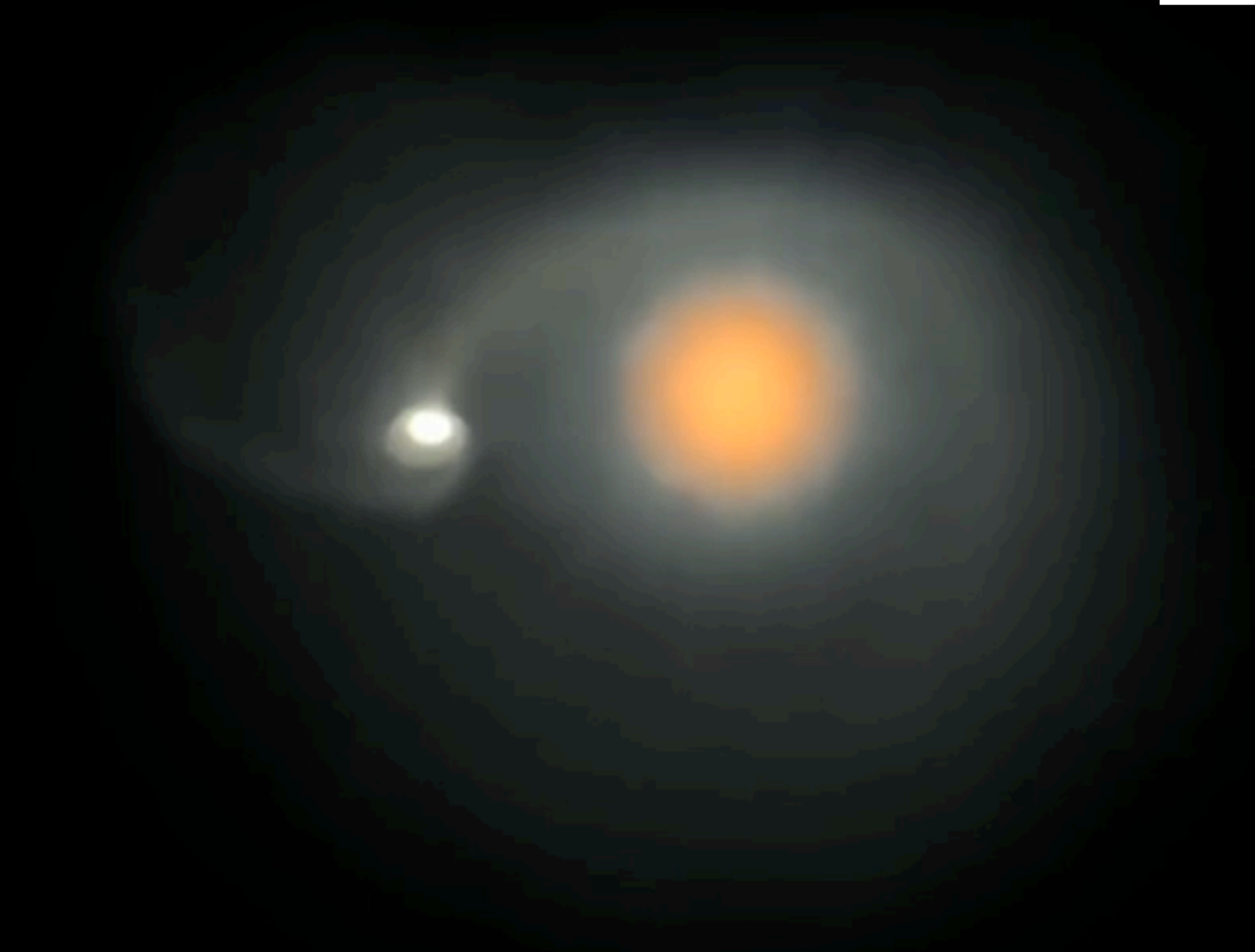
# Wind mass transfer in binaries and its effect on orbital evolution

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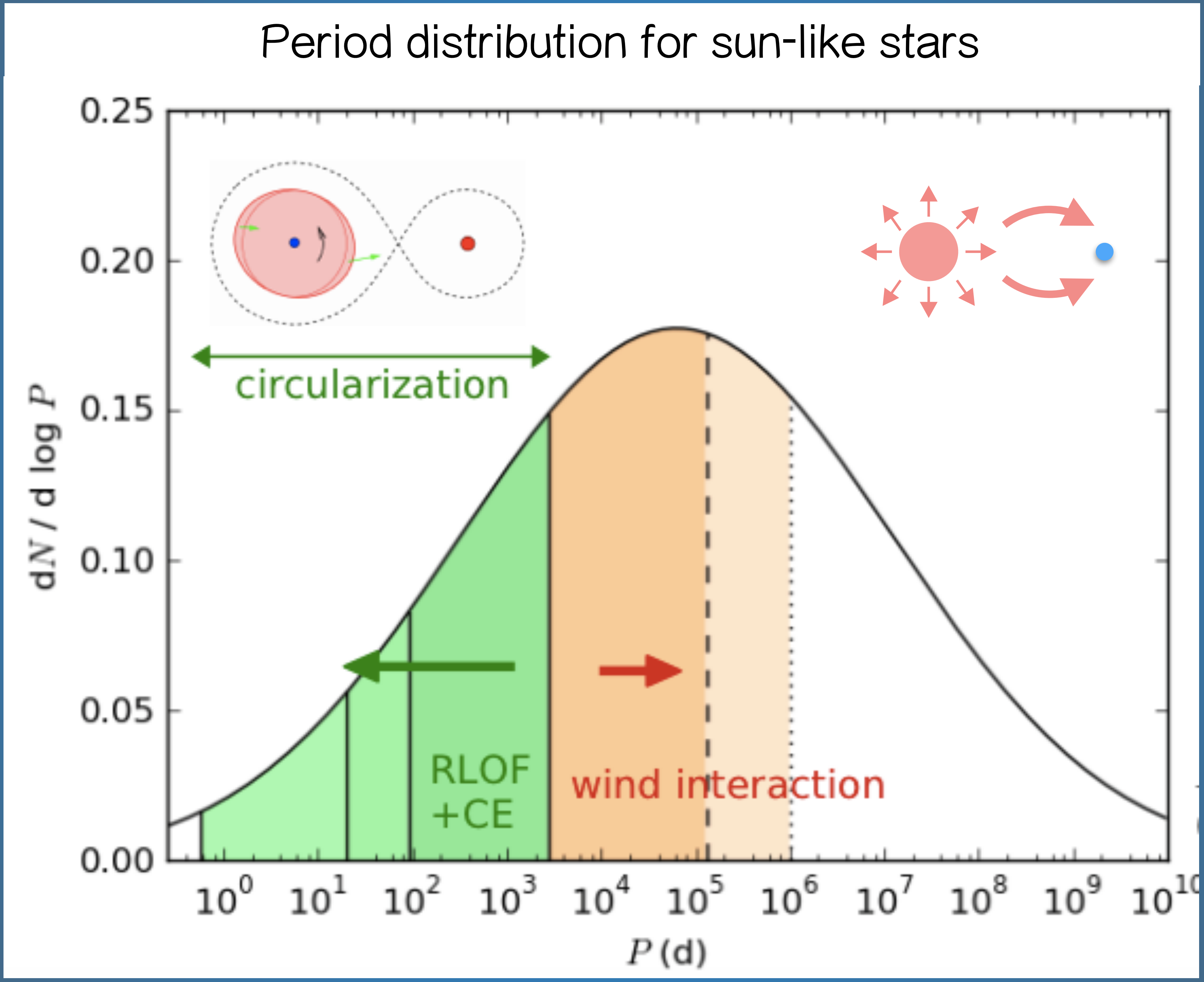
Simon Portegies-Zwart

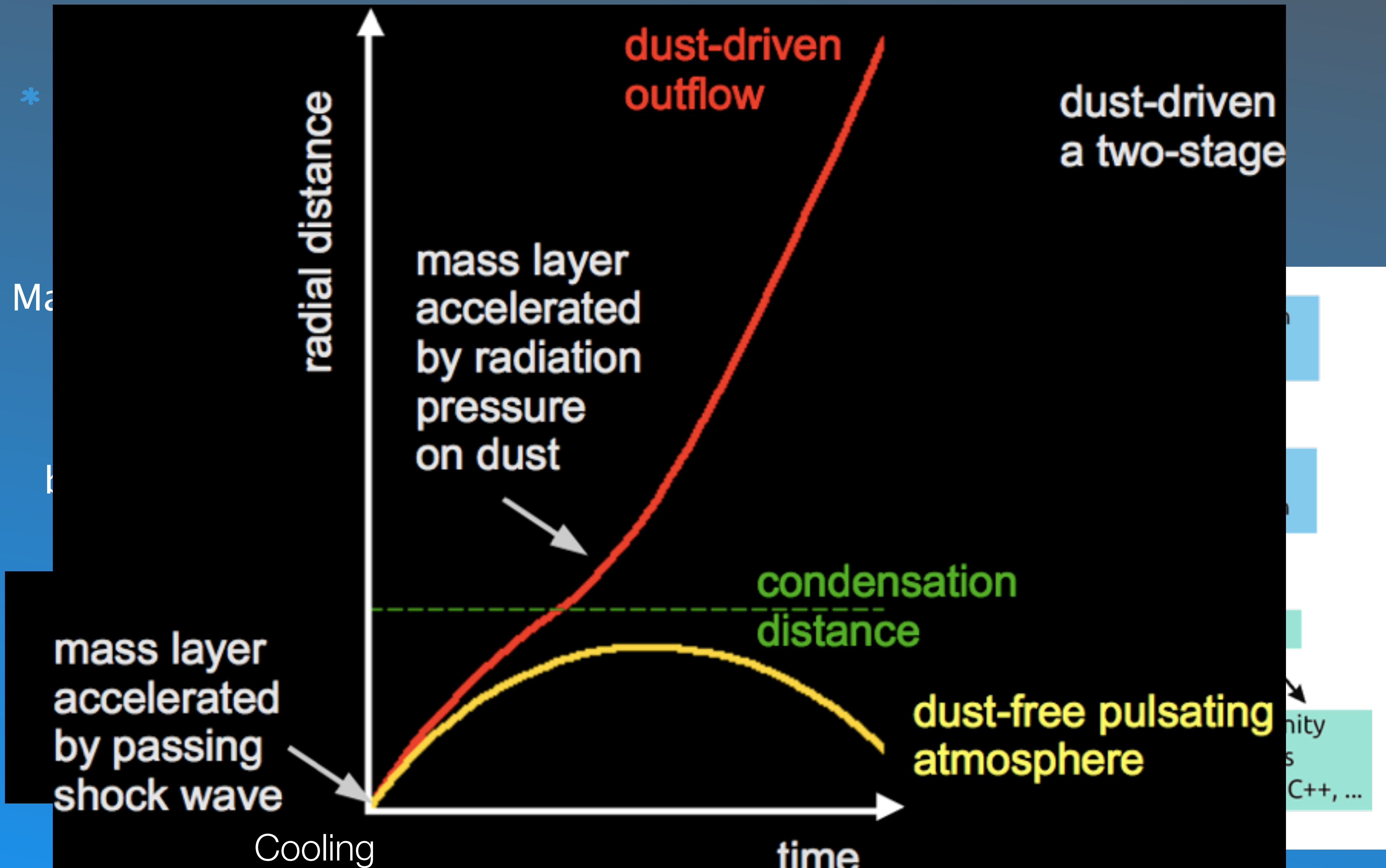
# Motivation




Close binary => orbit shrinks and circularizes

Wide binary => orbit widens

# Model




Portegies-Zwart+(2013); Pelupessy+(2013); van Elteren+(2014)

Bowen (1988) + Schure (2009)

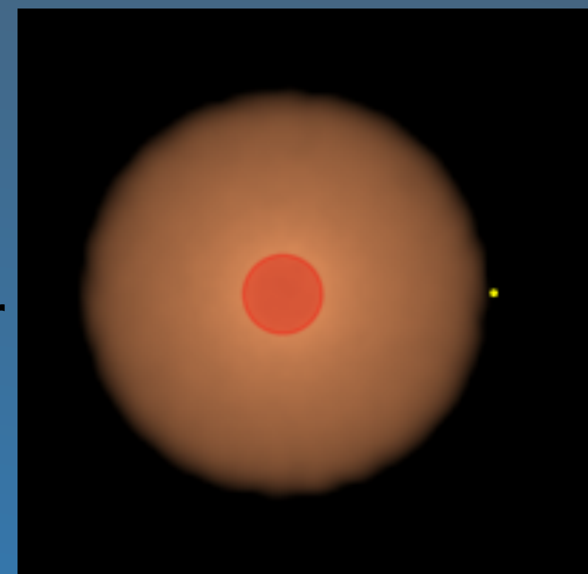
STELLAR_WIND.PY

van der Helm, Saladino, + (in prep)

# Case studies

$M_1 = 3\ M_\odot$

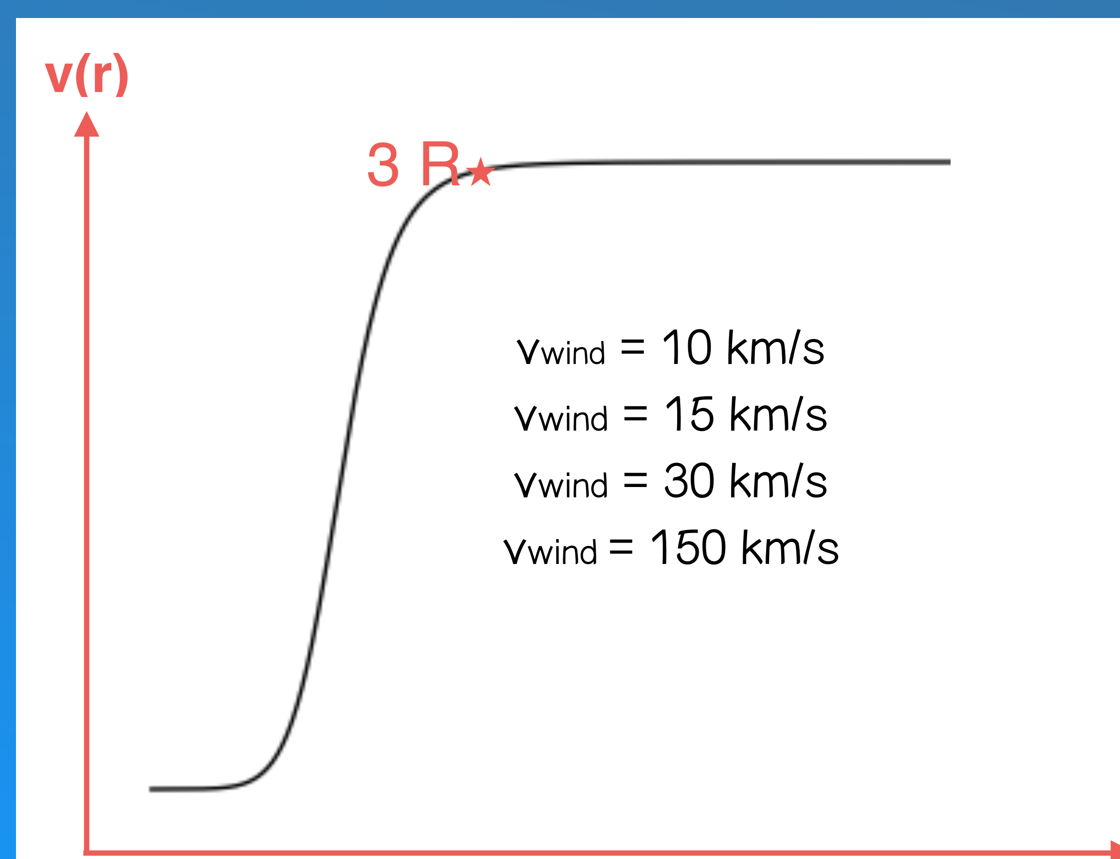
$\dot{M}_1 = 1e{-}06\ M_\odot/yr$



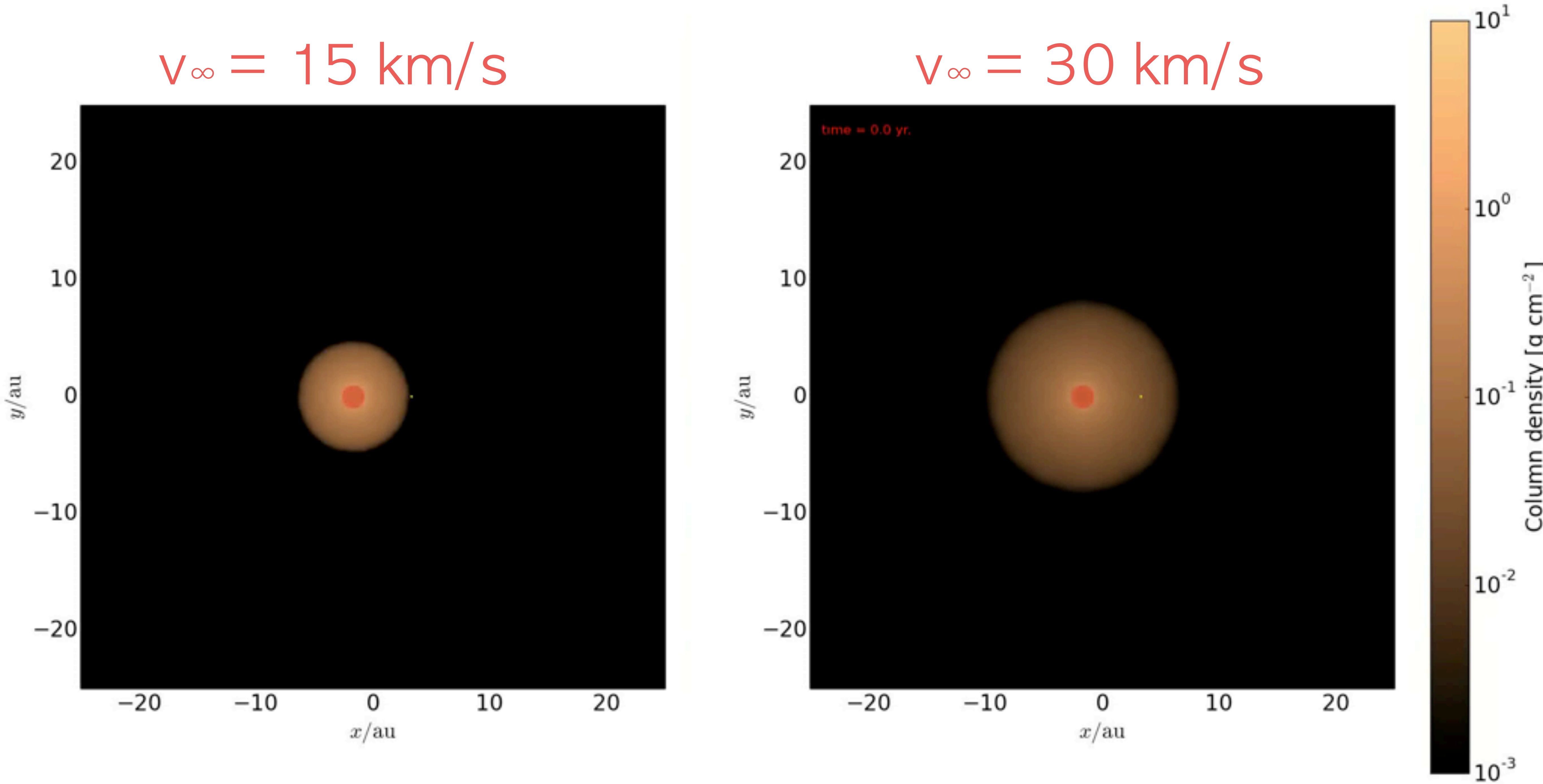
$M_2 = 1.5\ M_\odot$

$a = 5$ AU

$v_{orb} = 28.2$ km/s

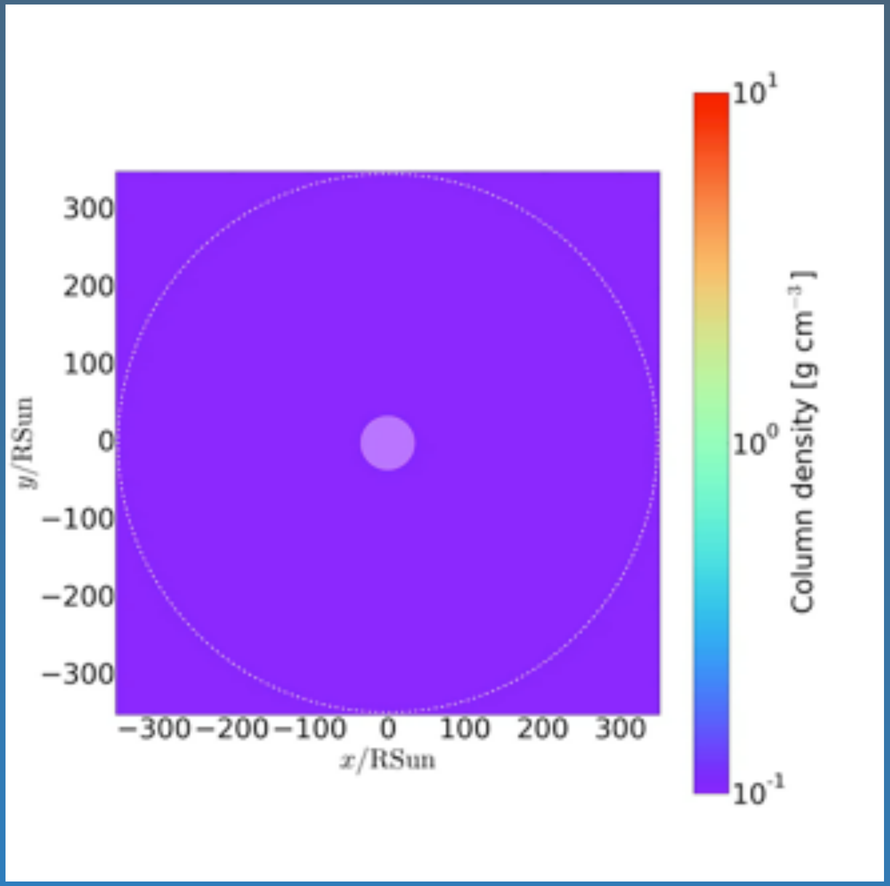


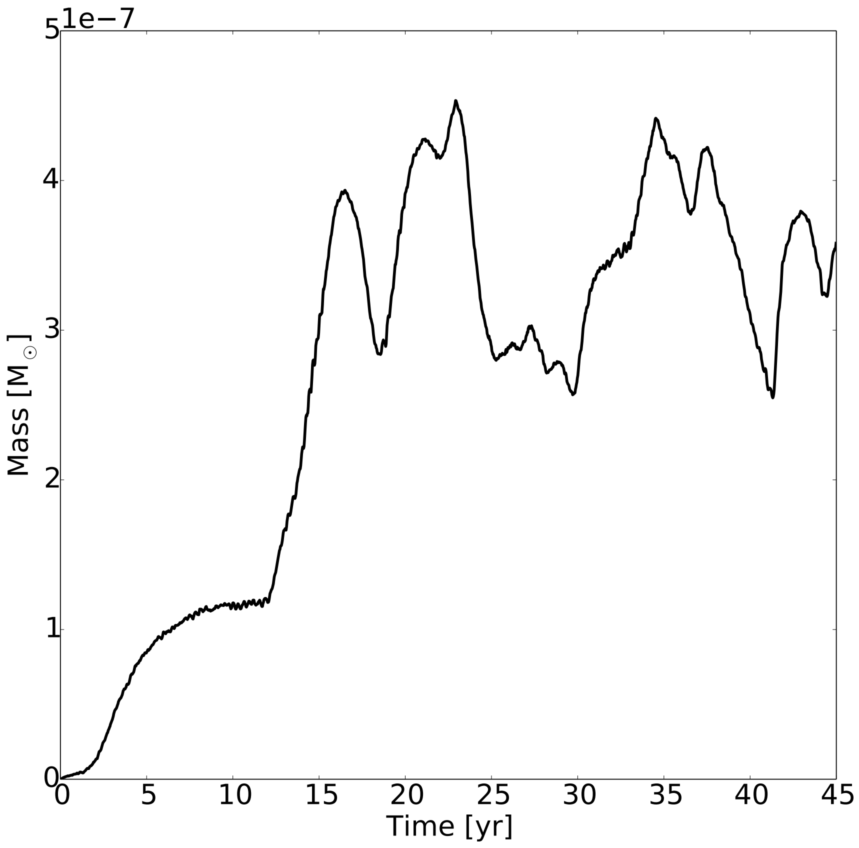
# Results


$v_\infty = 15$ km/s
$v_\infty = 30$ km/s
time = 0.0 yr.
20
10
0
−10
−20
$y$/au
$x$/au
−20
−10
0
10
20
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-3}$
Column density [g cm$^{-2}$]

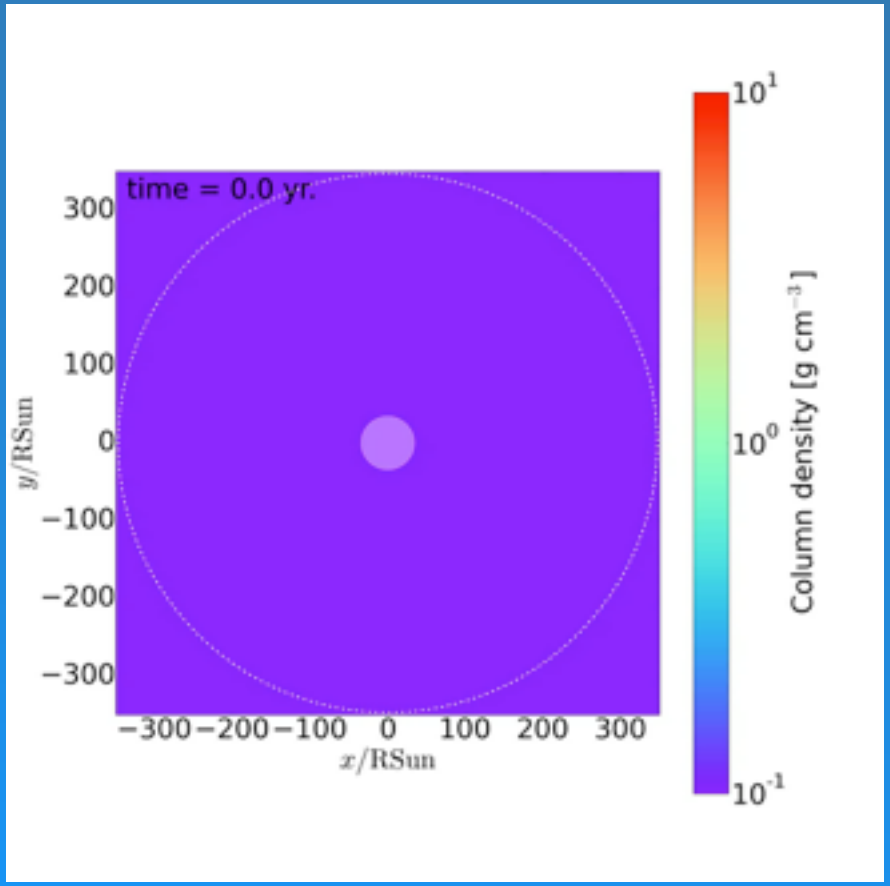
# Accretion disk

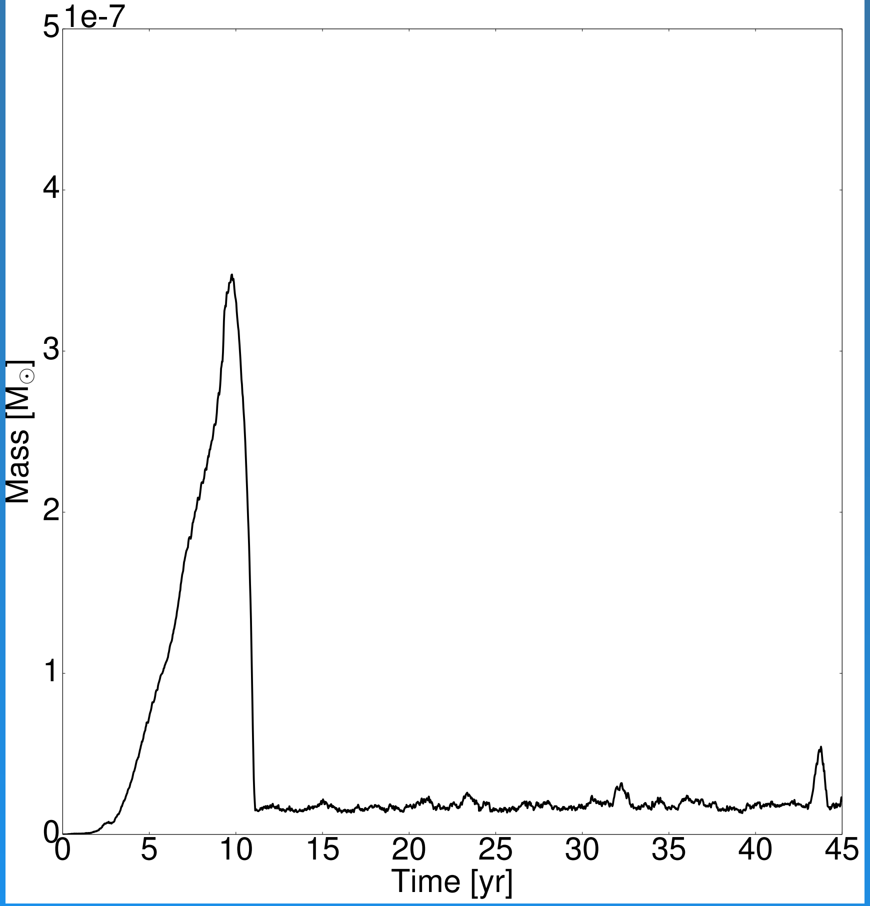
v∞ = 15 km/s




v∞ = 10 km/s



# Orbital evolution

From angular momentum conservation:

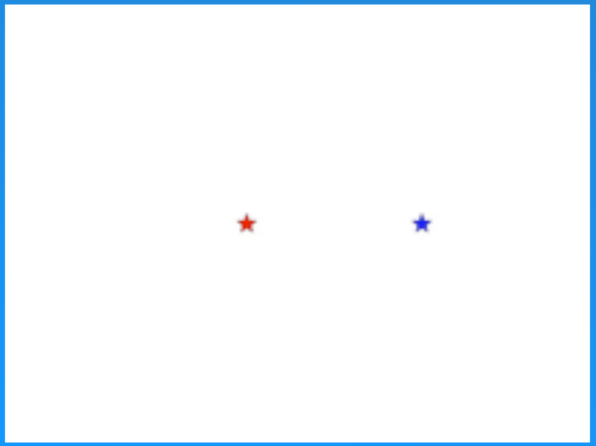
$$\frac{\dot{a}}{a} = -2\frac{\dot{M}_d}{M_d}\left[1 - \beta q - \eta(1-\beta)(q+1) - (1-\beta)\frac{q}{2(q+1)}\right]$$

Fraction of mass accreted

$$\beta = \frac{\dot{M}_2}{\dot{M}_1}$$

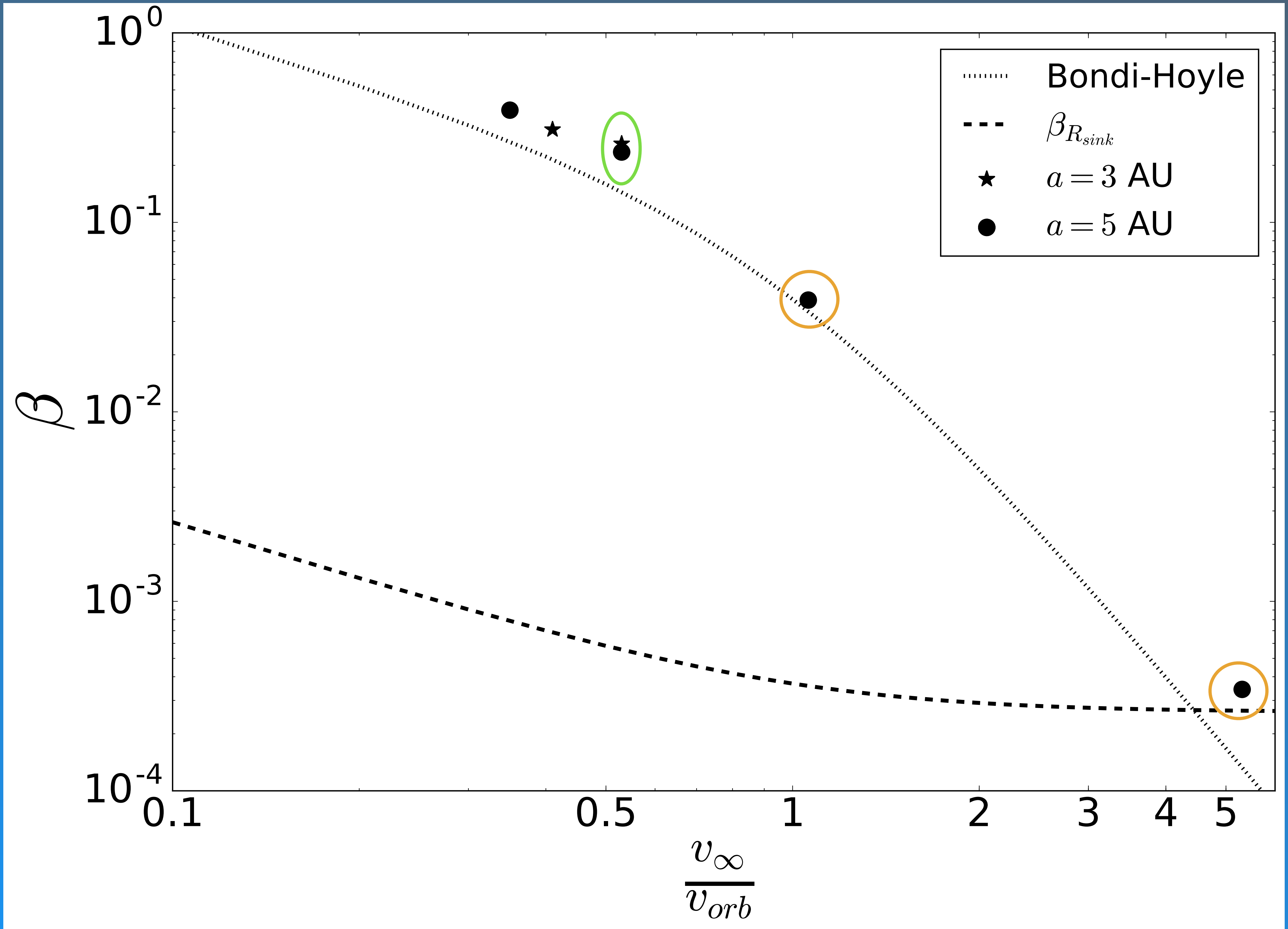
Specific angular momentum of mass lost

$$\eta \equiv \frac{1}{a^2\Omega}\left(\frac{\dot{J}}{\dot{M}}\right)_{loss}$$



# Mass accretion rate

$$\beta = \frac{\dot{M}_2}{\dot{M}_1}$$

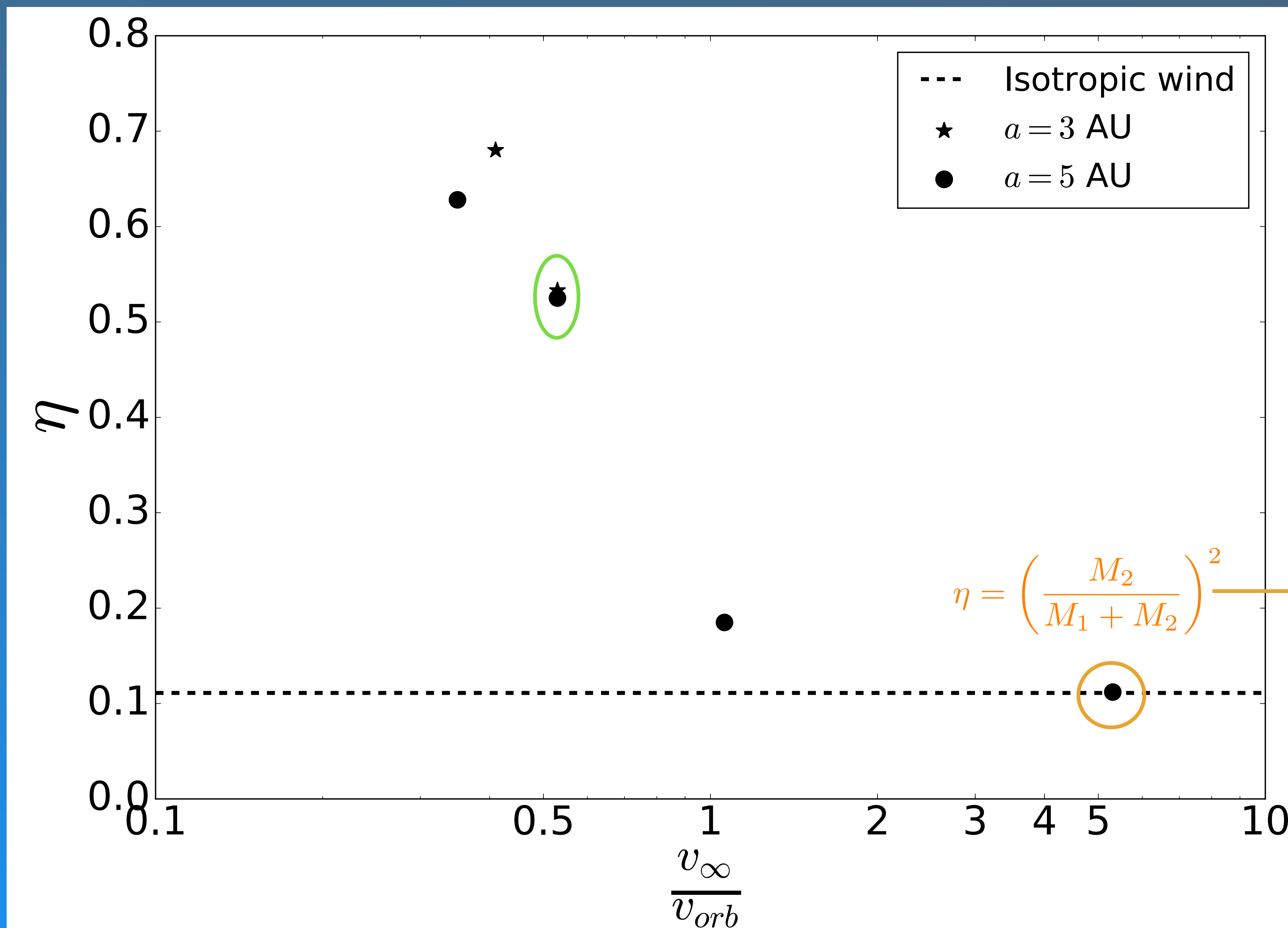



Theuns+(1996)

e.g. Mohamed (2007)

# Specific angular momentum loss

$$\eta \equiv \frac{1}{a^2\Omega}\left(\frac{\dot{J}}{\dot{M}}\right)_{loss}$$

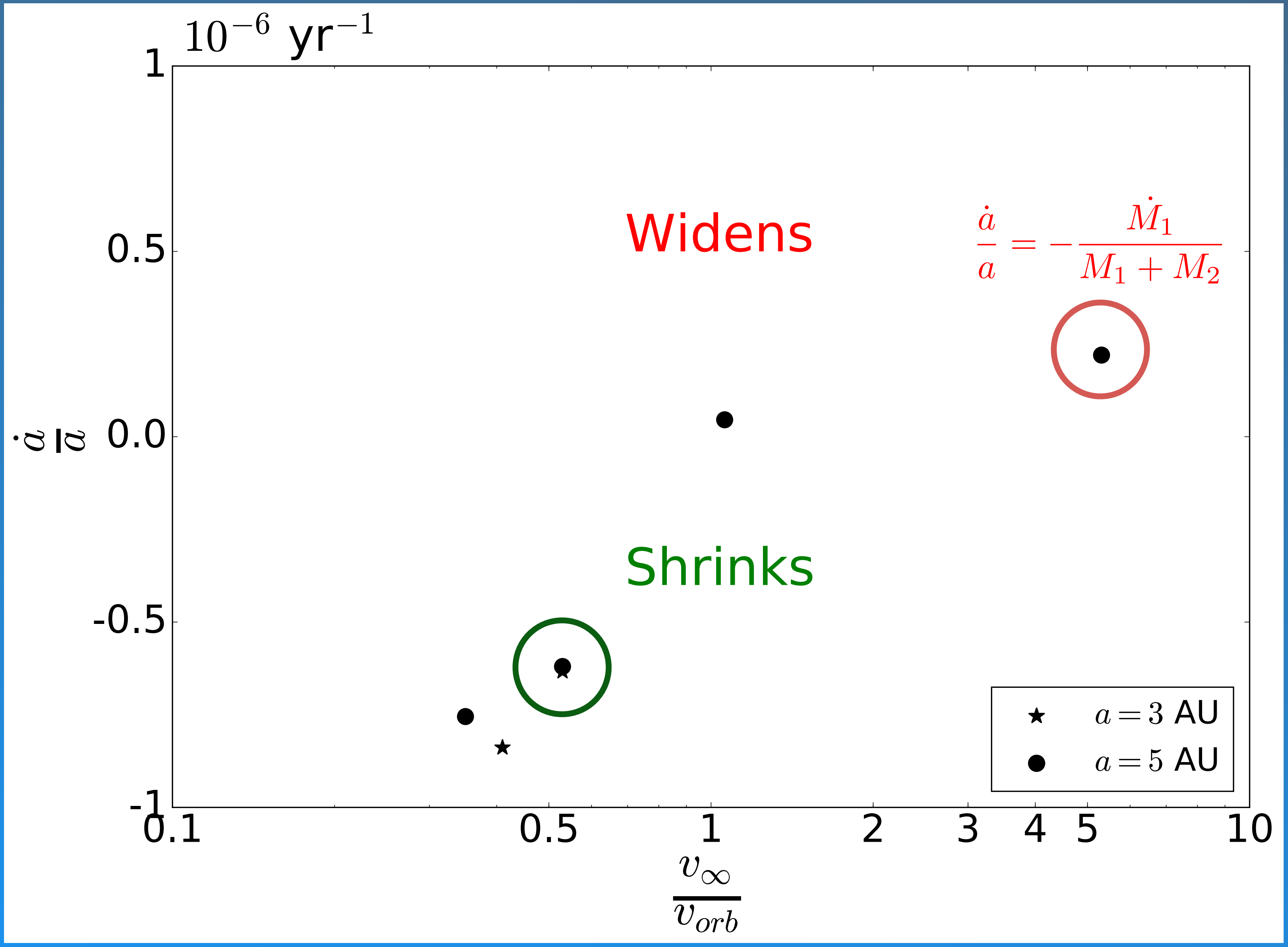



Isotropic mass loss

Jahanara+ (2005), Chen+ (2017) → Different method, similar results

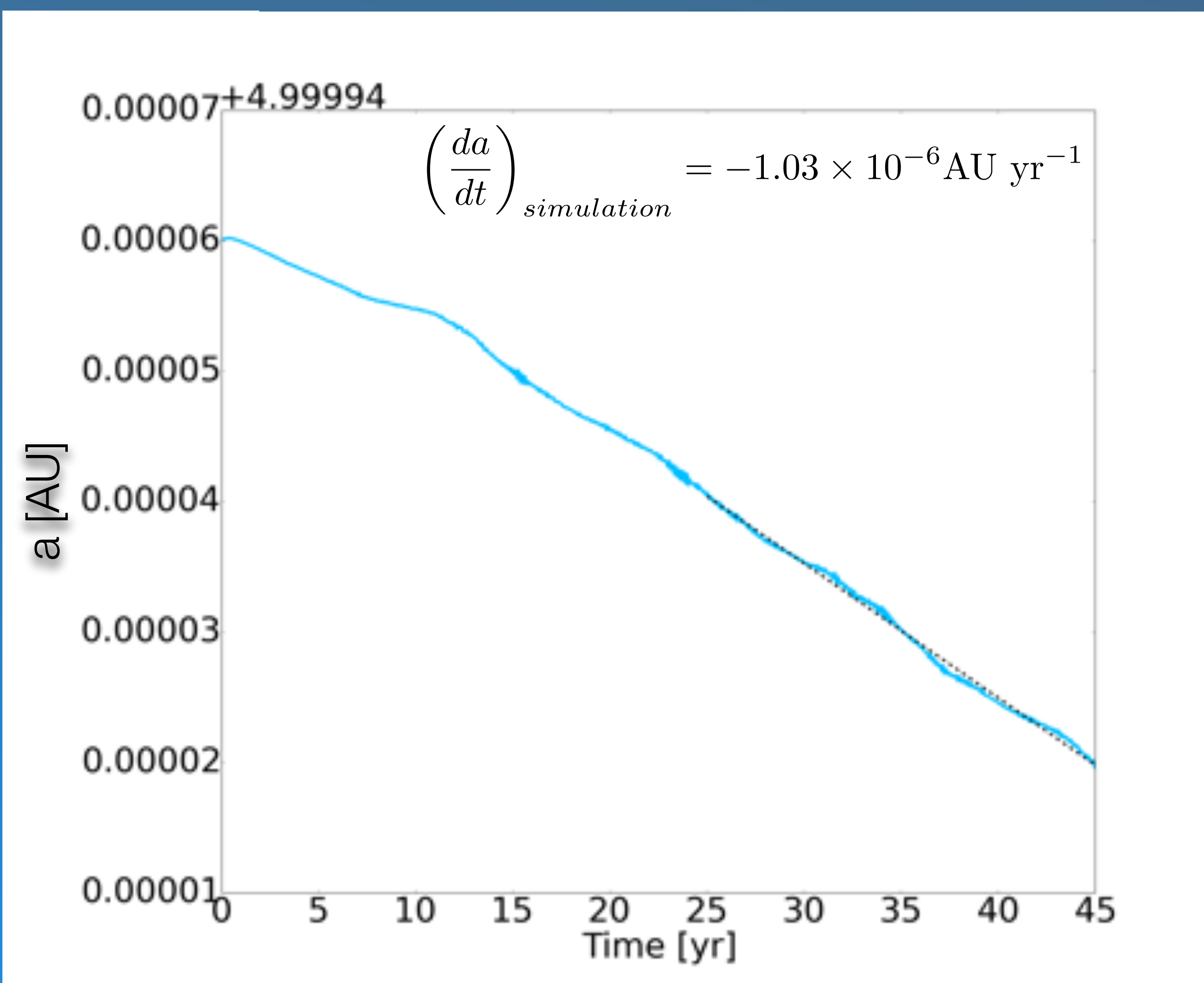
# Prediction on the orbits

$$\frac{\dot{a}}{a} = -2\frac{\dot{M}_d}{M_d}\left[1-\beta q-\eta(1-\beta)(q+1)-(1-\beta)\frac{q}{2(q+1)}\right]$$



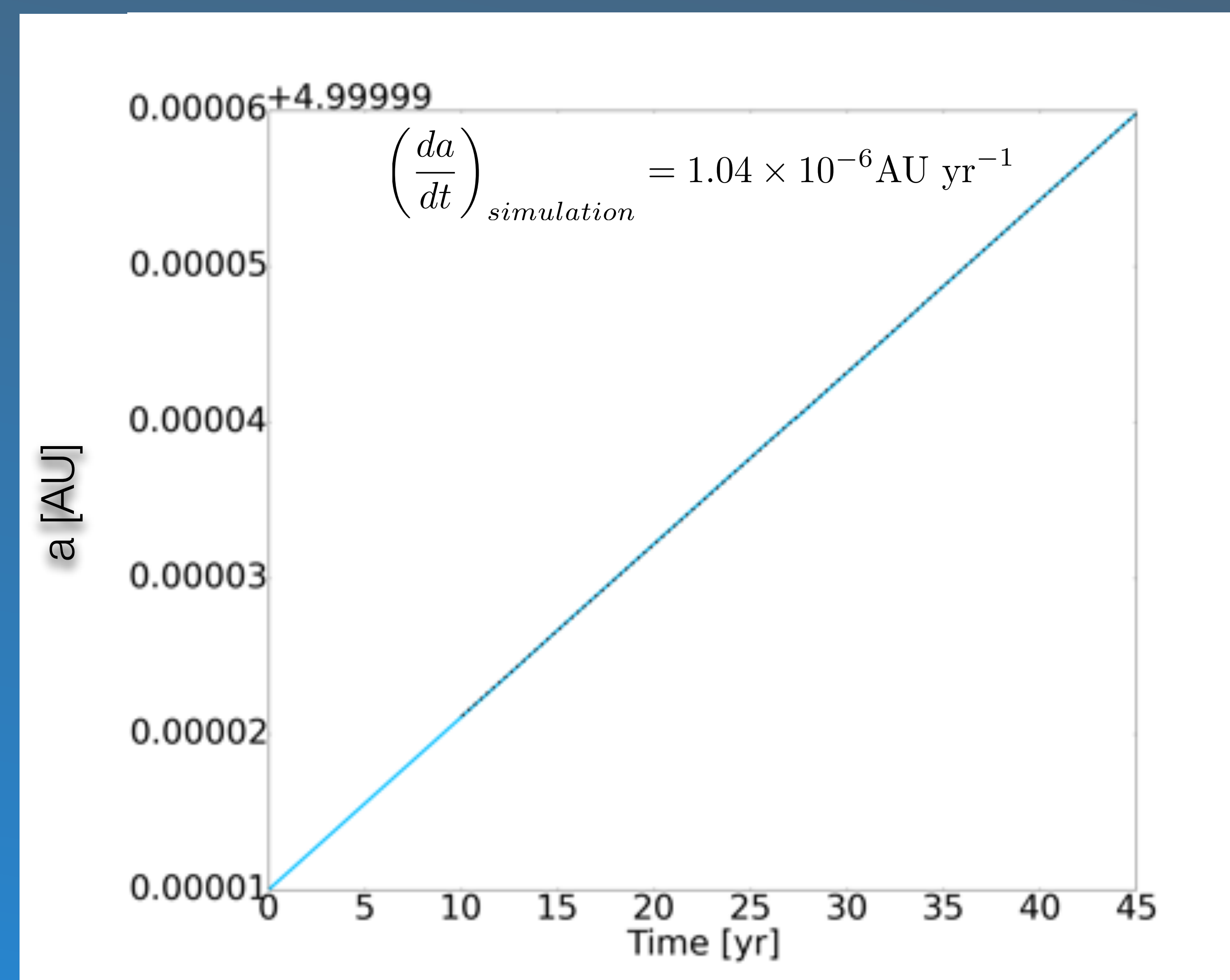
# Directly measuring orbital evolution

## $v_\infty$ = 15 km/s




expected $\left(\frac{da}{dt}\right) = -3.8 \times 10^{-6}\mathrm{AU\ yr}^{-1}$

## $v_\infty$ = 150 km/s




expected $\left(\frac{da}{dt}\right) = 1.11 \times 10^{-6}\mathrm{AU\ yr}^{-1}$

# Conclusions

- At low velocity ratios an accretion disk is formed.
- The presence of an accretion disk induces variability in the mass accreted by the companion.
- If $v_\infty / v_{orb} > 1 \Rightarrow \beta$ small and $\eta$ small $\Rightarrow$ orbit widens.
- If $v_\infty / v_{orb} < 1 \Rightarrow \beta$ large and $\eta$ large $\Rightarrow$ orbit shrinks.
- This may explain the orbital sizes seen in post-AGB binaries.
- It will also likely increase the number of systems going to CE.