Astro 8501 – 6944

# Binary Stars

**Thursdays 9am**
**AIfA 0.008**

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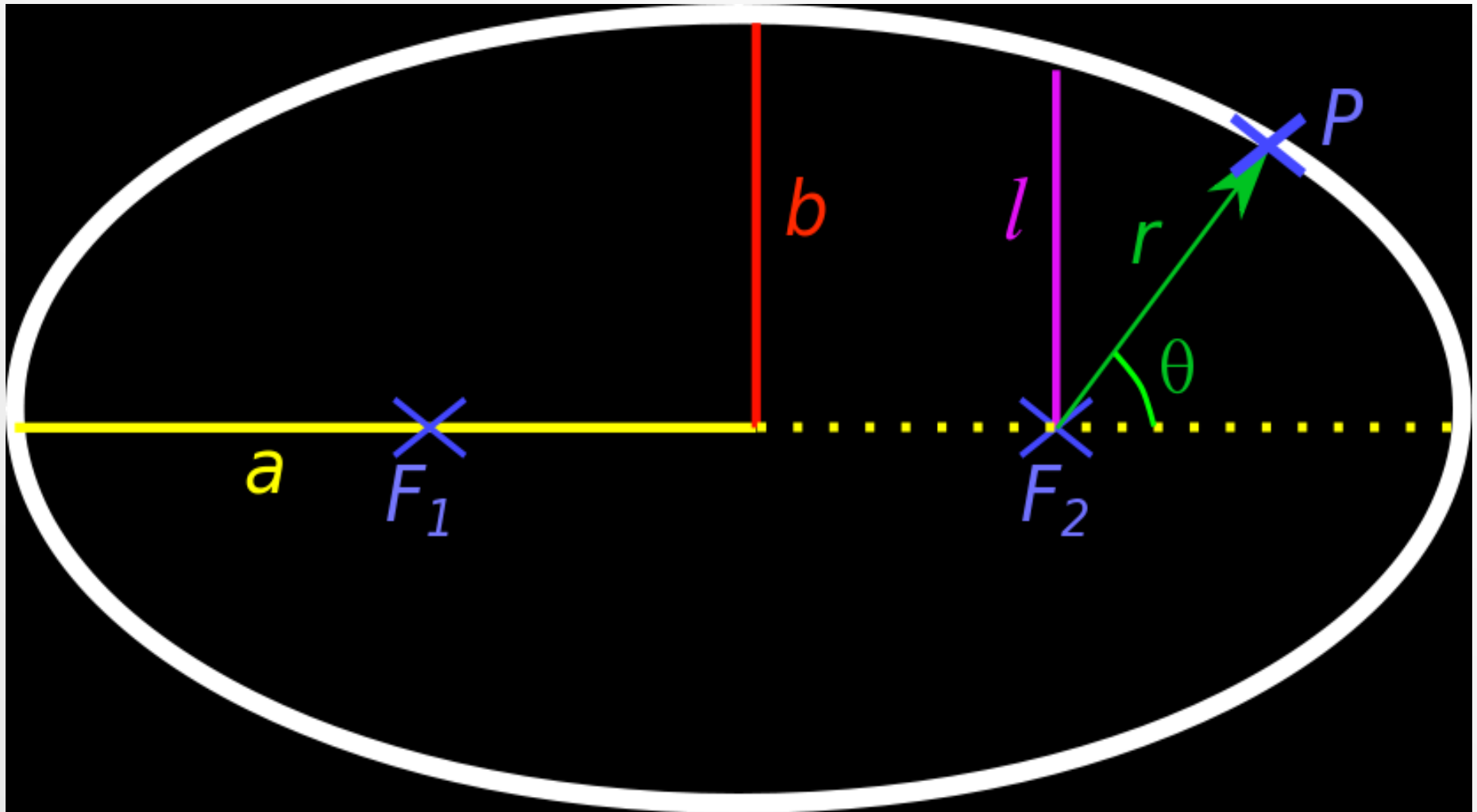http://www.astro.uni-bonn.de/~izzard/binary_stars.html

# Kepler's Laws

- Bound Orbits are ellipses
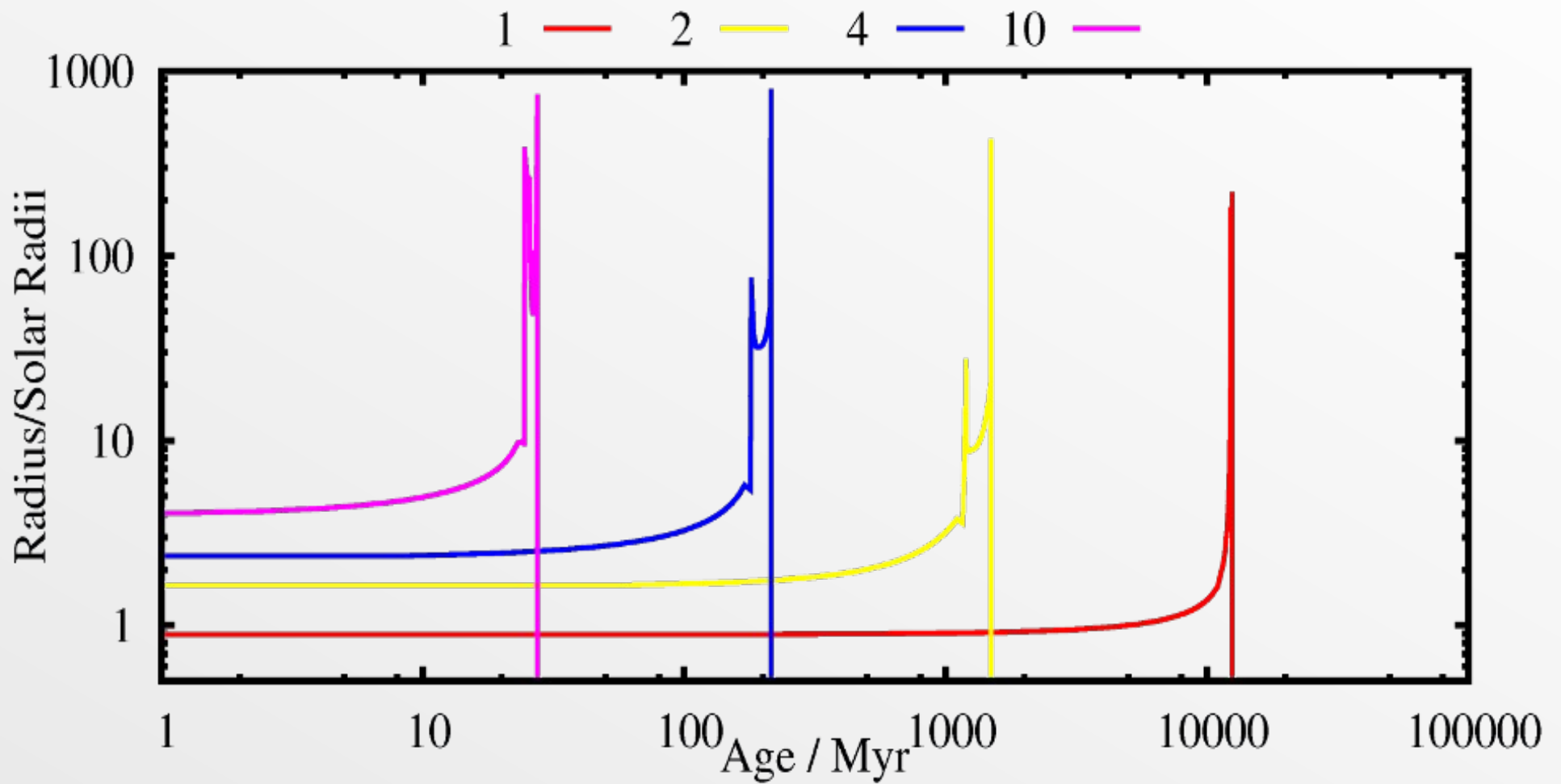
- Equal areas swept in equal times

$$P^2 \propto a^3$$

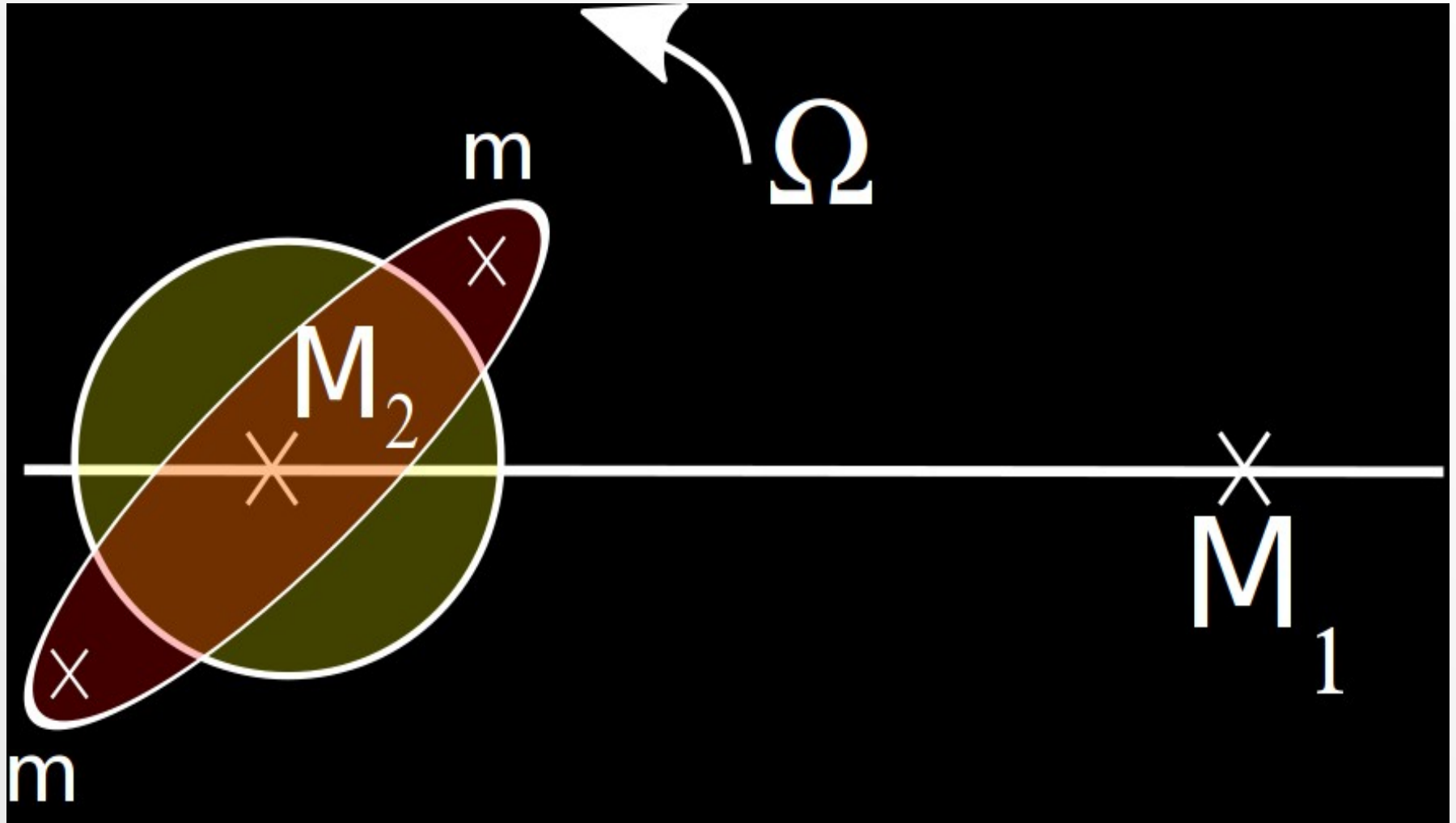$$\dot{\mathbf{J}} = \mathbf{0} \qquad \dot{E} = 0$$

# Elliptical Motion

# Stellar Evolution

# Tidal System

# Tides Overview

- Tides synchronise, then circularise
- Rate $\sim (R/a)^{6,8}$
- Close binaries should be sync. and circular
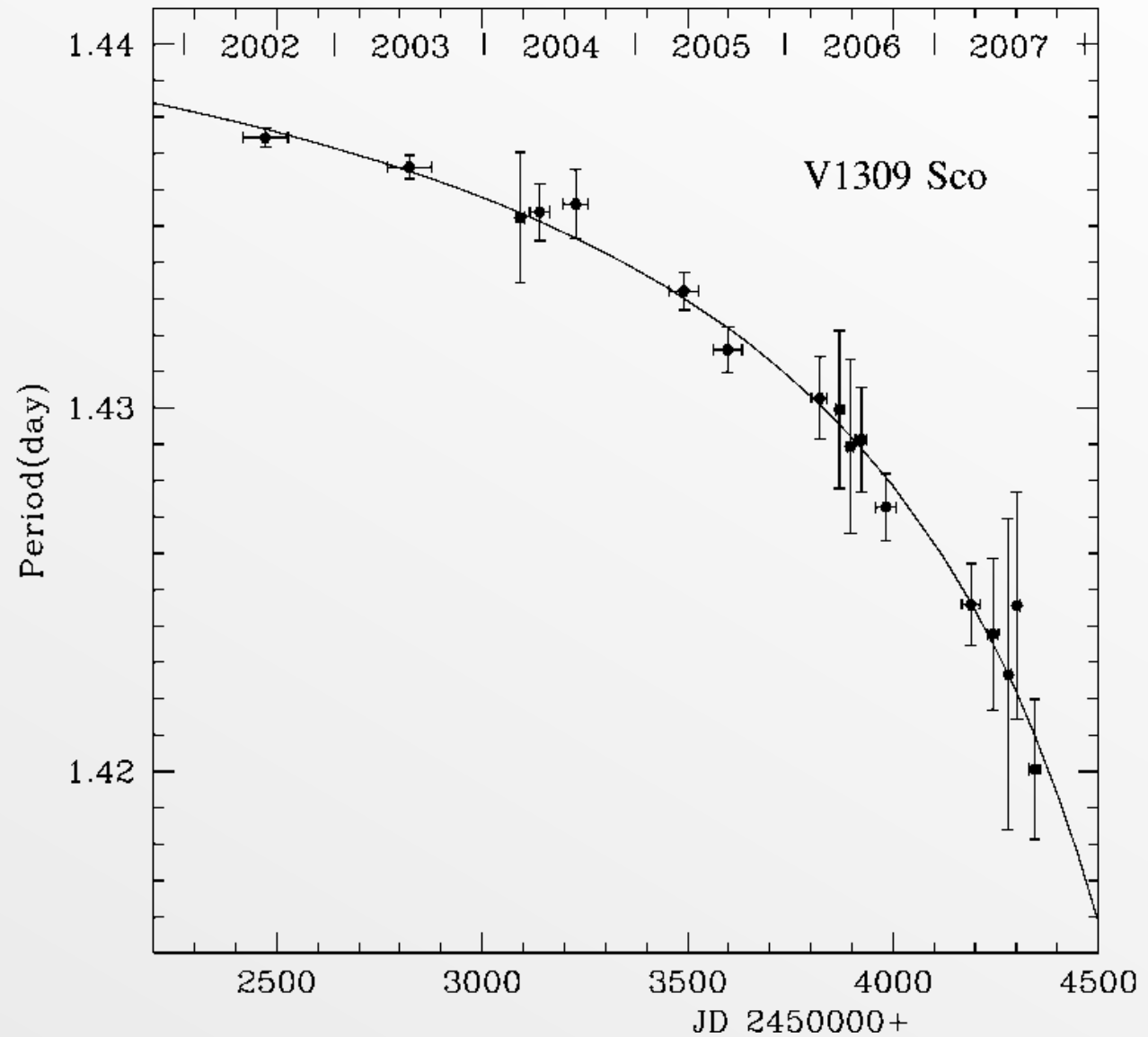- Assuming $\Omega = \omega$ and $e = 0$

  we continue our analysis by moving to

  close, circular binaries and interaction by

  exchange of *angular momentum and mass*

- Some assumptions $\longrightarrow$ problem is tractable

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# Darwin Instability Seen!

- V1309 Sco

- Tylenda et al.
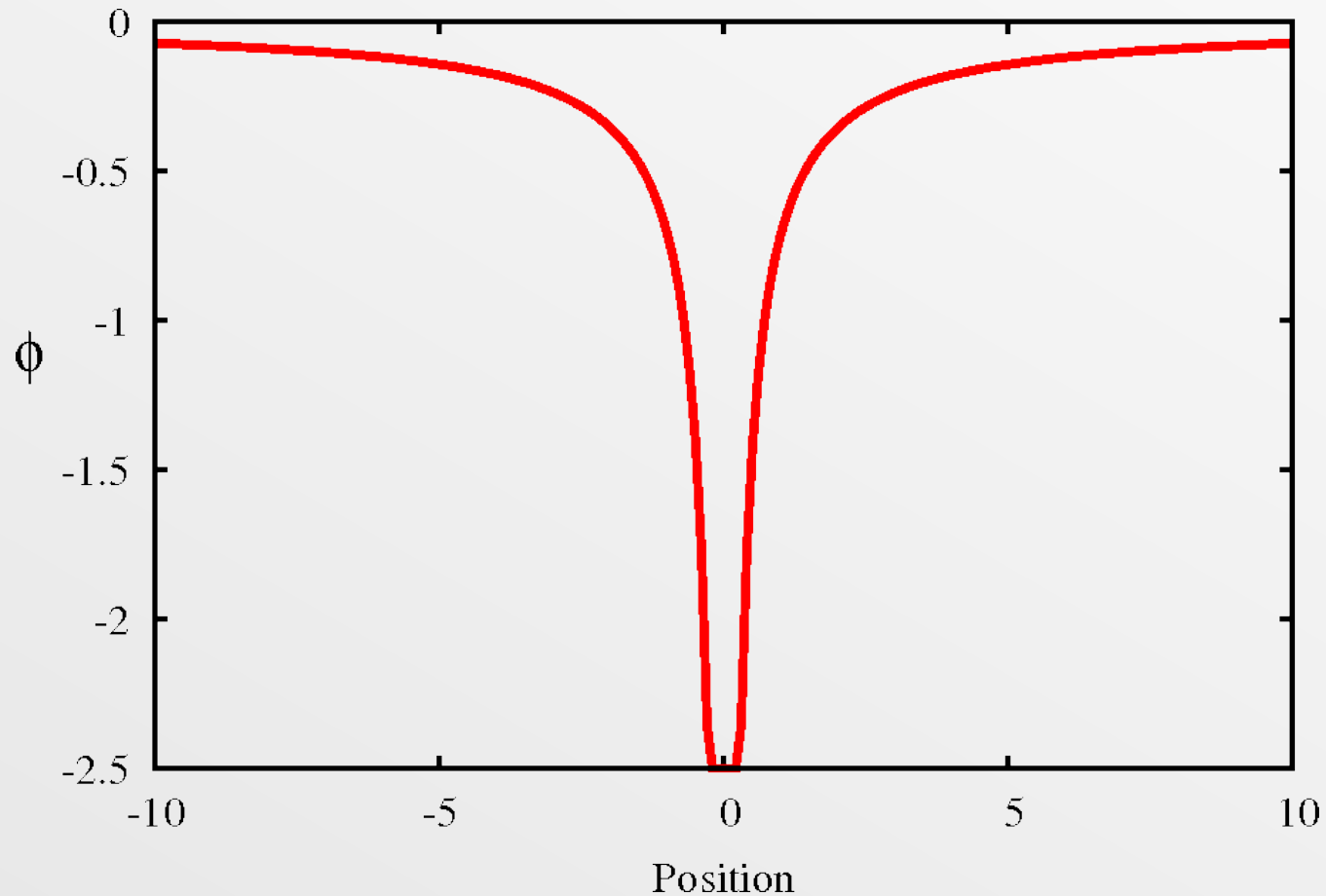
  2011 A&A 528,114

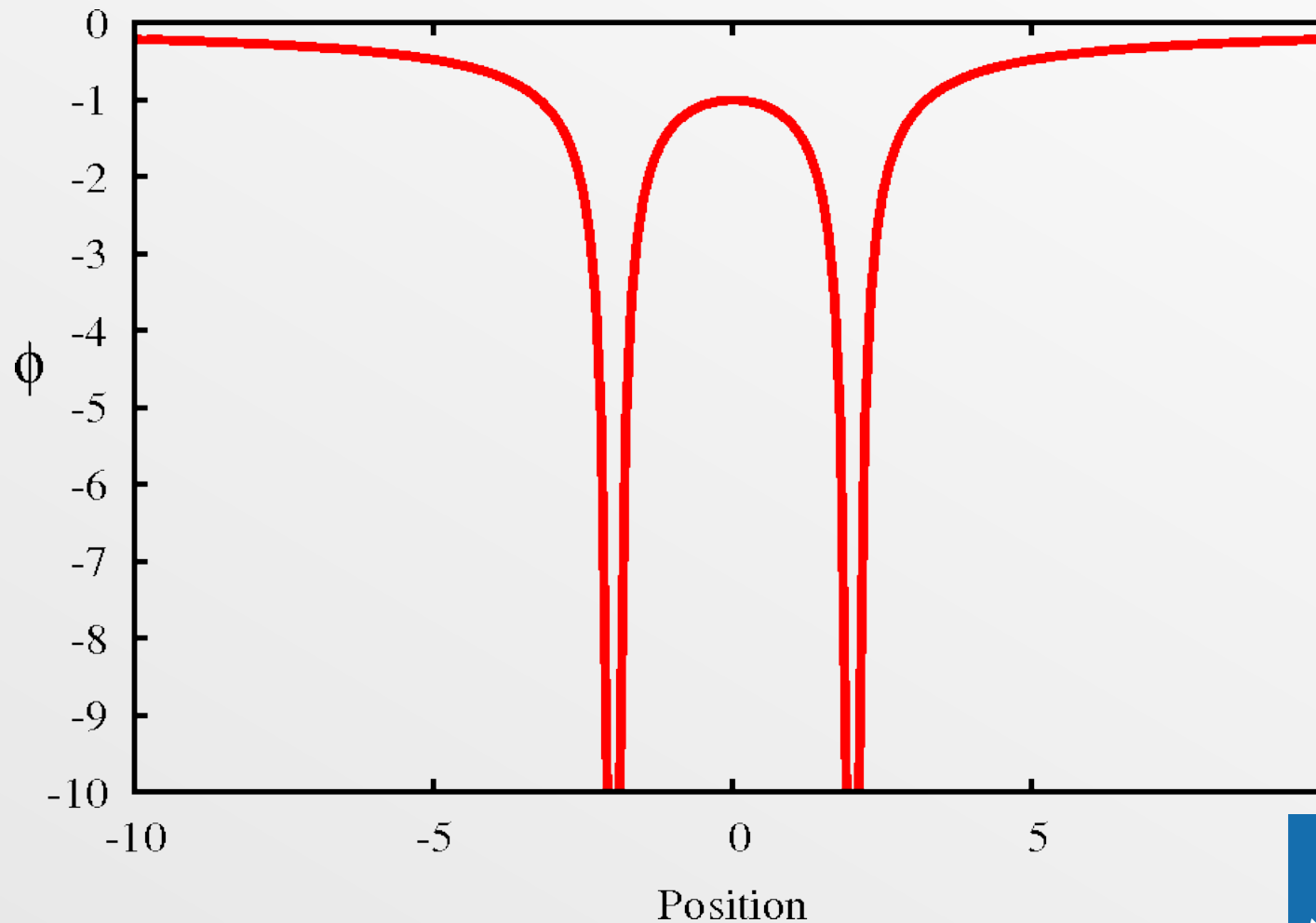# **Potential**

$$\phi = -\frac{GM}{r}$$

- Potential due to a point mass (star~point!)



Binary Stars 3

# Potential

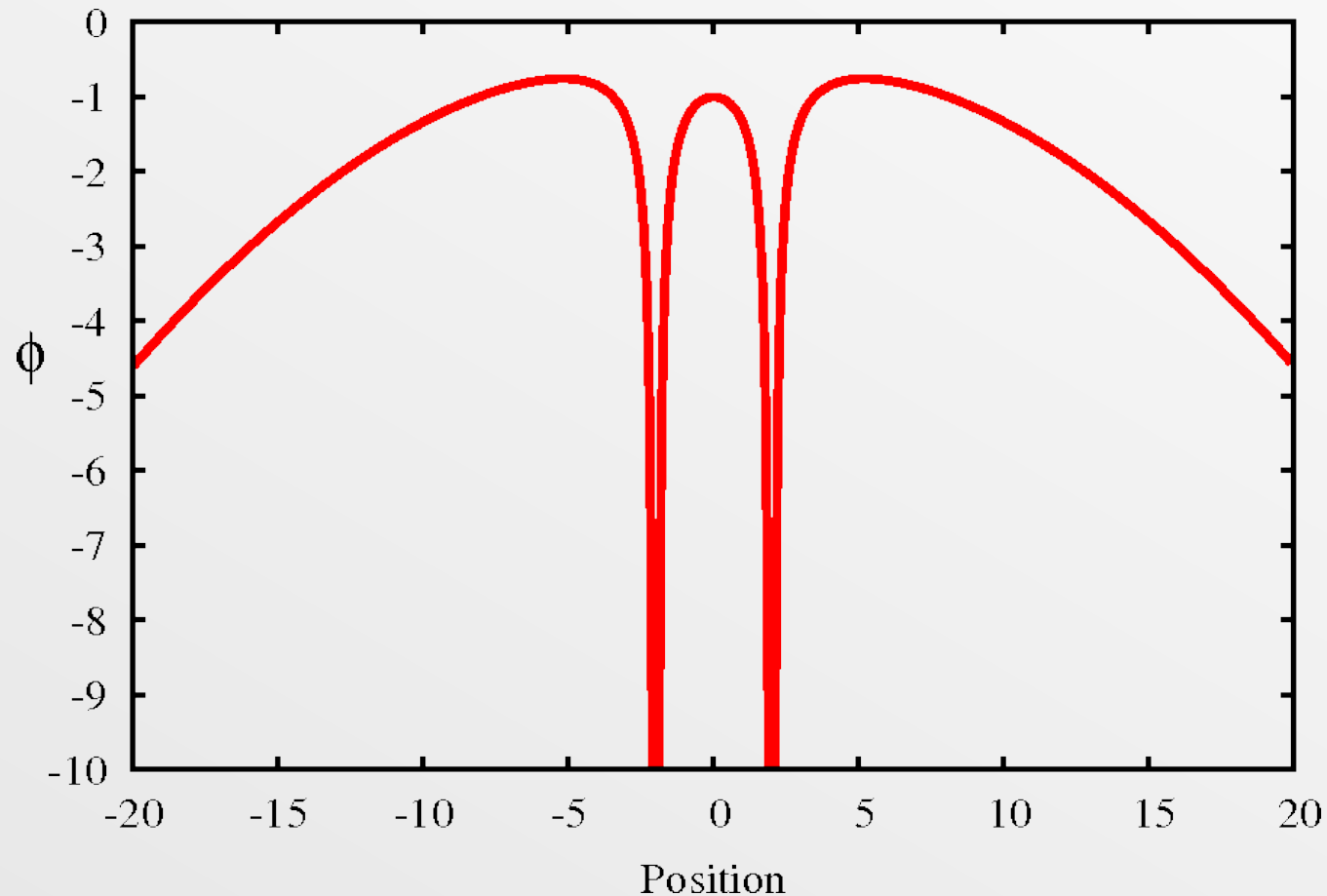$$\phi = -\frac{GM_1}{r_1} - \frac{GM_2}{r_2}$$
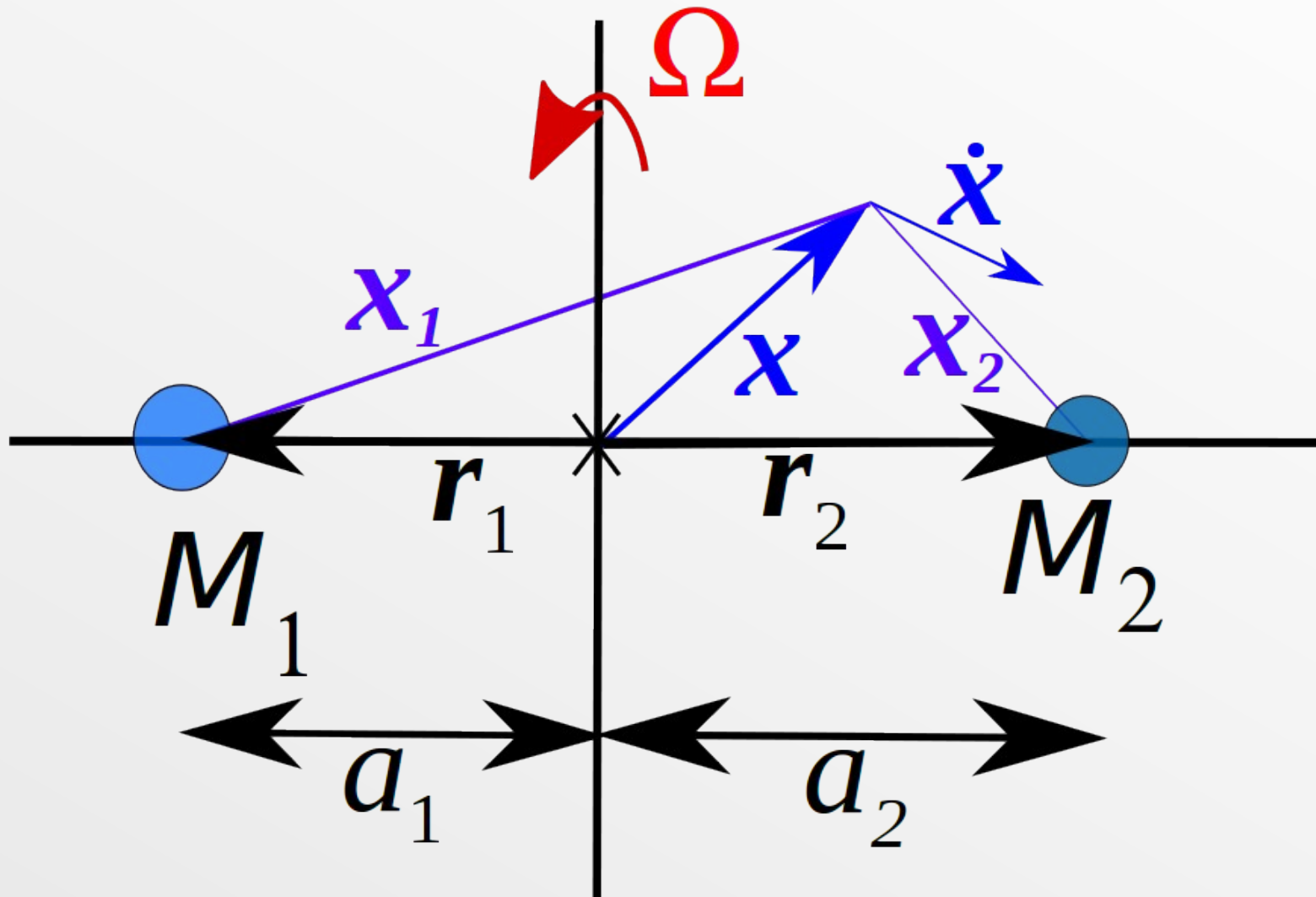
- Potential due to two point masses

# Potential

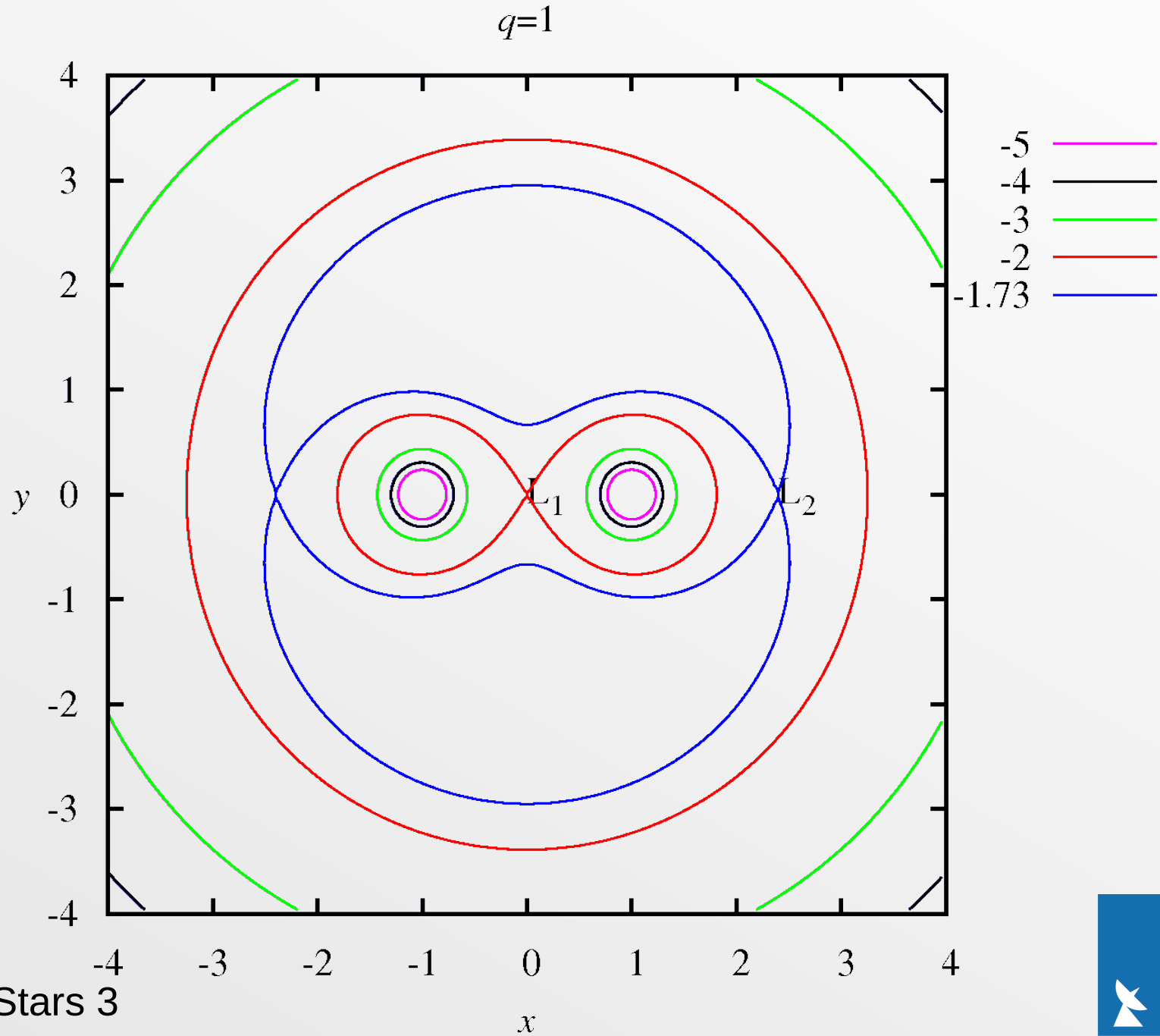$$\phi = -\frac{GM_1}{r_1} - \frac{GM_2}{r_2} - \frac{1}{2}\omega^2 s^2$$

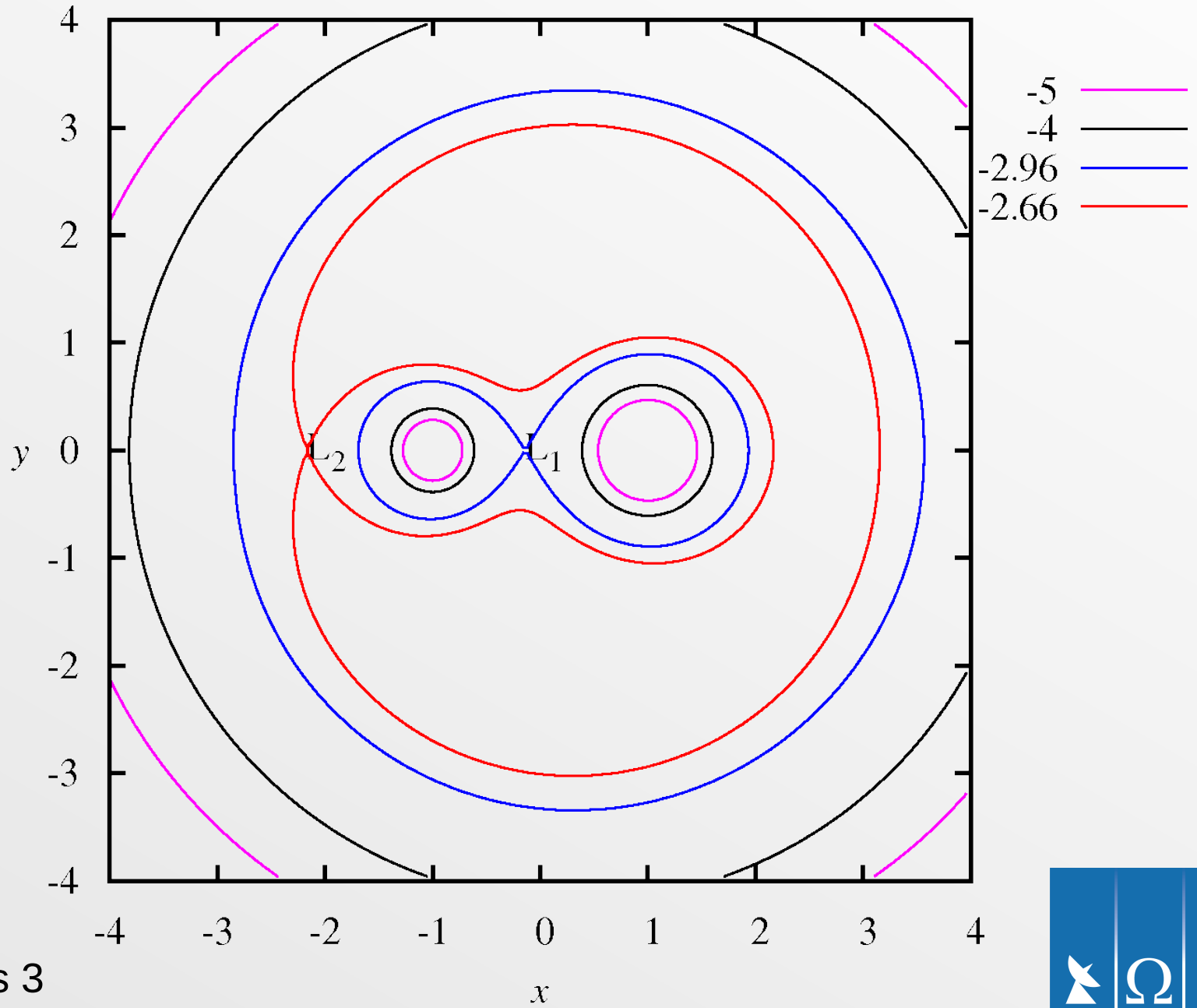- Potential due to two point masses in *corotating frame*
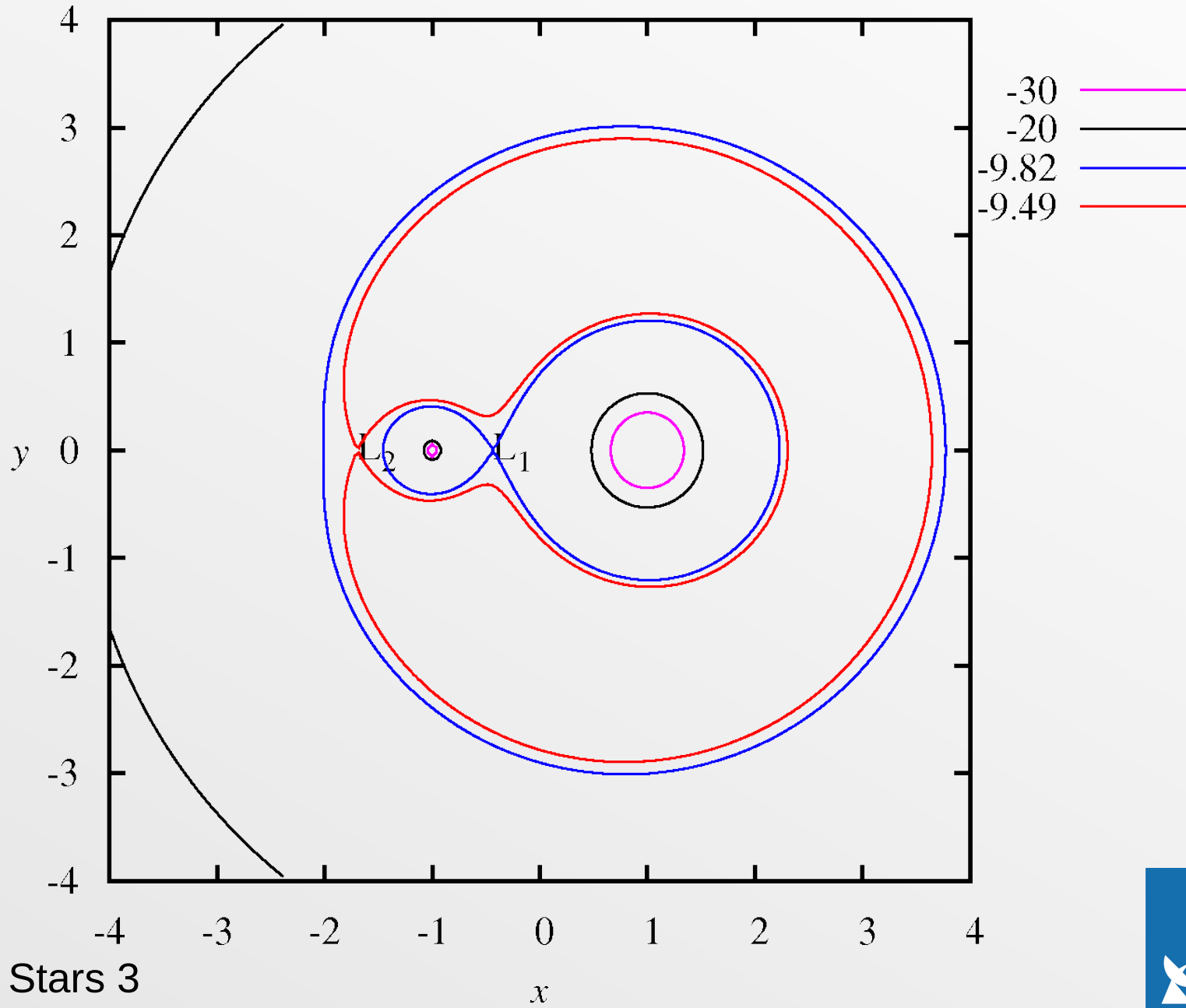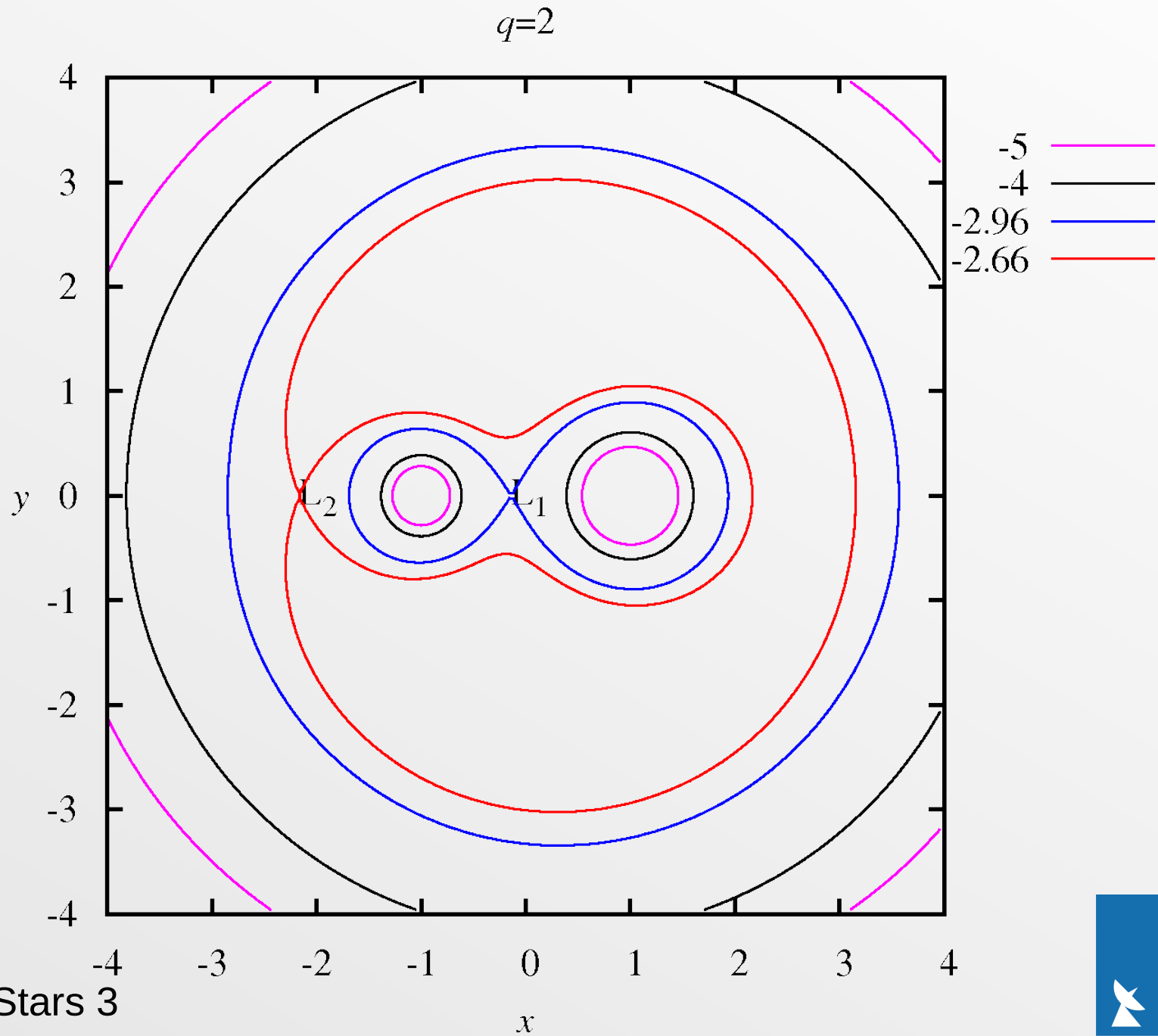
# Roche potential

# q=1

# q=2

# q=10

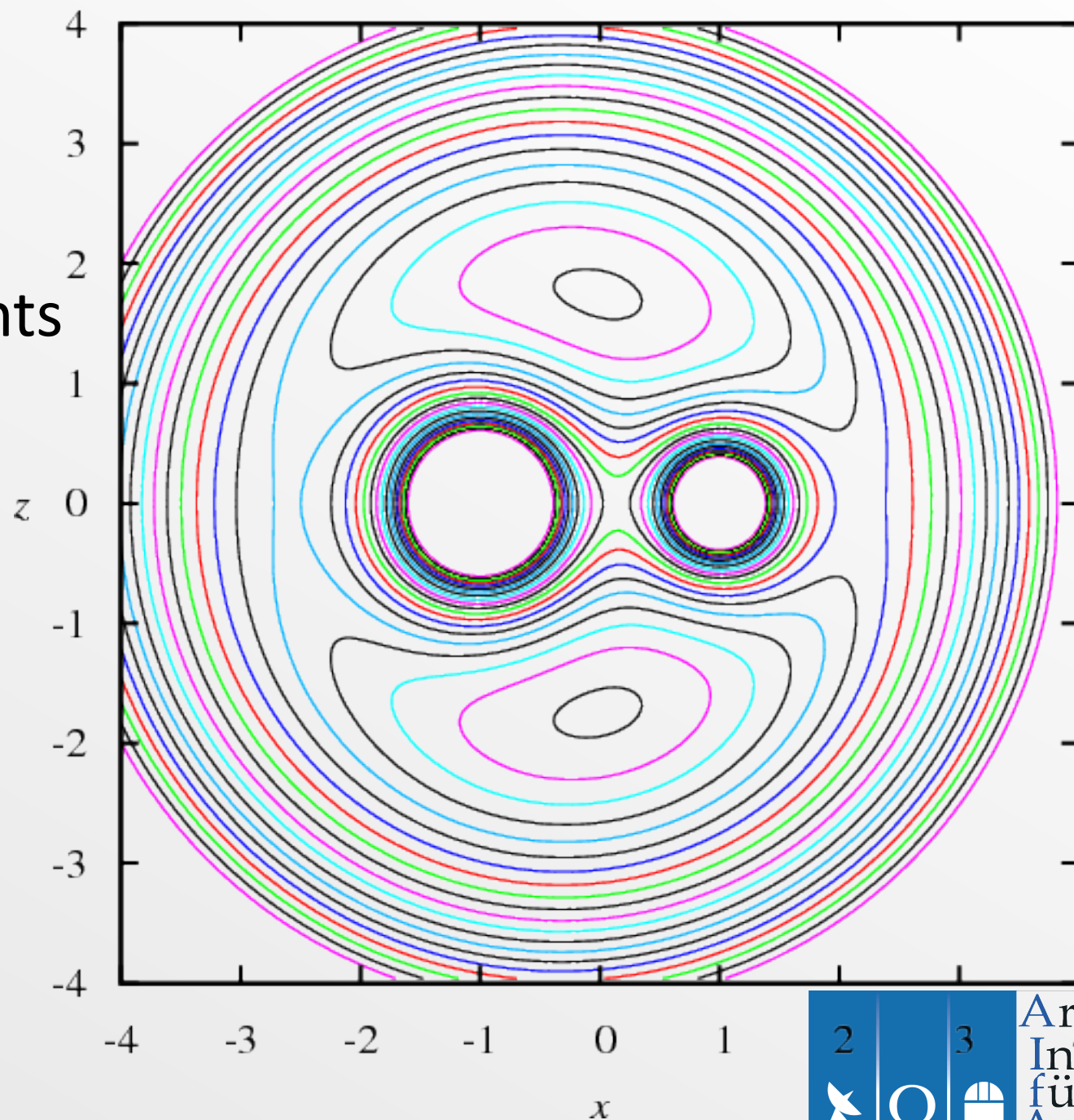# q=2

# L$_4$ and L$_5$

$q{=}0.5$



- Off-axis Lagrange points
- Potential Maxima
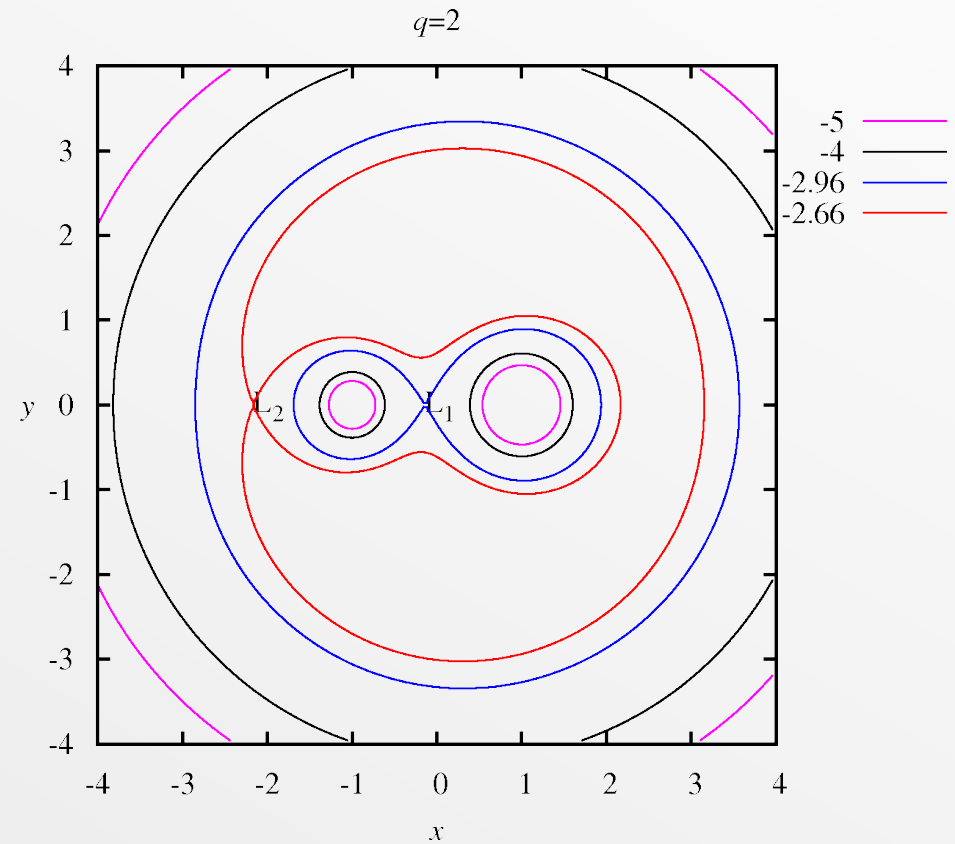- Not stable

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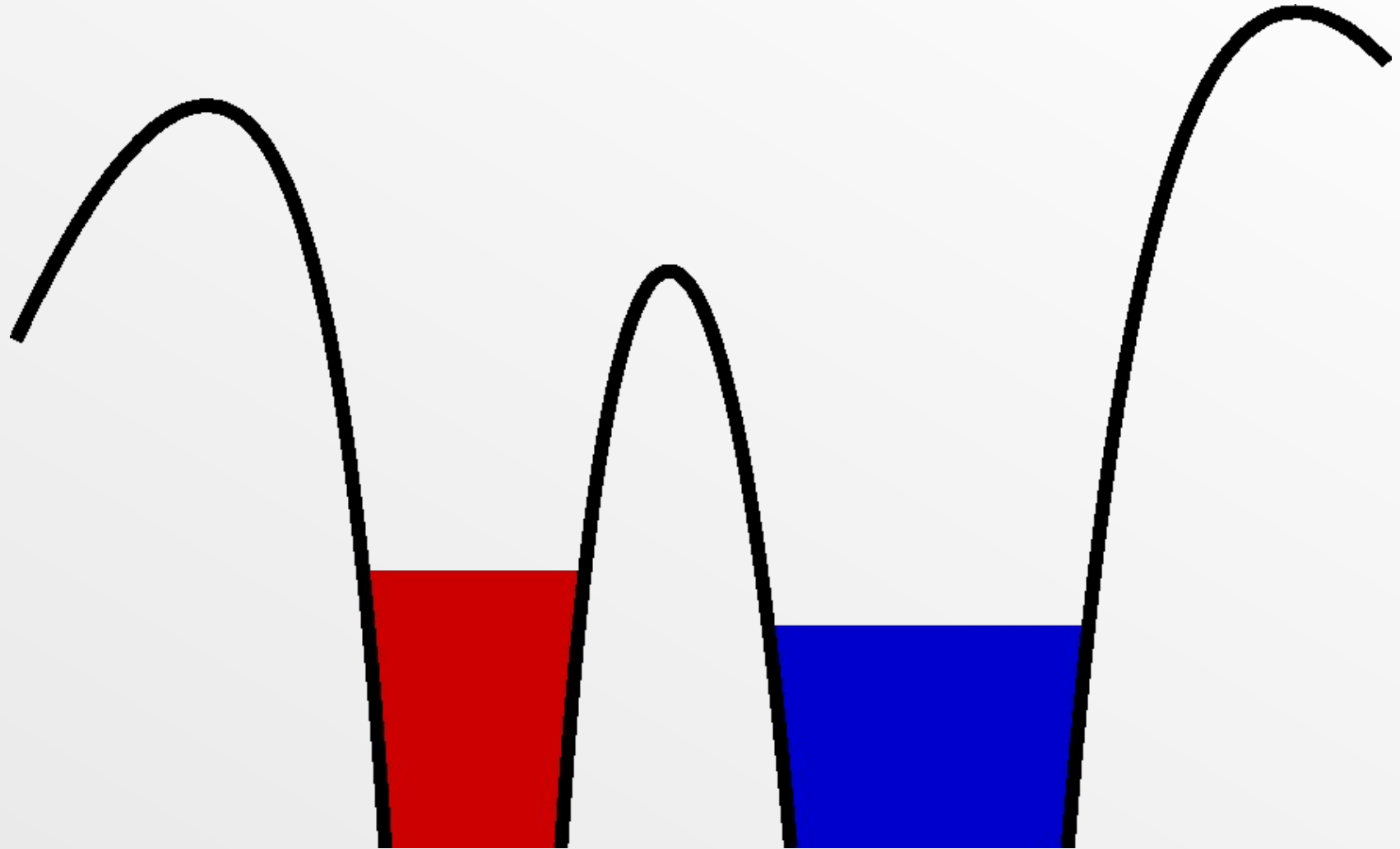Astrono

# *Binary* Stellar Evolution
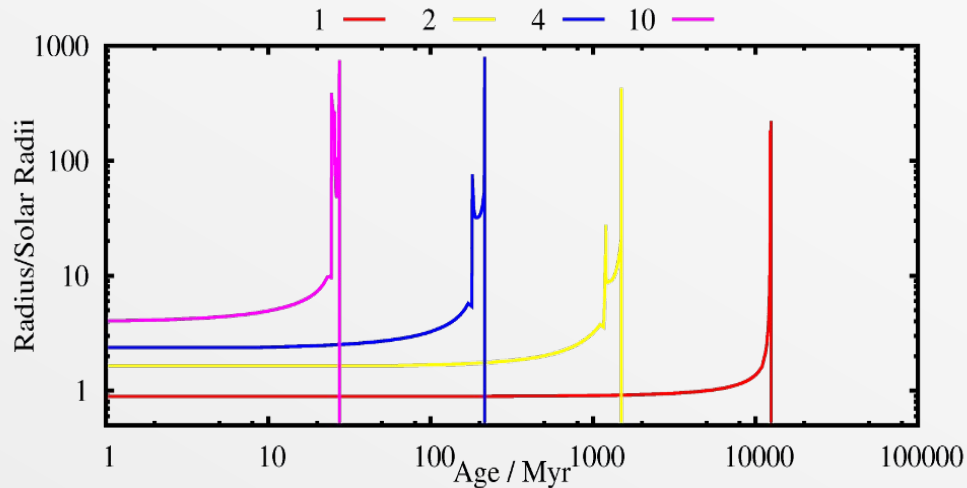


Radius increases with time
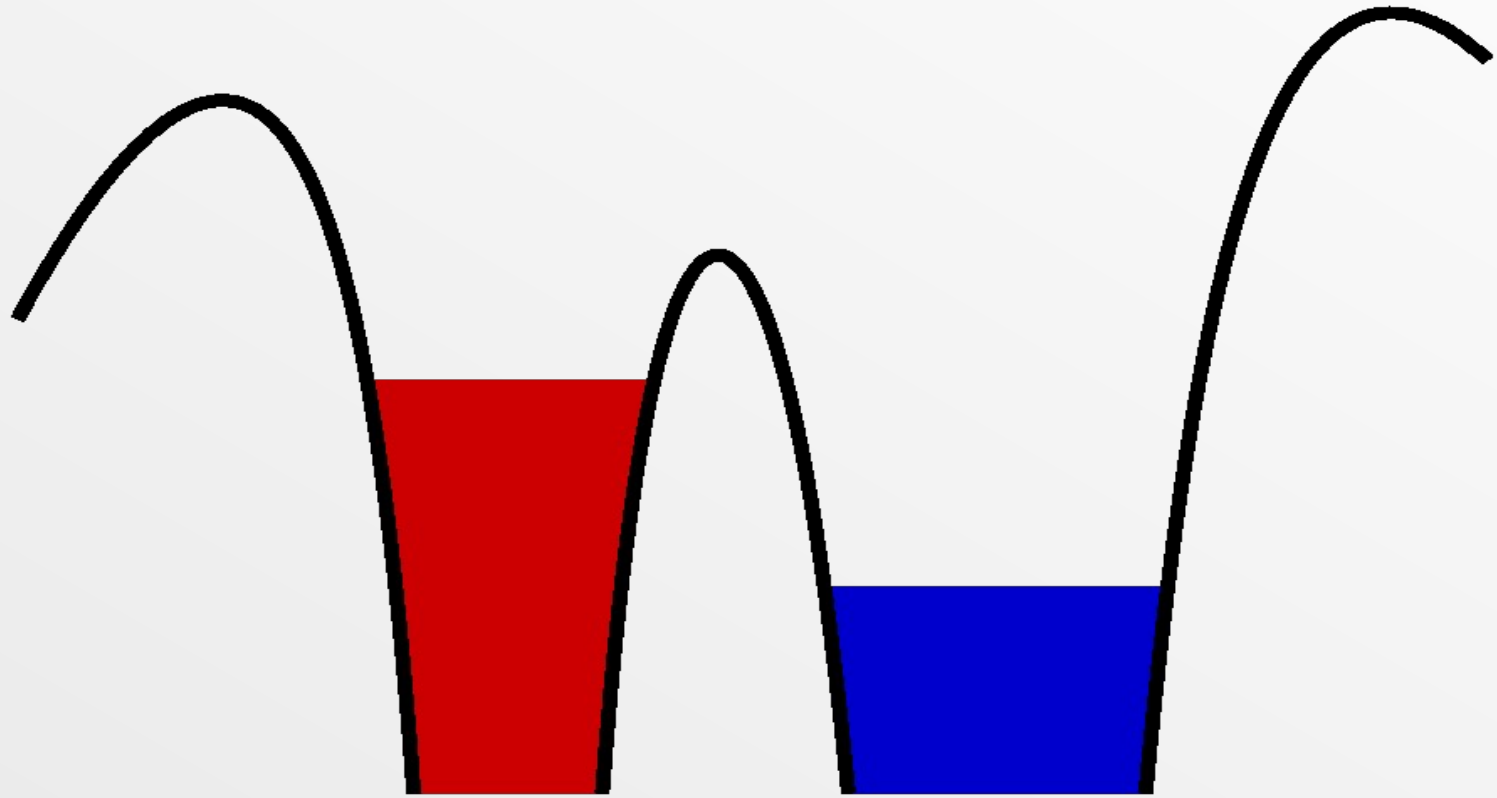
Star will eventually
     expand beyond $R_L$
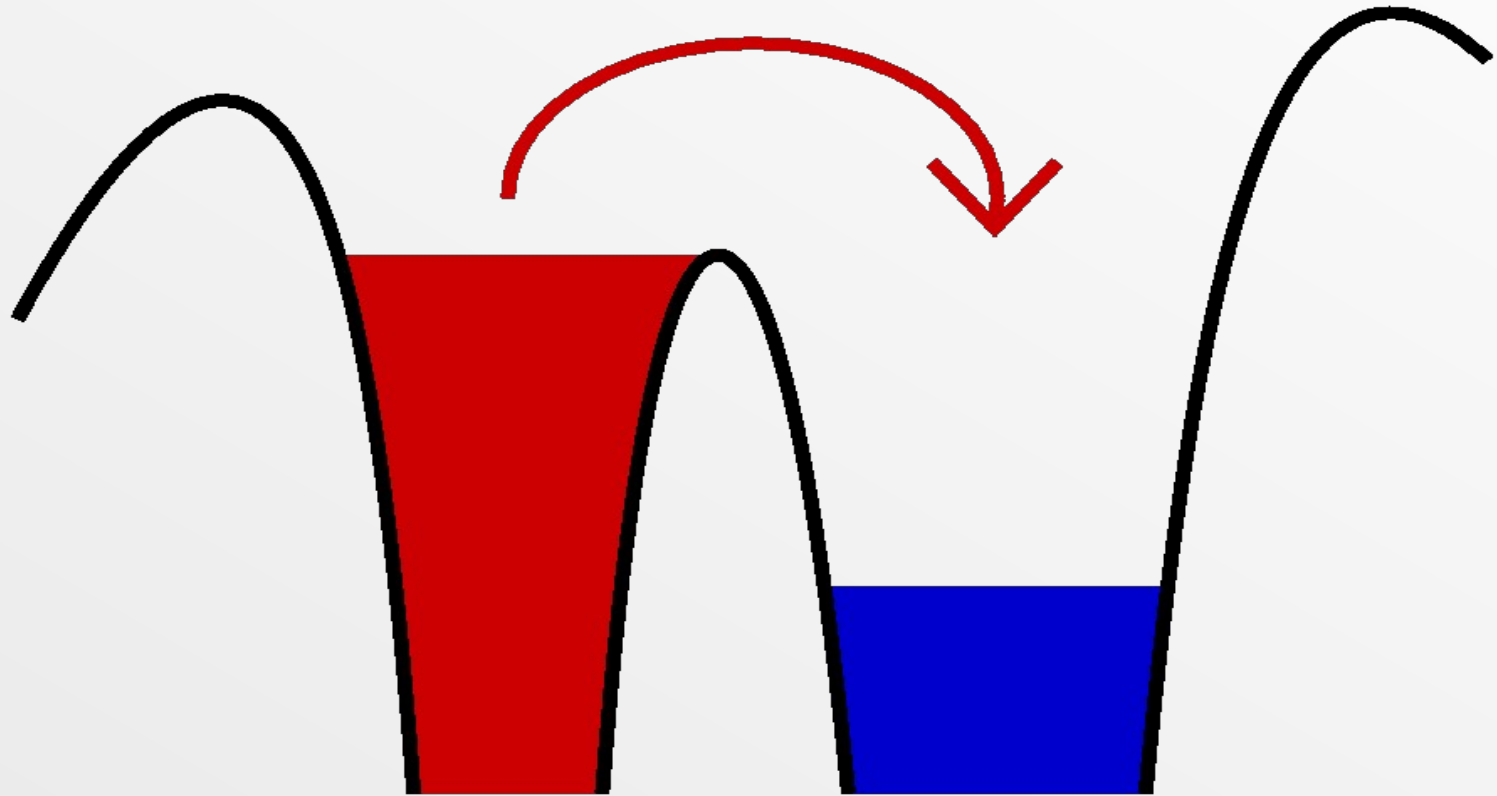
… Then what?
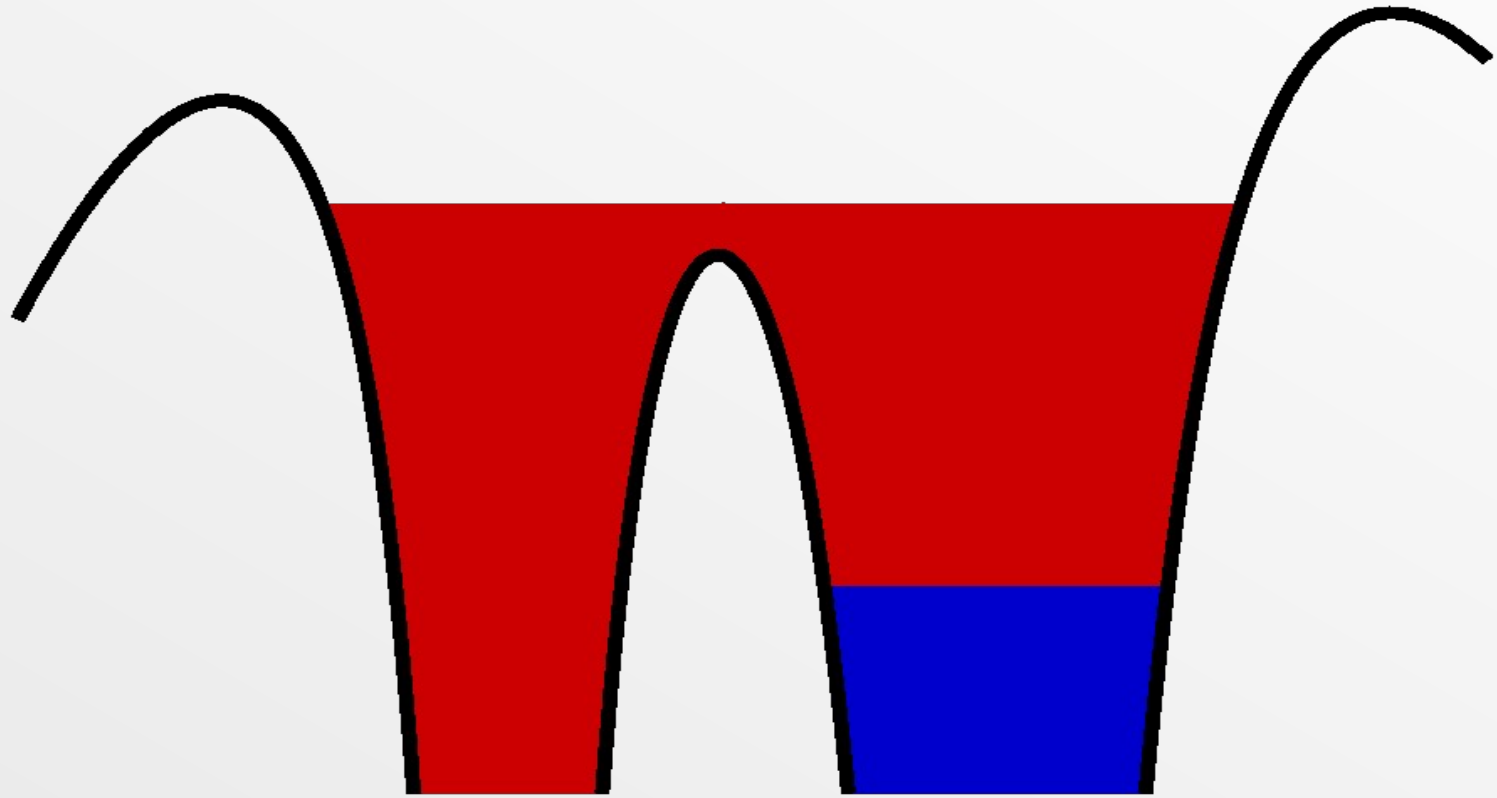
# Detached binary

# Evolved Detached binary
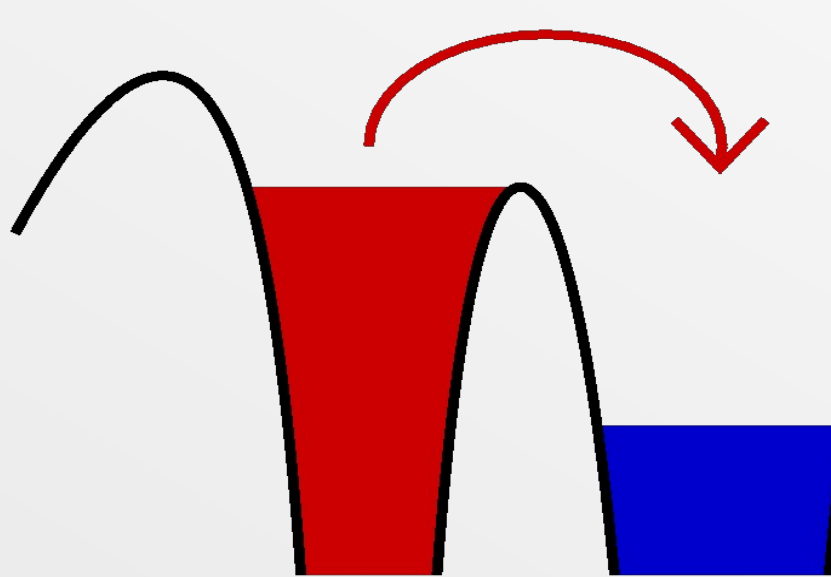
# Semi-detached Binary

## Roche Lobe Overflow

# Contact Binary

# Roche Lobe Overflow



- Primary expands
- $R > R_L$
- Mass "overflow"
- Questions:
- Conservative?
- Non-Conservative?
- Donor response
- Accretor response
- Final Fate…?

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