# ASTR 1040 Recitation: Mass Transfer

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# This Week

- Midterms Returned Tomorrow – Hooray!!
- Homework Due Tomorrow – Hooray??

# Today's Schedule

- Past / Current Homework Questions?
- Basics of Mass Transfer
- Roche Lobes
- Binary Systems

# Comments on Last Homework

- Quickly go over last week's homework
- Some stumbling points and how to get around them
- This may help for current homework

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- Core inert, still contracting, H shell dumps He onto core
- Temp in core rises, but not pressure (inert)
- Temp rises to $\sim 100 \times 10^6$ K, He fusion in core starts

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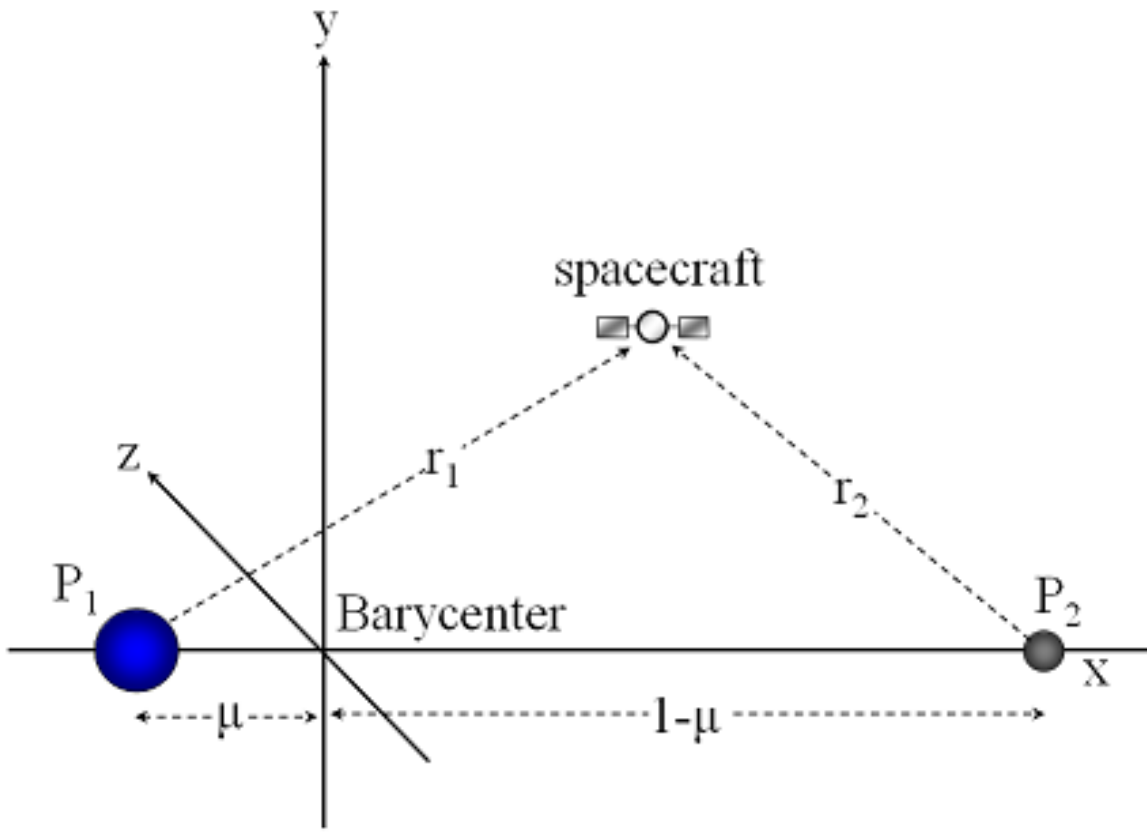
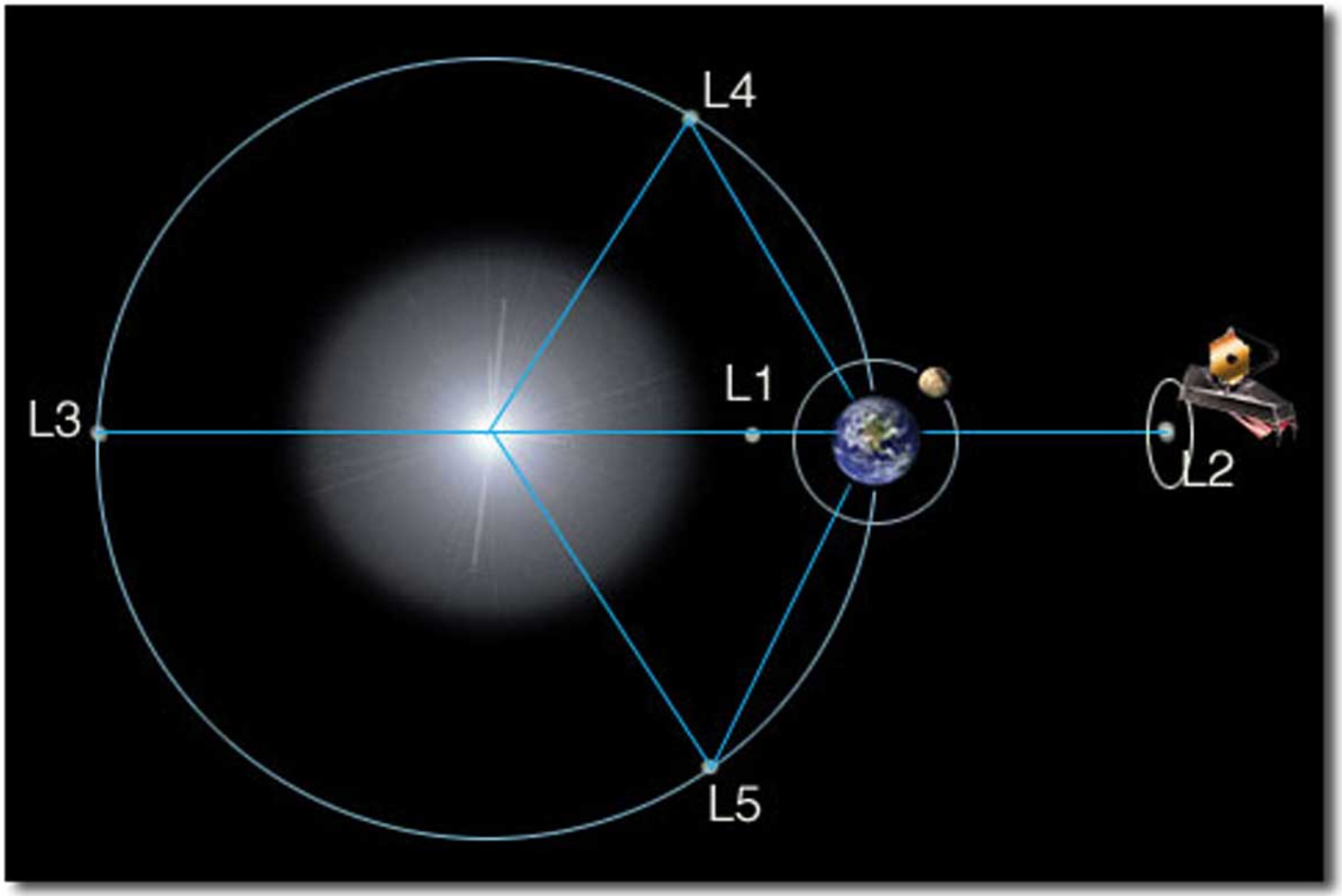
- Result: planetary nebulae and white dwarf with C core

# Lagrangian Points

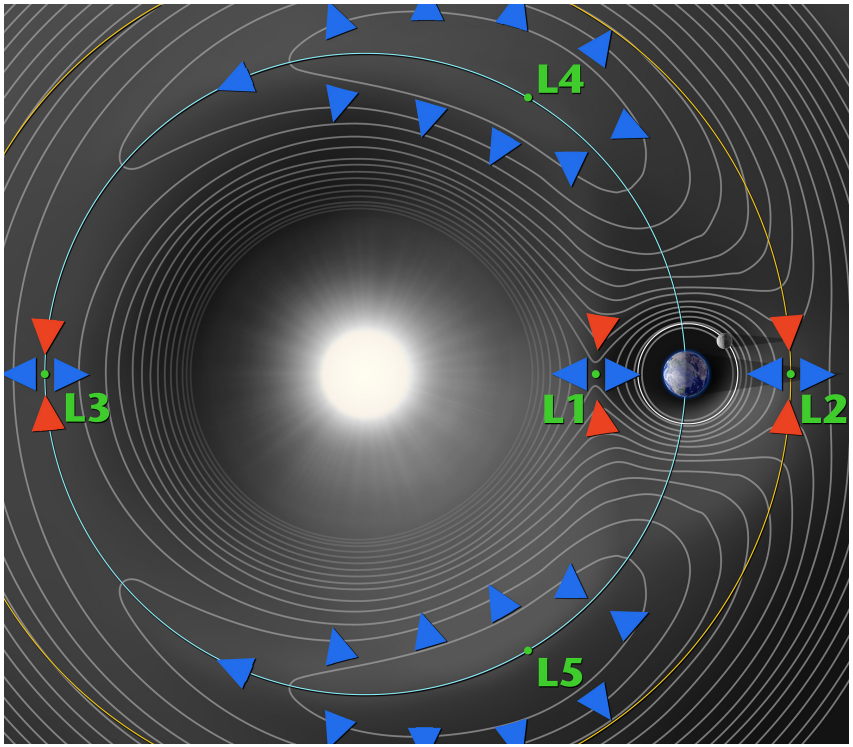
- Transform to the rotating frame
- In this frame, there is no net force on spacecraft at the Lagrange points
- Without transforming: combined gravity of two objects keeps spacecraft in orbit

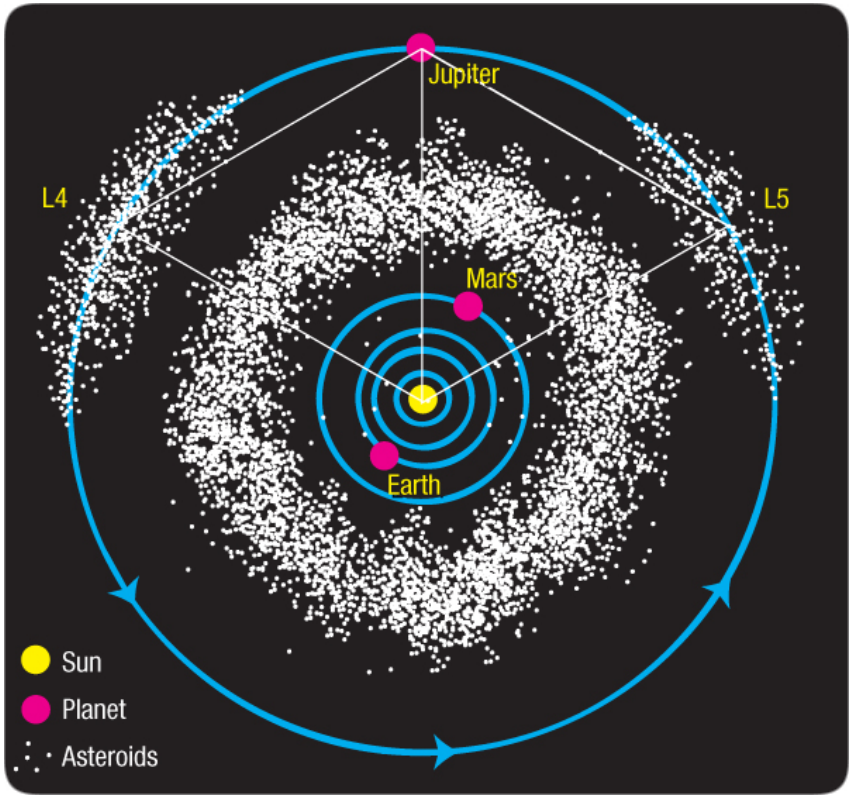


# 5 Special Points

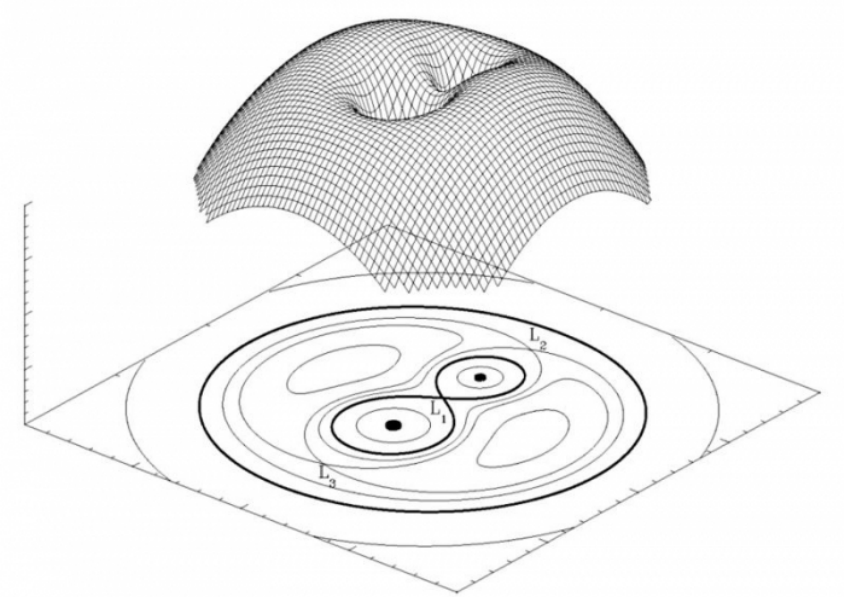


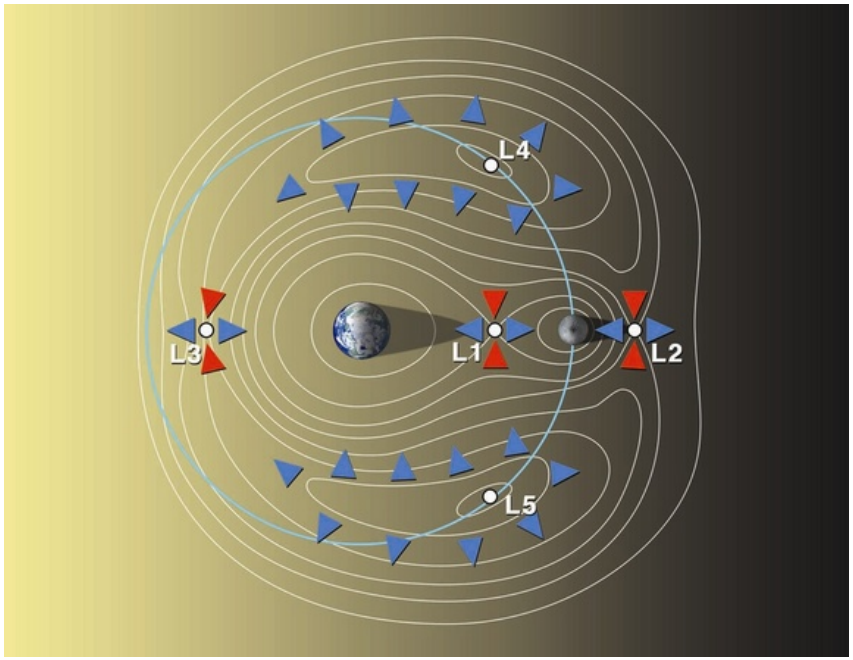
# Only Two are Stable



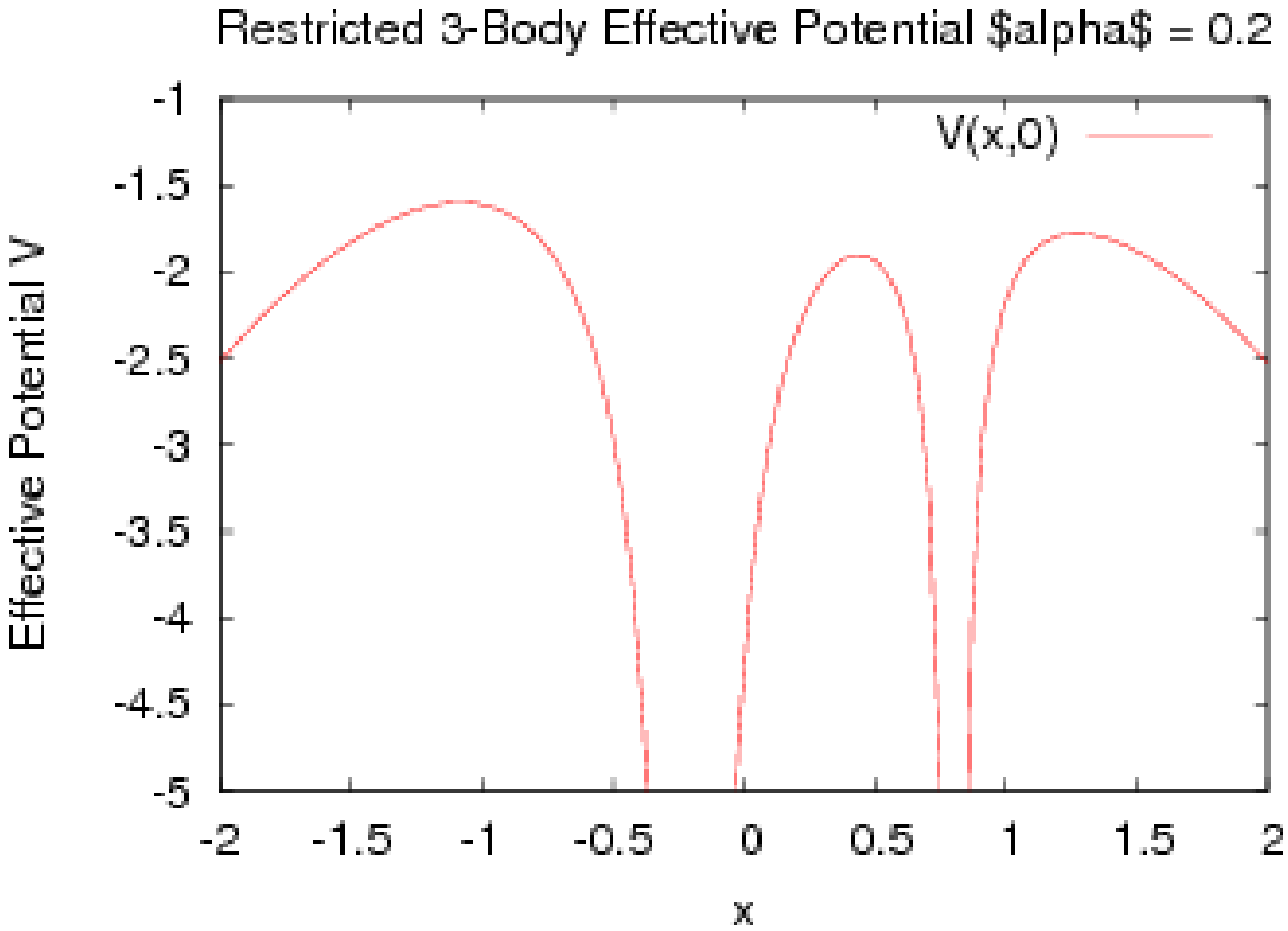



# The Other Three are Unstable



# Plot Gravitational Potential



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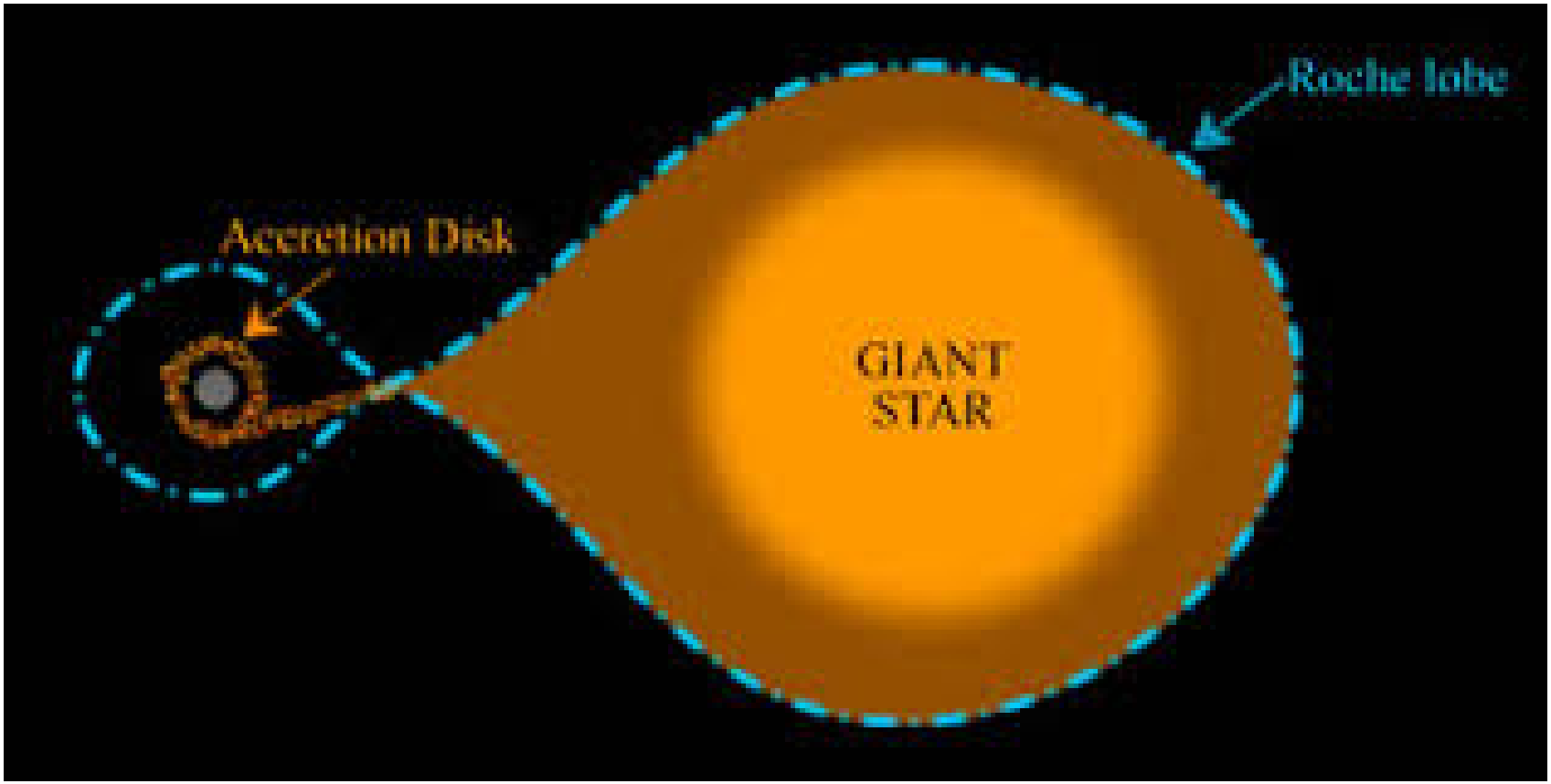
- Mass Transfer!!

# Roch Lobe Overflow



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- Massive stars evolve quicker: $t_{\rm MS} \sim M^{-3}$
- Observe Algol A on main sequence and Algol B as a subgiant star
- Algol A is more massive then Algol B
- Paradox??

# Algol Paradox – Not Really a Paradox

Algol A (more massive) is on main sequence
Algol B (less massive) is subgiant

- Suppose initially: $M_B = 3\ \mathrm{M}_\odot$ and $M_A = 1\ \mathrm{M}_\odot$

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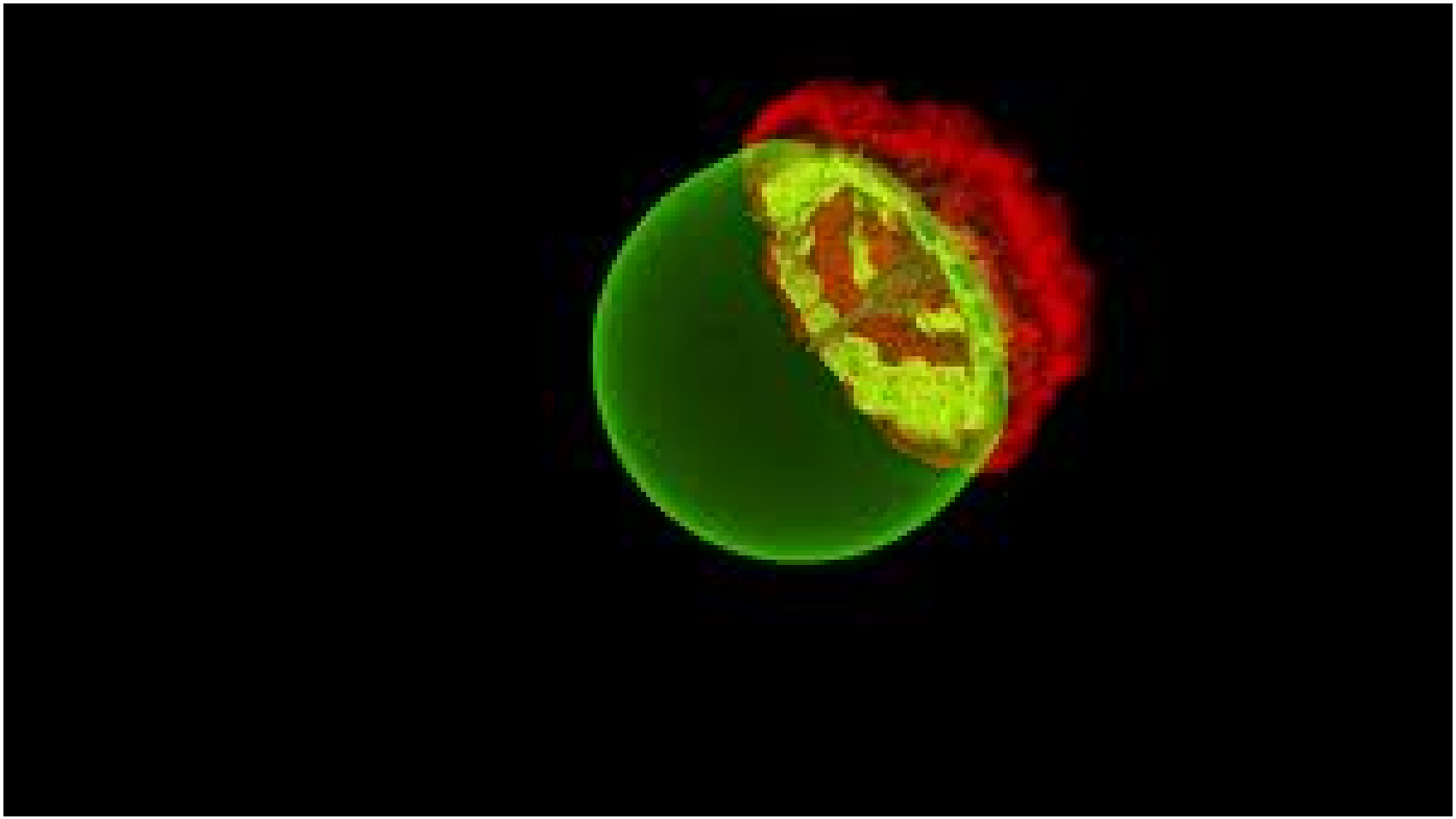
- As more mass transfers, $M_A \approx 3\ \mathrm{M}_\odot$ & $\mathrm{M}_B \approx 1\ \mathrm{M}_\odot$, while Algol A = MS, Algol B = subgiant

# Binary Stars That Go Boom – Type Ia

- Binary system with two different mass stars
- Massive one evolves first, transfers mass, mass ratio switches
- Massive star becomes white dwarf, no longer transfers mass
- Other star evolves, overflows its Roche Lobe, transfers mass onto WD
- If accretion rate is high enough, can ignite carbon fusion and star explodes

# Simulating Stars That Go Boom – Type Ia



Step 1: flame reaches the surface

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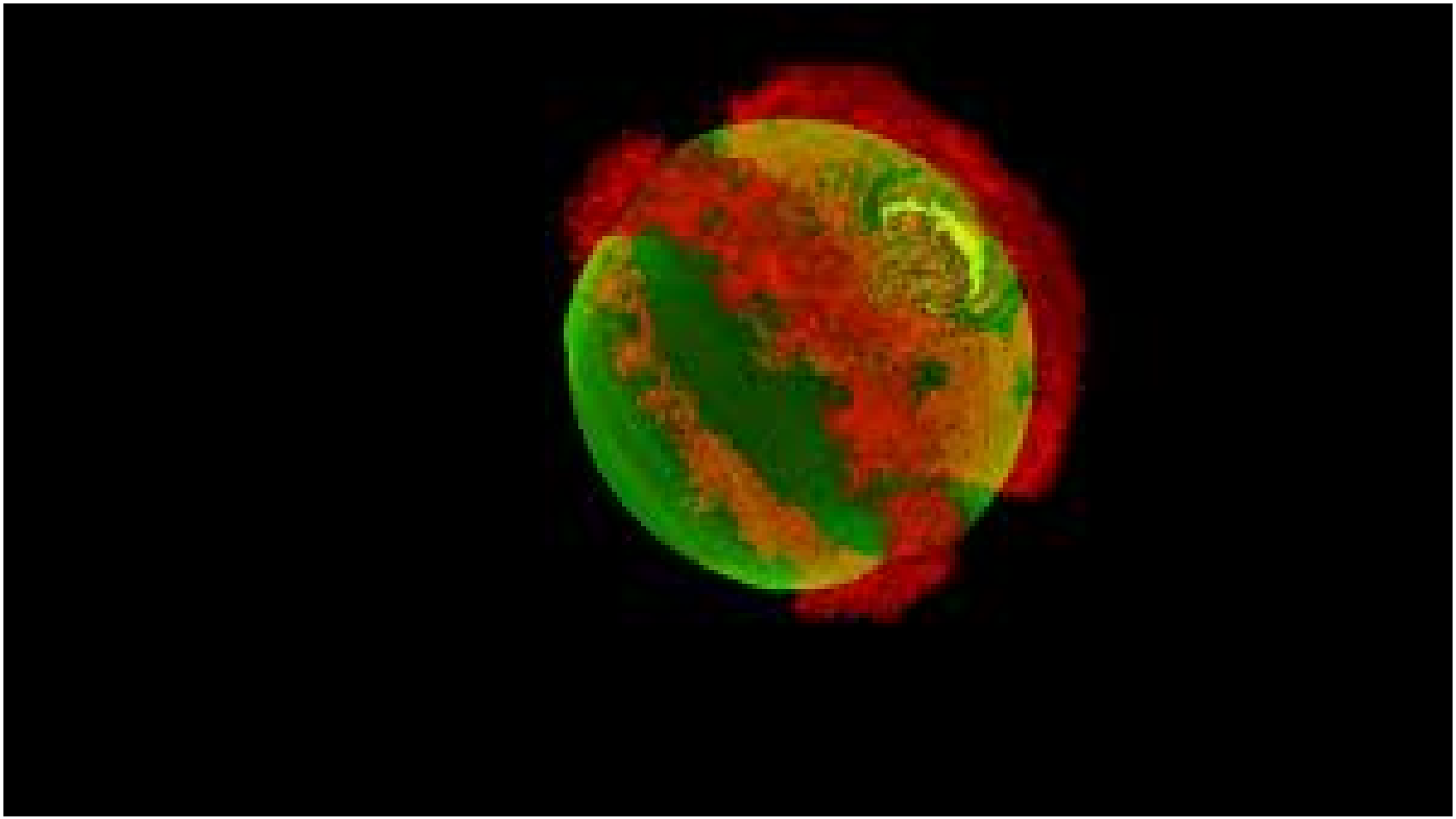

Step 2: flame travels along the surface, think water waves

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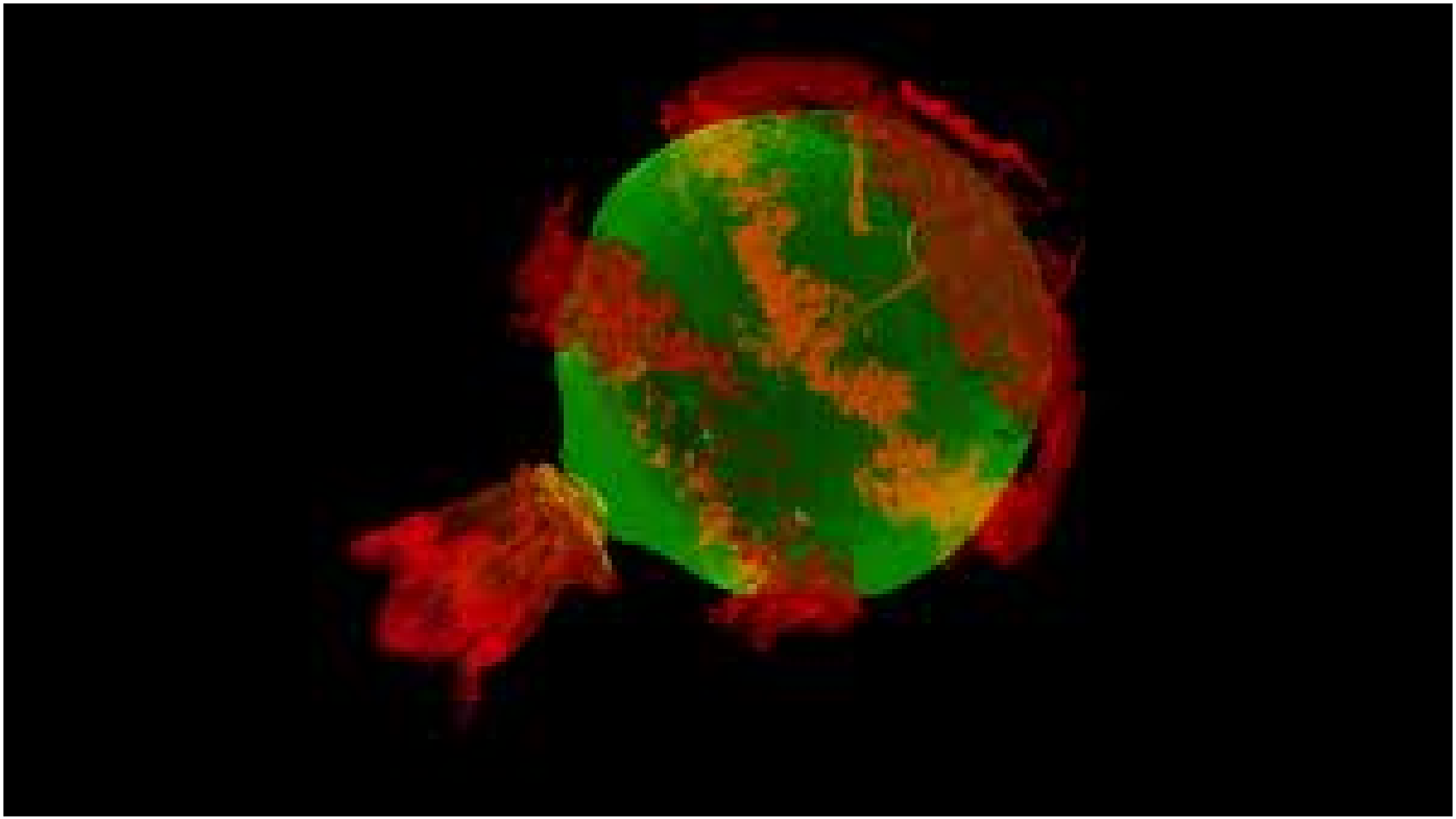
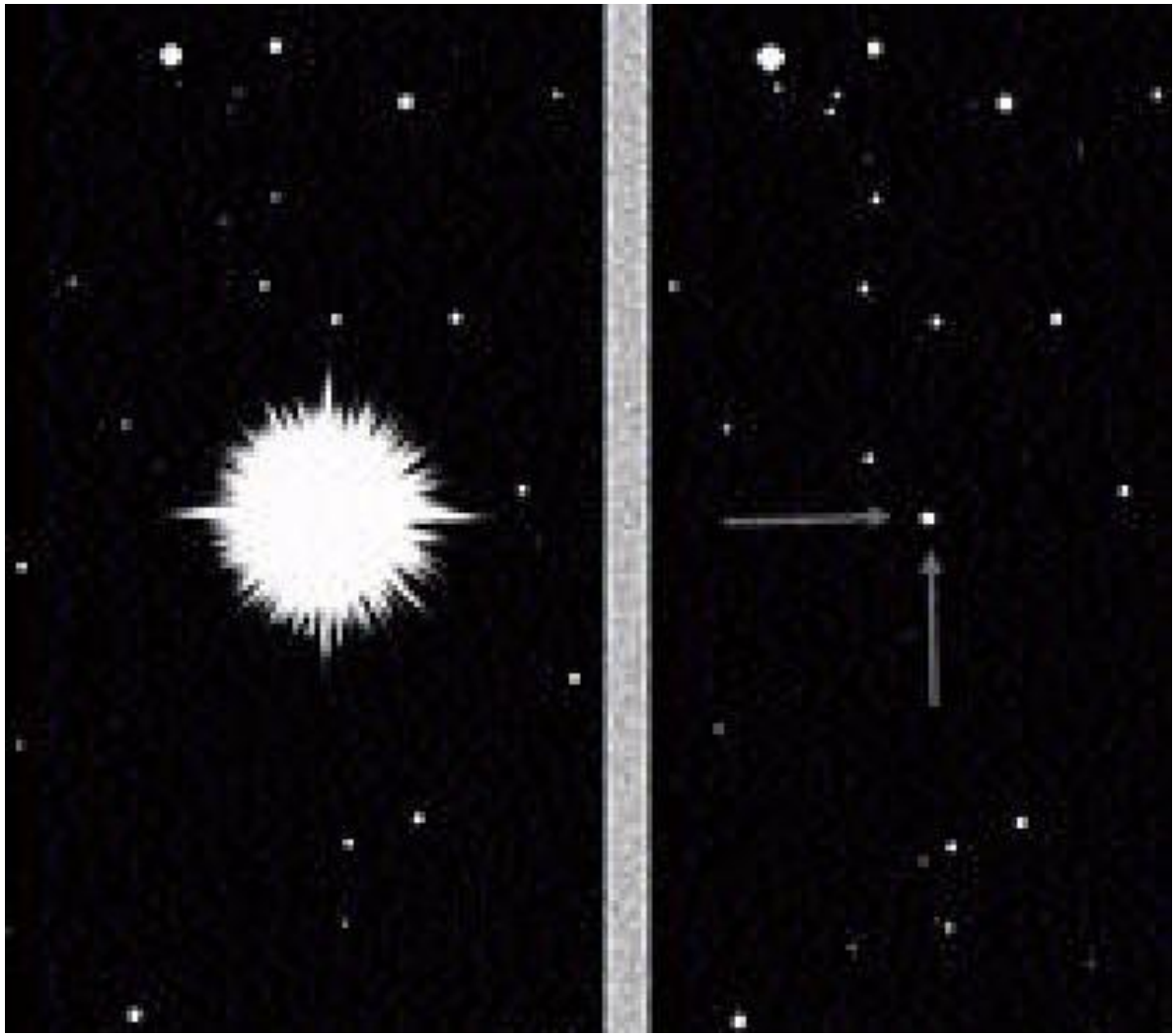


Step 3: the surface waves compress material at the other pole

# Binary Stars That Go Boom – Novae

- Evolution is the same as supernova (up to a point)
- End up with a white dwarf and a subgiant star that transfers mass to WD
- Accretion rate is smaller then SNe case
- Mass piles on WD in a slow manner, only enough to ignite H/He on surface
- Surface explosions, sometimes more then one

# Binary Stars That Go Boom – Novae



Zoomed in on left, regular field of view in right

# Binary Stars That Go Boom – Other Possibilities

- Could have a neutron star - regular star systems
- Could have a black hole - regular star systems
- Could have a neutron star - neutron star systems
- Could have a neutron star - black hole systems
- Could have a black hole - black hole systems

# Do We See These Systems?

Black Hole: Cygnus X-1

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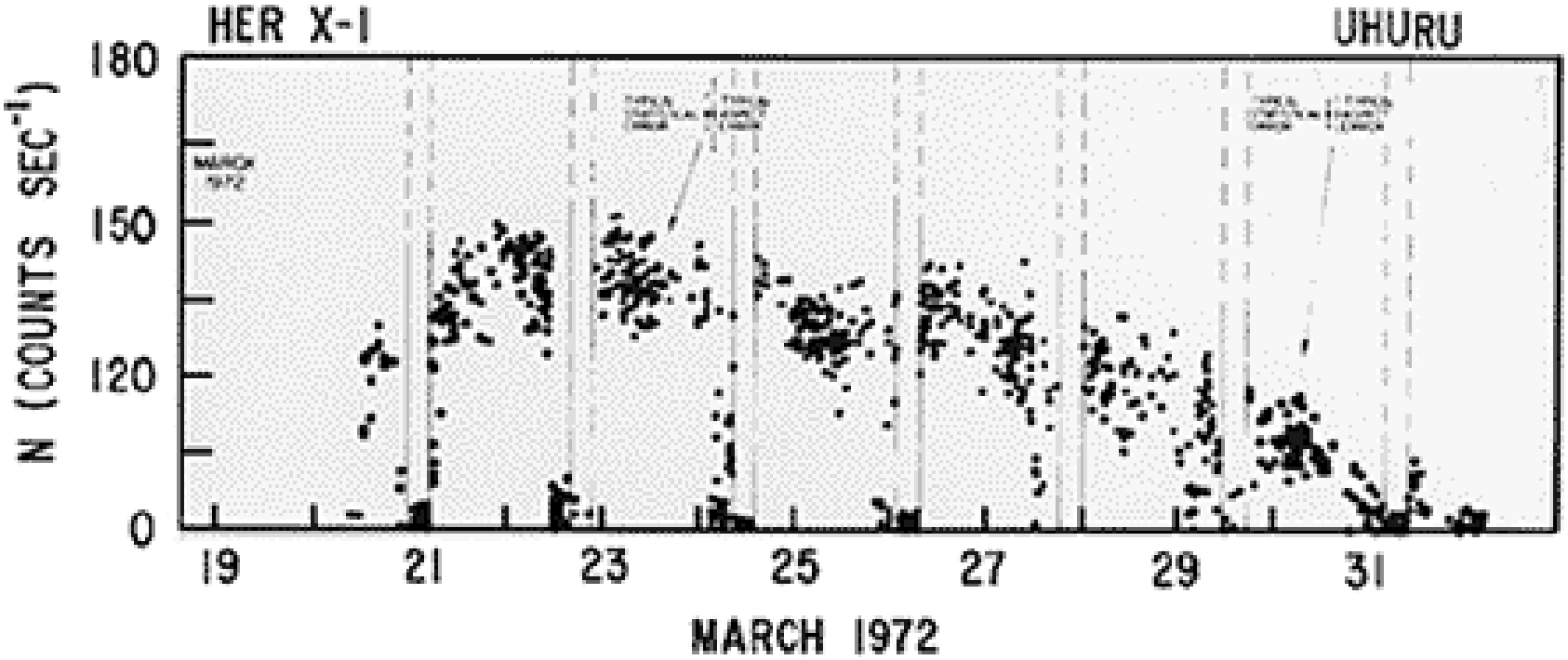


Neutron Star: Hercules X-1