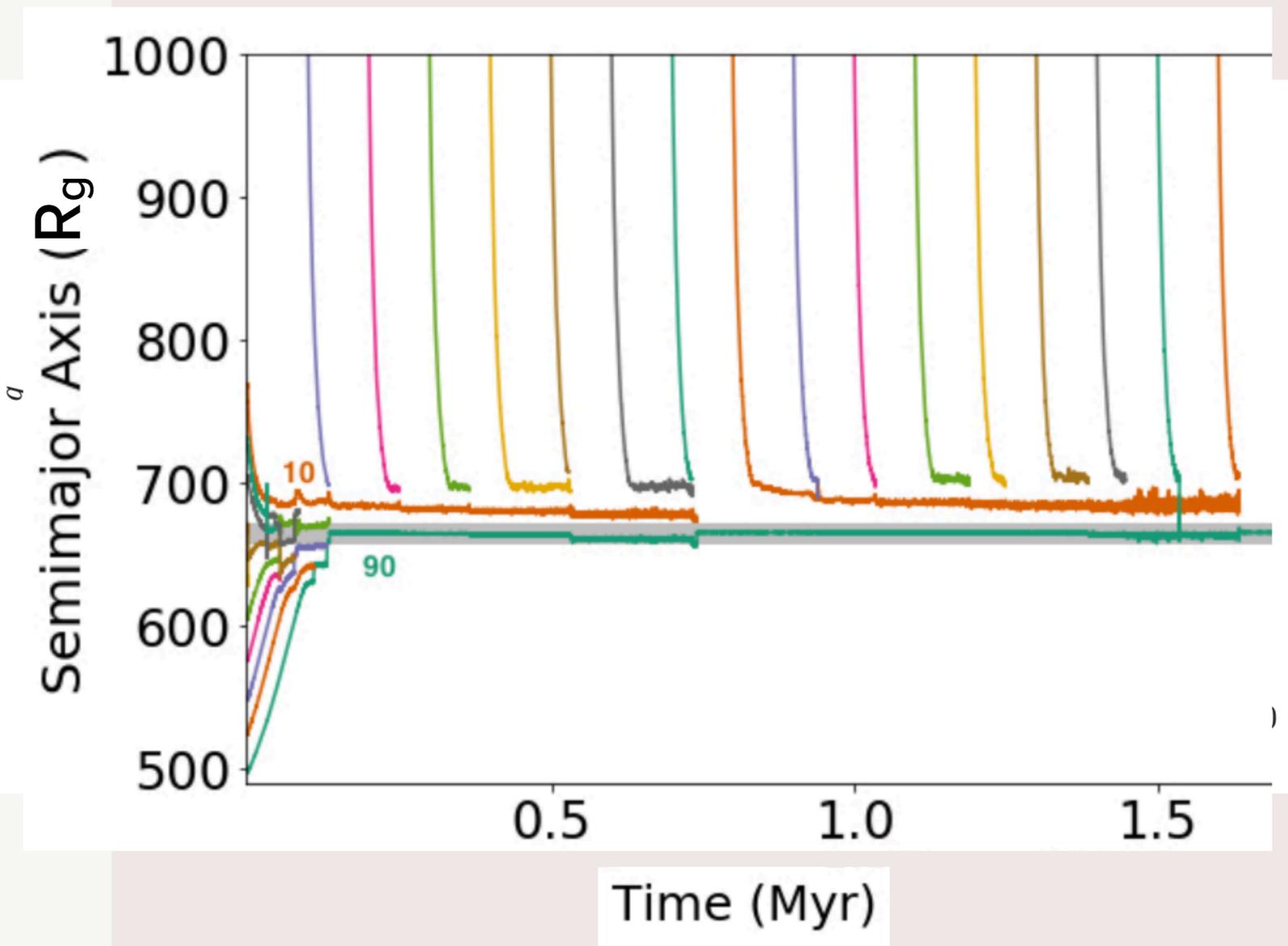
- Relative kinetic energy < Binding energy

$$K_{rel} = \frac{1}{2} \mu v_{rel}^2 < U = \frac{Gm_i m_j}{2R_{mH}}$$









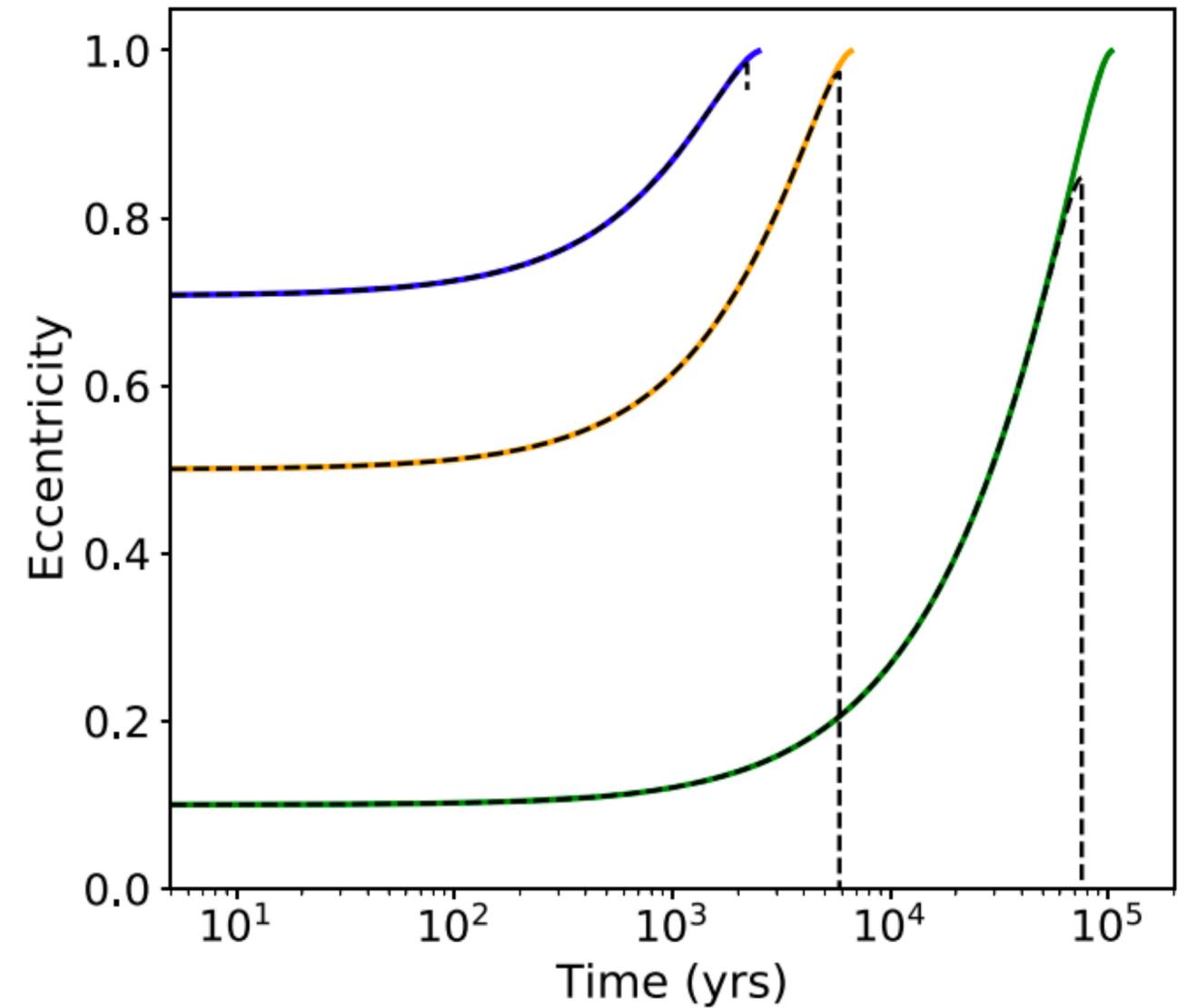
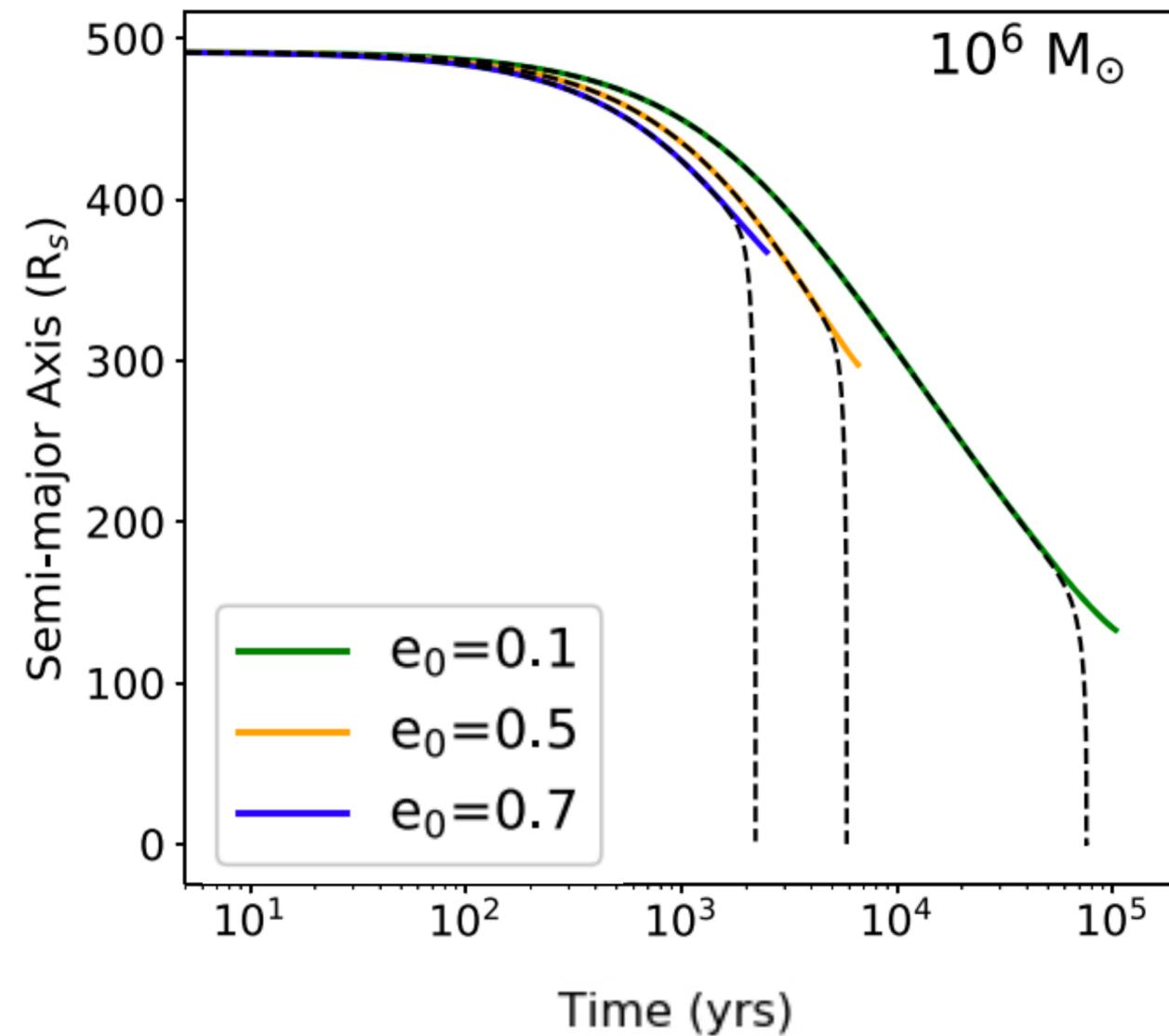
Retrograde Orbiters

- Fundamentally different orbital evolution
- Have large relative velocities from prograde orbiters

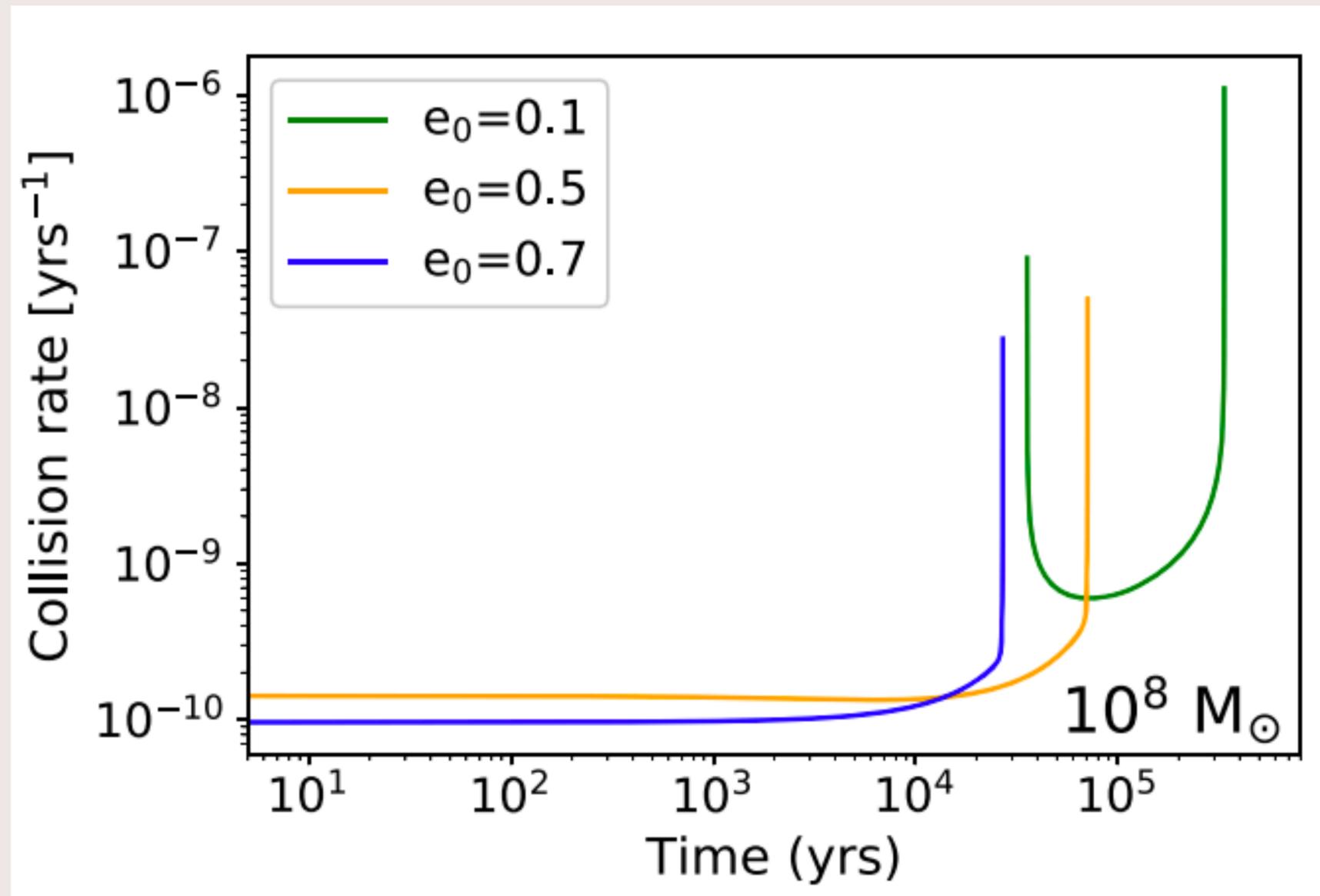
Orbital Evolution

$$\mathbf{F}_{\text{drag}} = -\frac{4\pi \ln \Lambda (Gm)^2 \rho}{v_{\text{rel}}^3} \mathbf{v}_{\text{rel}}$$

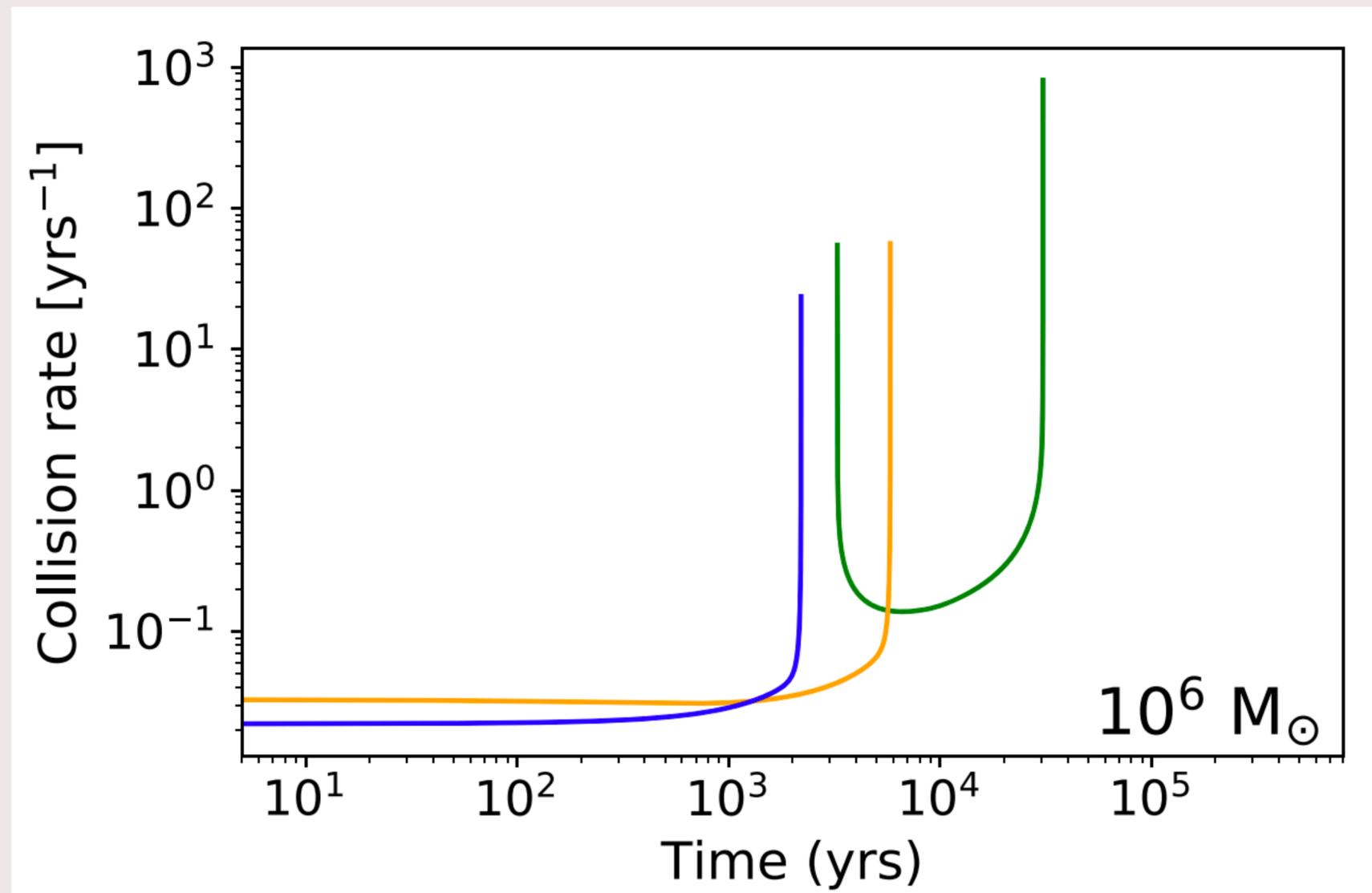
Retrograde Orbital Evolution



Retrograde Collision Probability



Retrograde Collision Probability



Conclusions

- Our “binaries” are good input for hydro codes
- Retrograde orbiters could lead to scattering