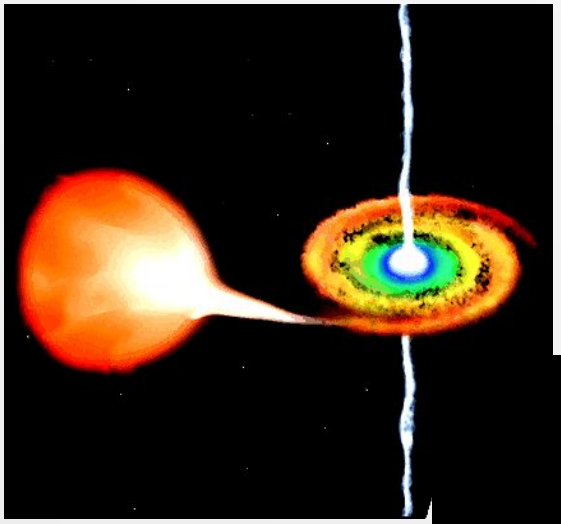
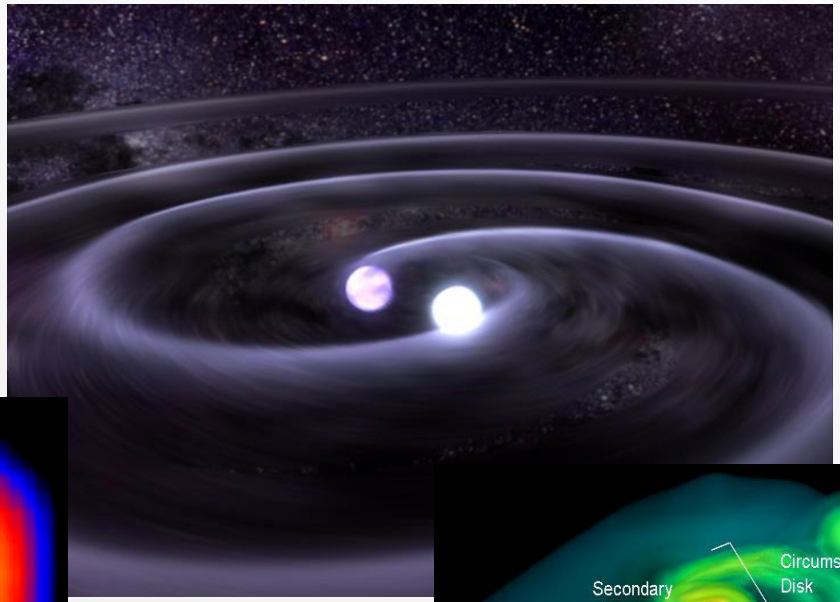
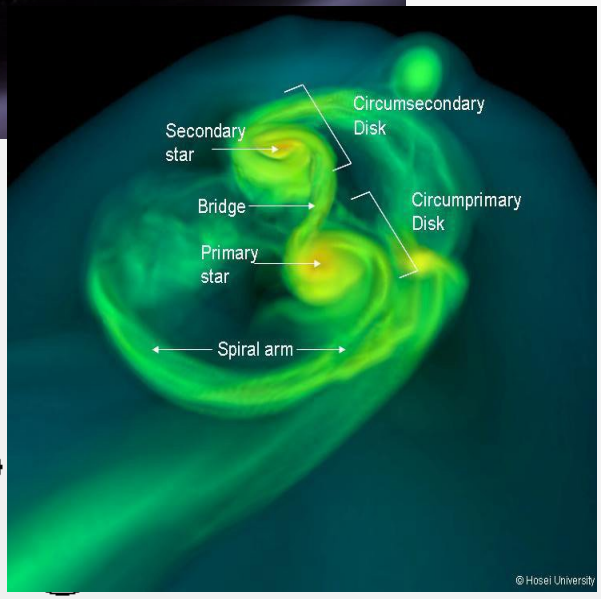
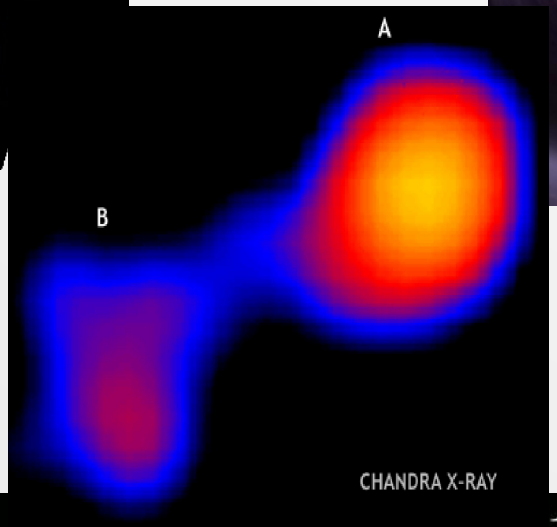
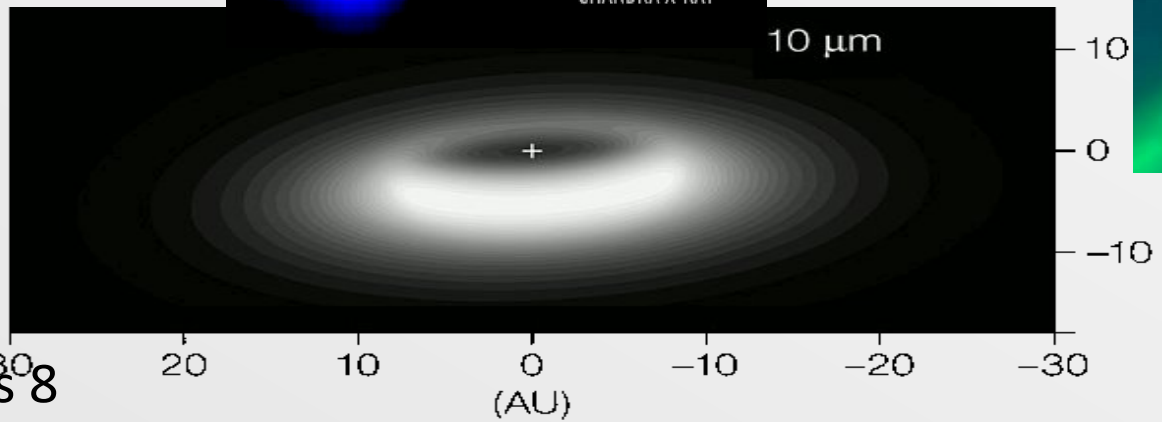
Binary Stars – Lecture 8











Astro 8501
6944

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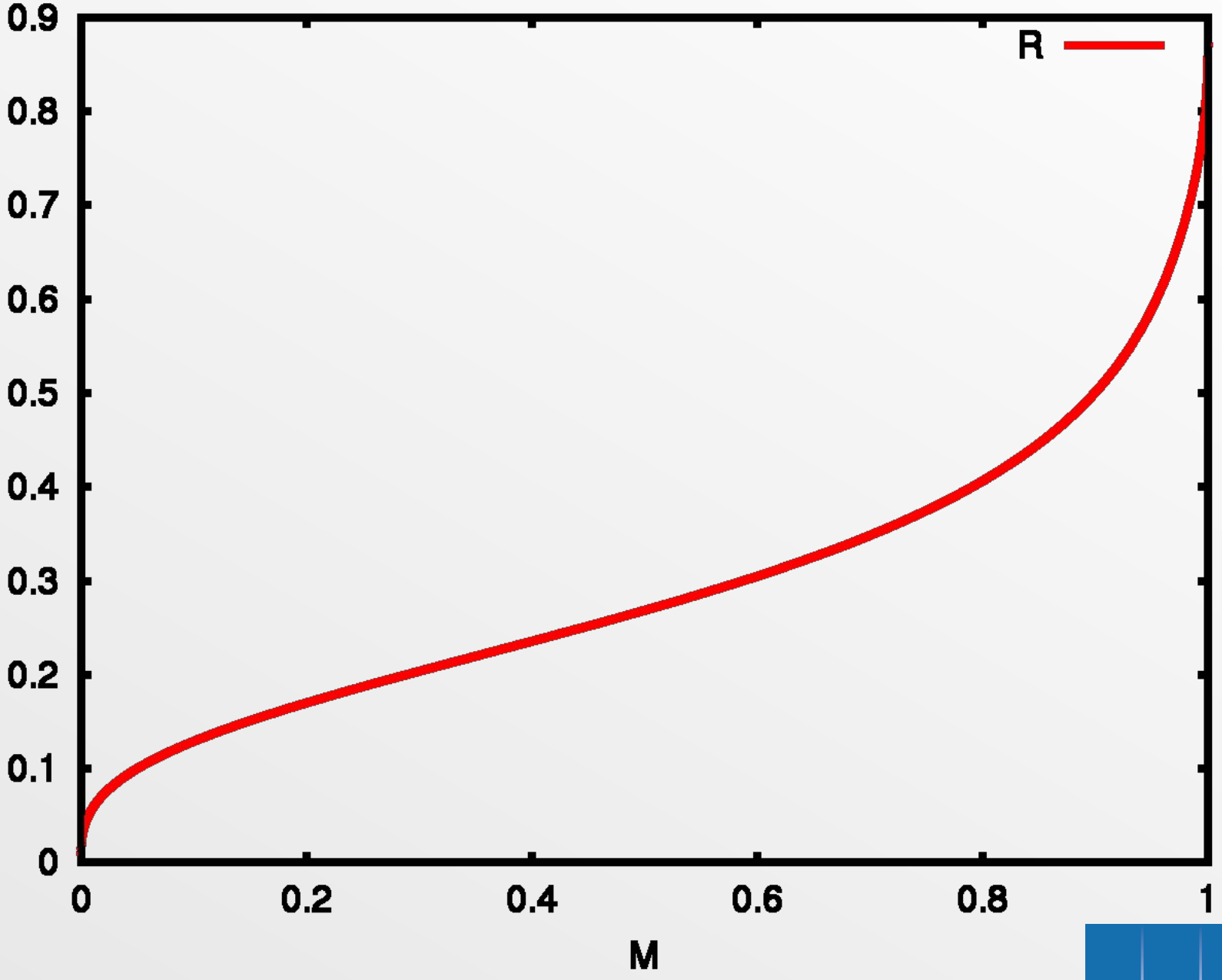
Stability of Mass Transfer

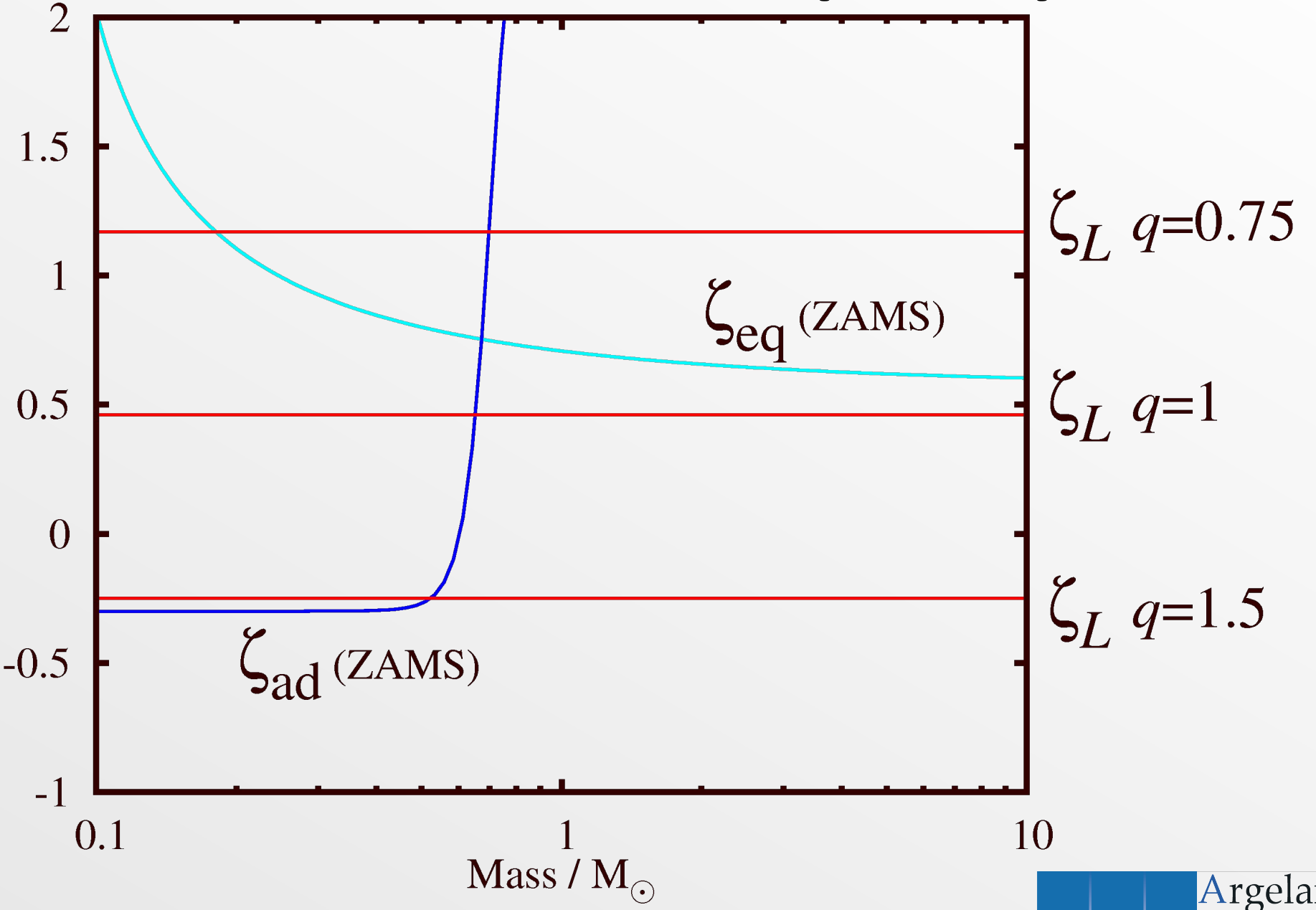
- Zeta derivative notation
- Radiative vs convective stars
- Case A : mass transfer from a main sequence star
- Case B/C : … from a giant
- When things run away:

  Common Envelope Evolution

1Msun star on the ZAMS



ZAMS Zetas f(Mass)



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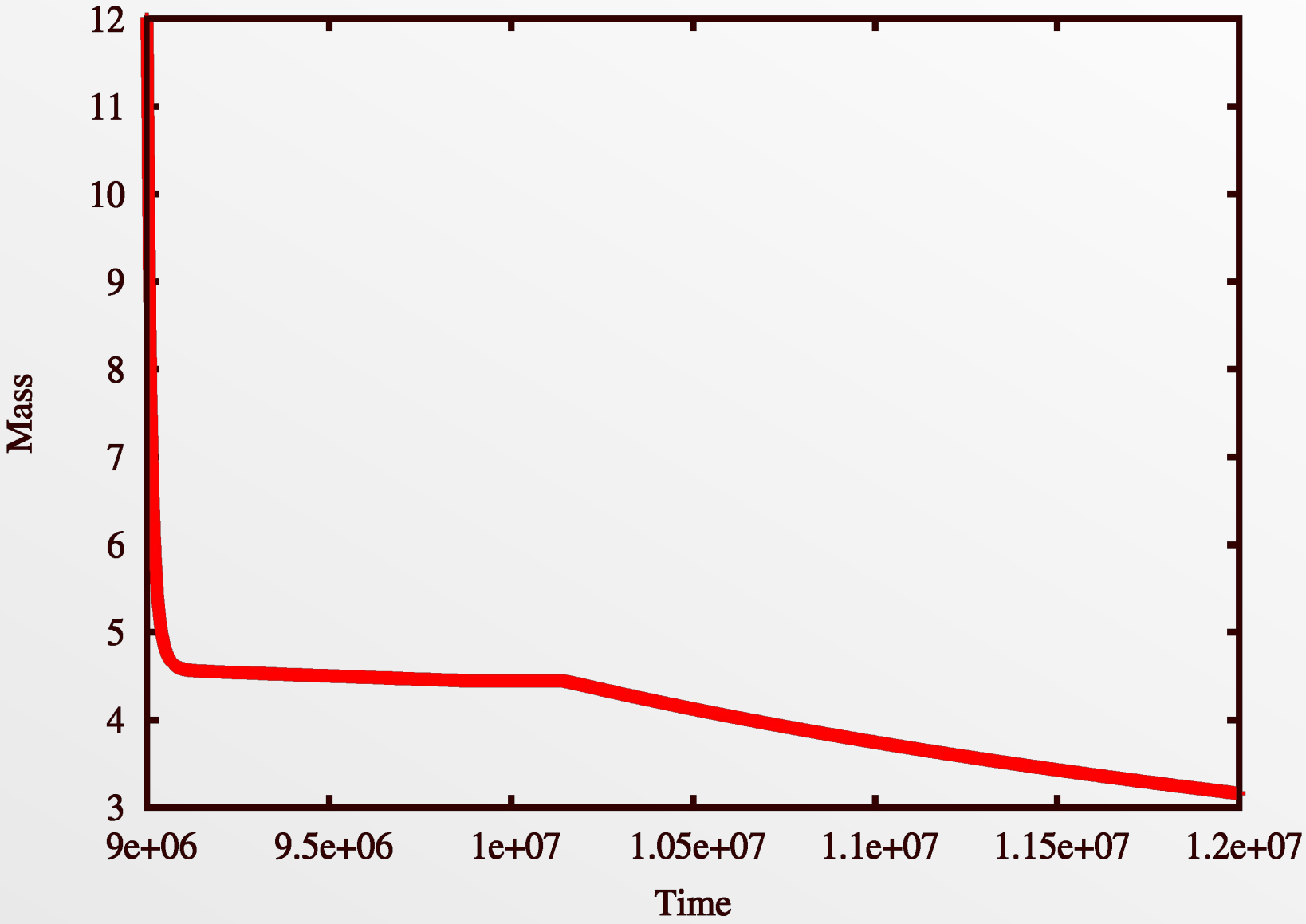
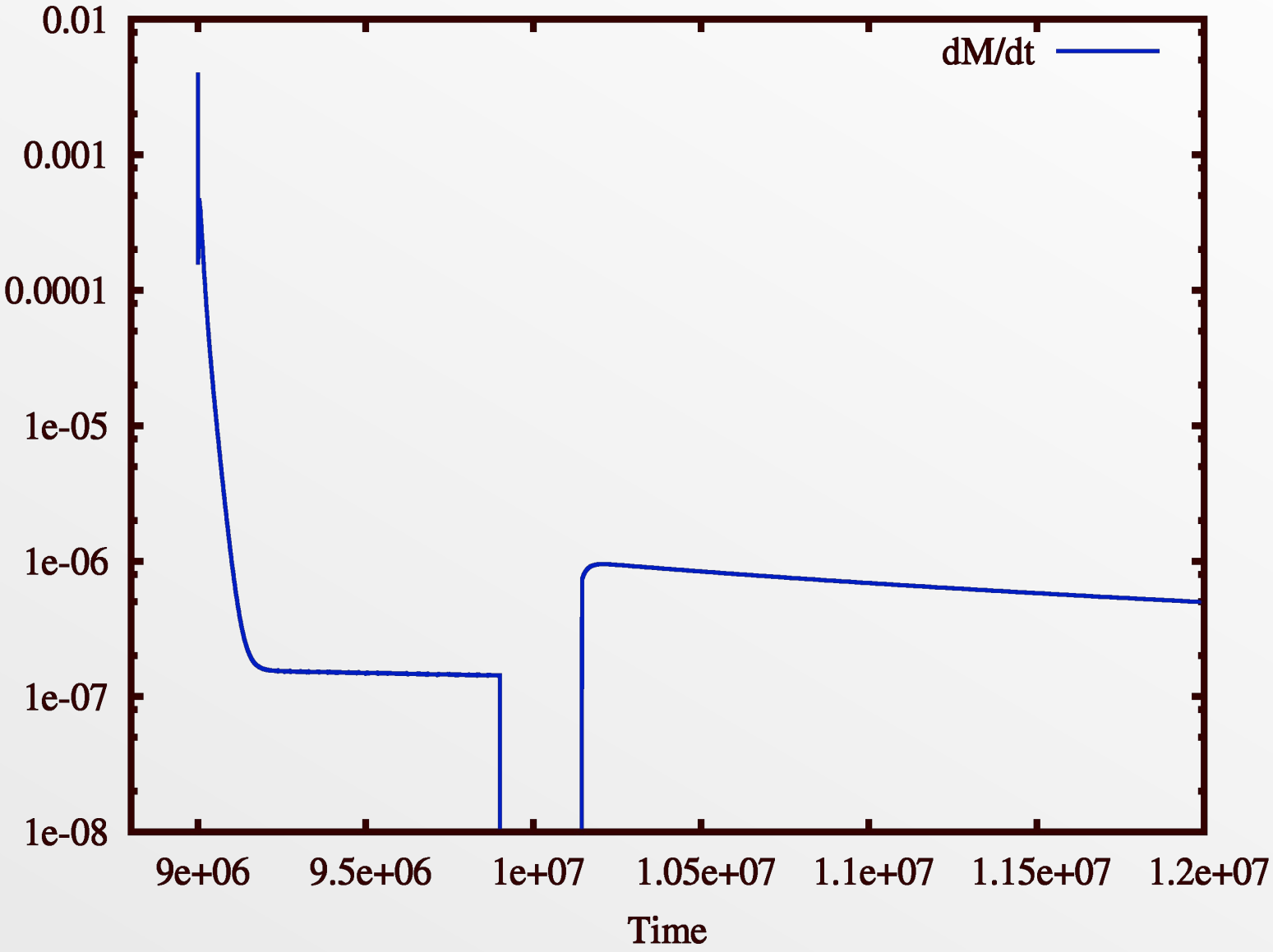
Case A mass transfer



Case A mass transfer



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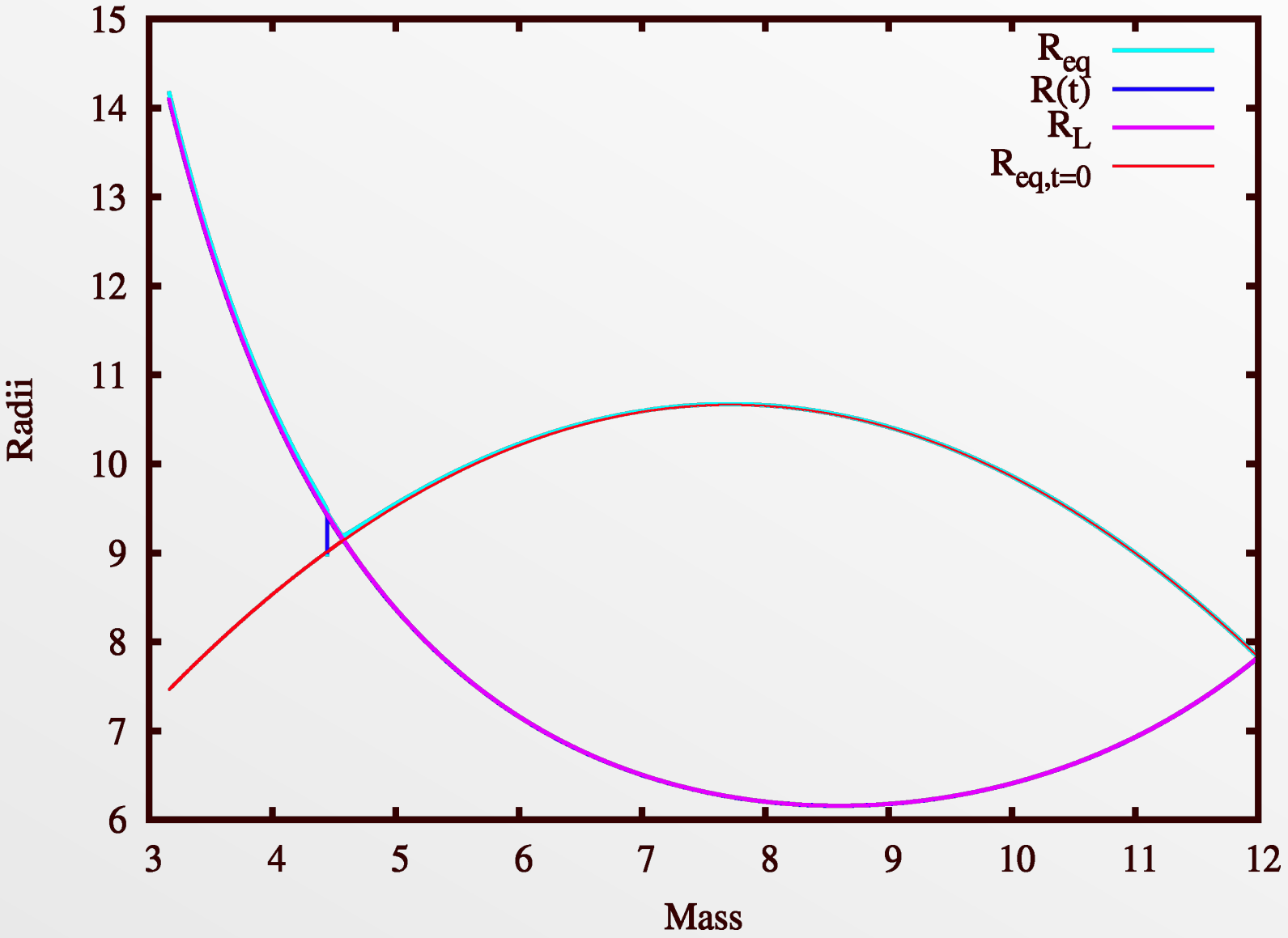
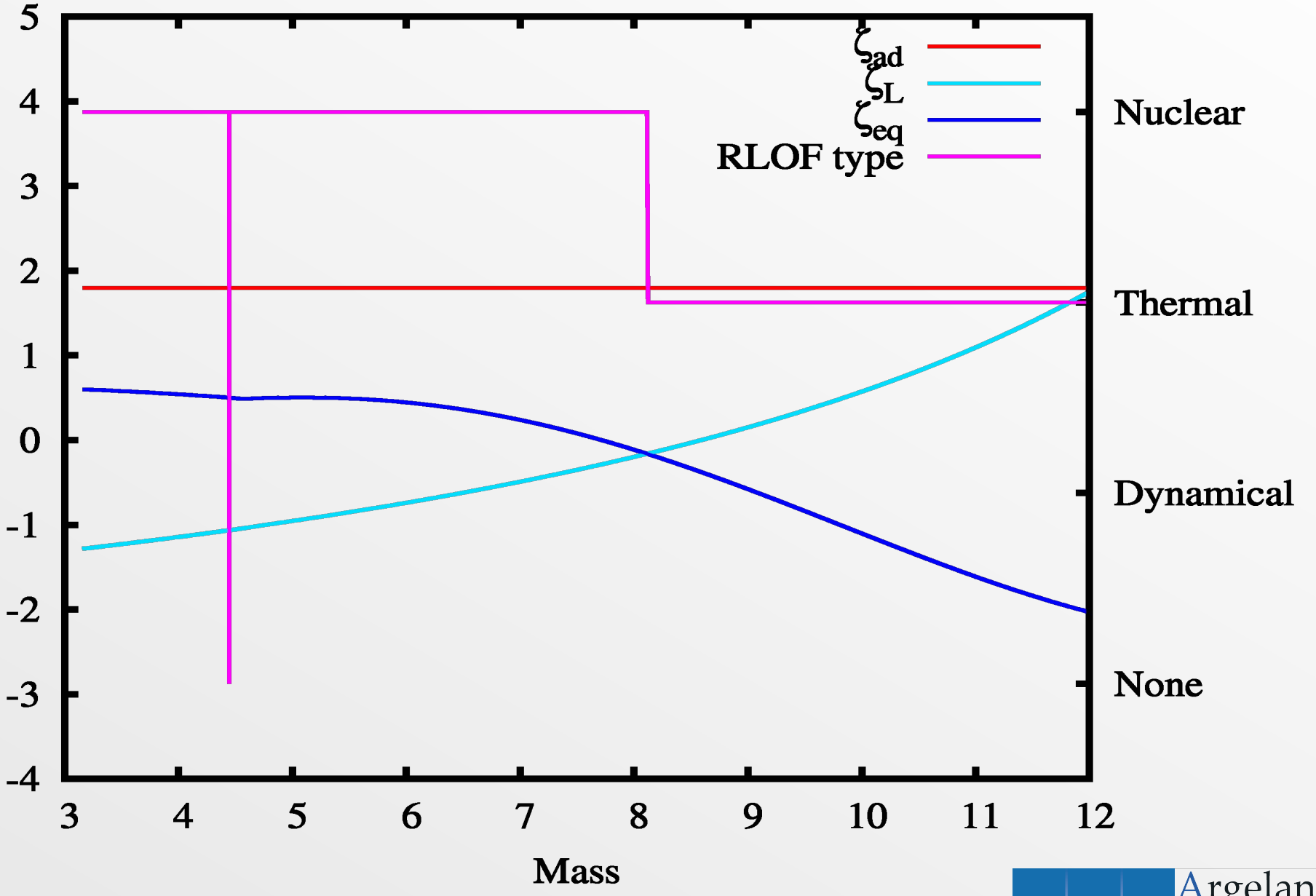
Case A mass transfer



Case A mass transfer



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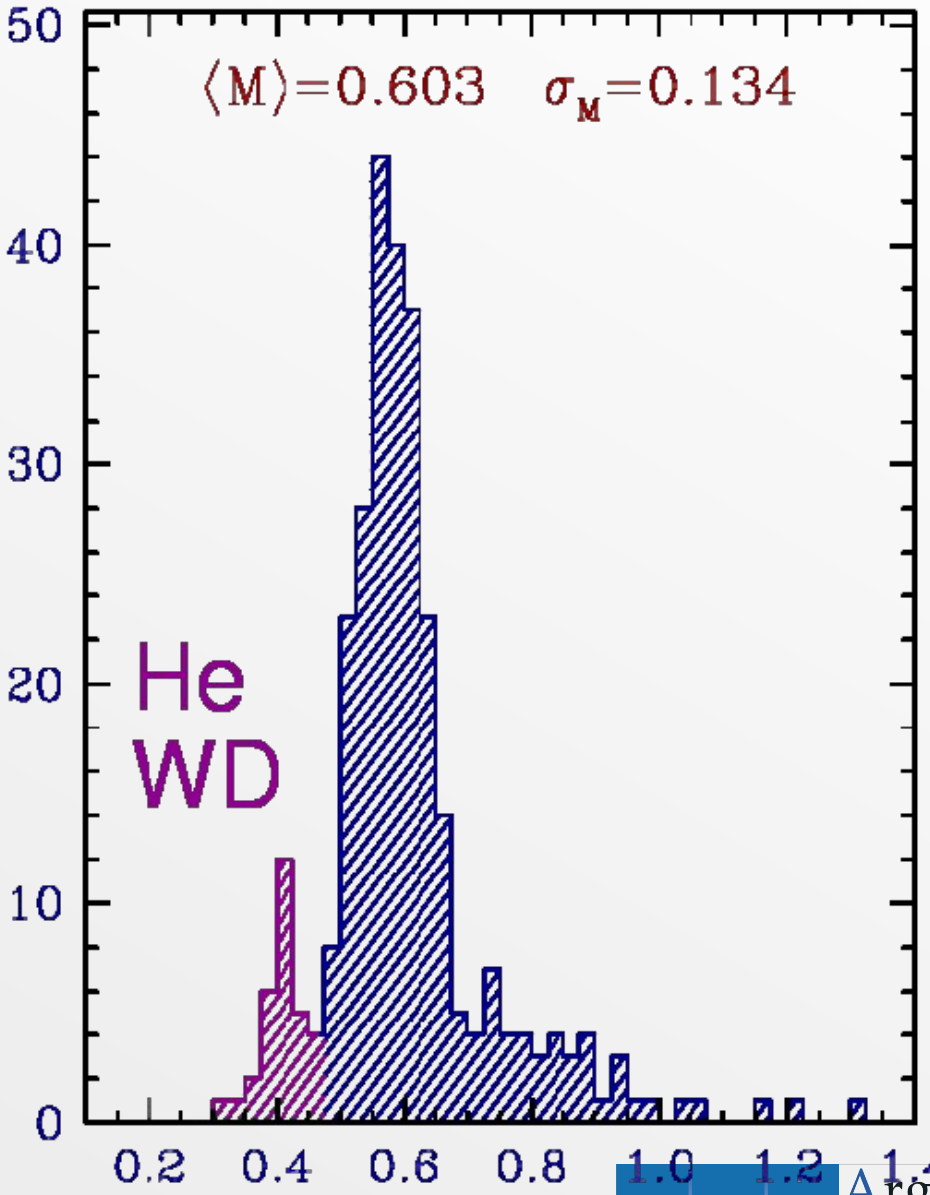
Short-Period Binaries

- 1970s: short-period binaries discovered
- Separation < giant radius
- Impossible?
- Energy+Angular momentum loss : shrinkage
- HeWDs (right)

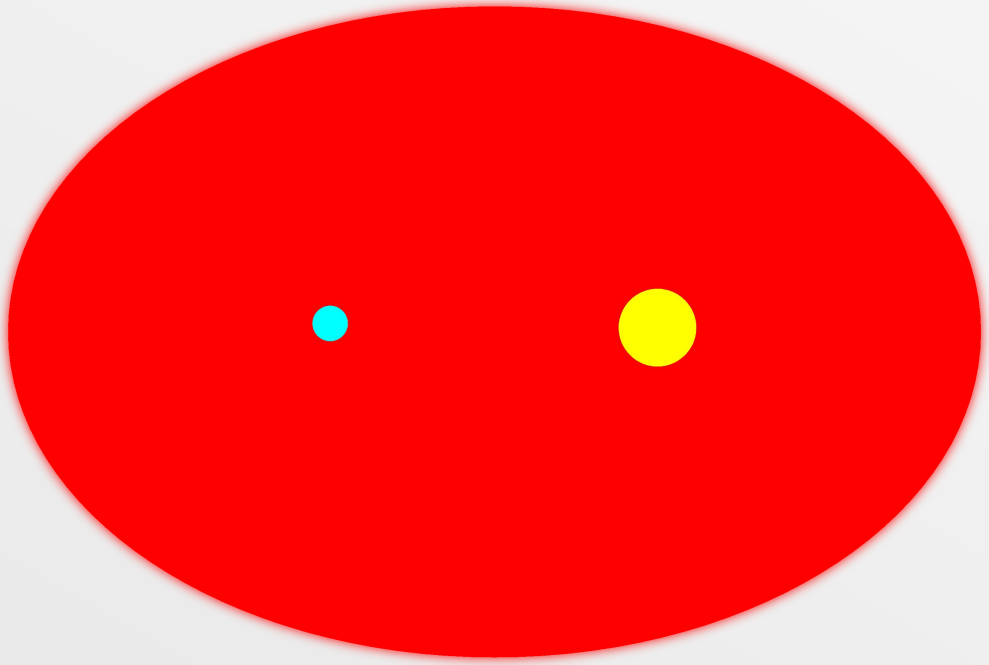


Liebert, Bergeron, Holberg (2005)

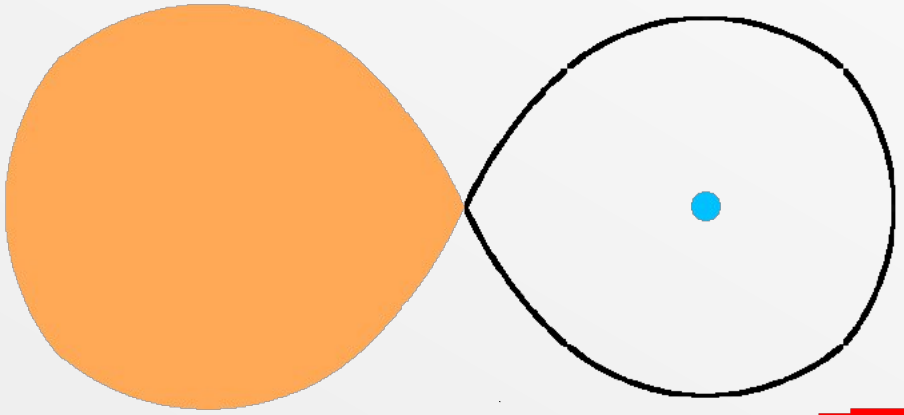
Instability???

- Unstable mass transfer $\tau_{\rm transfer} \sim \tau_{\rm dyn,1}$
- Tidal Instability?
- Companion engulfed
- Common Envelope Evolution

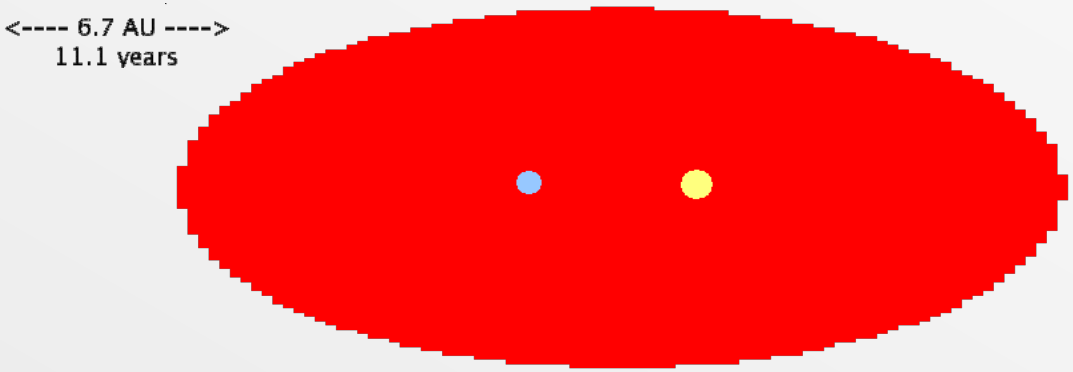
$\tau_{\rm acc} \sim \tau_{\rm thermal,2}$



Close Binary Systems



$a \lesssim 1500\mathrm{R}_\odot$



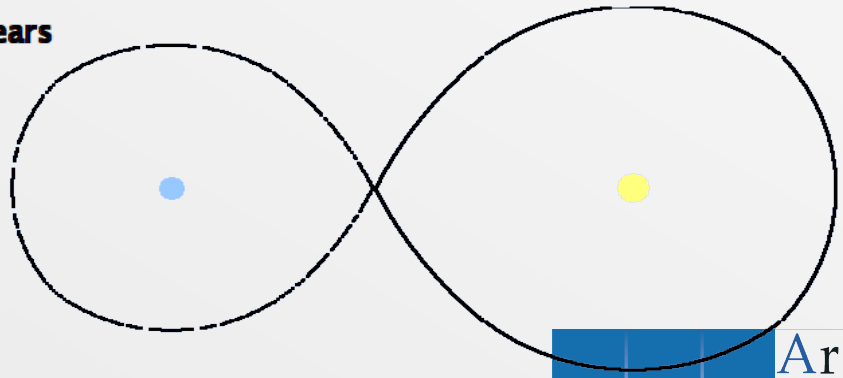
$M_1 = 3\mathrm{M}_\odot$

TPAGB

<---- 6.7 AU ---->
11.1 years

$M_2 = 1\mathrm{M}_\odot$

Main Sequence



Common Envelope Evolution

- Drag
- Energy and Angular Momentum transfer
- Envelope lost?
- Cores merge?
- Energy?
- Angular momentum?

$$\dot{E} \sim \pi R_A^2 \rho v^3$$

$$R_A = \frac{2GM}{v^2 + c^2}$$

See e.g. Taam & Sanquist (2000)

Comenv Prescriptions

α

Energy of orbit

Vs

Energy of Envelope

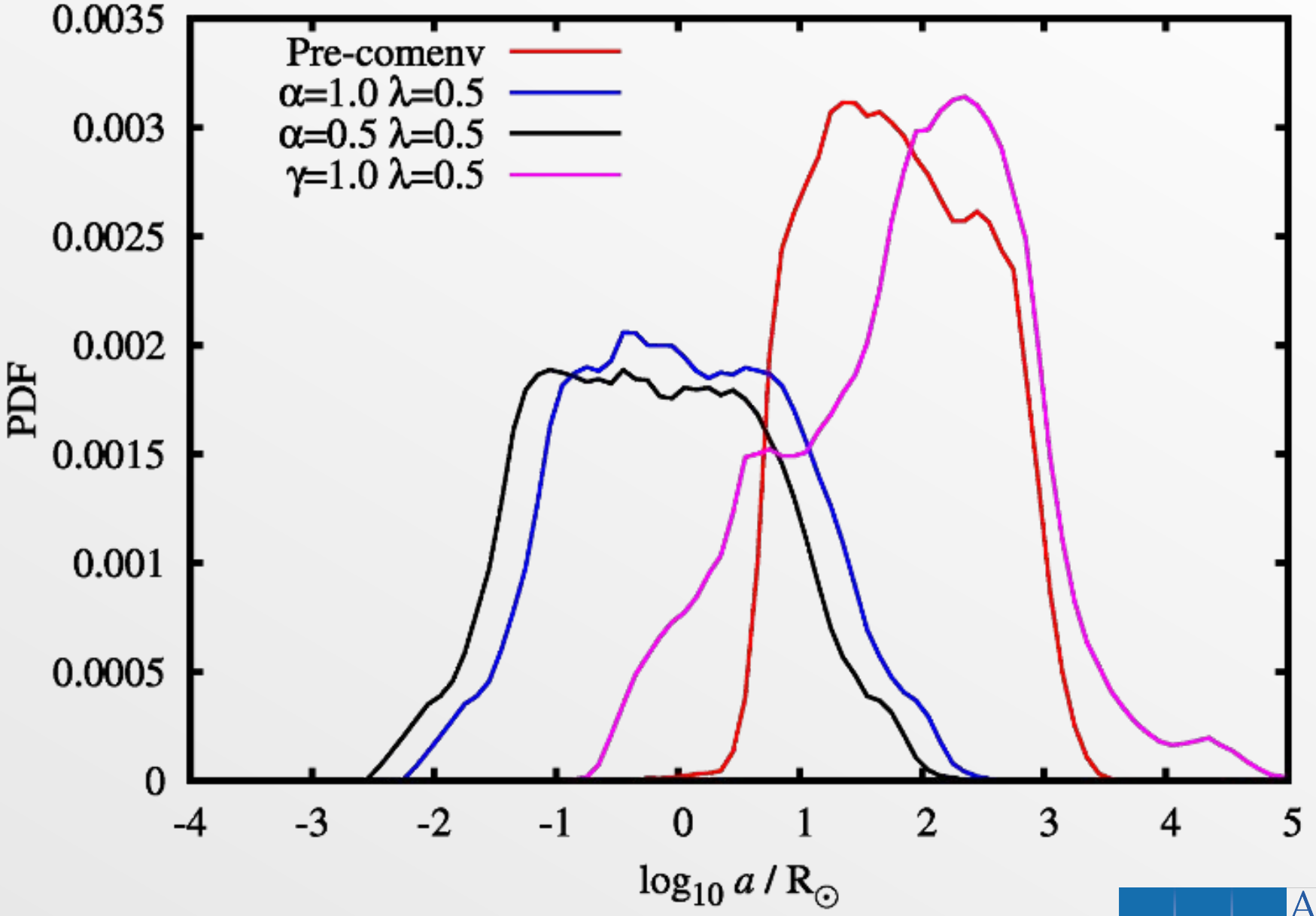
γ

Angular Momentum of orbit

Vs

Ang Mom. of Envelope

Comenv Simulations



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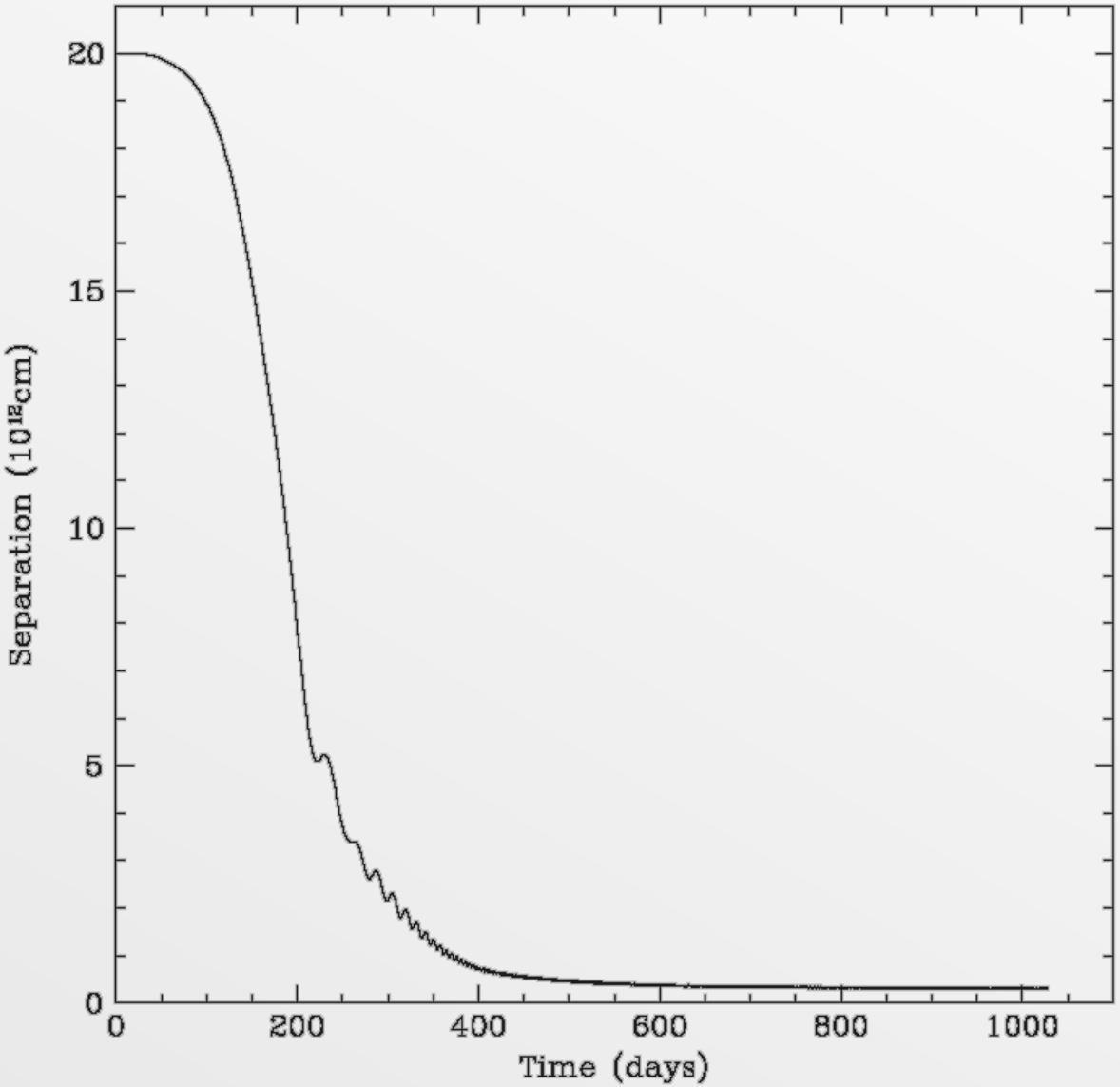
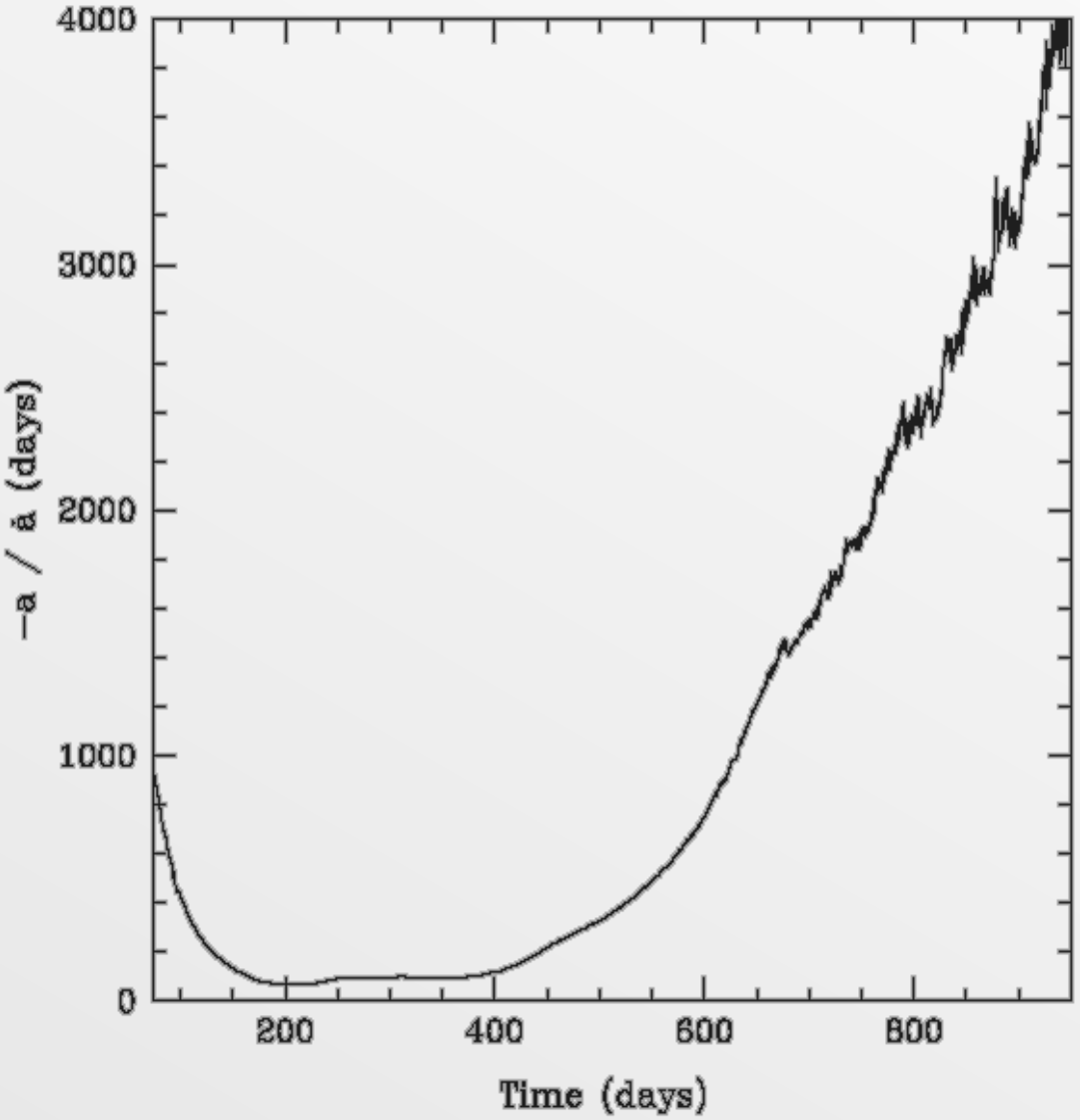
3D Simulations



$$M_1 = 3\mathrm{M}_\odot$$
$$M_{c1} = 0.7\mathrm{M}_\odot$$
$$M_2 = 0.4\mathrm{M}_\odot$$
$$P = 0.84\mathrm{years}$$

Sandquist et al. 1998/Ricker and Taam 2010

3D Simulations



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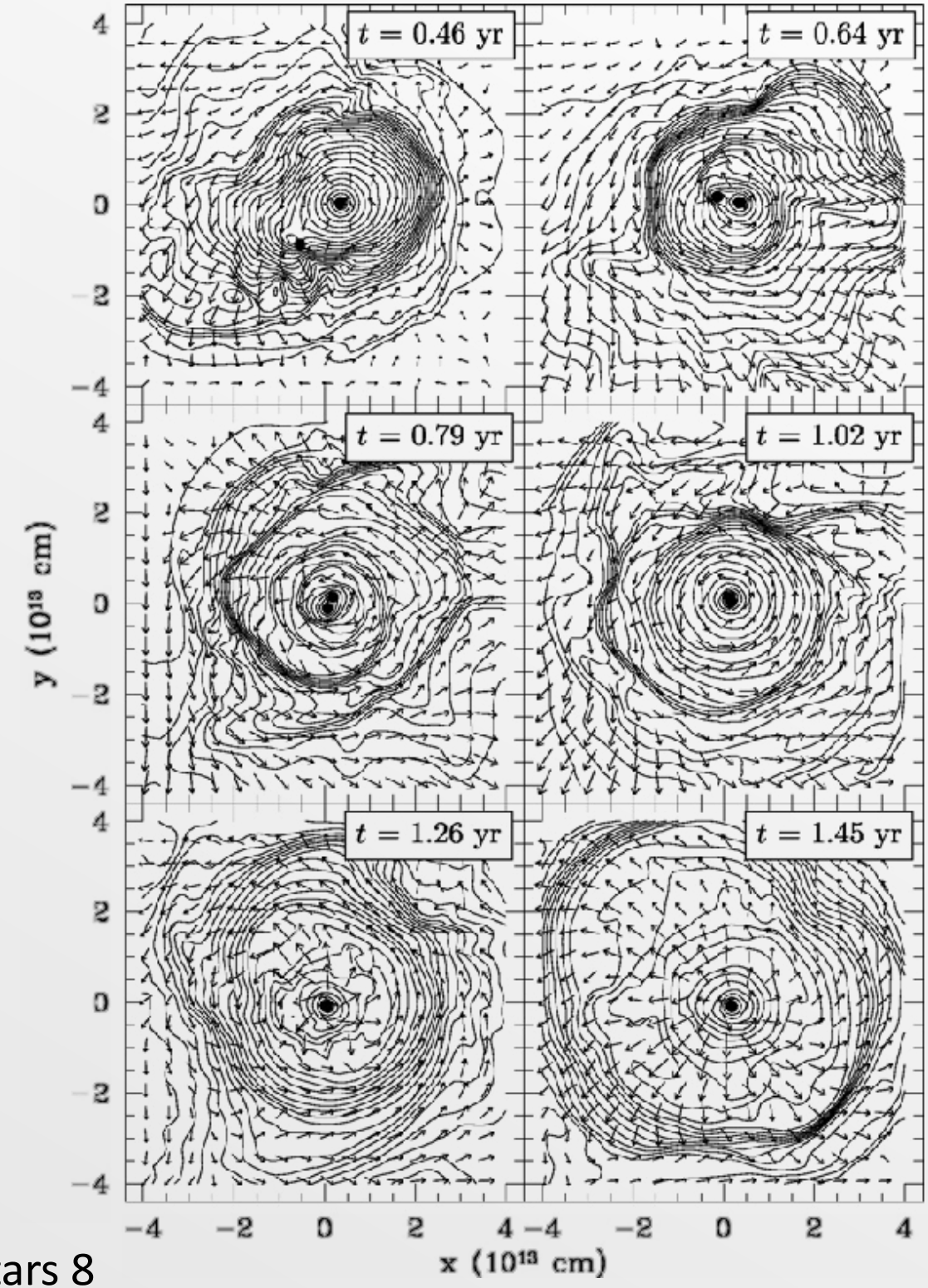
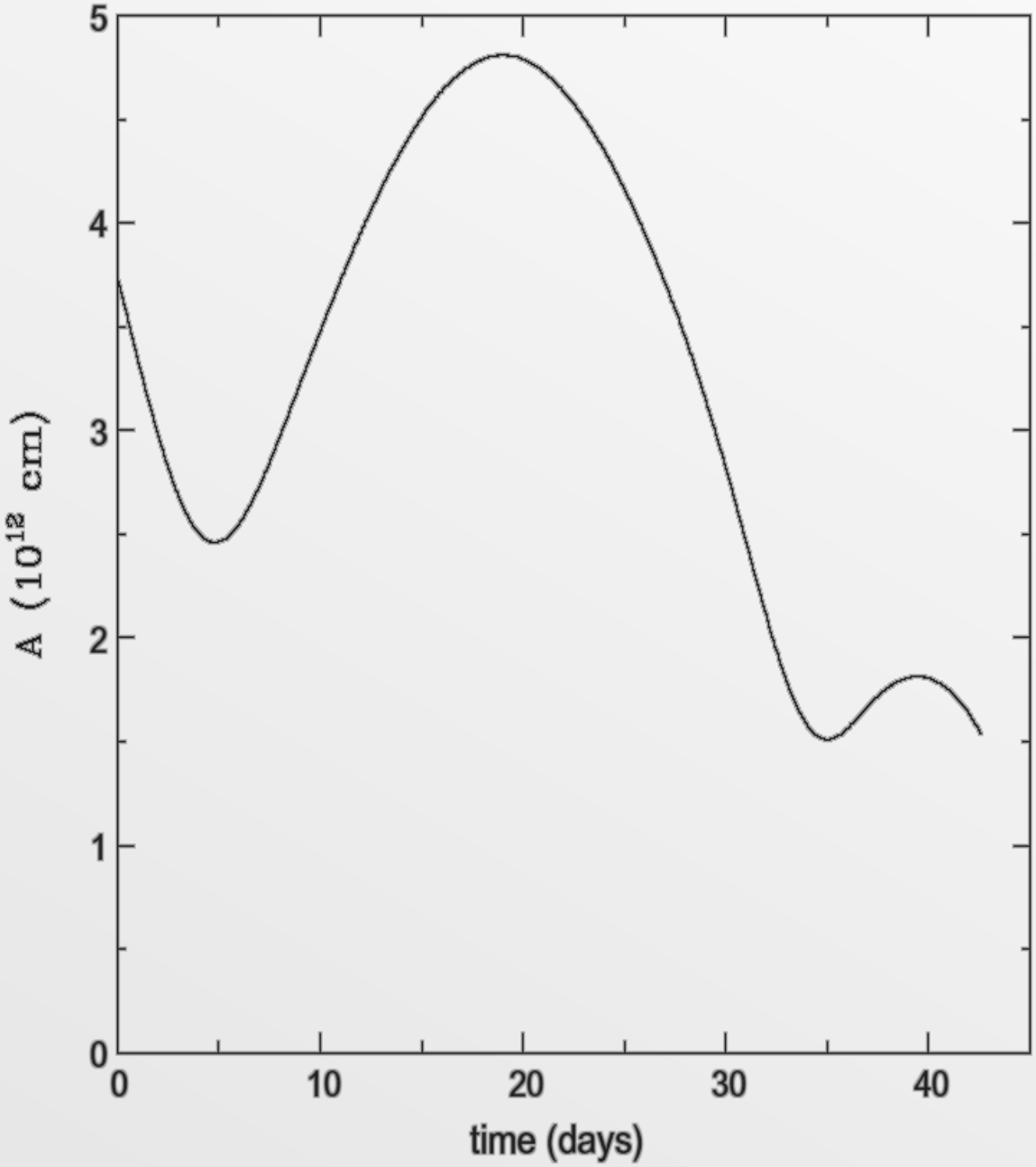


Density contours

$$M_1 = 3\mathrm{M}_\odot$$
$$M_{c1} = 0.7\mathrm{M}_\odot$$
$$M_2 = 0.4\mathrm{M}_\odot$$
$$P = 0.84\mathrm{years}$$

Sandquist et al. 1998
Ricker and Taam 2010

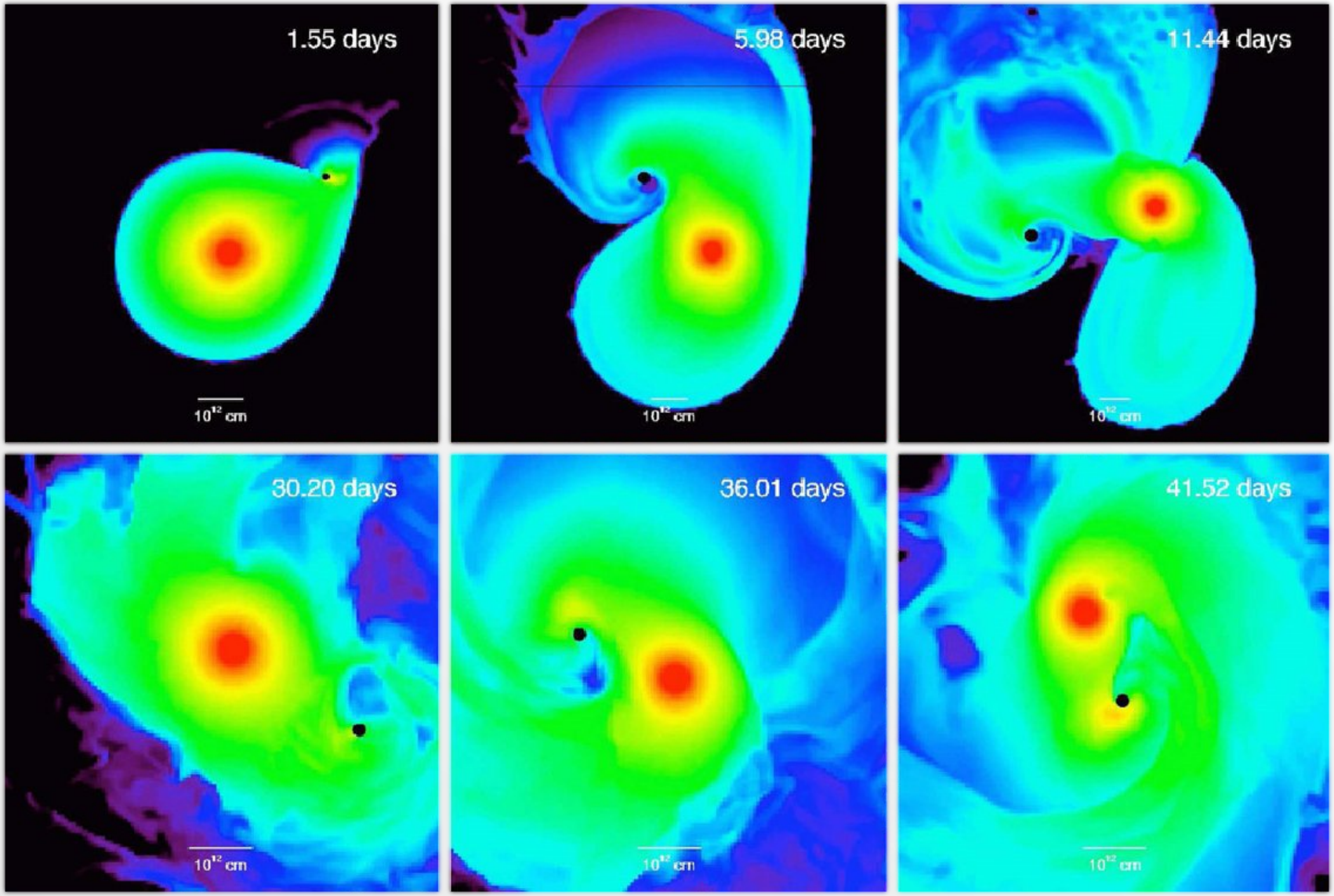
3D Simulations



$$M_1 = 1\mathrm{M}_\odot$$
$$M_2 = 0.7\mathrm{M}_\odot$$
$$P = 1\,\mathrm{month}$$

Sandquist et al. 2000
Ricker and Taam 2010

3D Simulations



$M_1 = 1\mathrm{M}_\odot \quad M_2 = 0.7\mathrm{M}_\odot \quad P = 1\,\mathrm{month}$

Sandquist et al. 2000
Ricker and Taam 2010