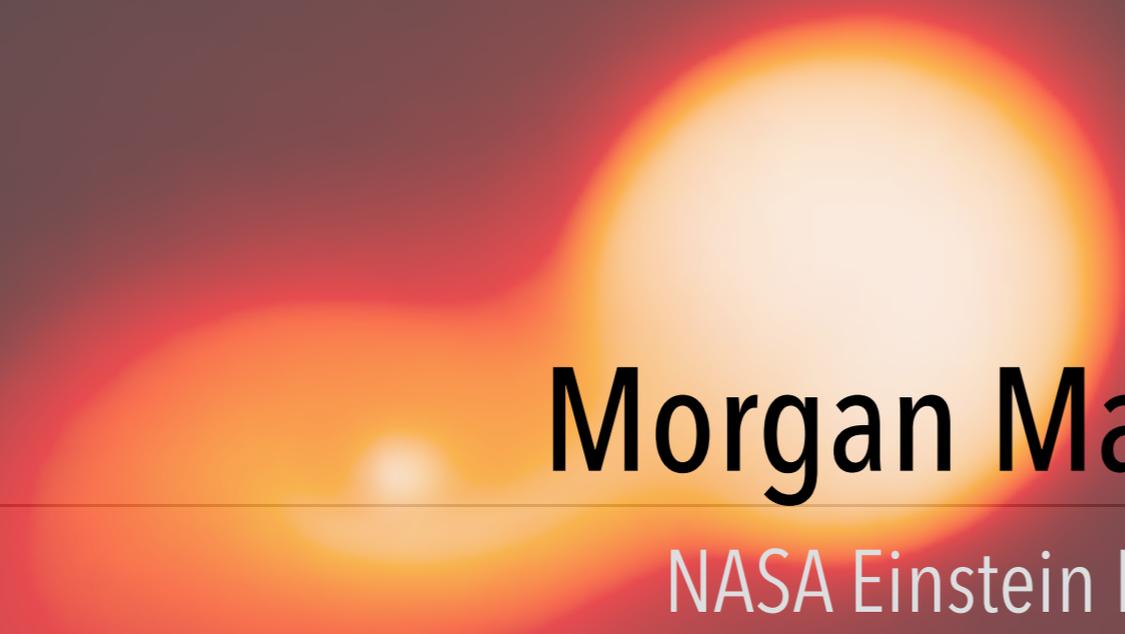


Illuminating the Night Sky with Common Envelope Events



Morgan MacLeod

NASA Einstein Fellow

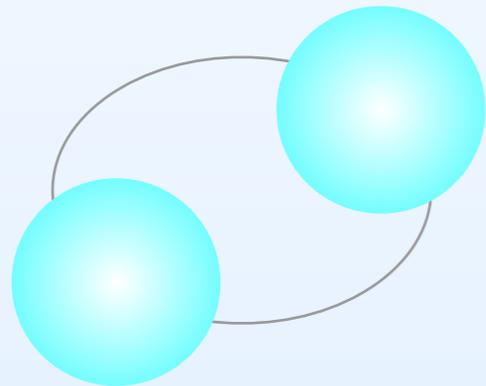
Smithsonian Astrophysical Observatory

Einstein Fellows Symposium
Oct 12, 2017

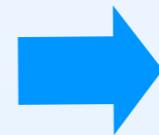
Common envelope interactions transform binary systems

Example: formation of merging pairs of neutron stars

Pair of massive stars
($>8x$ sun's mass)



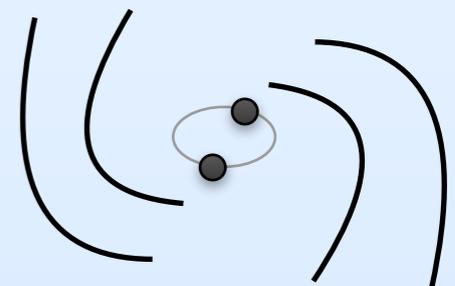
draws the binary
closer together



much closer pair of
neutron stars



gravitational wave
inspiral

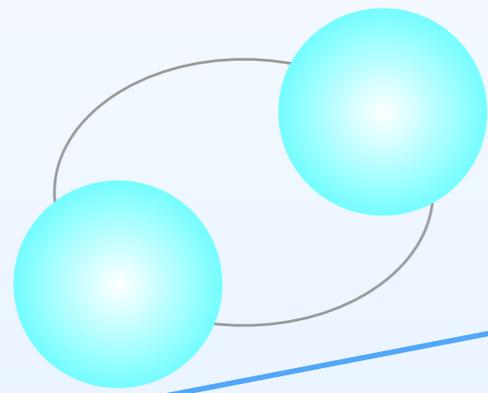


Orbital transformation is key in
formation of compact binaries

Common envelope interactions transform binary systems

Example: formation of merging pairs of neutron stars

Pair of massive stars
($>8x$ sun's mass)



**Common
Envelope
Phase**



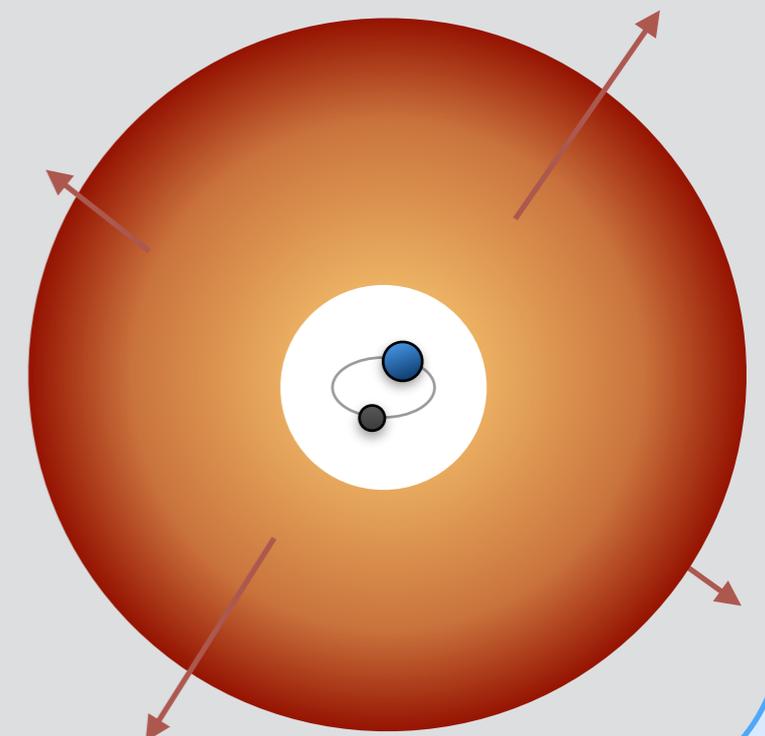
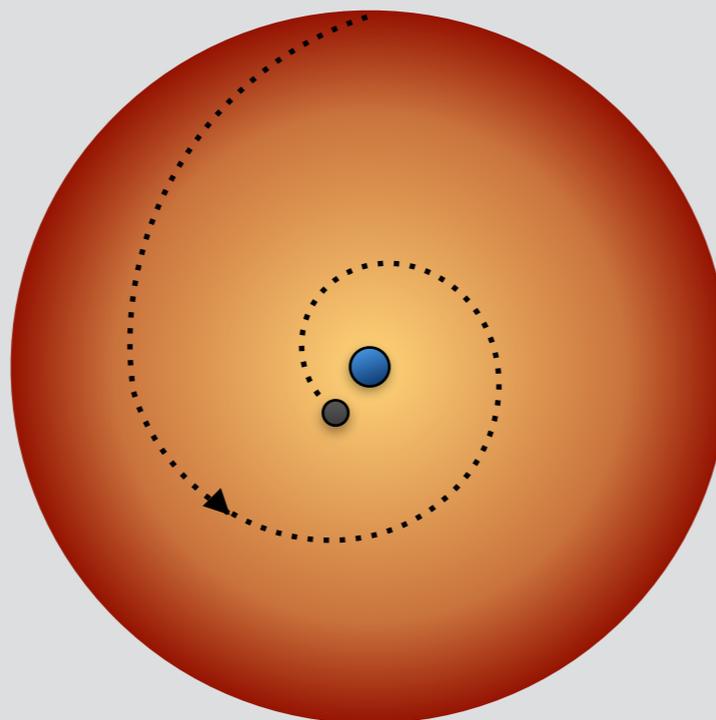
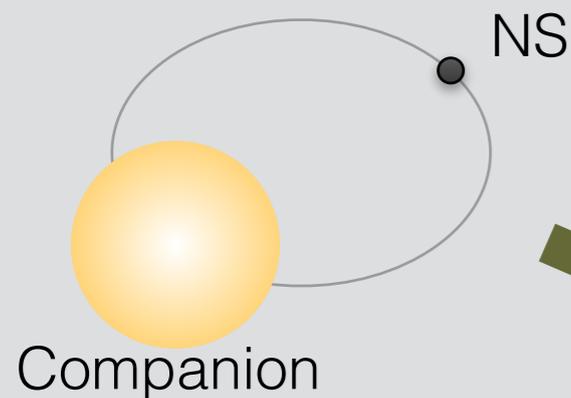
much closer pair of
neutron stars



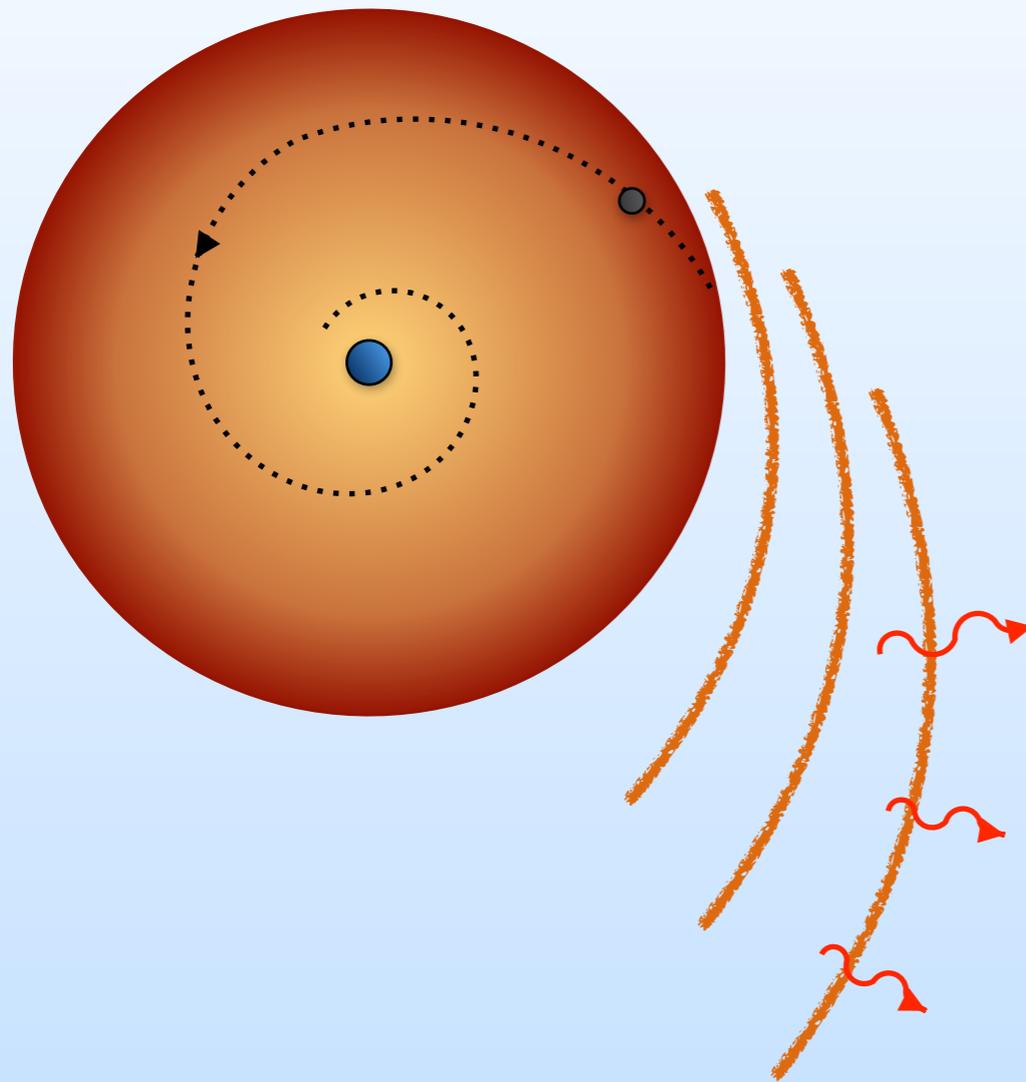
Drag on surrounding
gas tightens the orbit

Orbit stabilizes as
envelope is ejected

Evolution to contact

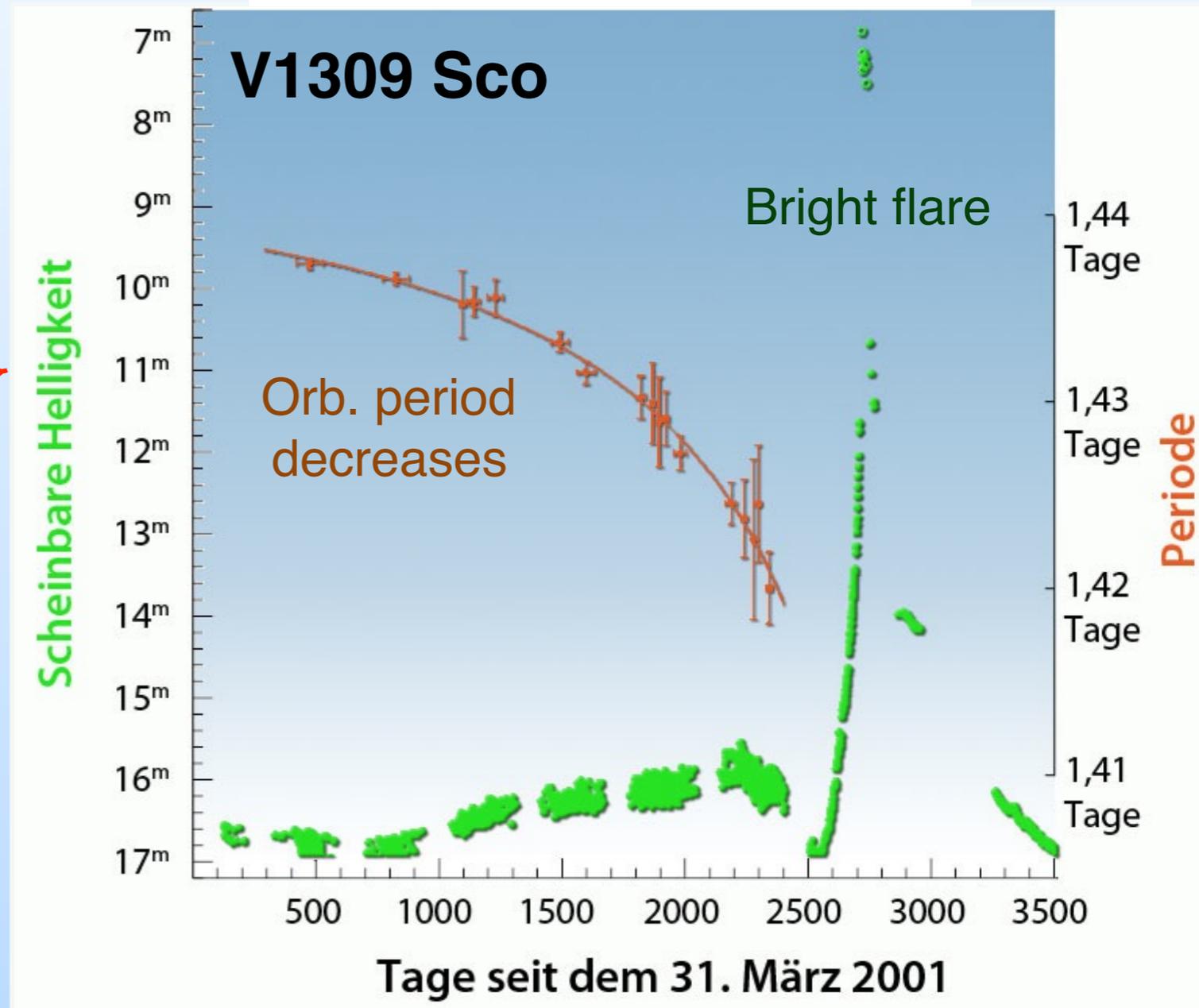


CE transients



hot ejecta radiate
as they cool

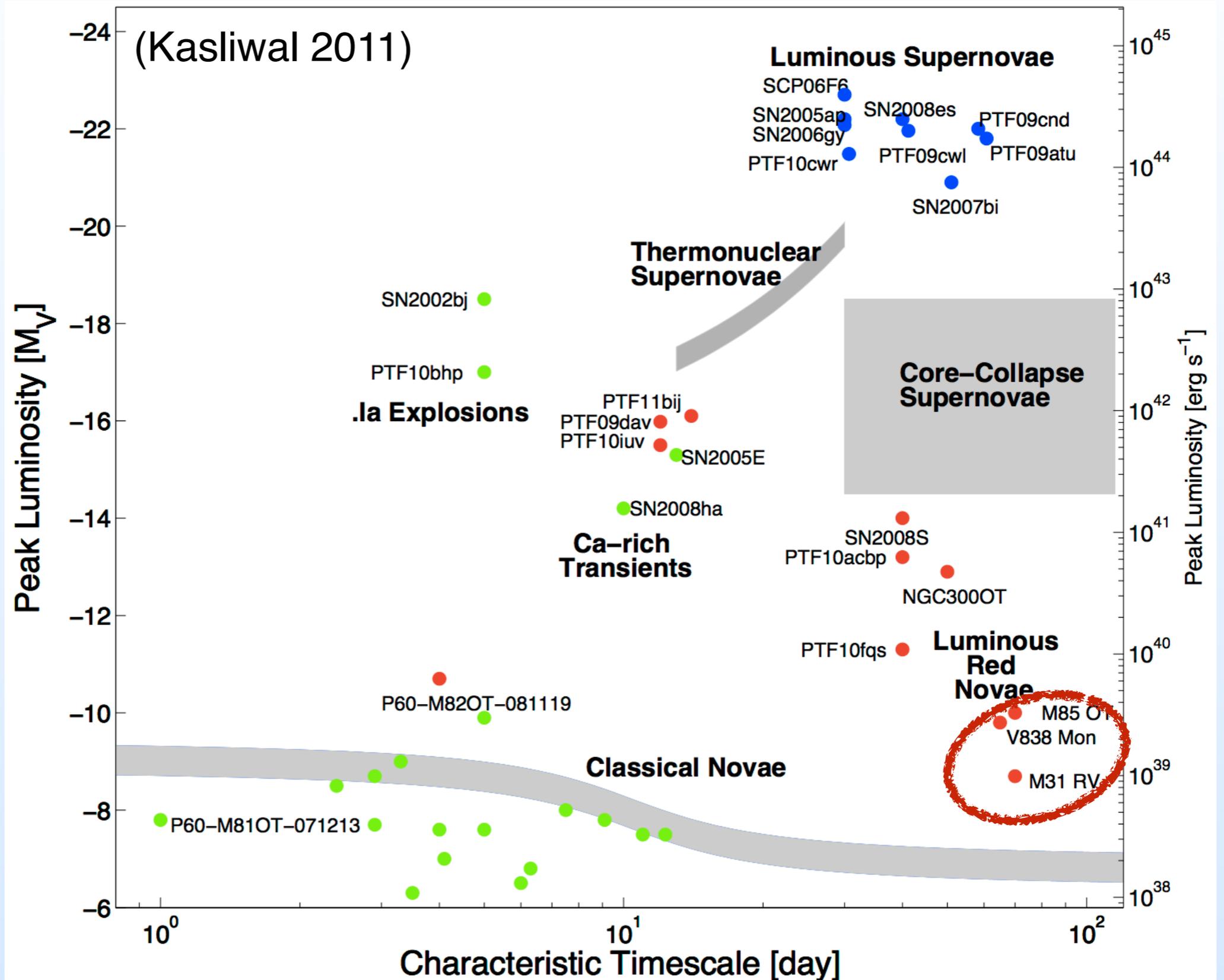
Luminous Red Novae:



(Mason+ 2010, Tylanda+ 2011)

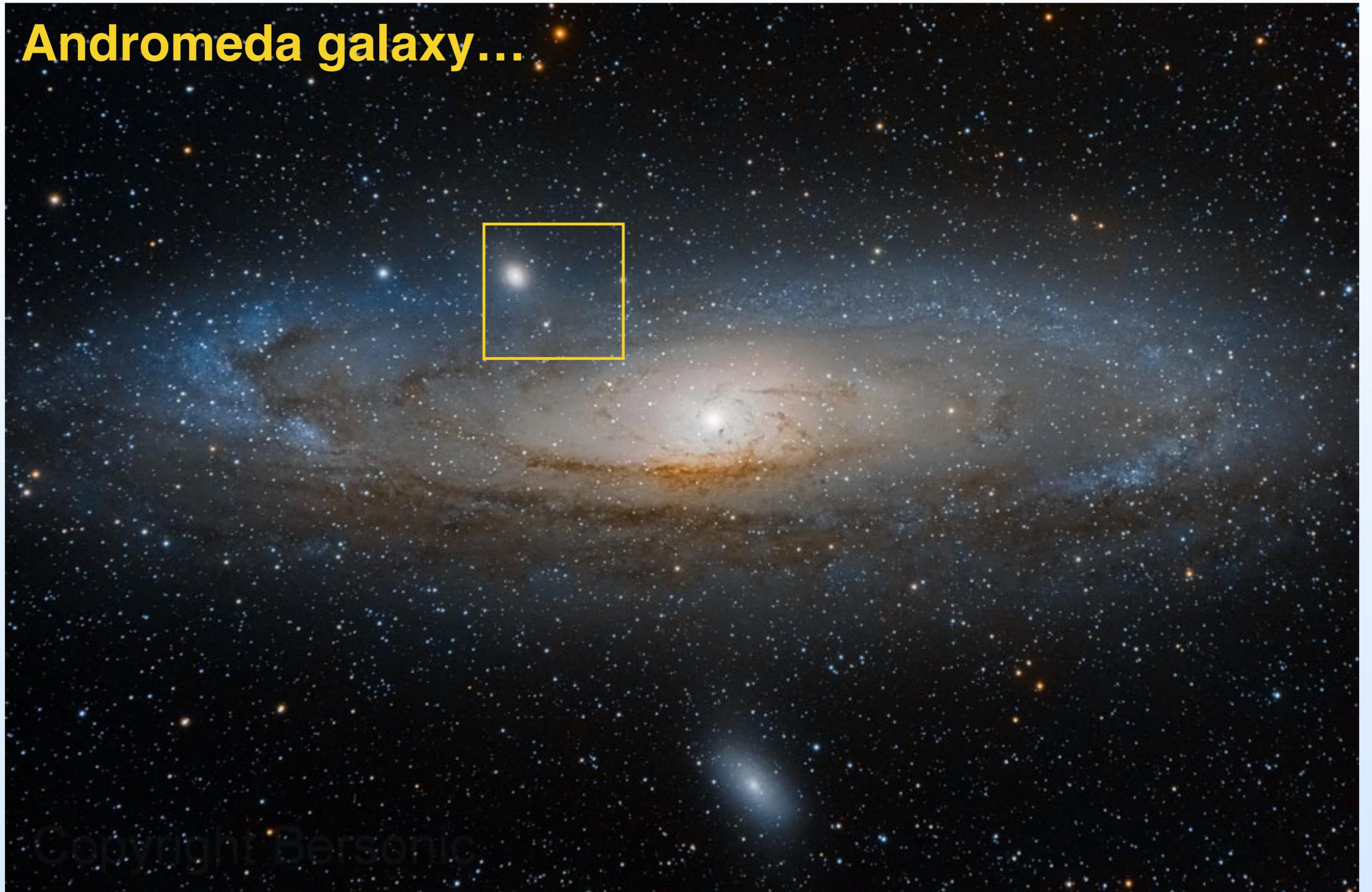
CE transients

Luminous Red Novae?



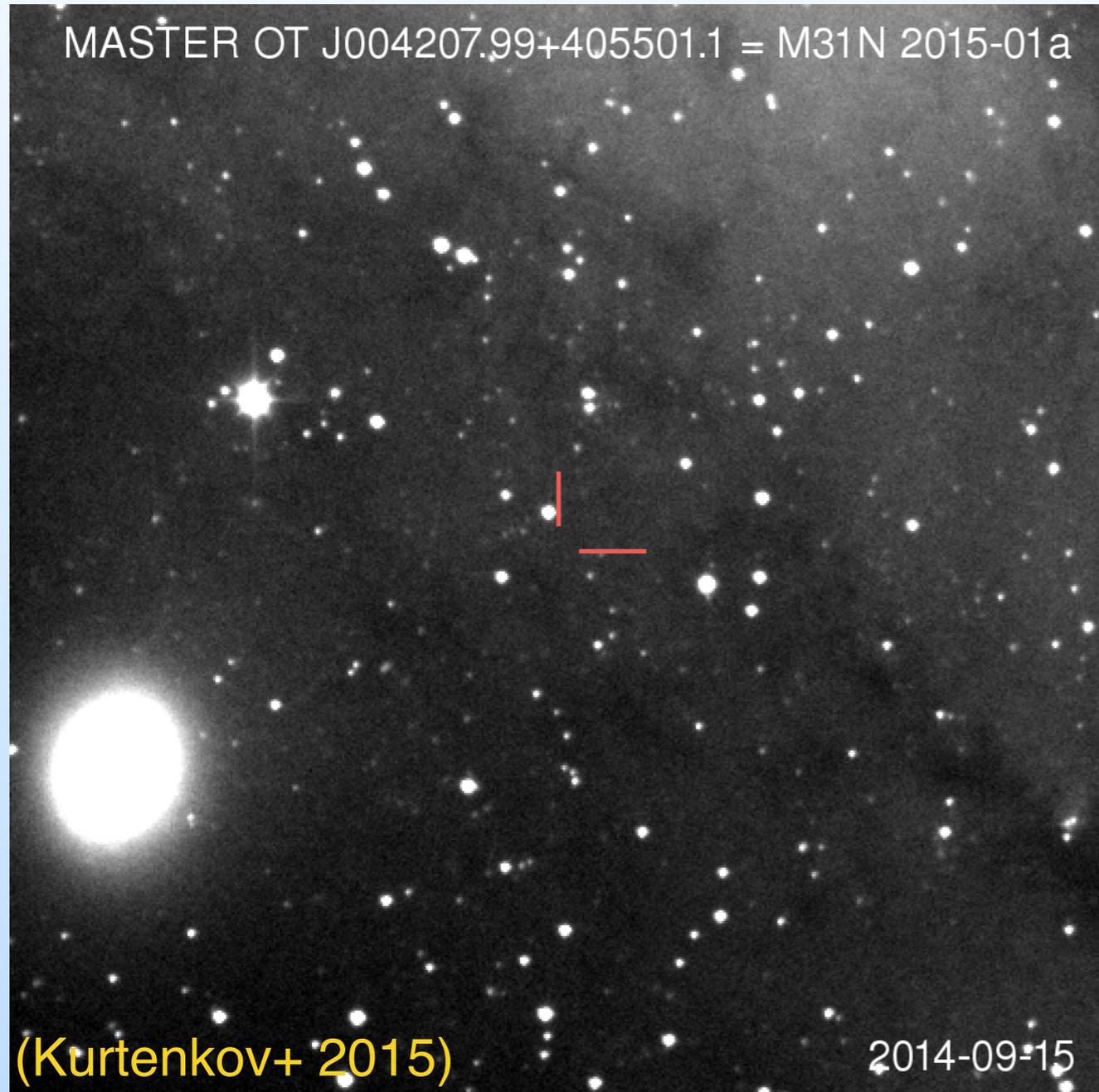
CE transients

Andromeda galaxy...

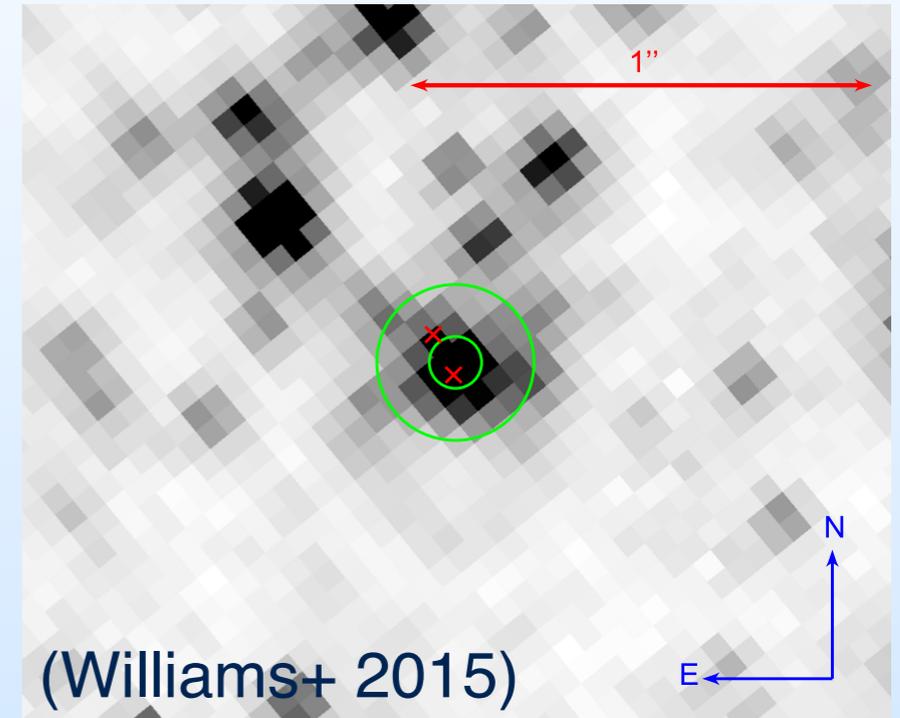


CE transients

M31 LRN 2015



Outburst in Andromeda galaxy in Jan 2015

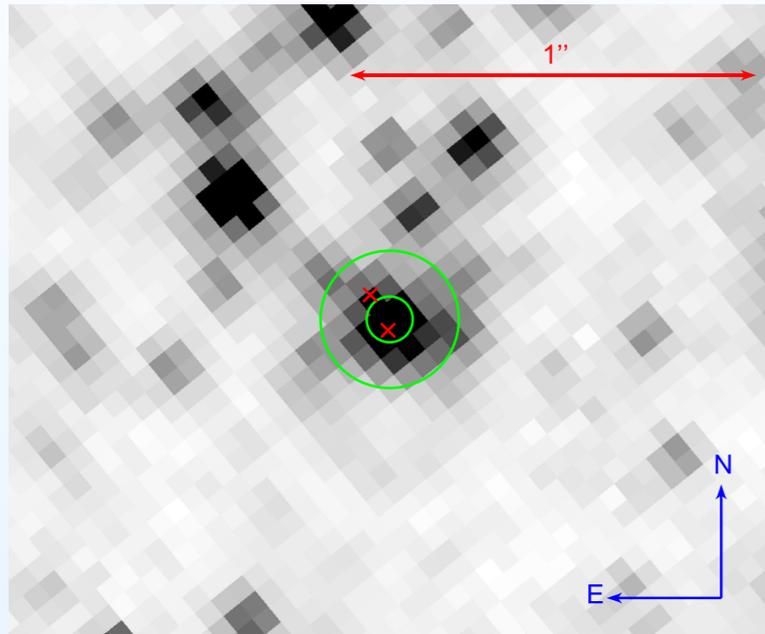


Pre-outburst source in *HST* imaging



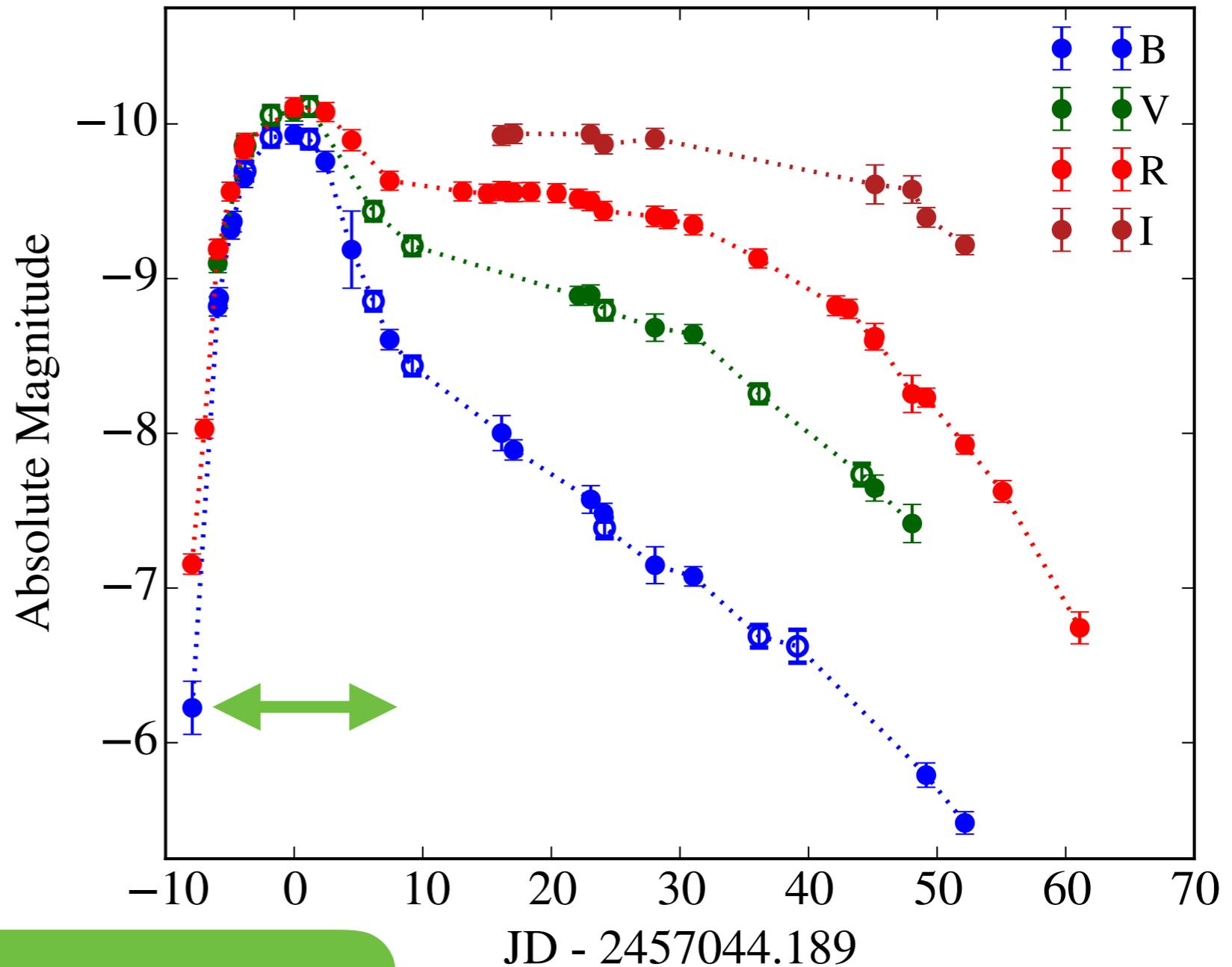
CE transients

M31 LRN 2015



sub-giant primary star

$$M_1 \approx 4 - 5M_{\odot}; \quad R_1 \approx 30R_{\odot}$$

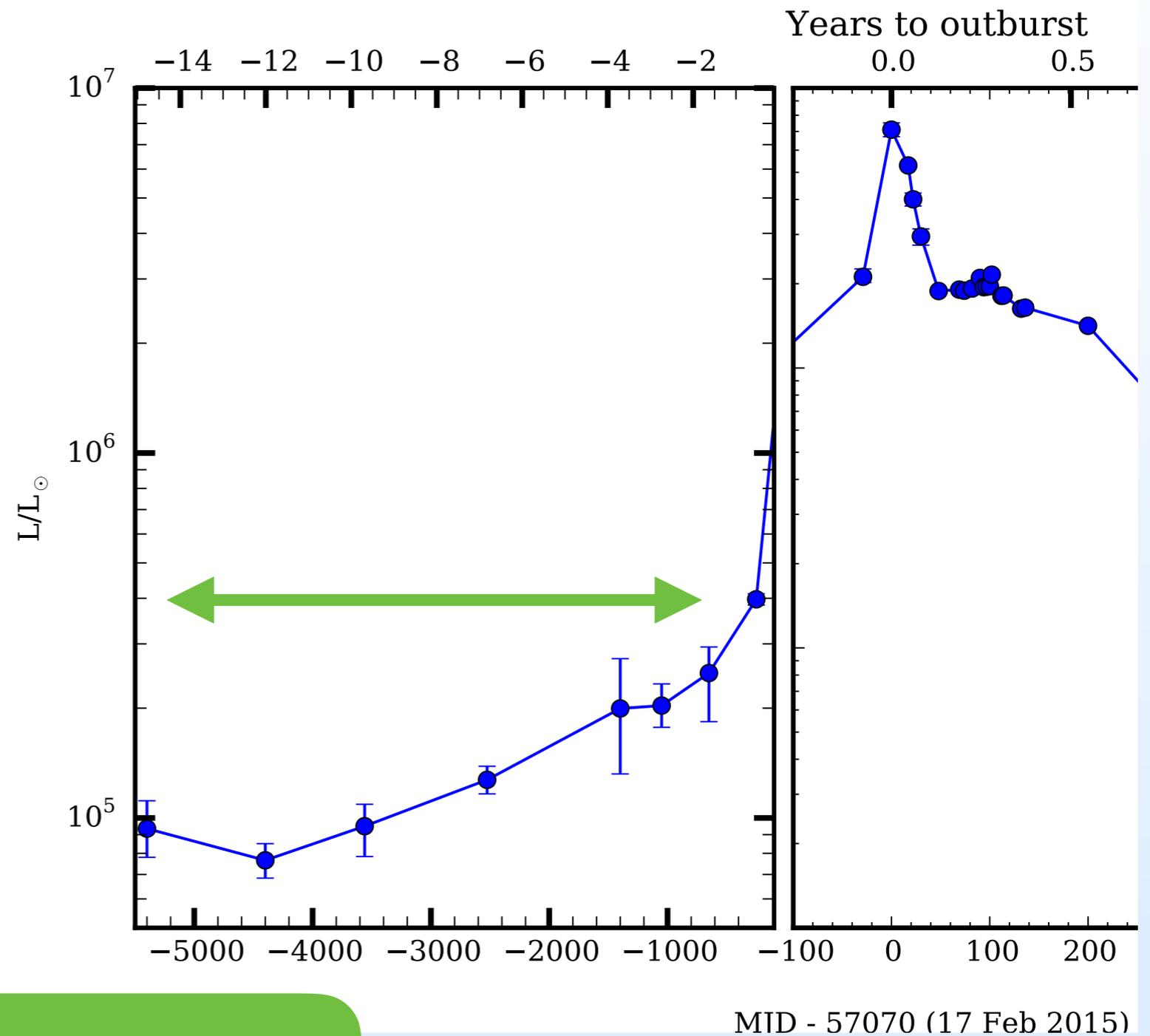
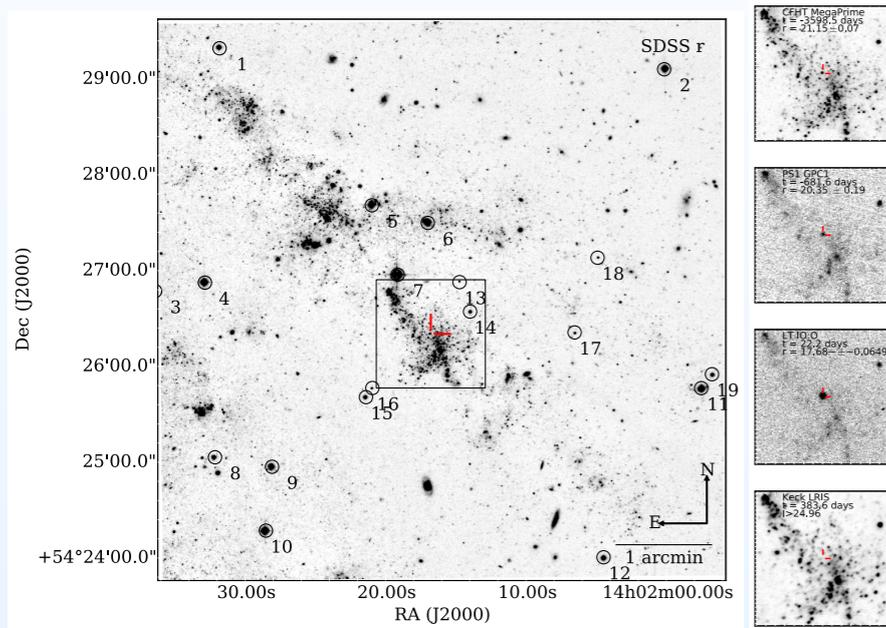


$$\Delta t_{\text{peak}} \sim t_{\text{orb}}$$

transient rise time similar
to orbital period

CE transients

M101 OT2015-1

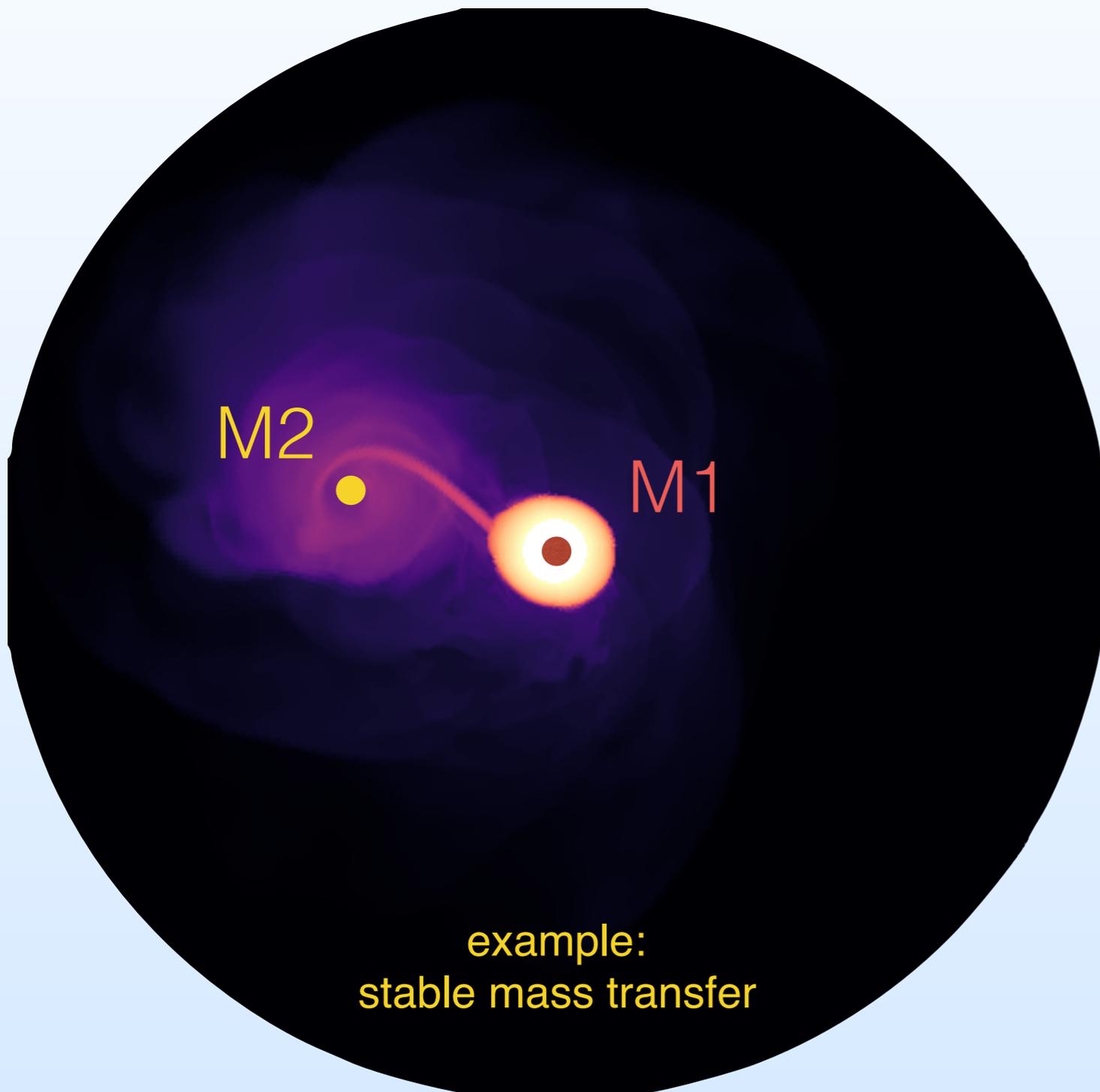


extended 'precursor'
brightening

How can we reconcile 'impulsive' outbursts and extended precursor emission?

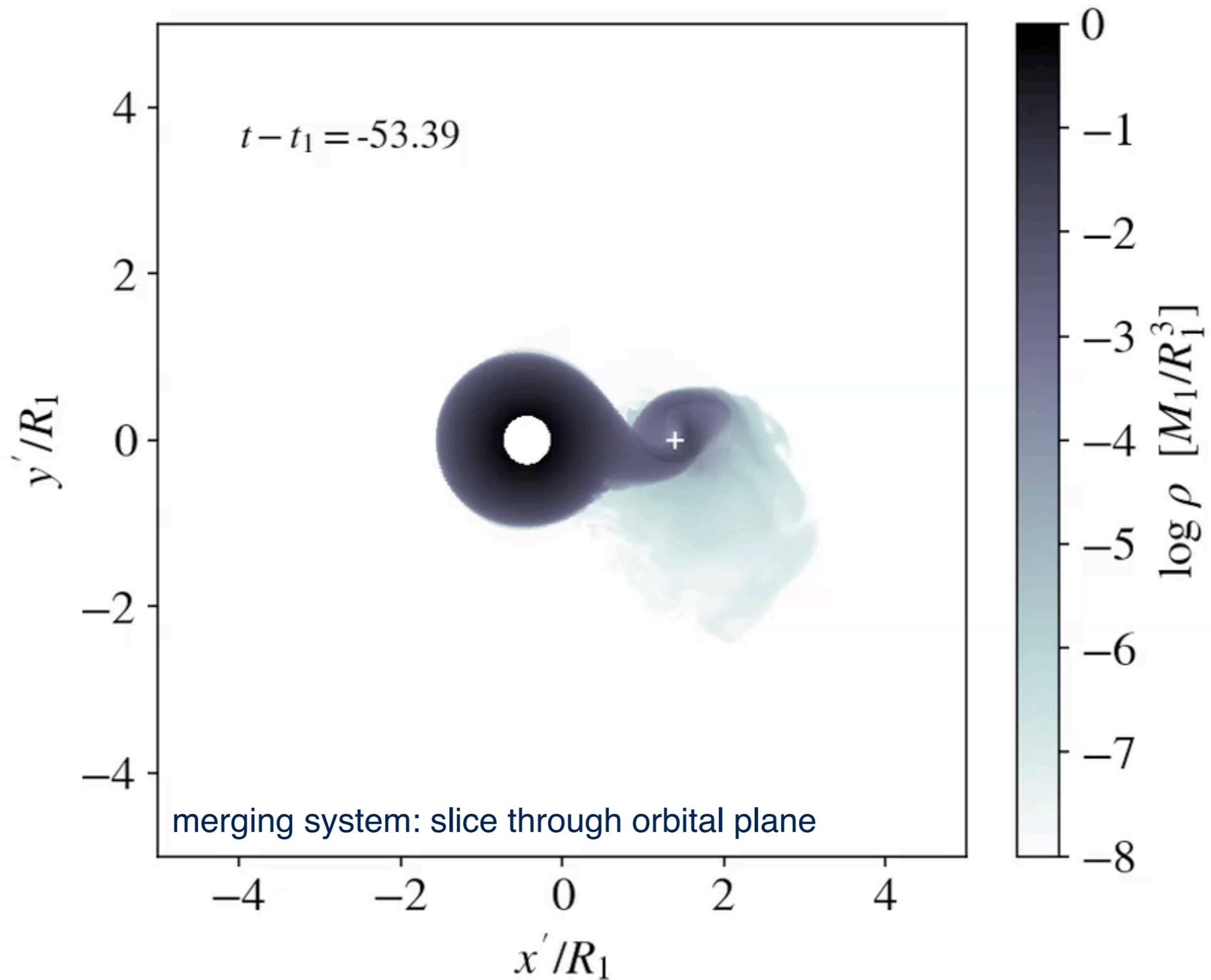
CE ejection modeling

A new setup to study interacting binaries in Athena++



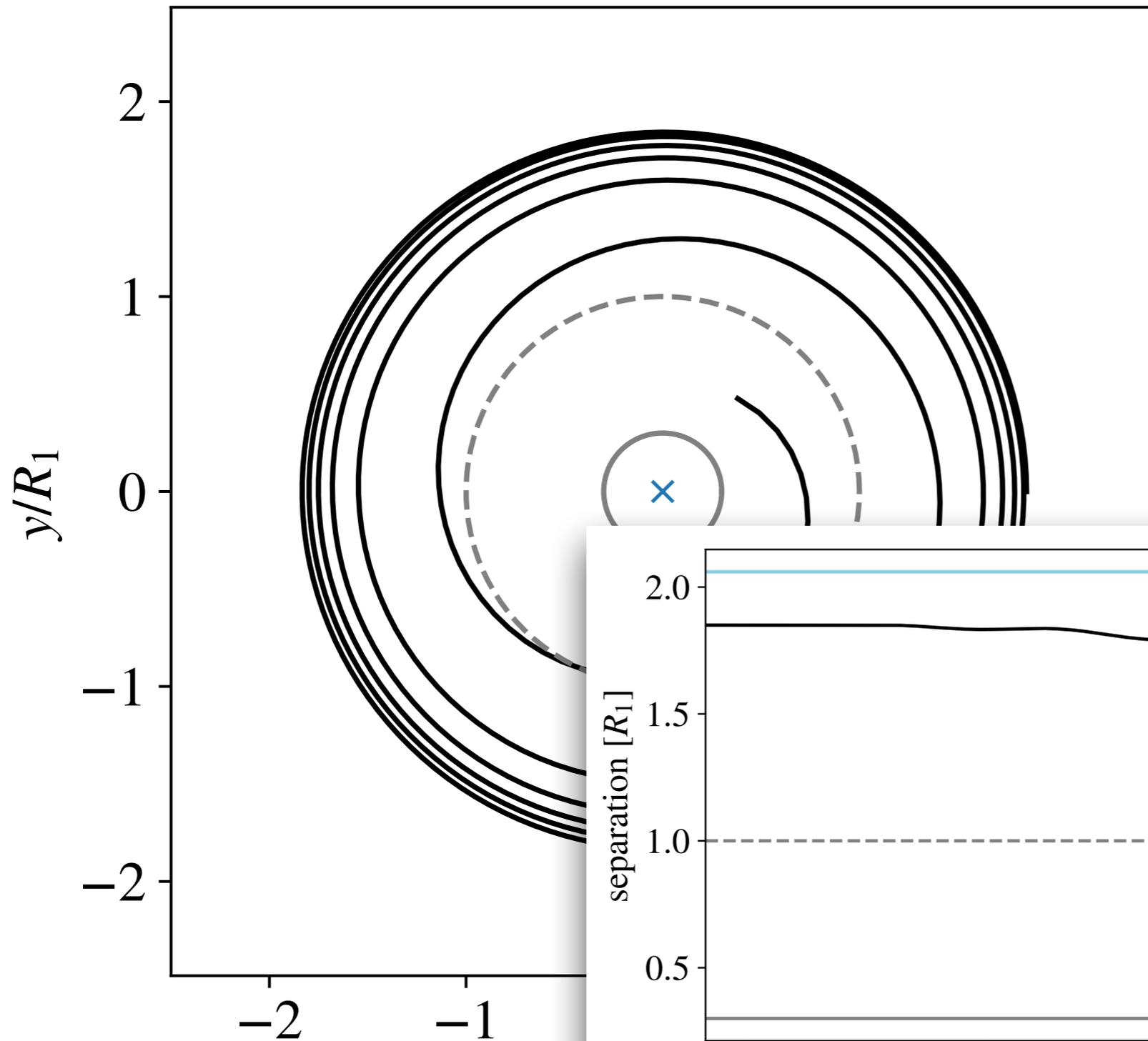
- Athena++ is a grid-based, magnetohydrodynamics code
- spherical coordinate system centered on the giant star
- gas in the domain interacts with two point masses
- in the reference frame of orbiting star

CE ejection modeling

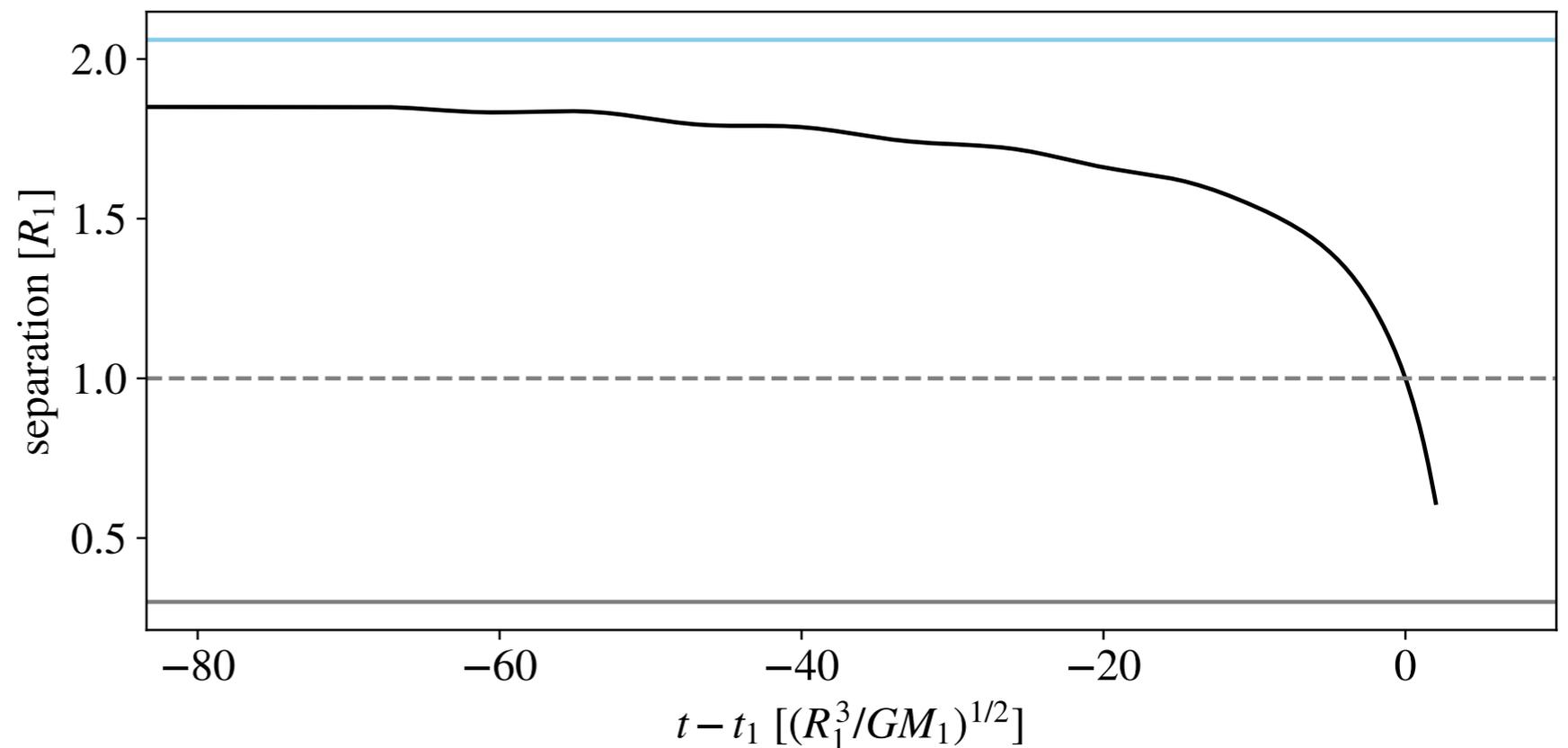


CE ejection modeling

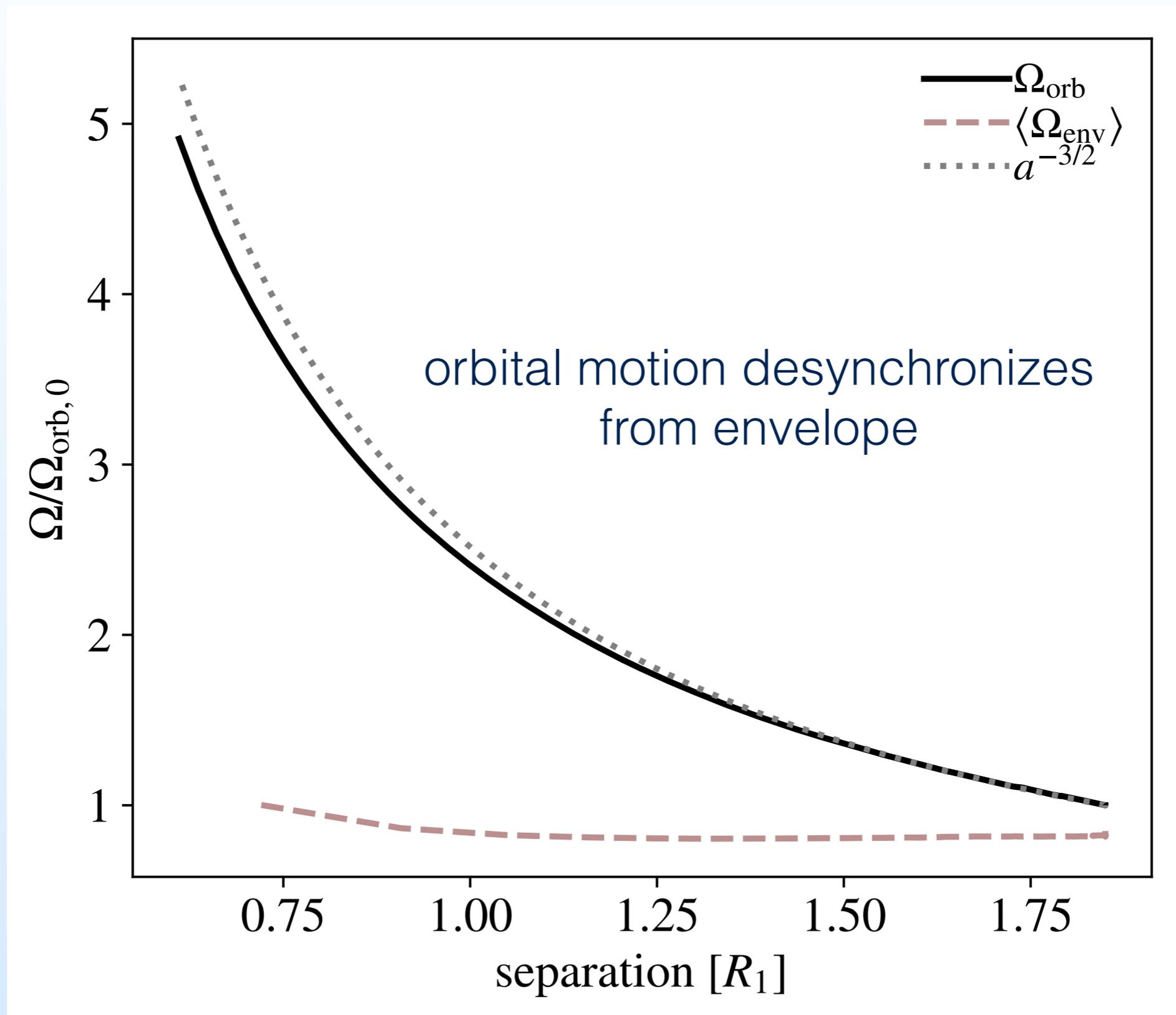
Simulation frame



orbital decay starts out gradual, then runs away



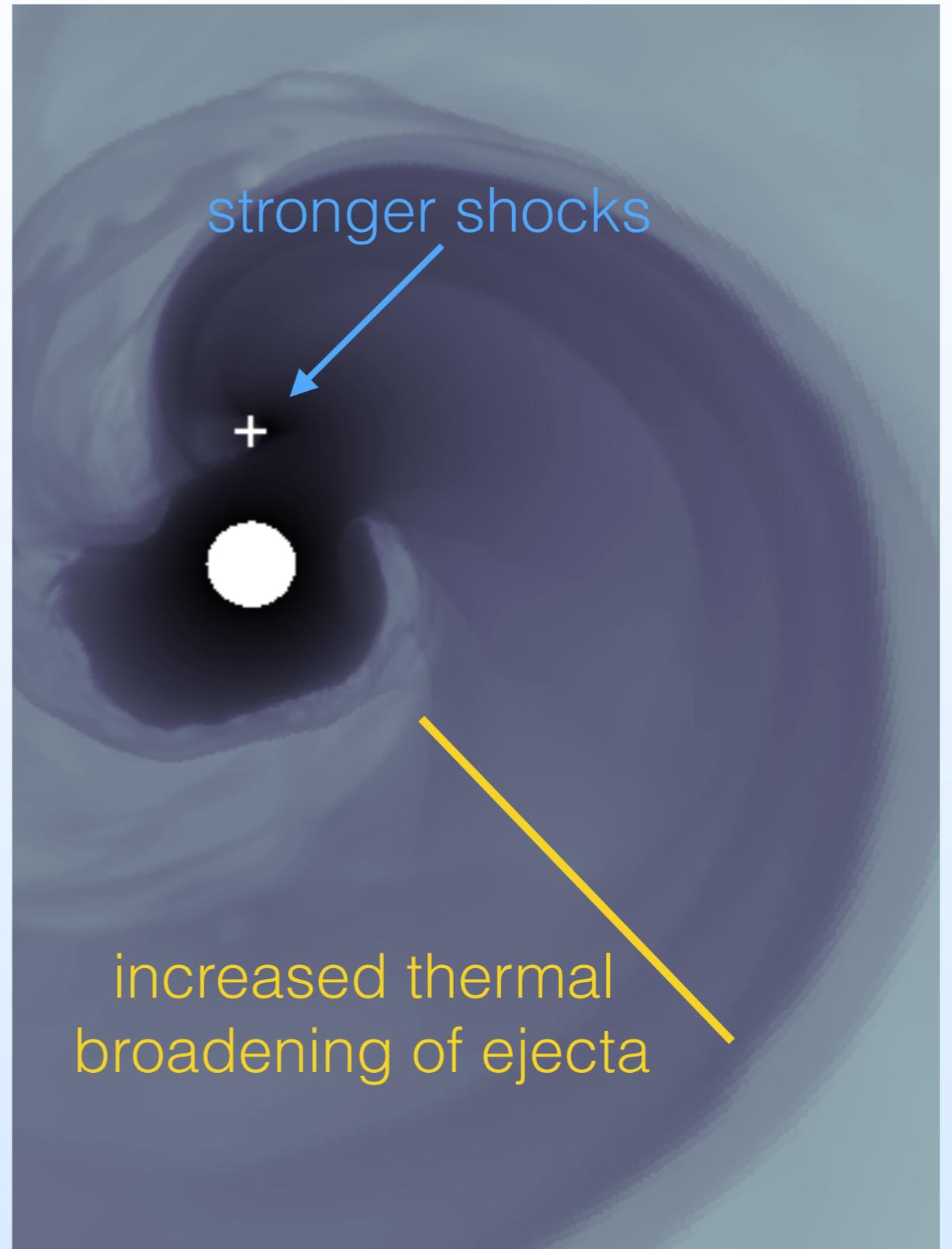
CE ejection modeling



CE ejection modeling



→
~5 orbits

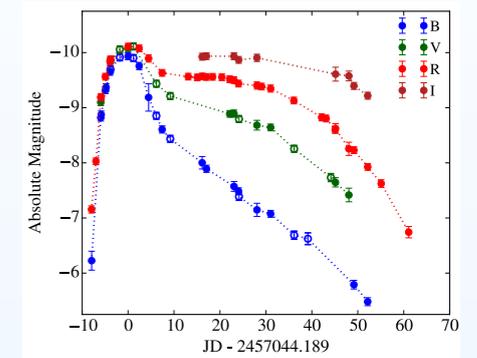


precursor

outburst

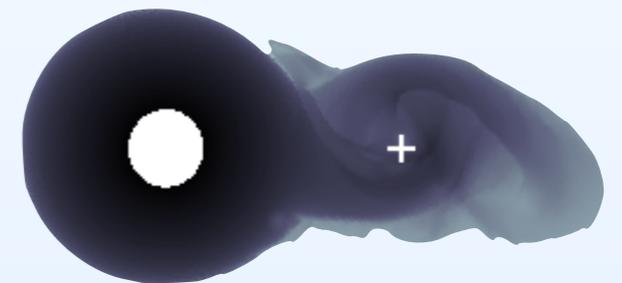
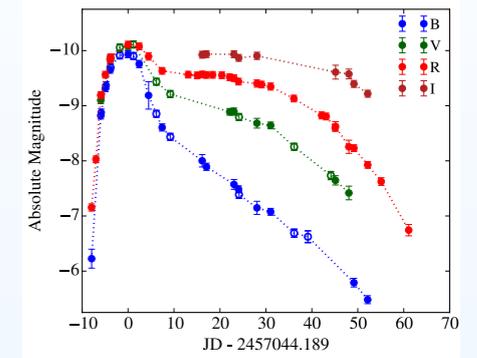
CE events illuminate the transient night sky

- CE events transform binary systems and leave an imprint in the transient night sky.



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- Catching these transients directly constrains our understanding of mass ejection in CE events.



CE events illuminate the transient night sky

- CE events transform binary systems and leave an imprint in the transient night sky.
- Catching these transients directly constrains our understanding of mass ejection in CE events.
- As we start to discover binaries merging through the emission of gravitational waves, it's extremely important to understand the assembly of these close systems through common envelope phases.

