# Encounter Dynamics and Tidal Response as Functions of Galaxy Structure

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# Motivation: Galaxy Encounters

Model as collision of equilibrium objects.

Initial conditions must specify:

- Initial orbit (mass ratio, eccentricity, separation)
- Encounter geometry (disk inclinations)

- Halo properties (mass, radius, cutoff)
- Stellar components (D/B, disk size, etc.)

} effect on outcome?

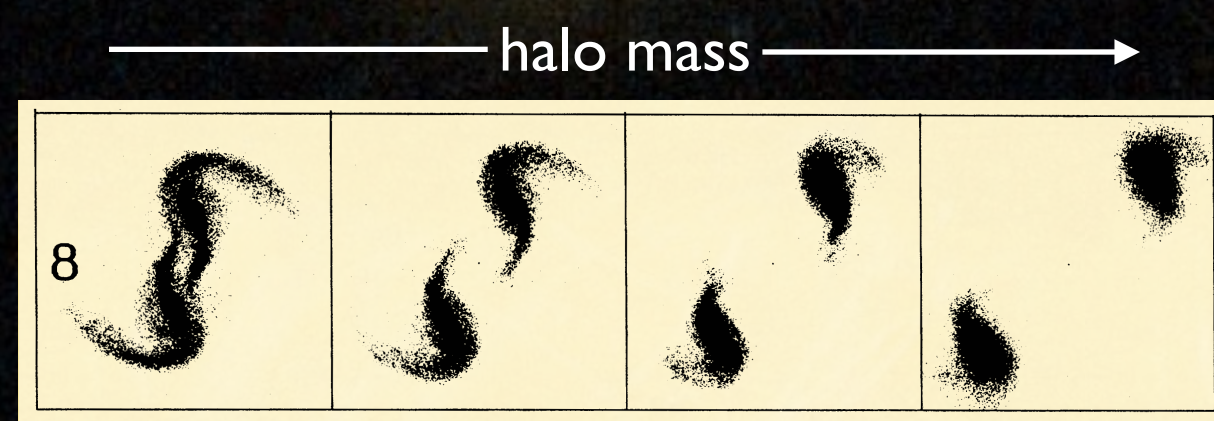
Deep potential wells inhibit tidal tails:

The parameter

$$\mathcal{E} \equiv \left[\frac{v_{\rm esc}}{v_{\rm cir}}\right]^2$$

correlates with tidal response.

Springel & White (1999, MNRAS 307, 162)




Dubinski et al.(1996, Ap. J. 462, 576)

VV 705/Markarian 848

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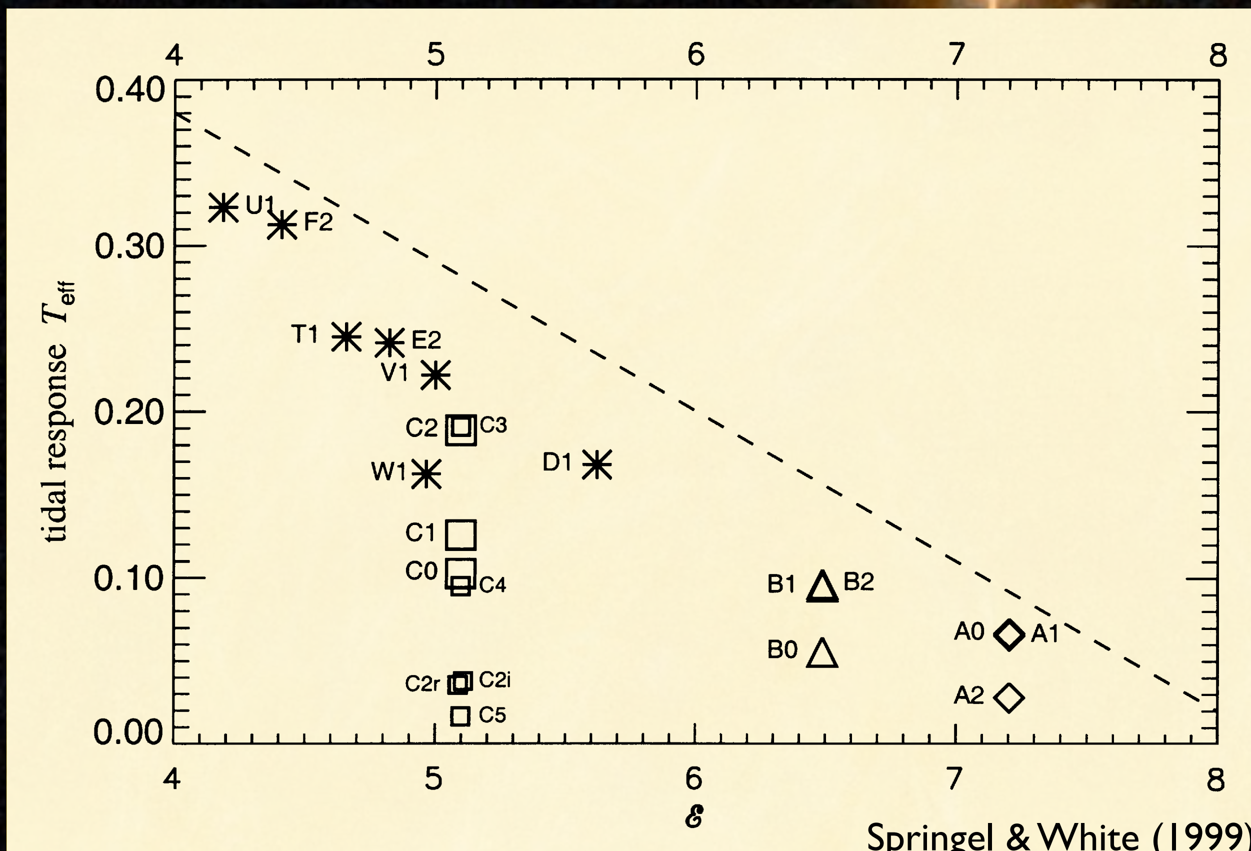


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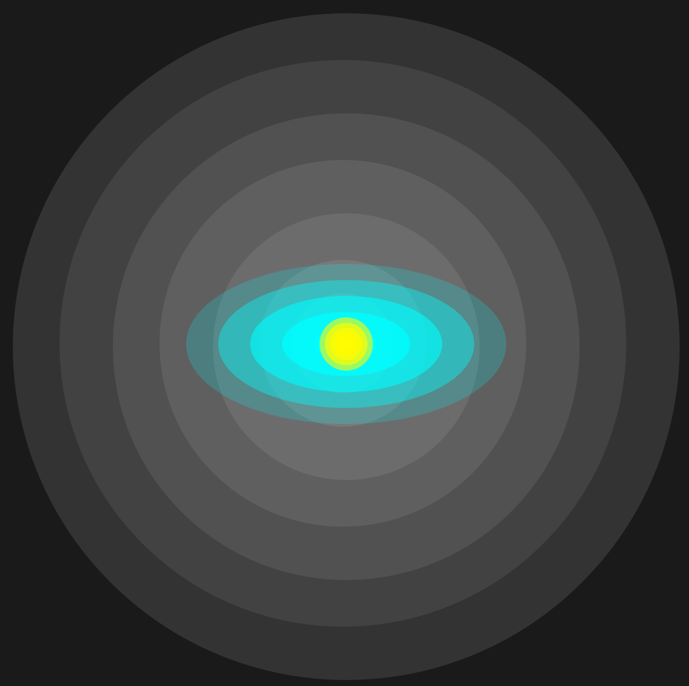
# Galaxy Models: Construction



Halo: "NFW" profile with smooth taper.

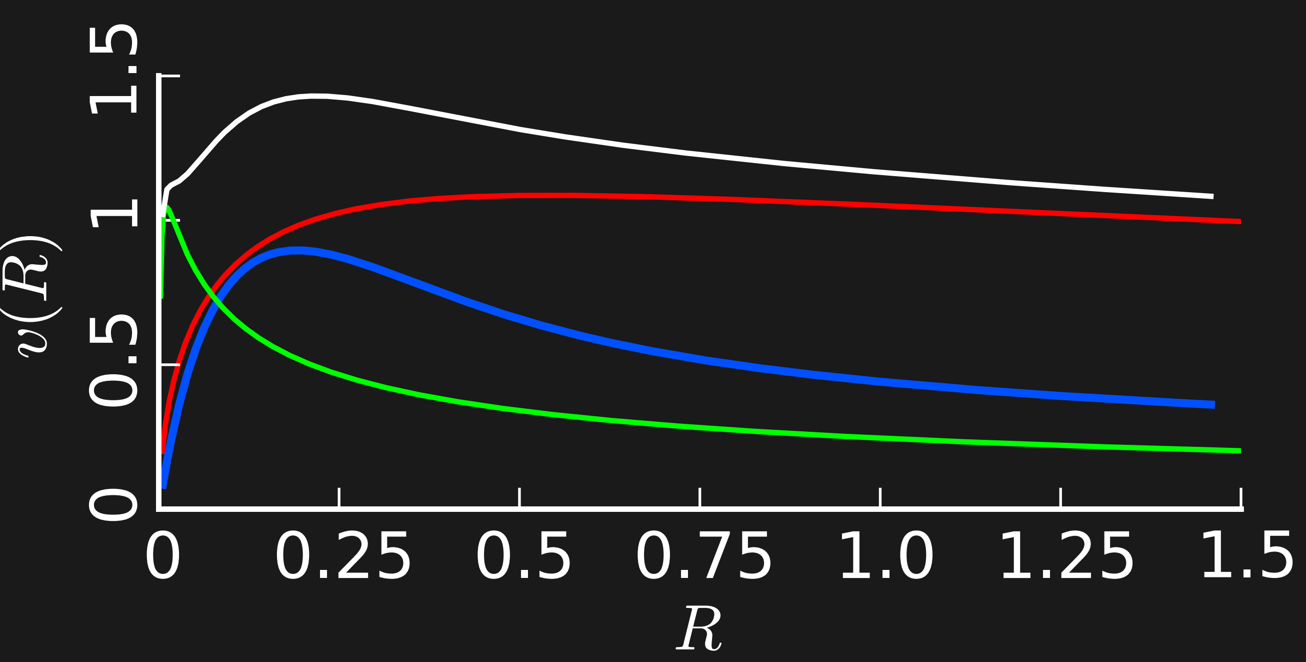
$$\rho_{\rm h}(r) \propto \begin{cases} r^{-1}\,(r+a_{\rm h})^{-2}\,, & r \le b_{\rm h} \\ r^{-\beta}\,e^{-r/a_{\rm h}}\,, & r > b_{\rm h} \end{cases}$$

Disk: exponential–isothermal profile.

$$\rho_{\rm d}(R,z) \propto e^{-\alpha R}\,{\rm sech}^2(z/z_{\rm d})$$

Bulge: steep-cusp profile (Jaffe 1983).

$$\rho_{\rm b}(r) \propto r^{-2}\,(r+a_{\rm b})^{-2}$$



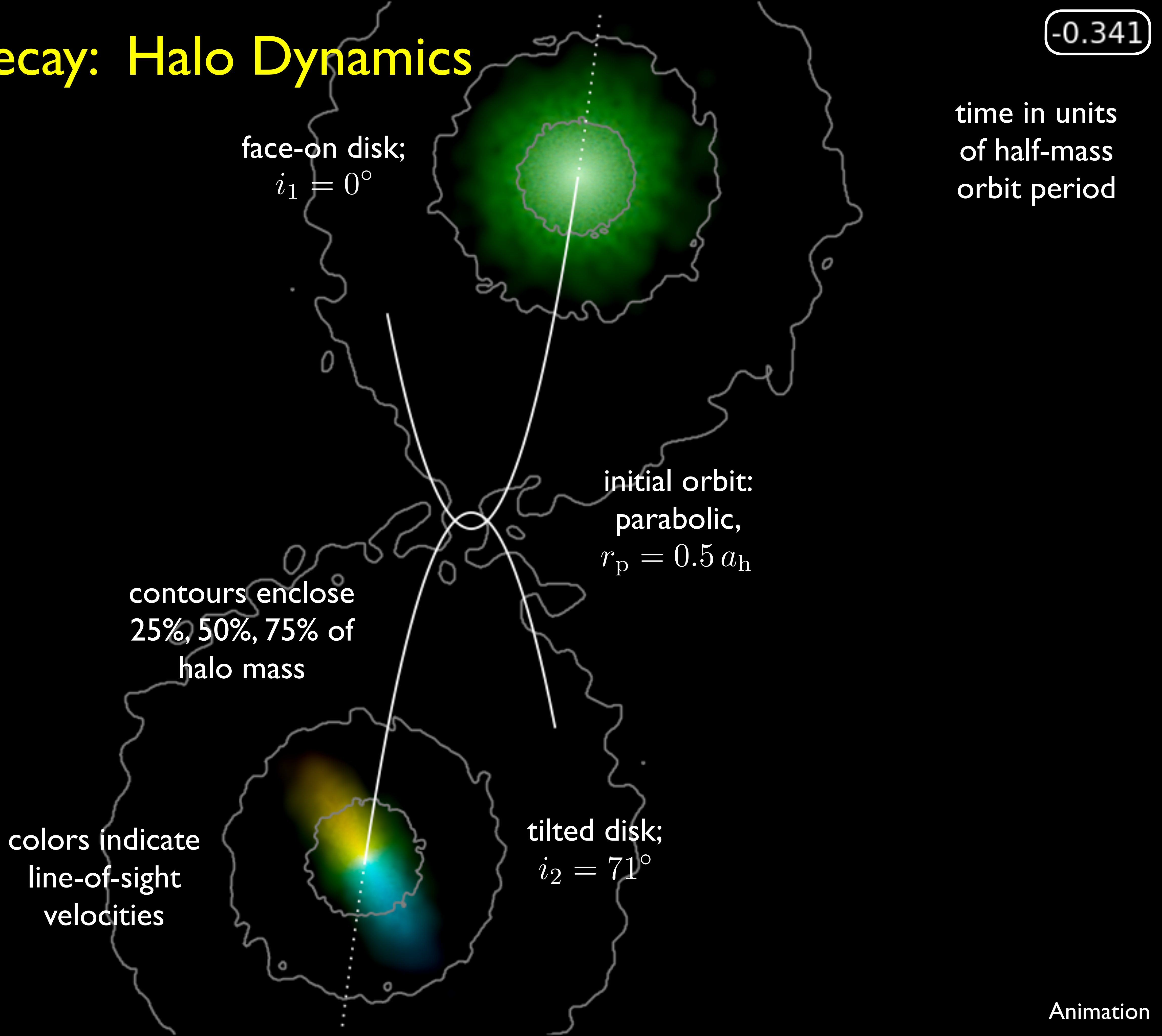

Parameter grid:

$$f_{\rm L} = 0.2,\ 0.1,\ 0.05$$

$$c_{\rm h} = b_{\rm h}/a_{\rm h} = 4,\ 8,\ 16$$

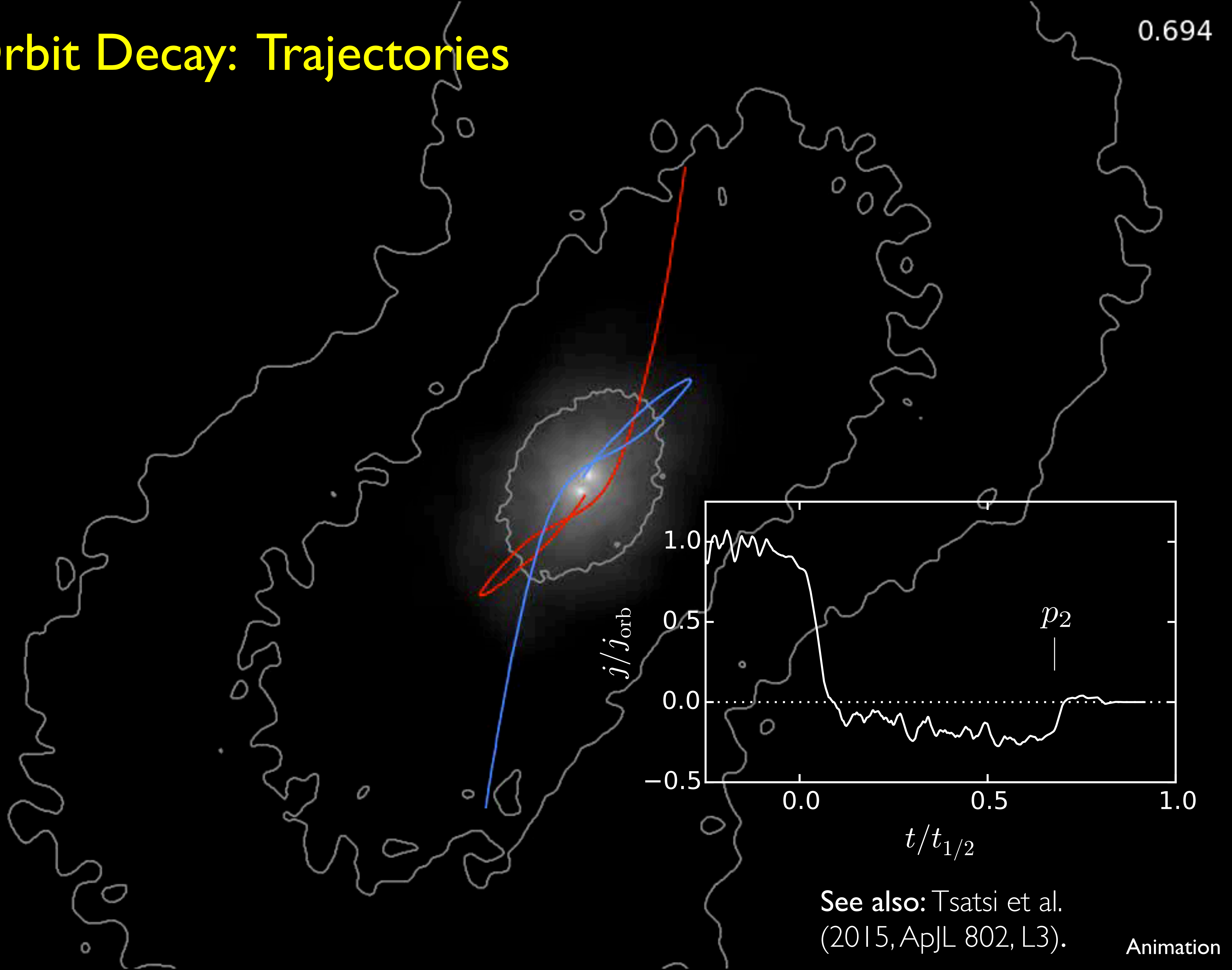
$$\alpha a_{\rm h} = 4.8,\ 3.75,\ 3.0,\ 2.4,\ 1.875$$

# Orbit Decay: Halo Dynamics




Animation

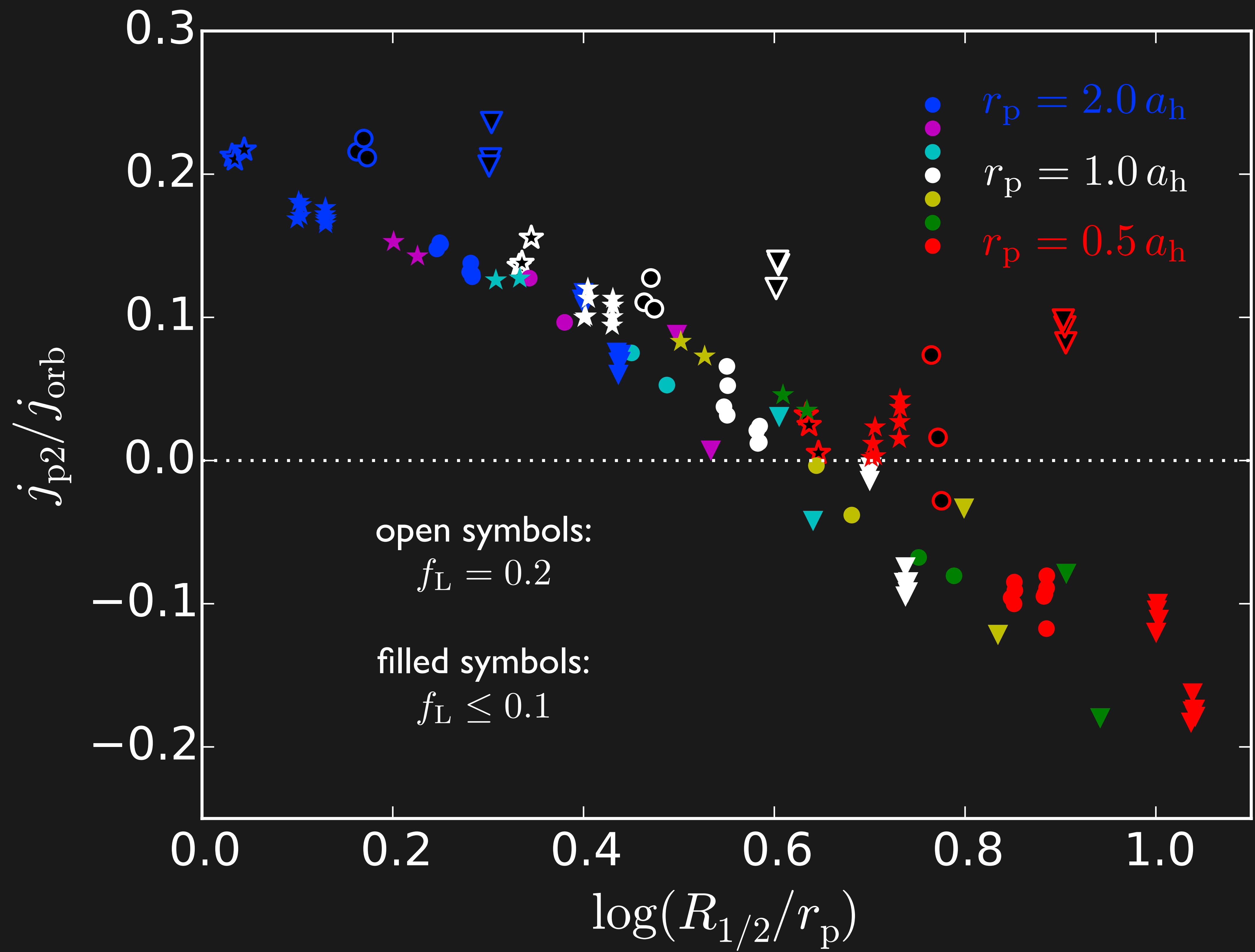
# Orbit Decay: Trajectories



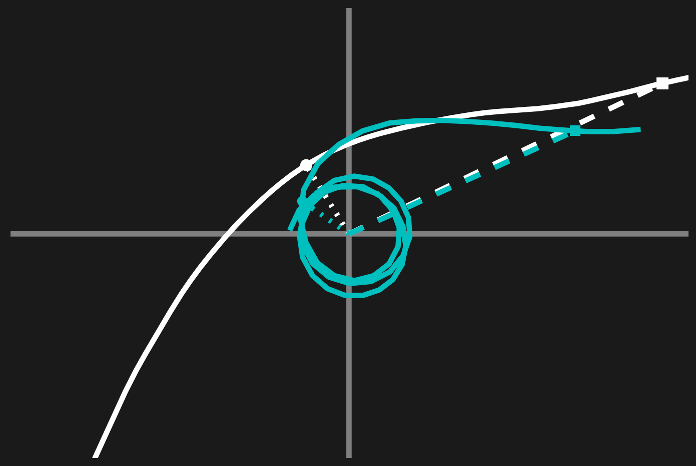

**See also:** Tsatsi et al. (2015, ApJL 802, L3).

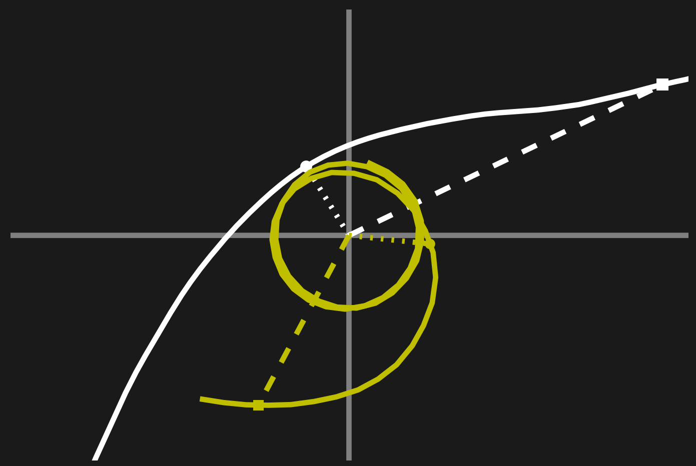
Animation

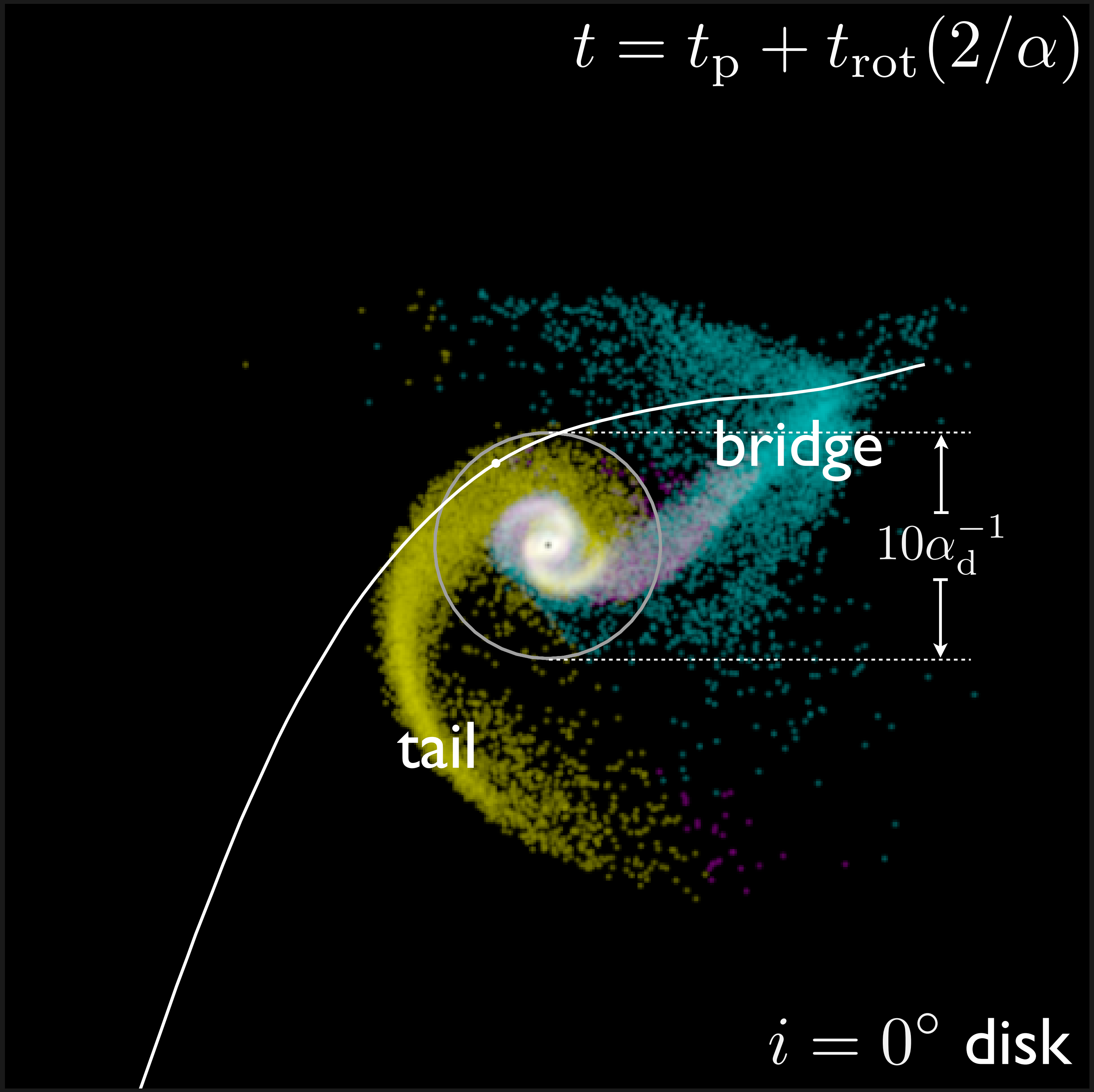
# Orbit Decay: Beyond The Zero



# Disk Response: Tidal Classification







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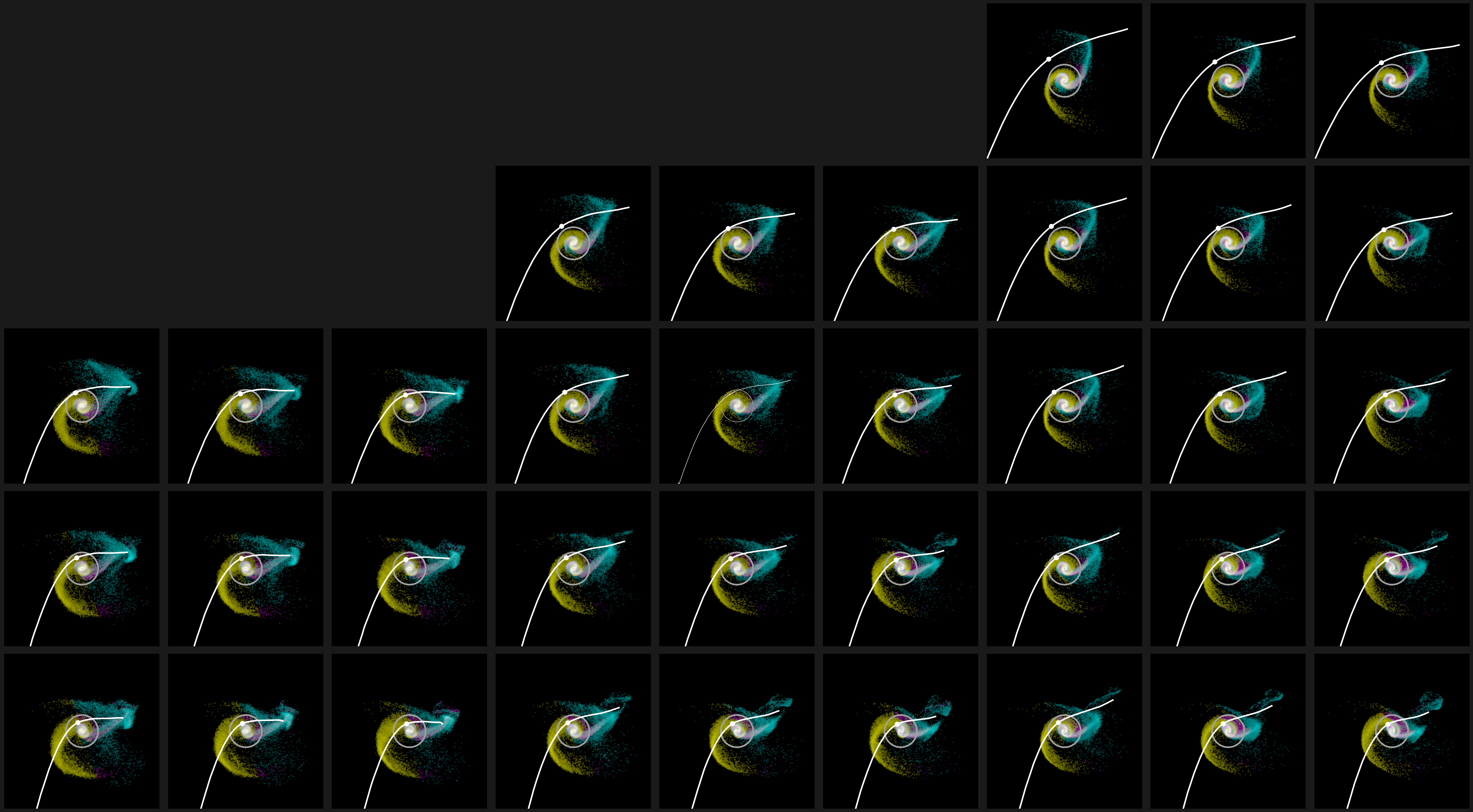
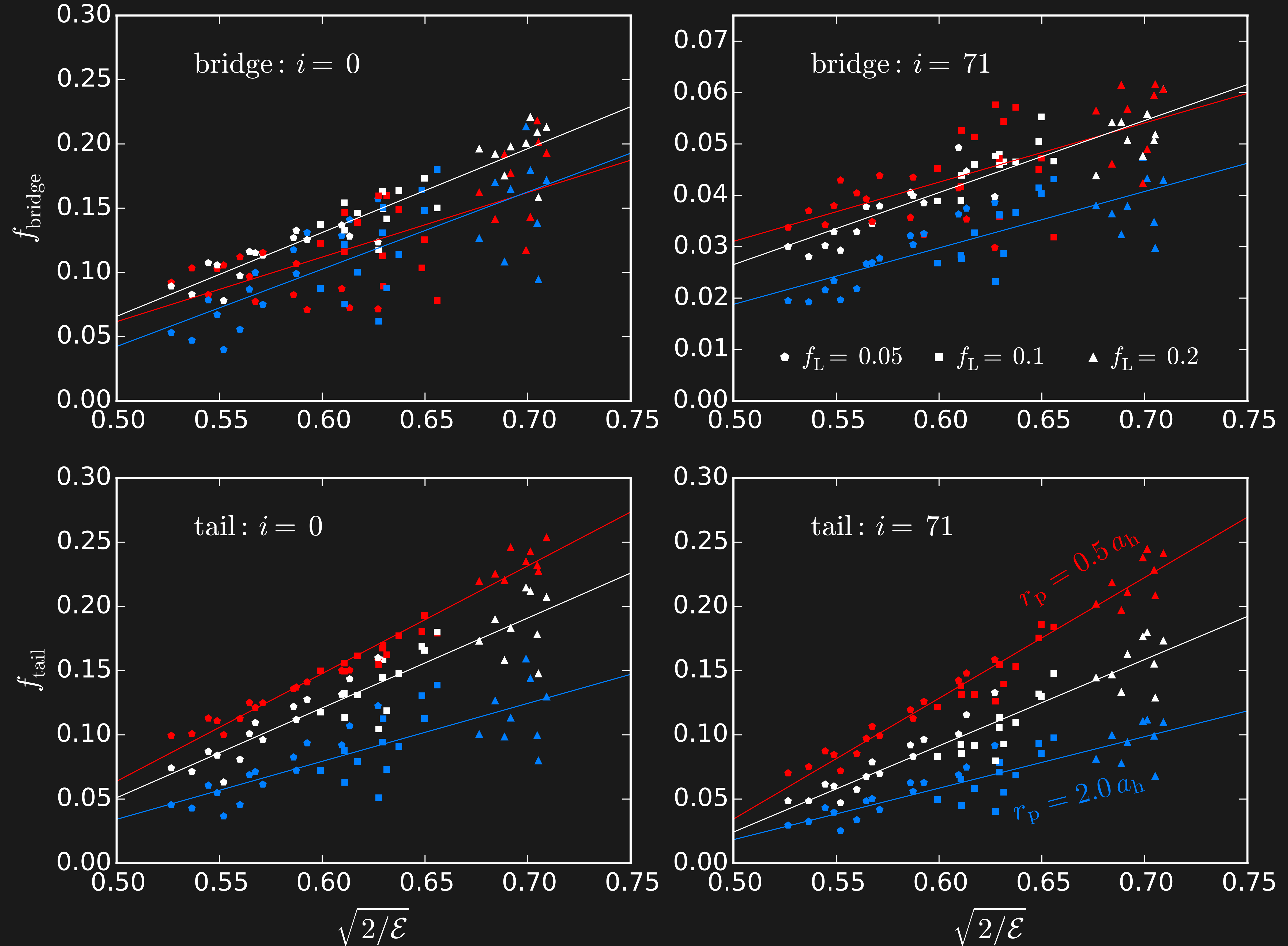


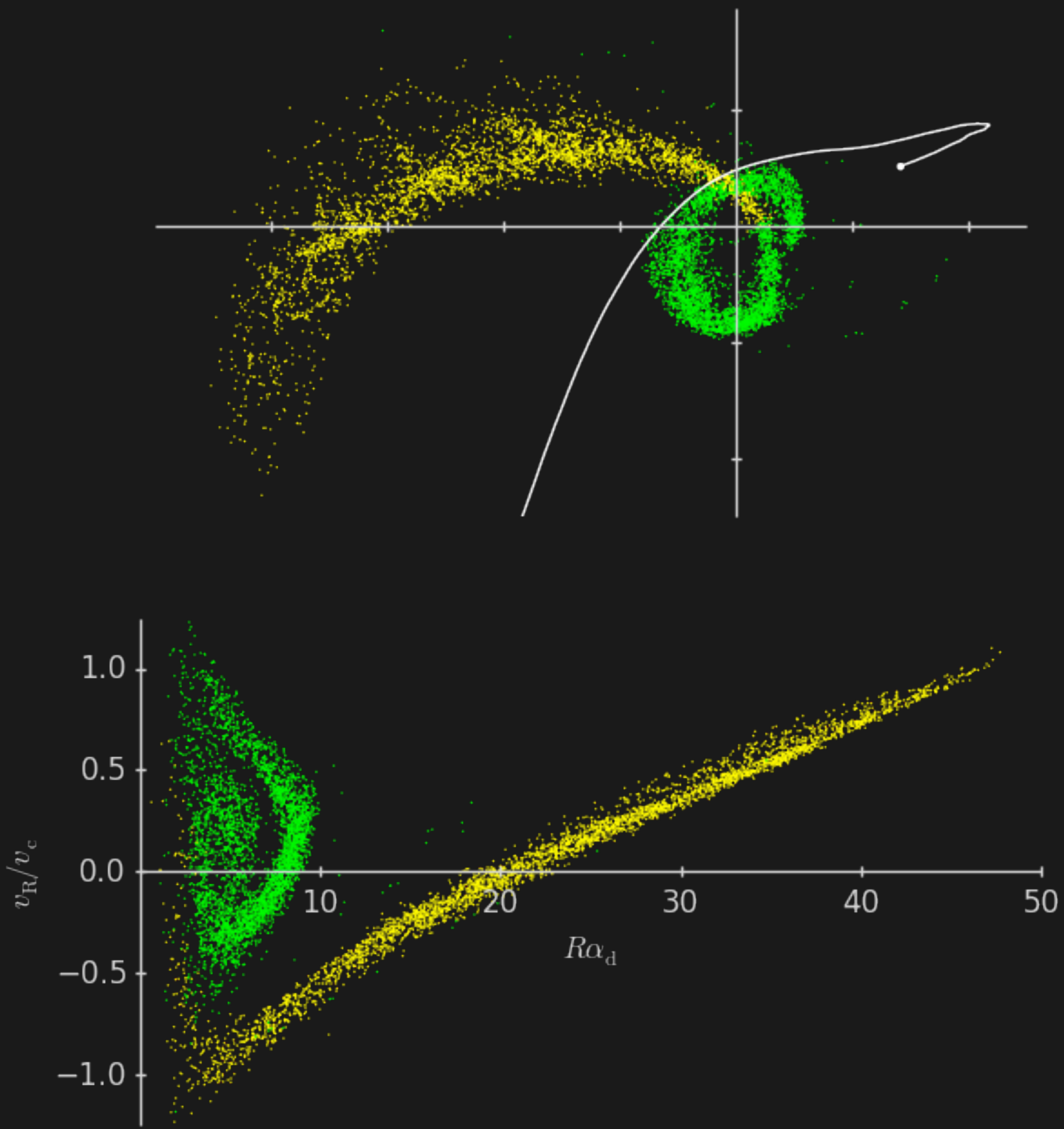
$r_{\rm p} = 1.0\, a_{\rm h}$

$i = 0^\circ$ **disks**

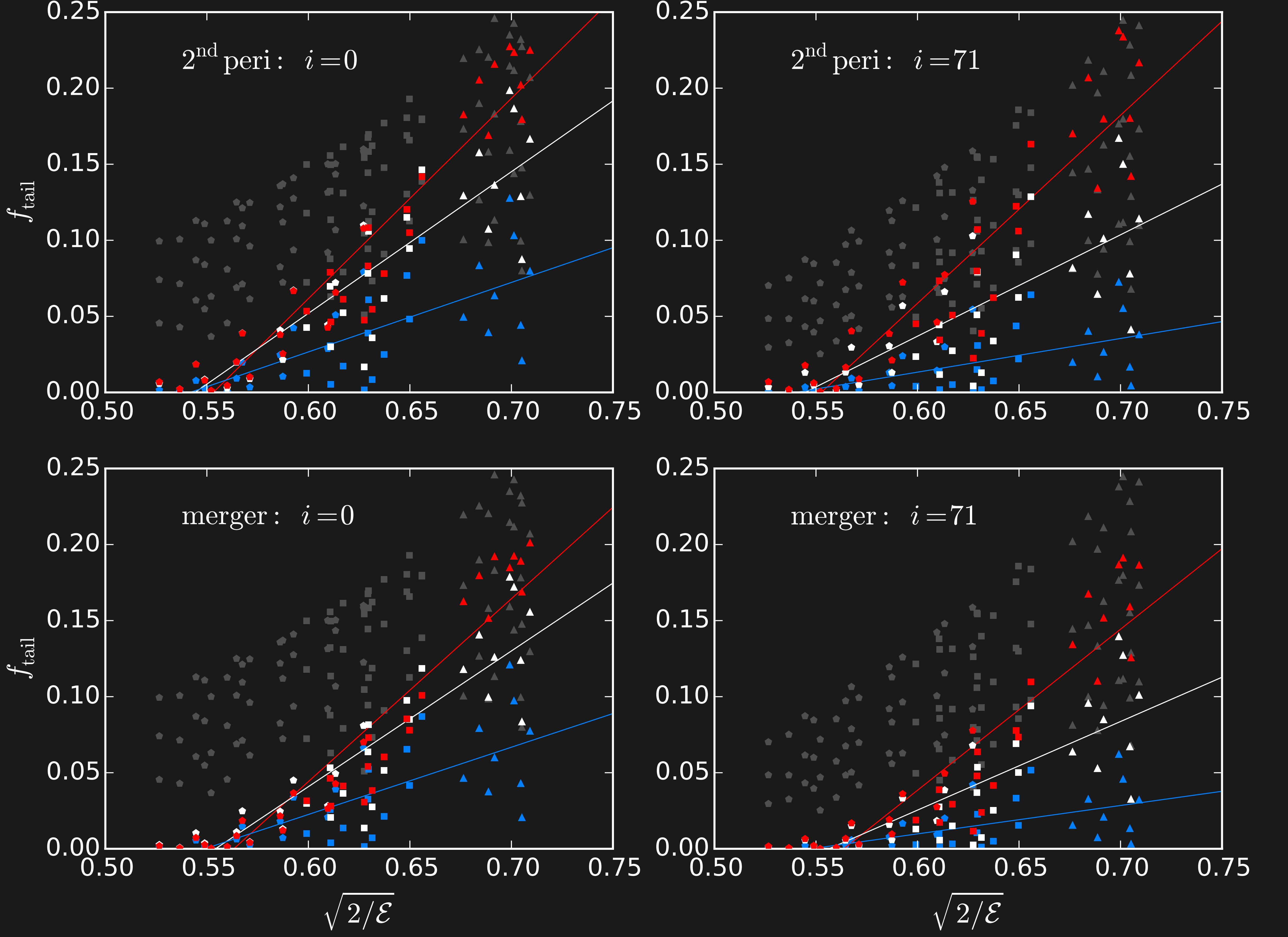
# Disk Response: Tidal Fractions



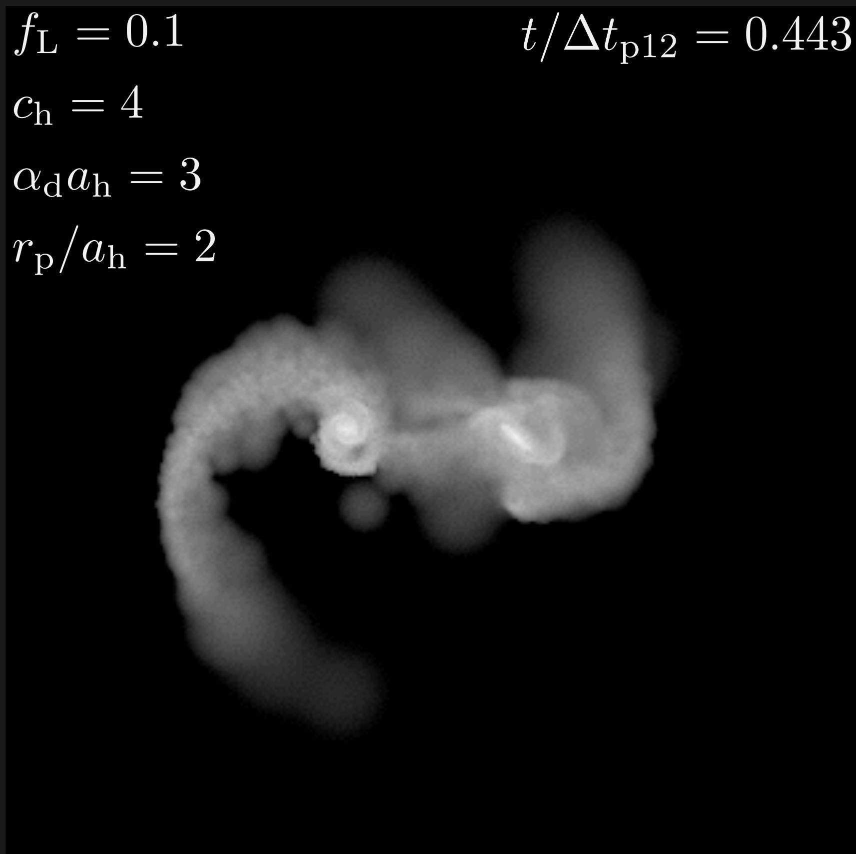
# Disk Response: Tail Re-accretion

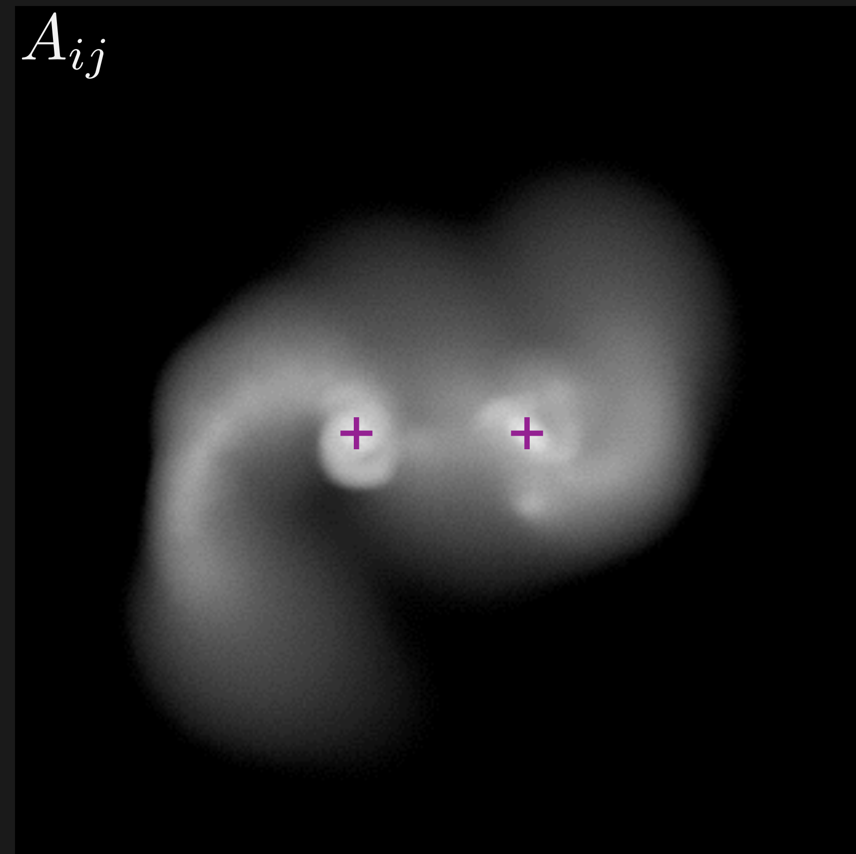


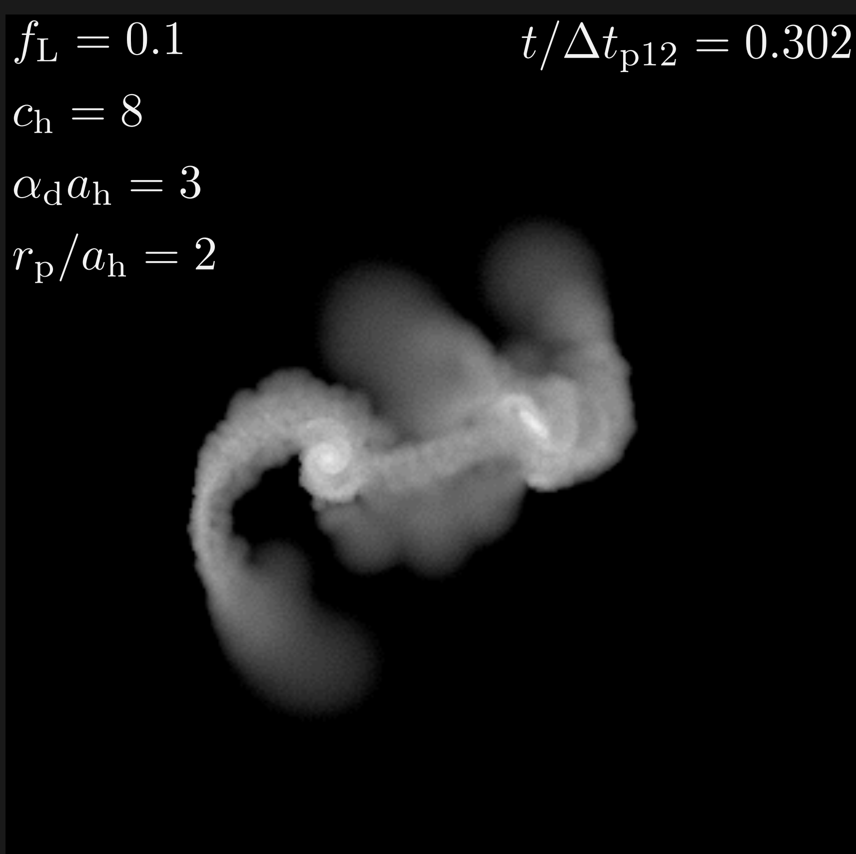
# Disk Response: Tail Fractions After Re-accretion

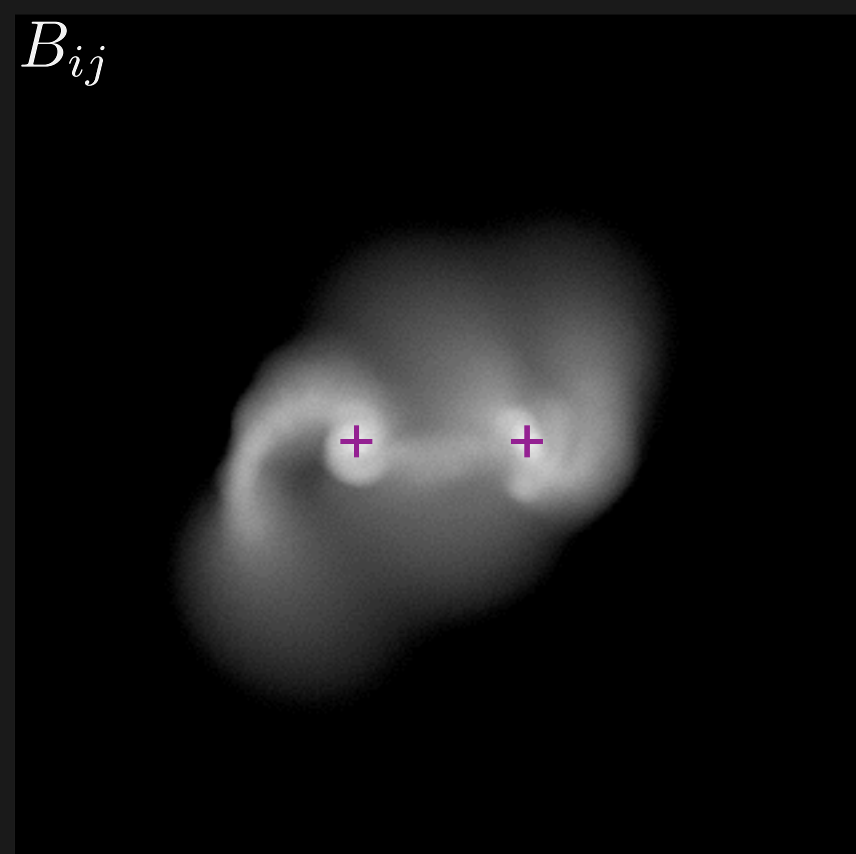


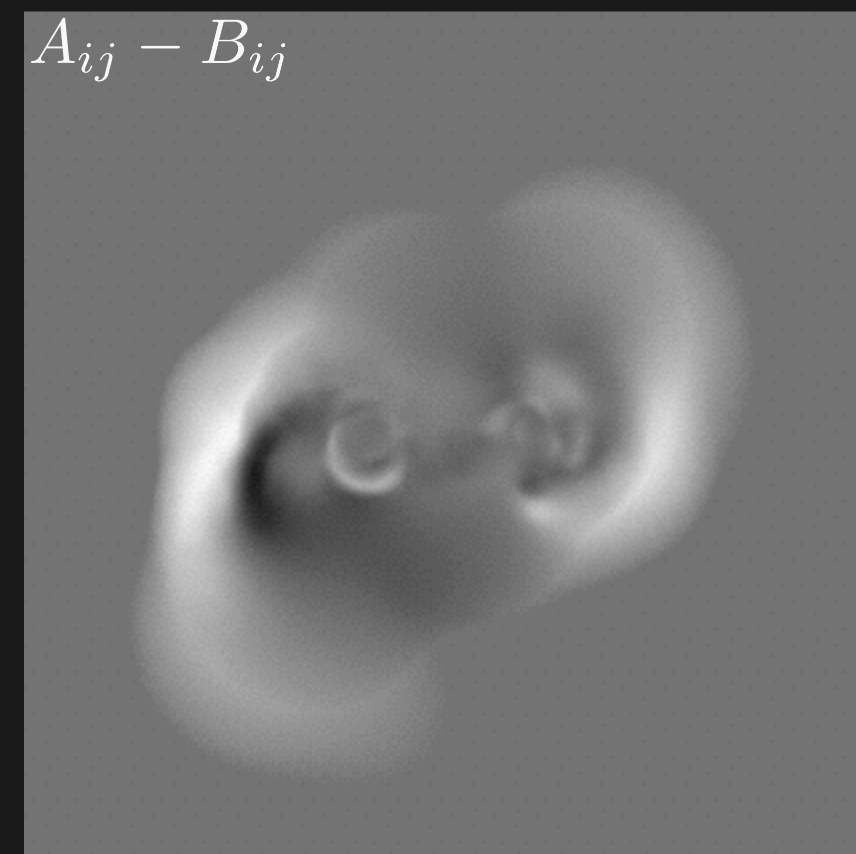
# Tidal Configurations: Image Comparison




$$\mathcal{D} \equiv \frac{\sum_{ij} |A_{ij} - B_{ij}|}{\sum_{ij} A_{ij} + B_{ij}}$$

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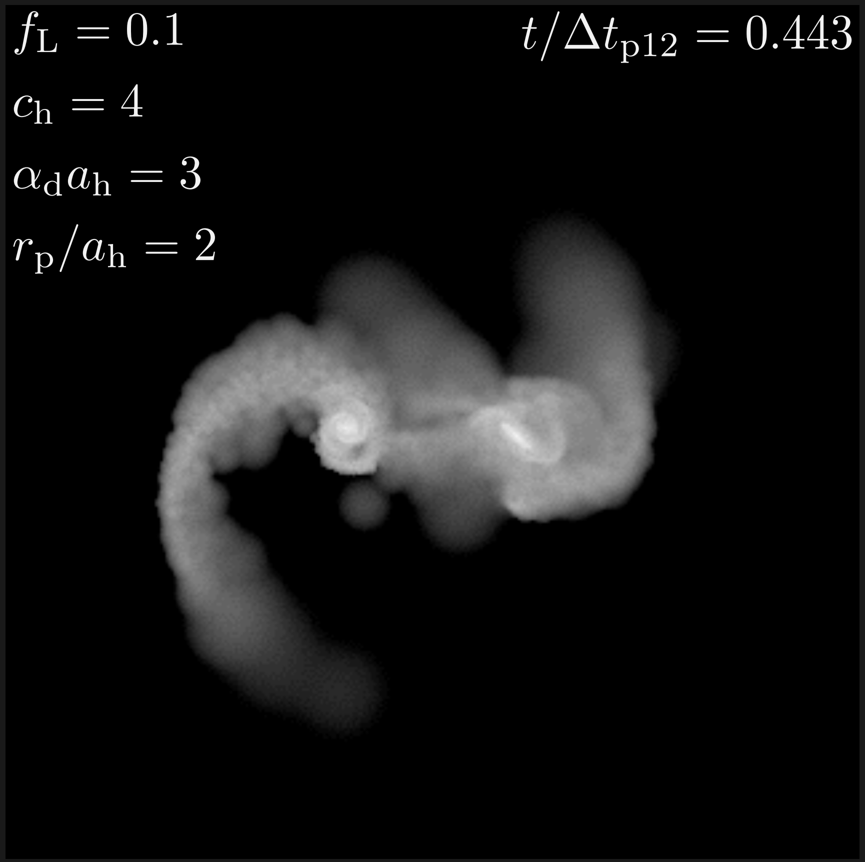


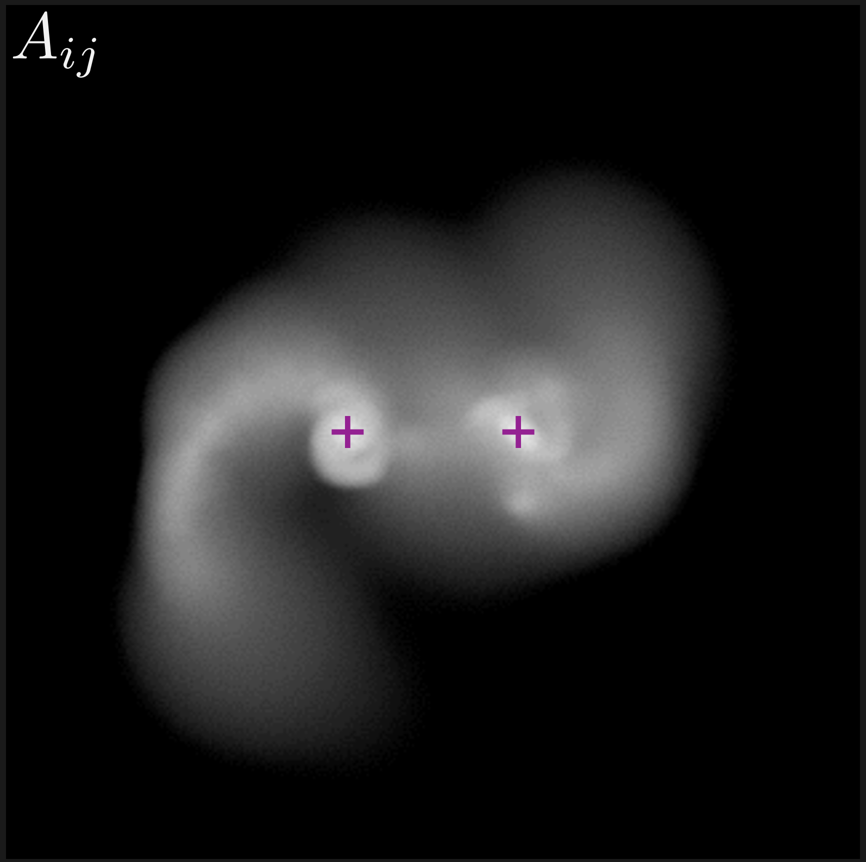


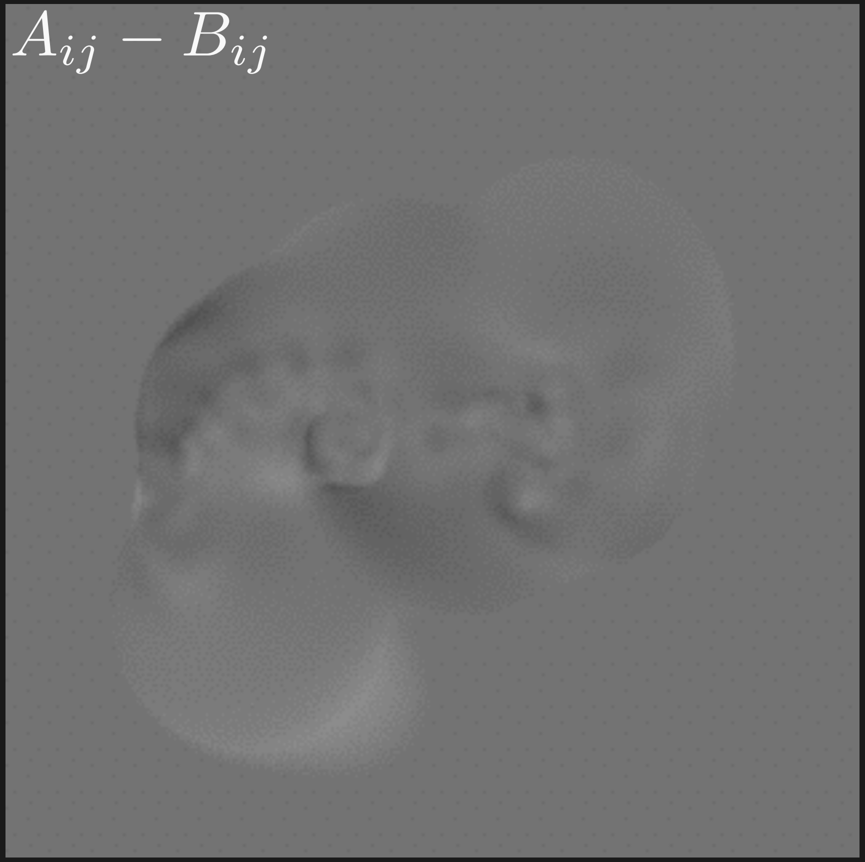


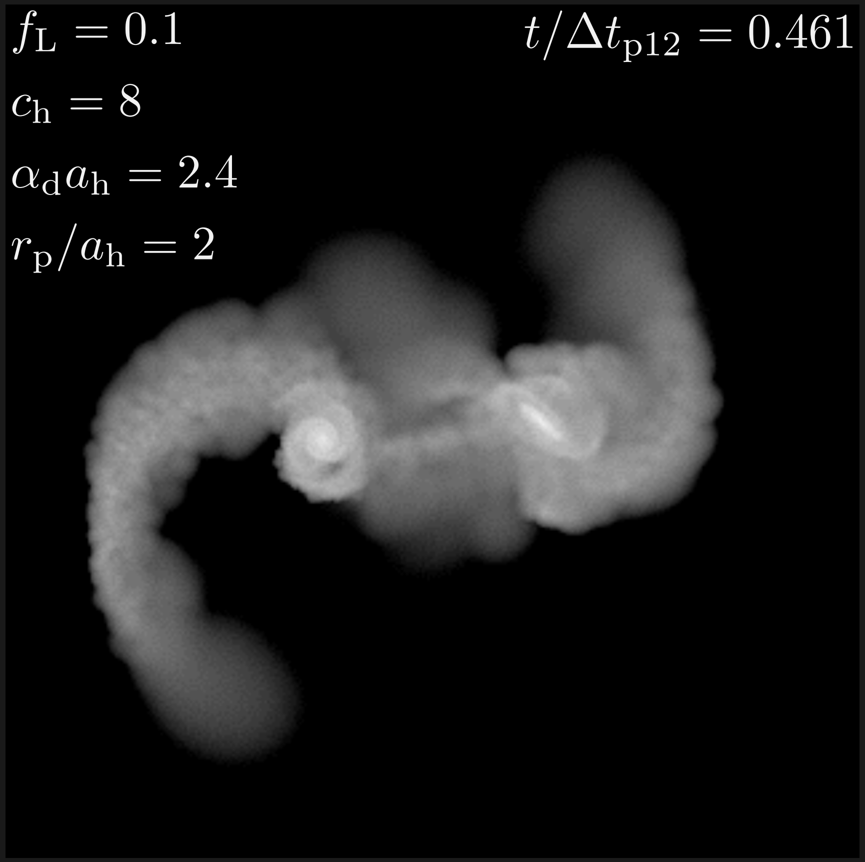


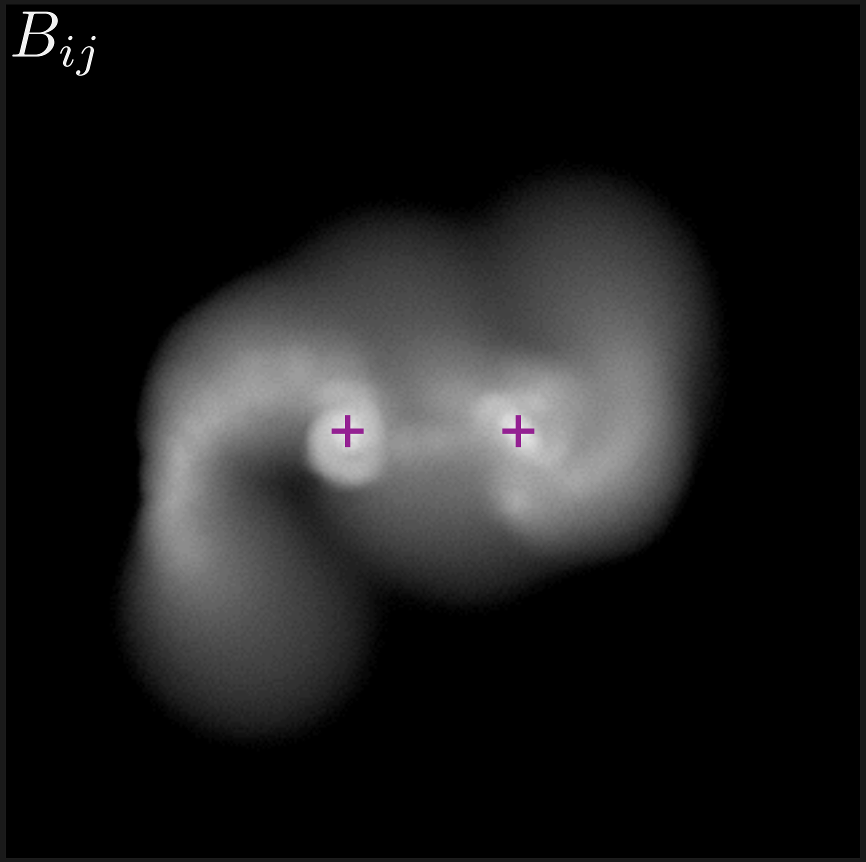


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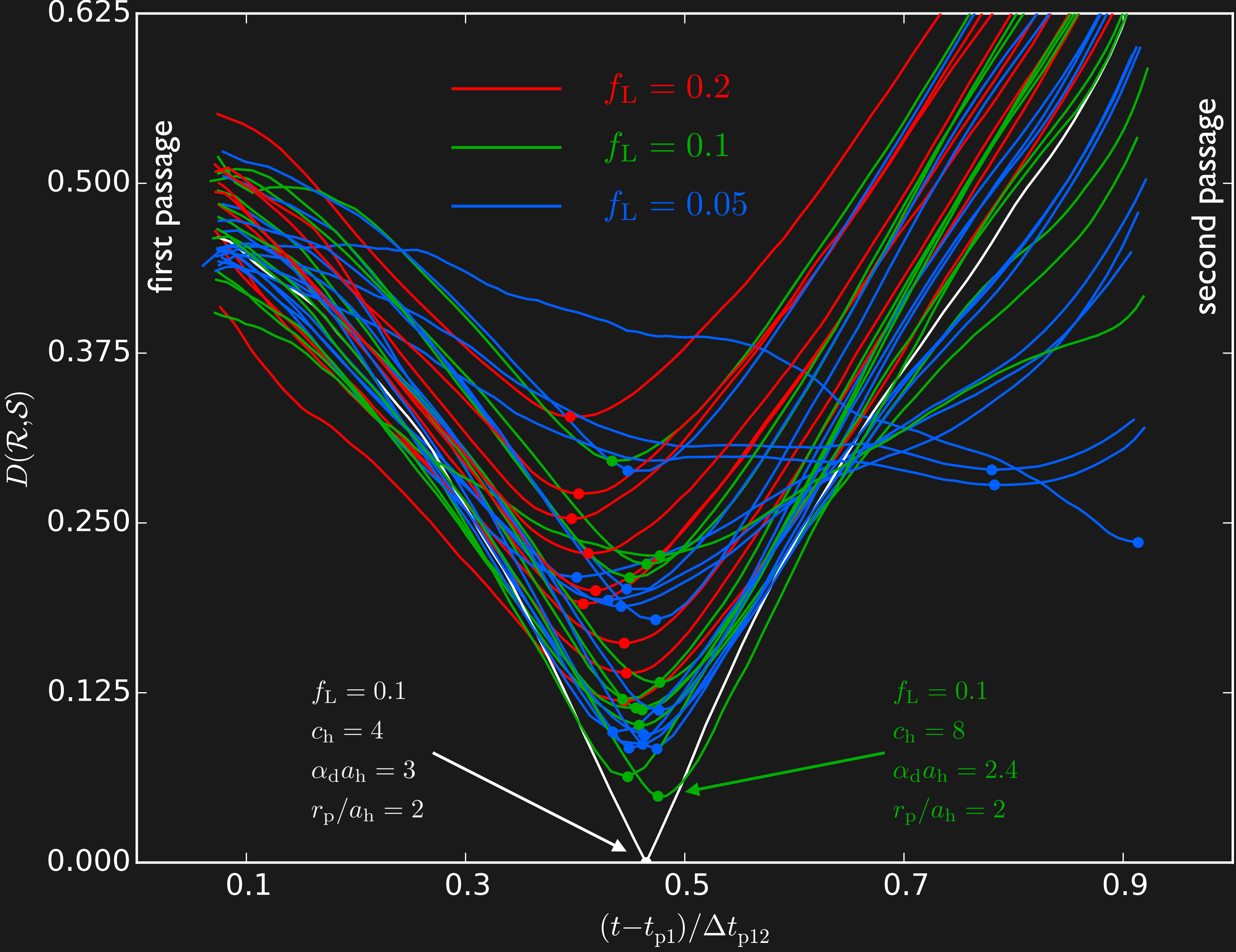
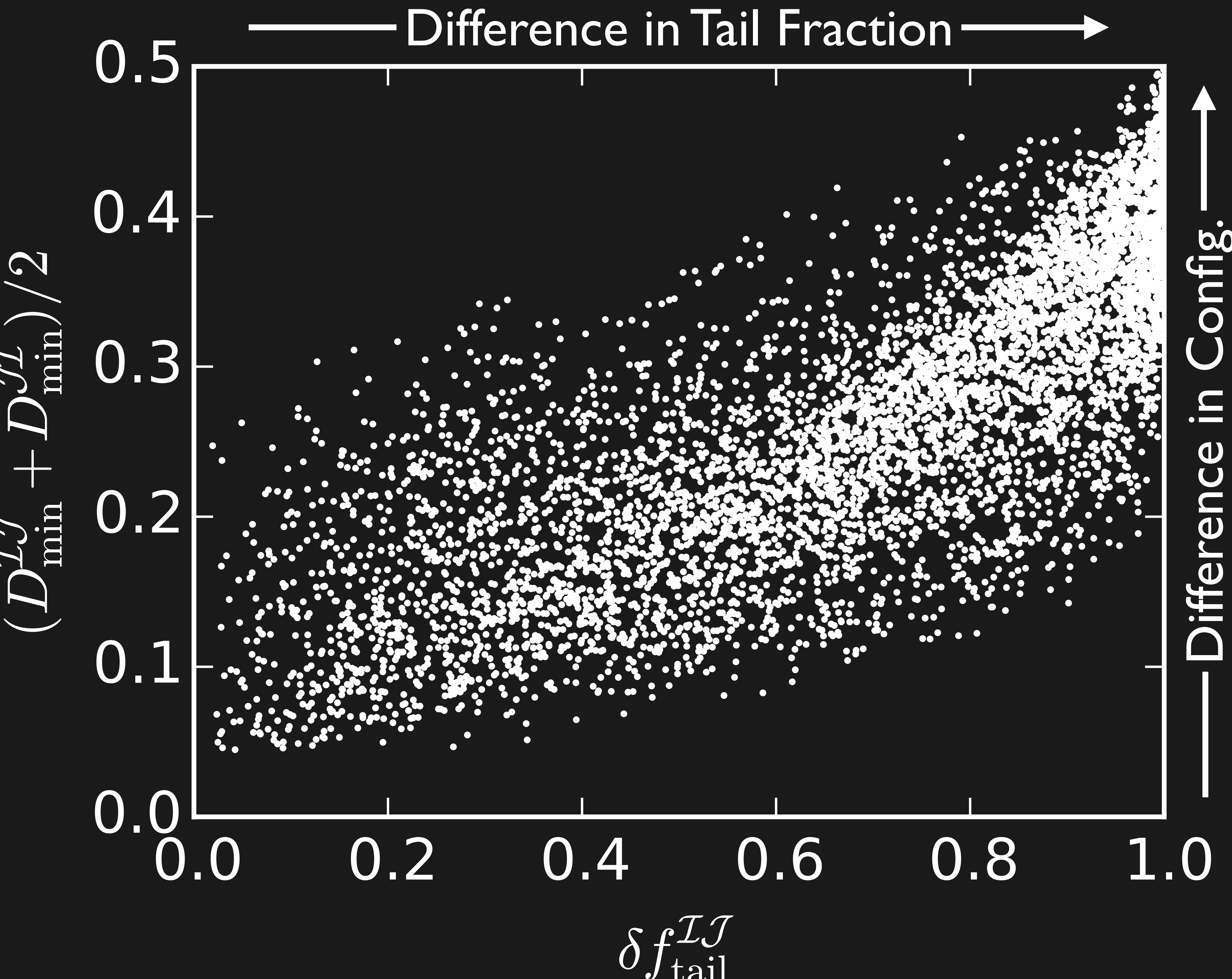
# Tidal Configurations: Finding Matches



# Tidal Configurations: Origin of Differences



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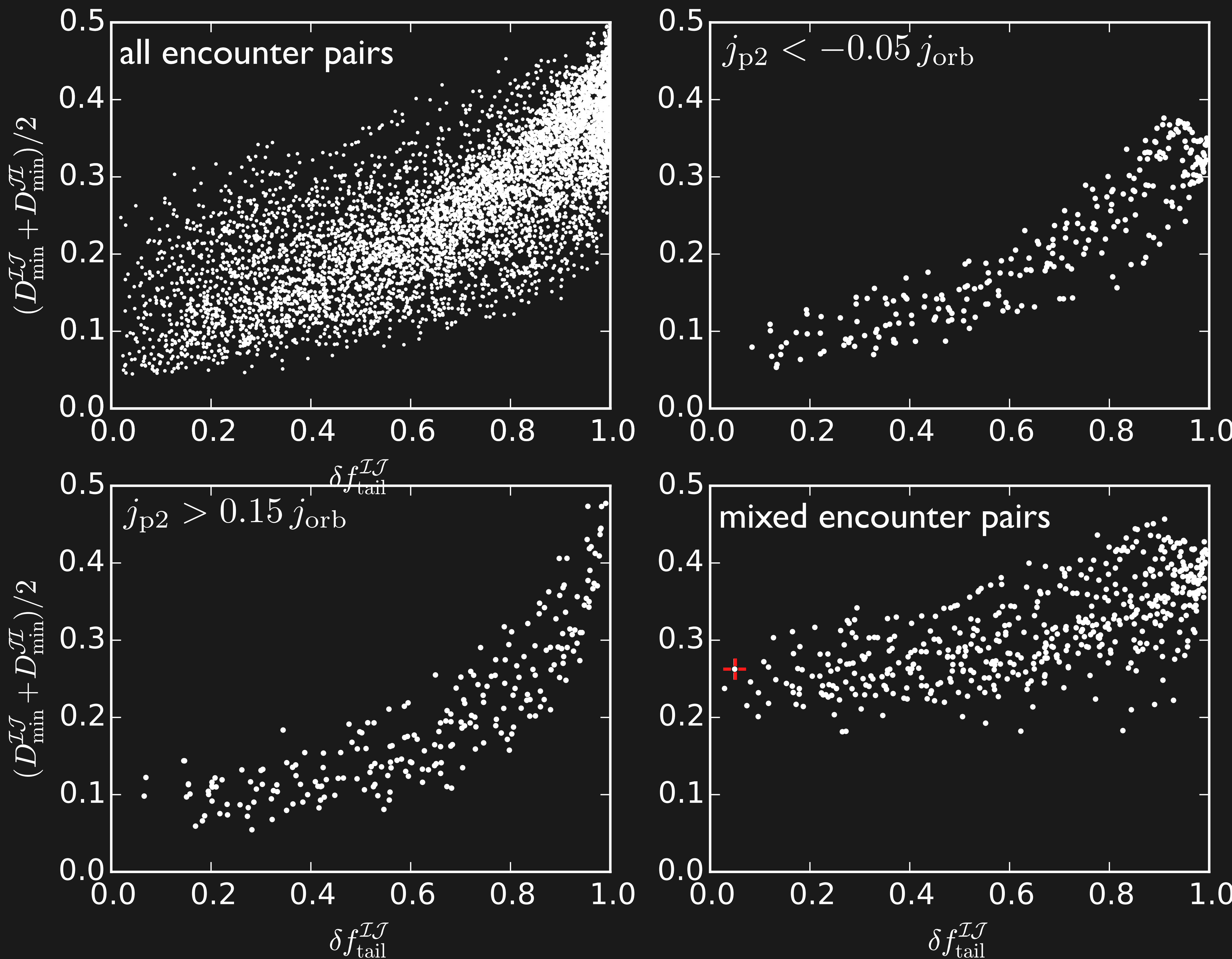
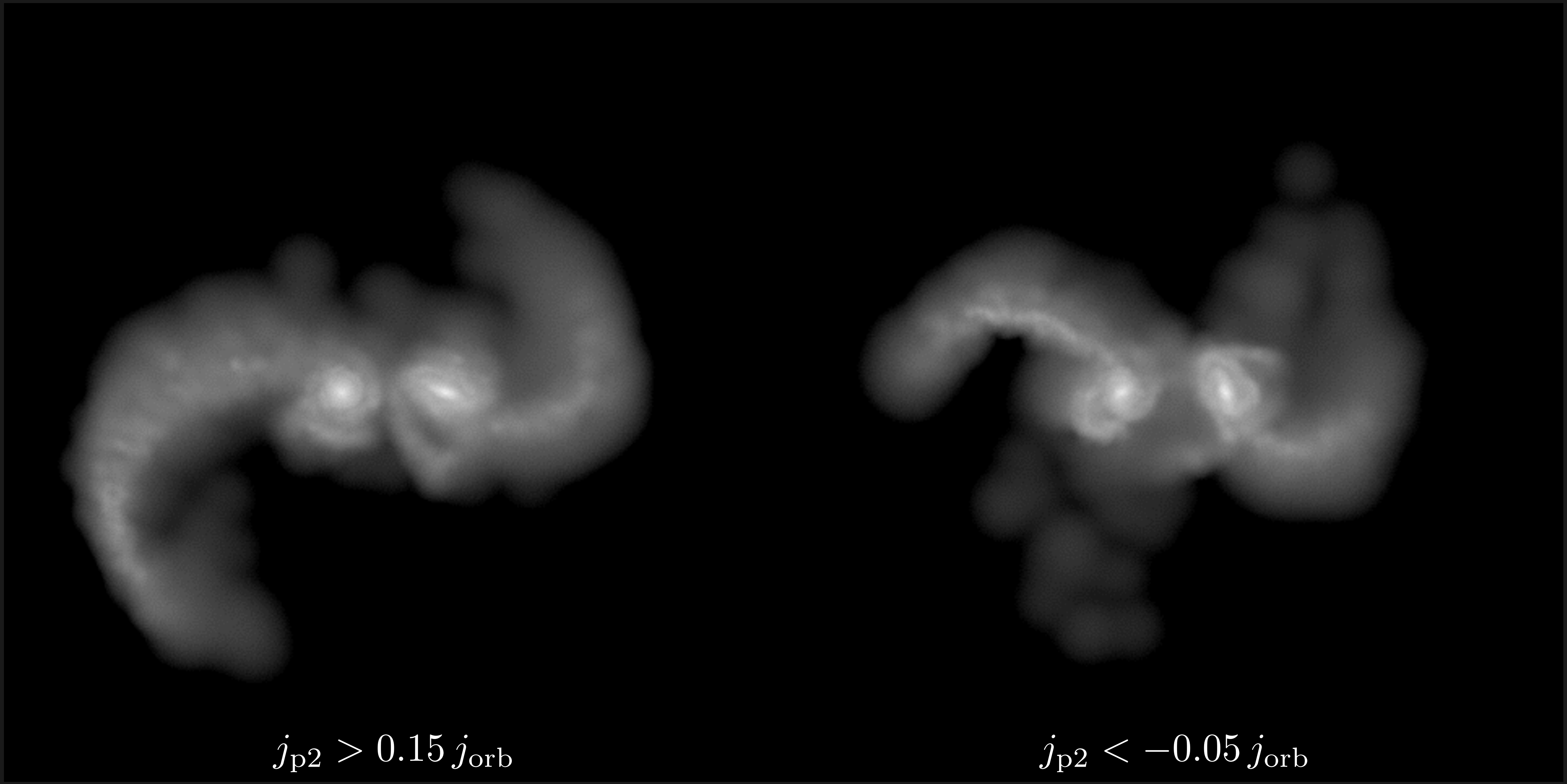


# Tidal Configurations: Effect of Orbit Decay



# Summary

Tidal configuration depends on:

- bridge and tail fractions: $f_{\rm bridge}, f_{\rm tail} \leftarrow \mathcal{E}, r_{\rm p}/a_{\rm h}, i$
- orbit decay: $j_{\rm p2}/j_{\rm orb} \leftarrow R_{1/2}/r_{\rm p}, f_{\rm L}$

Plausible variations in galaxy structure produce observable differences in tidal configuration: internal structure matters.

- must consider in detailed modeling of mergers
- models can probe amount and distribution of DM

Quantitative analysis of tidal features worth further investigation.

Unequal encounters are largely unexplored.

Detailed modeling may yield unexpected results!

Thank You!