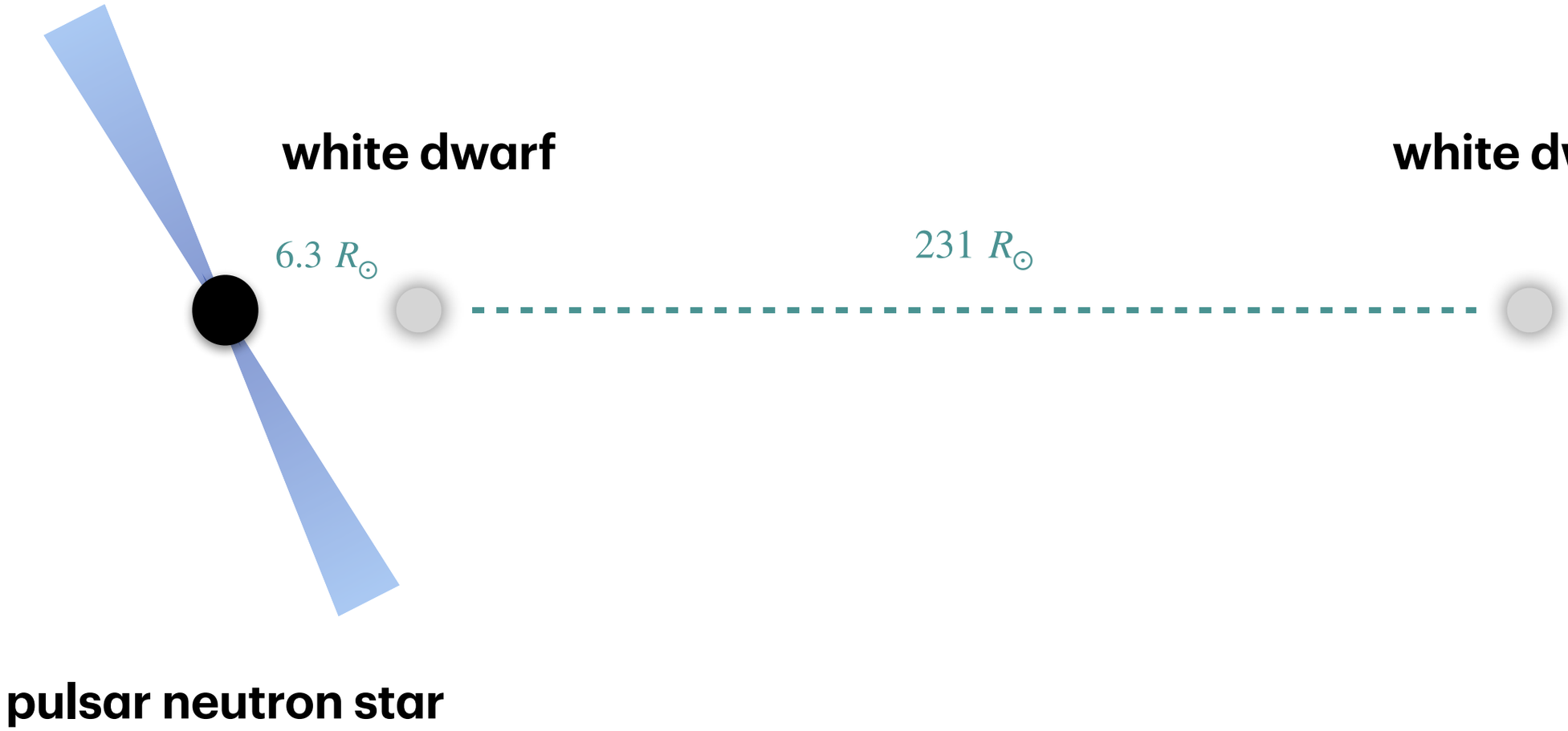
Understanding binaries in common envelope and the case study of the pulsar triple system PSR J0337+1715

Alejandra Rosselli-Calderon
UC Santa Cruz

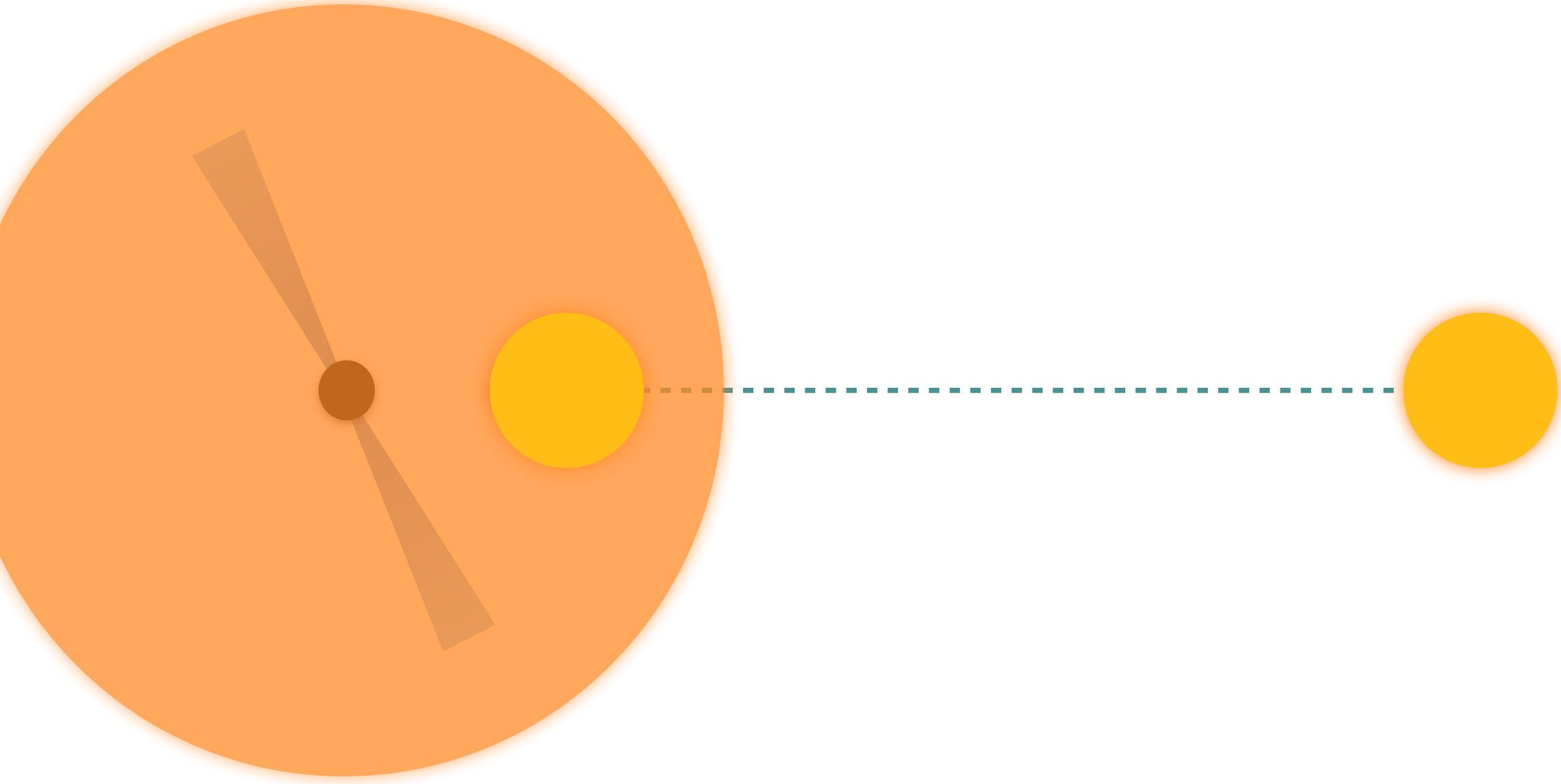
Collaborators: Enrico Ramirez-Ruiz, Ricardo Yarza, Ariadna Murguia-Berthier, Rosa Wallace Everson

N3AS 2023 Summer School, UC Santa Cruz
July 2023

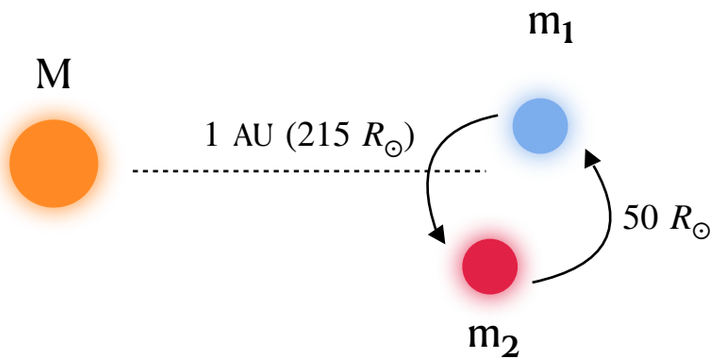
Pulsar Triple System PSR J0337+1715

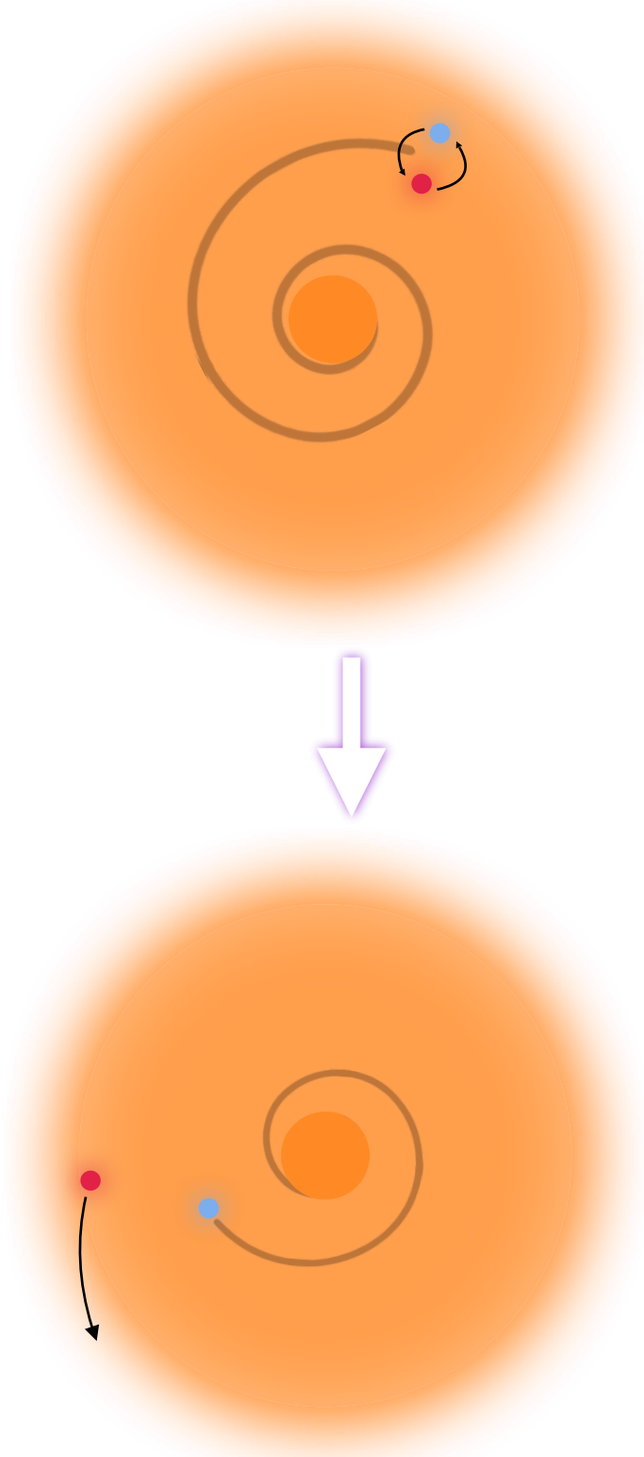


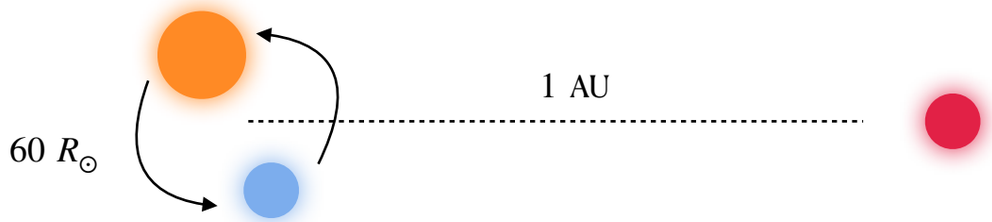
Pulsar Triple System PSR J0337+1715



Common Envelope Evolution

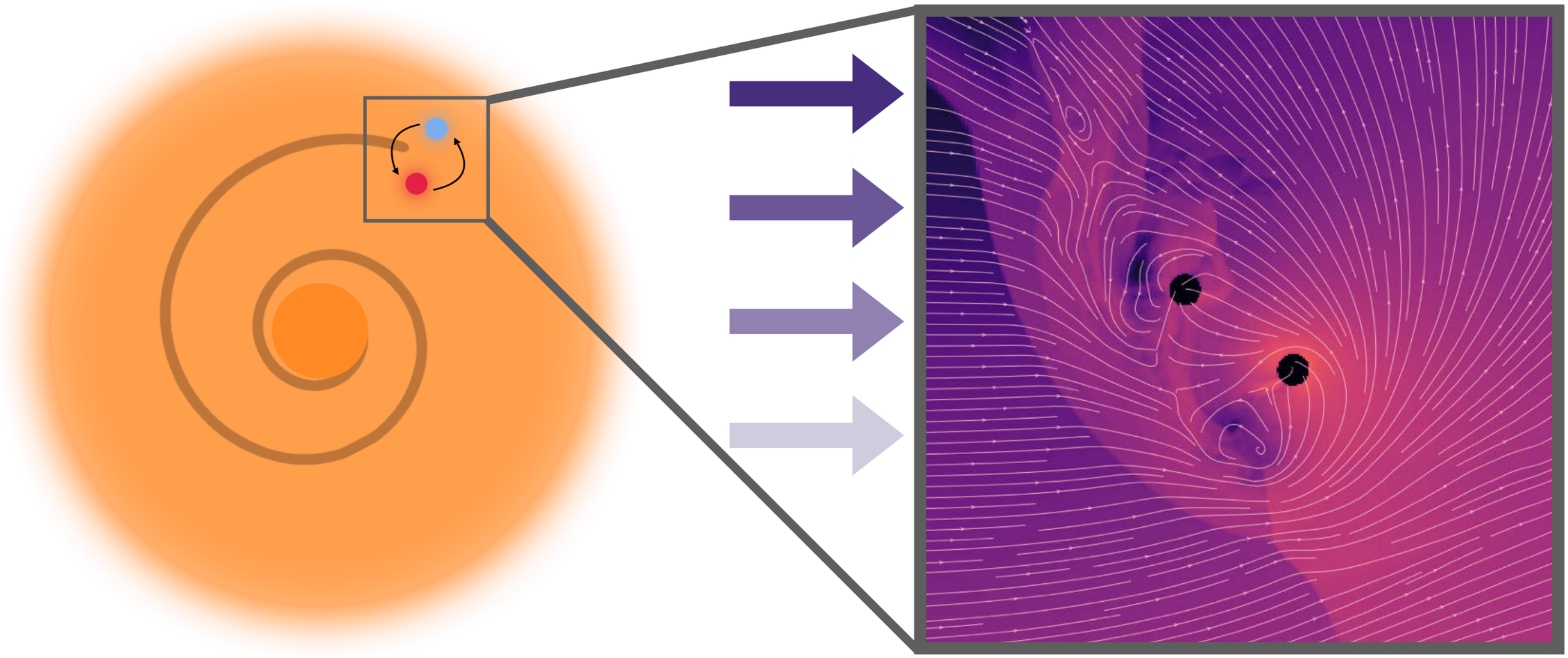




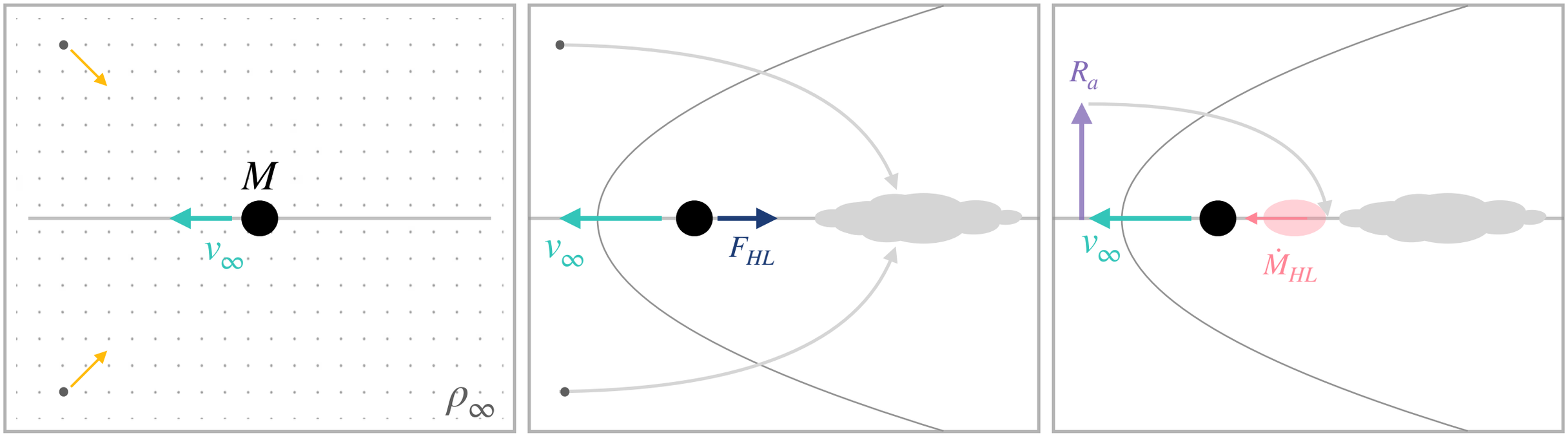


Final configuration of the system

Common Envelope Evolution



Hoyle Lyttleton Accretion (HLA)

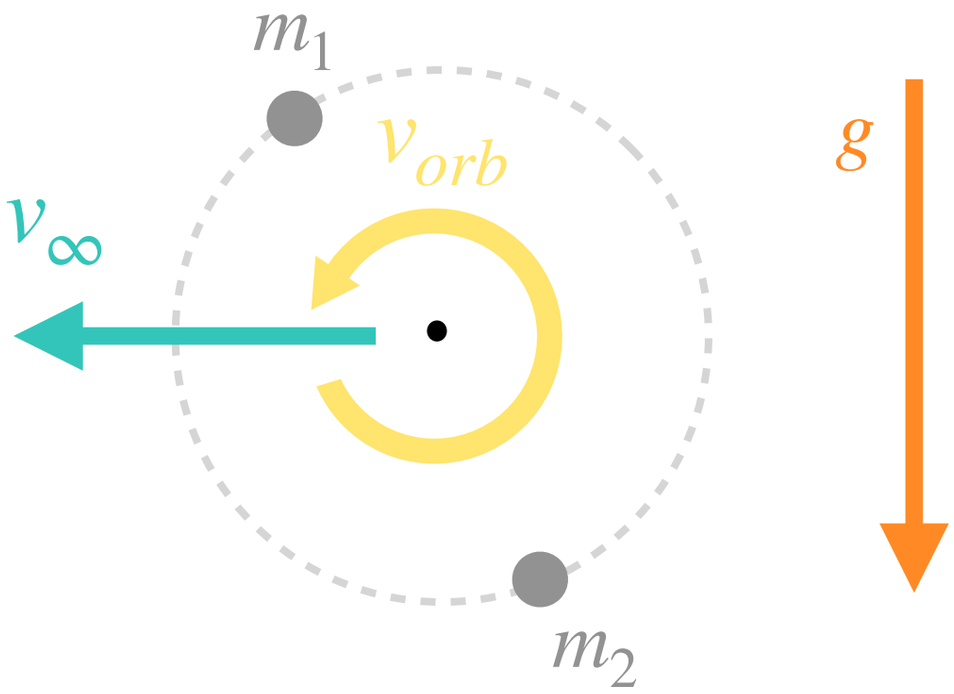


$$R_a = \frac{2GM}{v_\infty^2}$$

$$\dot{M}_{\mathrm{HL}} = \pi R_a^2 \rho_\infty v_\infty$$

$$F_{\mathrm{HL}} = \dot{M}_{\mathrm{HL}} v_\infty$$

Binary Hoyle Lyttleton Accretion



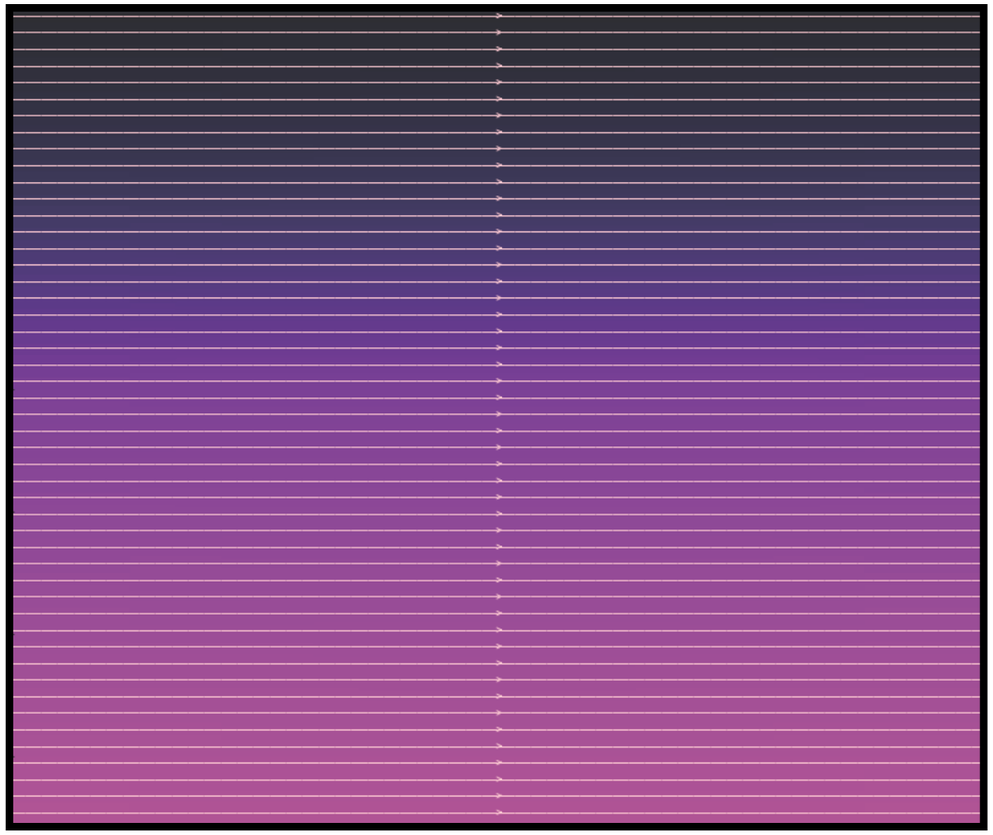
$$R_a = \frac{2Gm}{v_\infty^2}$$

$$v_k = \left(\frac{GM}{r}\right)^{1/2} = v_\infty$$

Semi-major axis, a_0

$$m = m_1 + m_2$$

Adding a density gradient



$$H_\rho = -\rho \frac{dr}{d\rho}$$

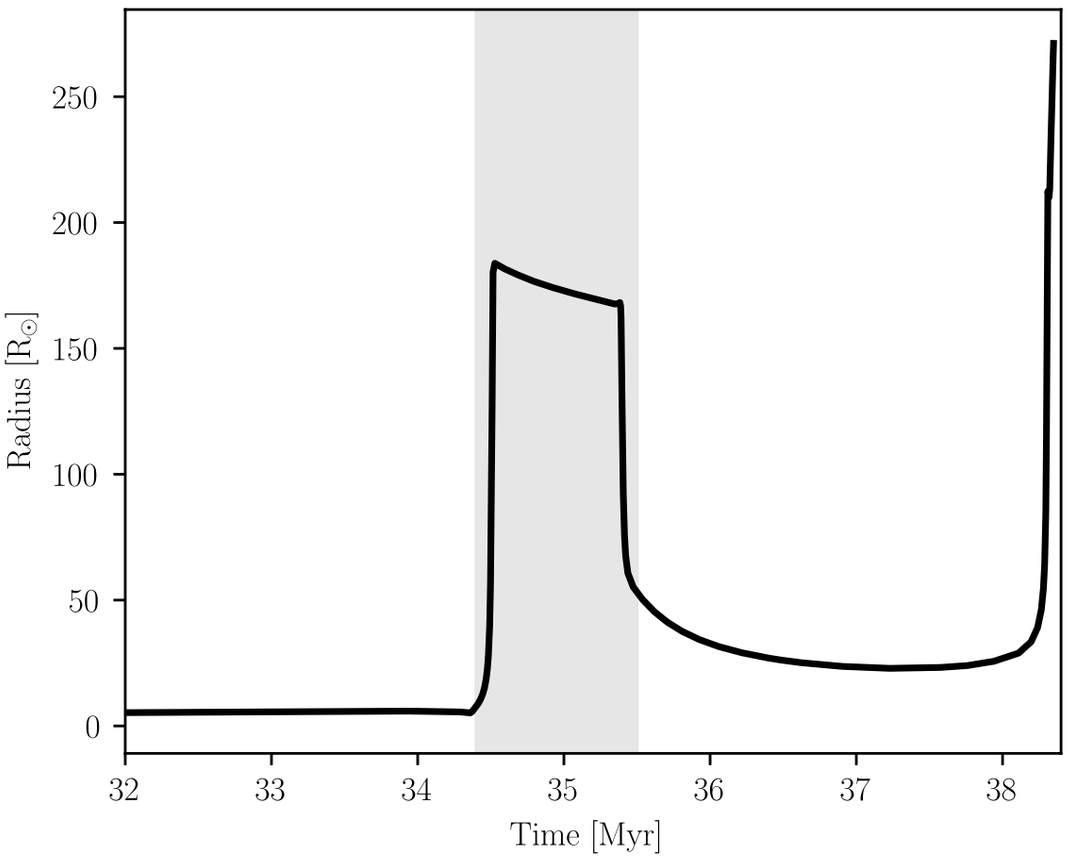
$$\varepsilon_\rho = \frac{R_a}{H_\rho}$$

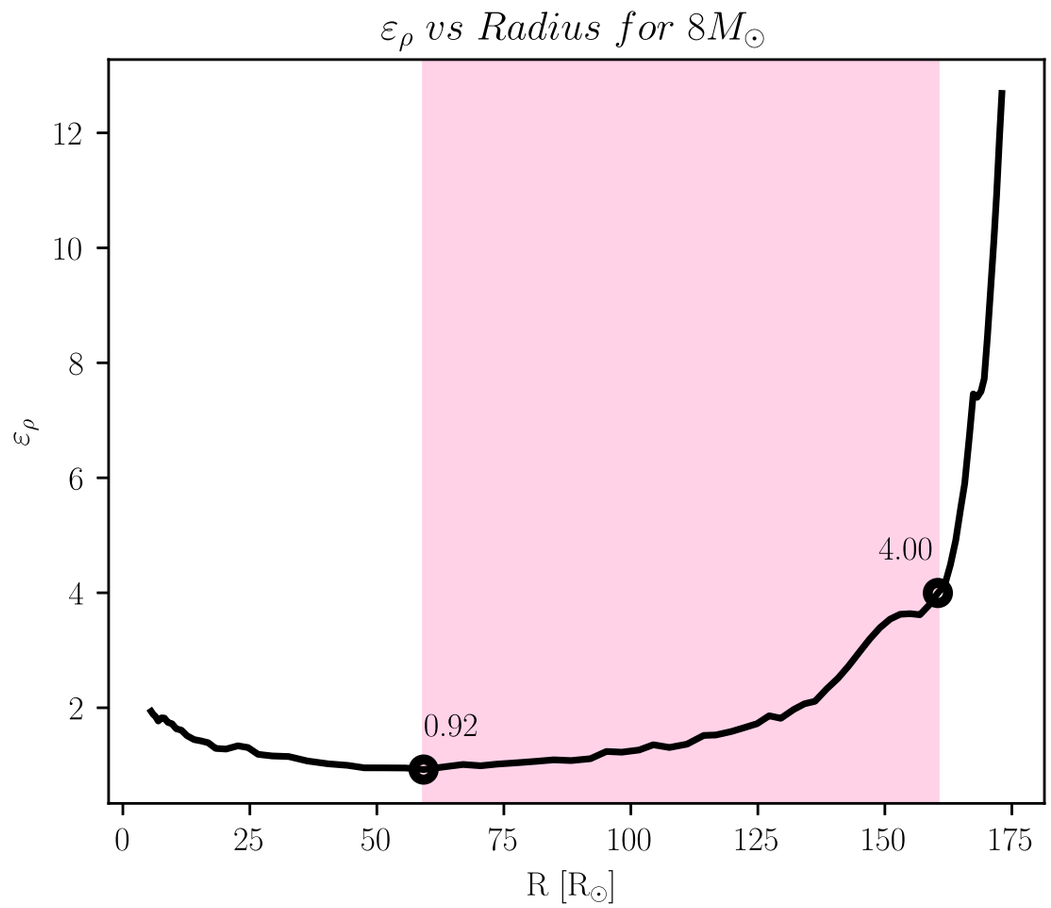
For no density gradient:

$$\varepsilon_\rho \to 0$$

$$\varepsilon_\rho = \frac{R_a}{H_\rho}$$
$$R_a = \frac{2Gm}{v_\infty^2}$$
$$H_\rho = -\rho \frac{dr}{d\rho}$$

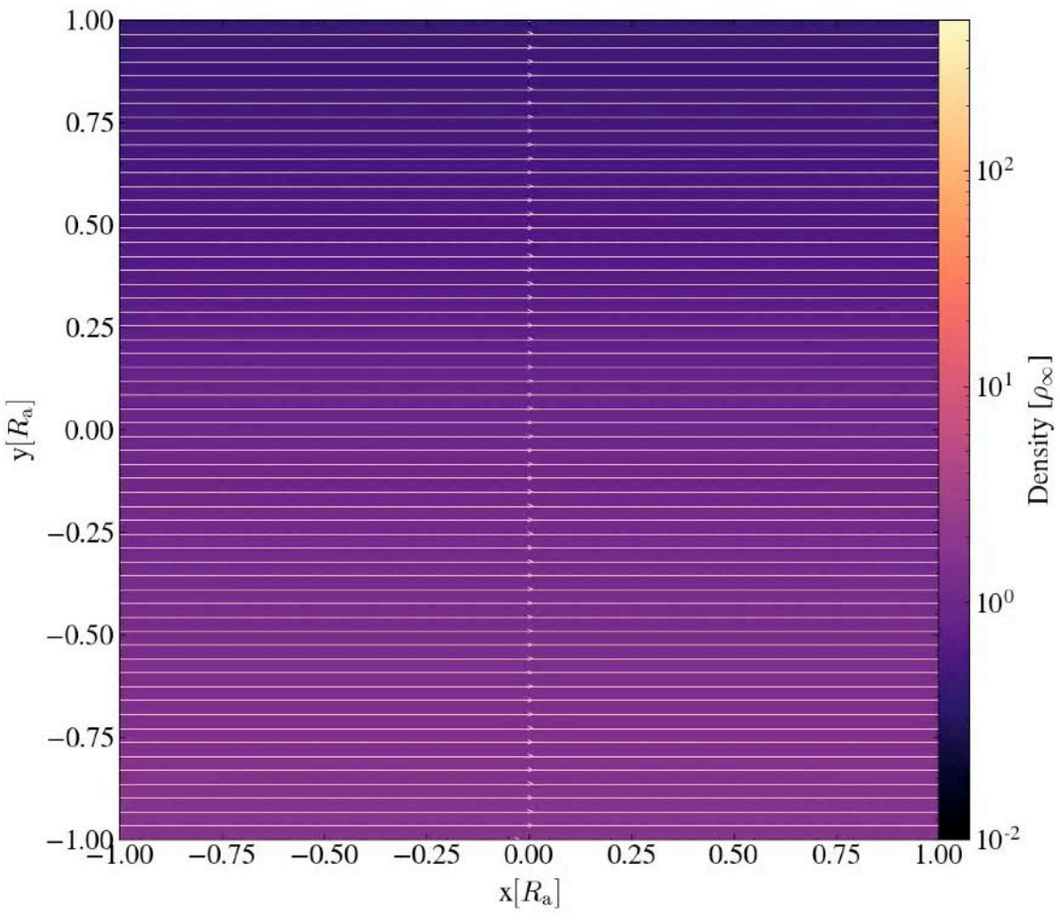
Range of Parameters to Explore



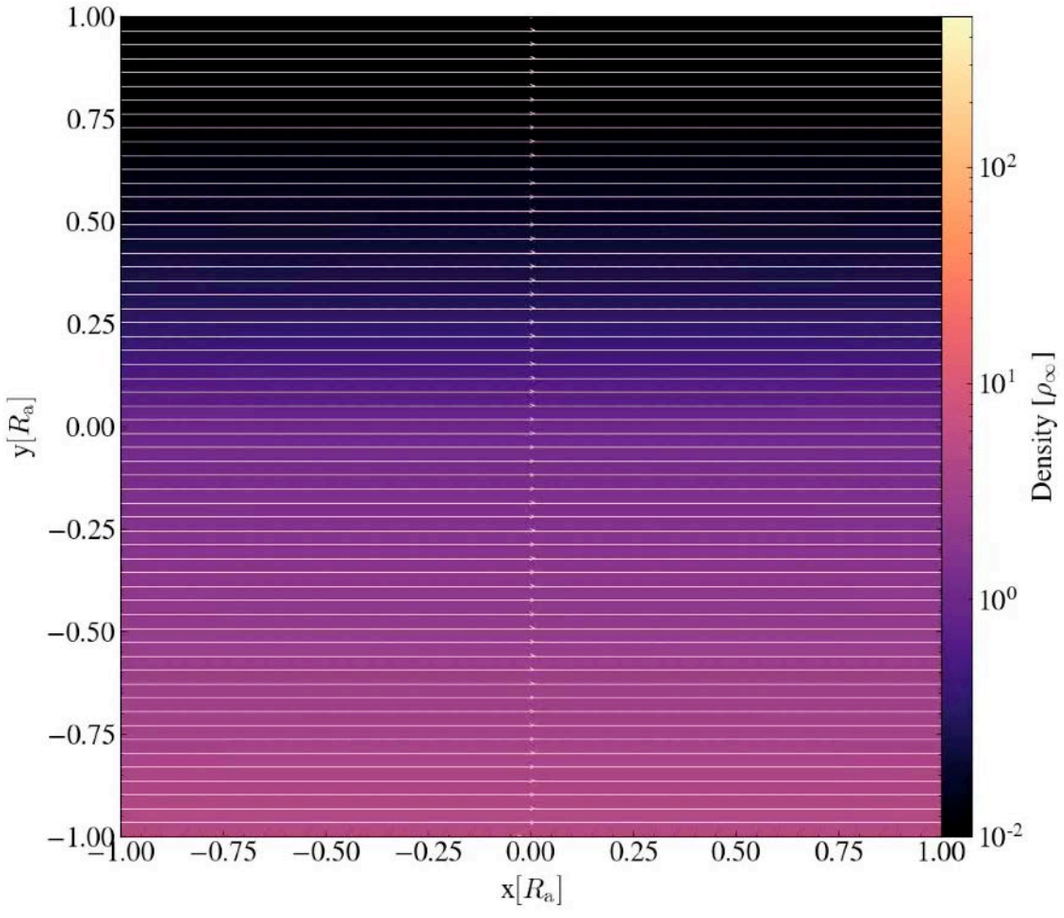


Hydro Simulations

$$\varepsilon_\rho = \frac{R_a}{H_\rho}$$
$$R_a = \frac{2Gm}{v_\infty^2}$$
$$H_\rho = -\rho \frac{dr}{d\rho}$$



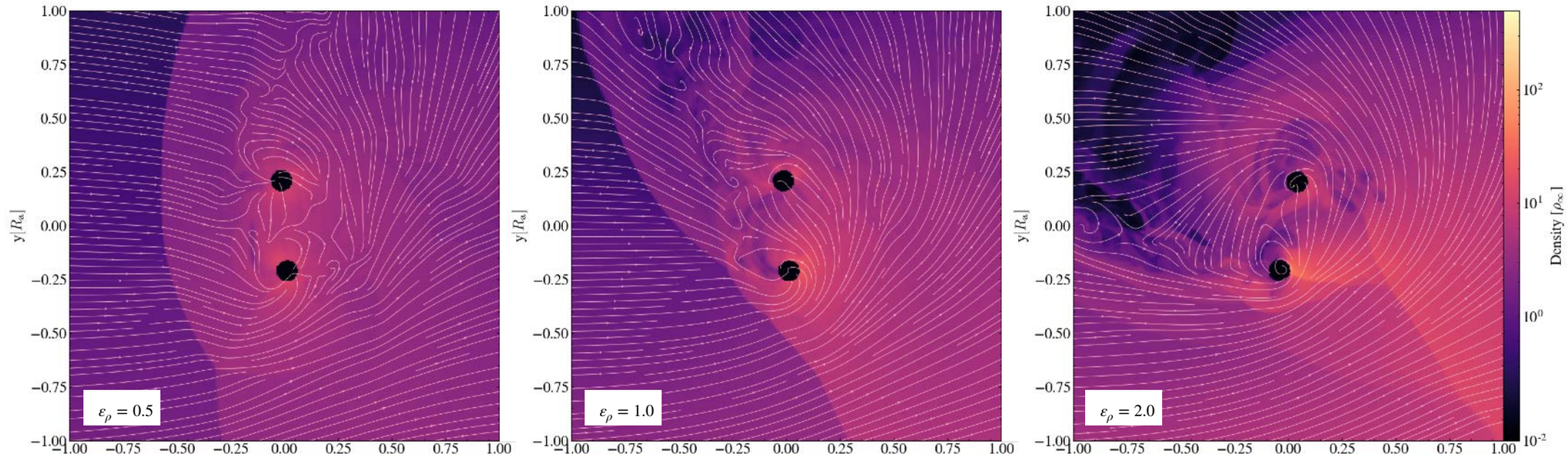
$\varepsilon_\rho = 0.5$

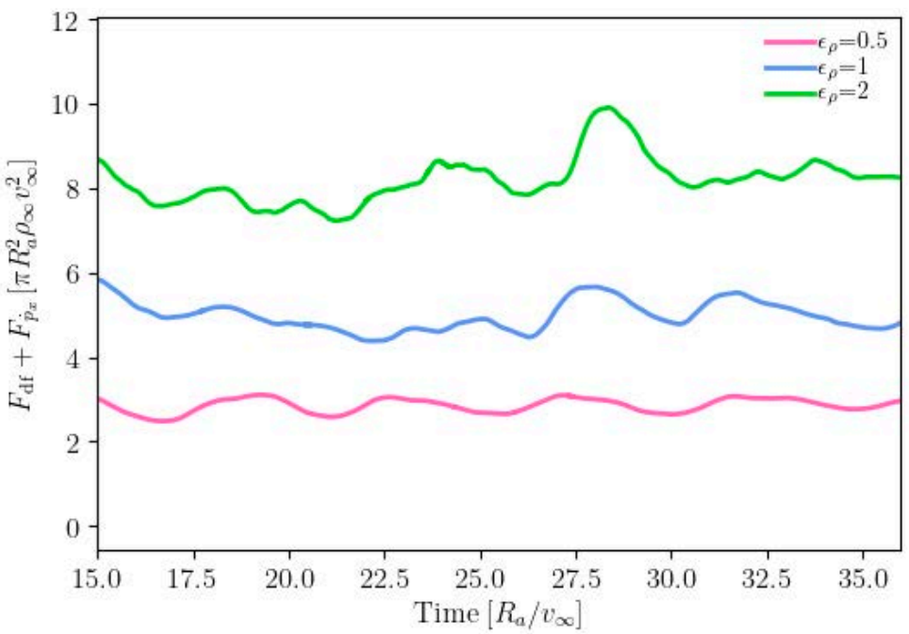


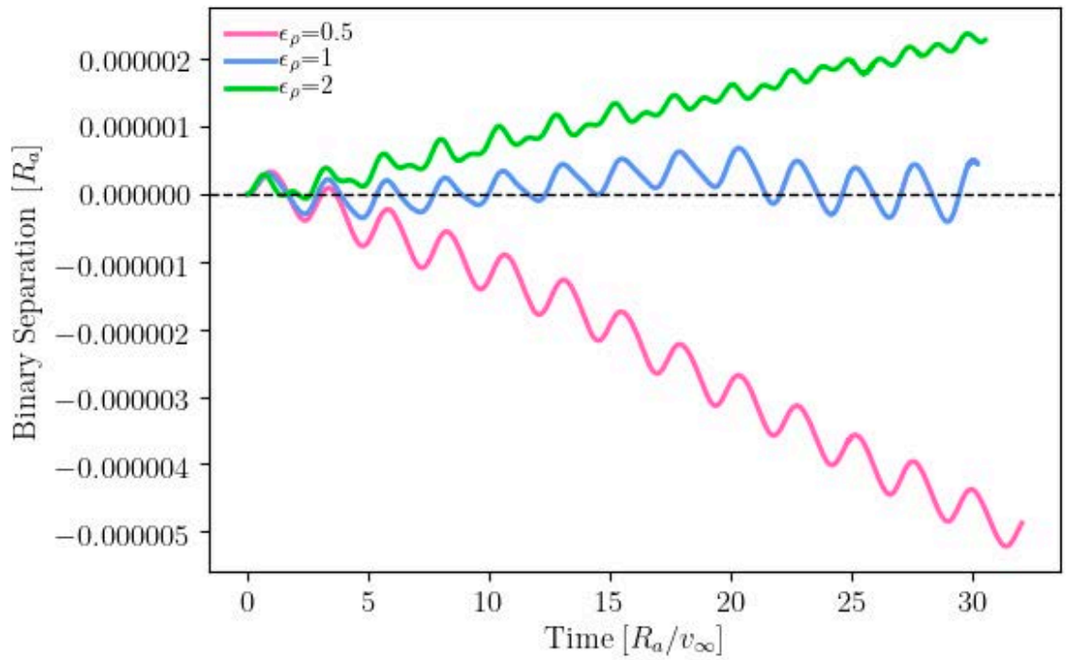
$\varepsilon_\rho = 2.0$

$$\varepsilon_\rho = \frac{R_a}{H_\rho}$$
$$R_a = \frac{2Gm}{v_\infty^2}$$
$$H_\rho = -\rho \frac{dr}{d\rho}$$

Dependance with ε_ρ

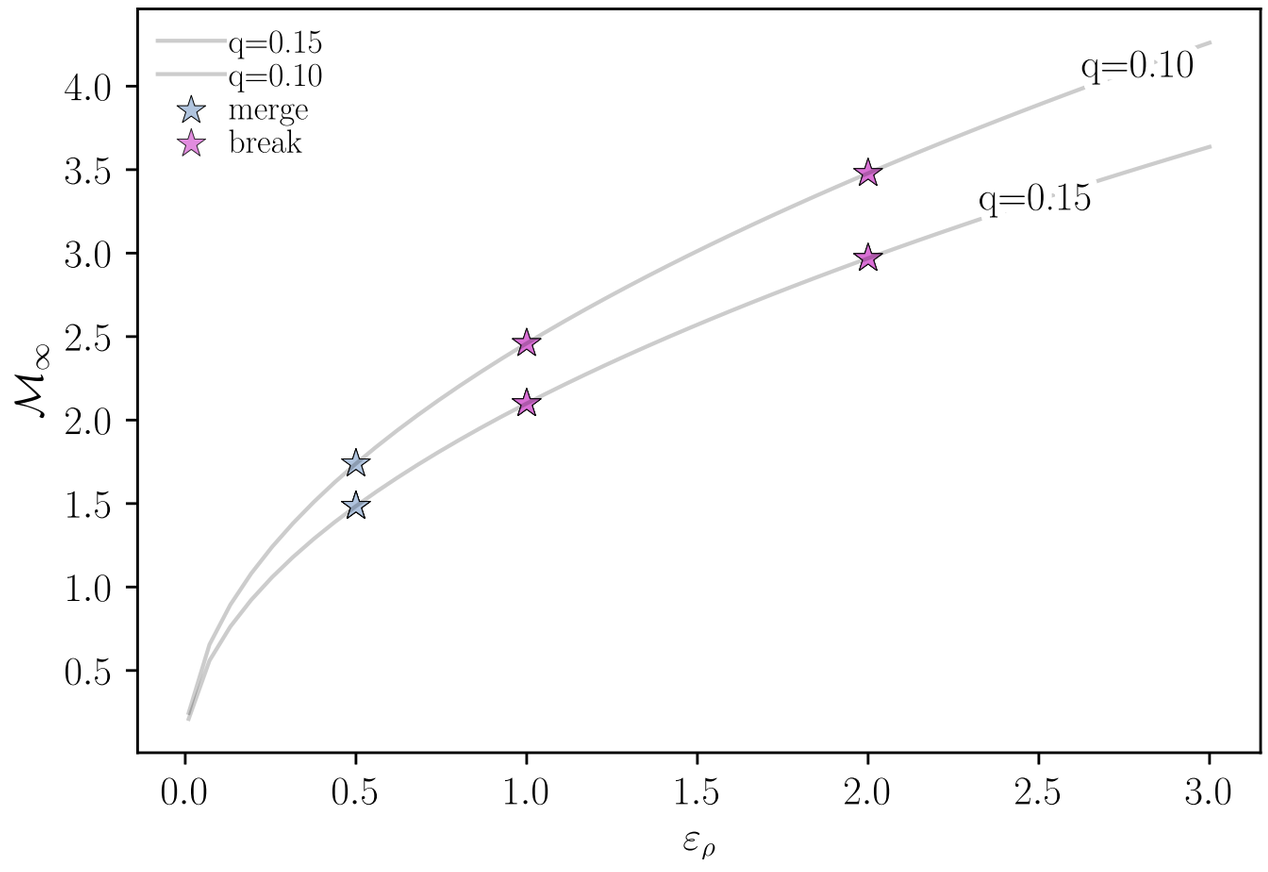






Relationships between gas parameters

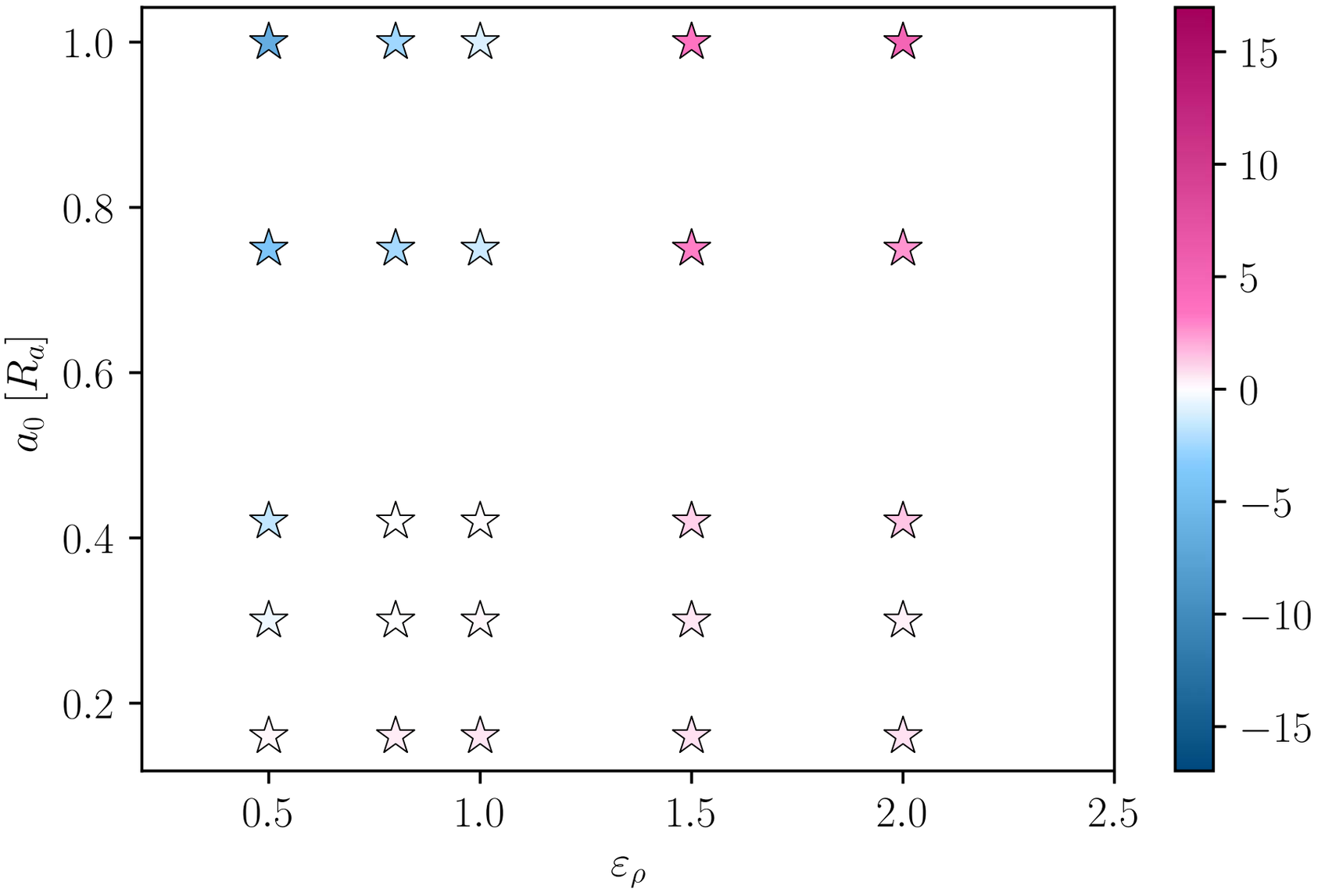
$$\varepsilon_\rho = \frac{R_a}{H_\rho}$$
$$R_a = \frac{2Gm}{v_\infty^2}$$
$$H_\rho = -\rho \frac{dr}{d\rho}$$



$$\mathscr{M}_\infty = \frac{v_\infty}{c_{s,\infty}} \qquad \varepsilon_\rho = \frac{R_a}{H_\rho} \qquad q = \frac{m}{M}$$

Dependance with a_0

$$\varepsilon_\rho = \frac{R_a}{H_\rho}$$
$$R_a = \frac{2Gm}{v_\infty^2}$$
$$H_\rho = -\rho \frac{dr}{d\rho}$$



Conclusions

- It is not always the case that the drag force due to the surrounding material will shrink a binary

- Depending on the initial conditions of the system, the tidal radius of the binary might change

- Under the common envelope conditions, we will most likely have a binary that expands and can never merge