

Illuminating the Night Sky with Common Envelope Events



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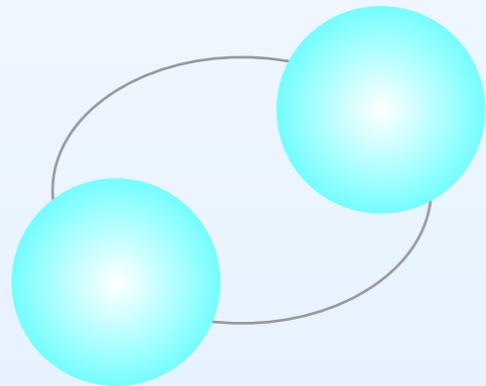
Smithsonian Astrophysical Observatory

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)



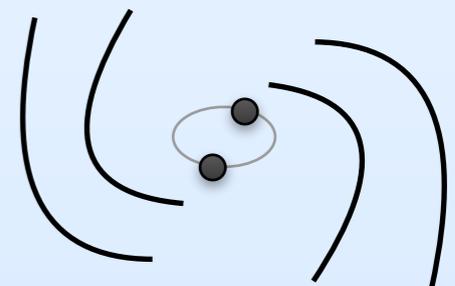
draws the binary
closer together



much closer pair of
neutron stars



gravitational wave
inspiral

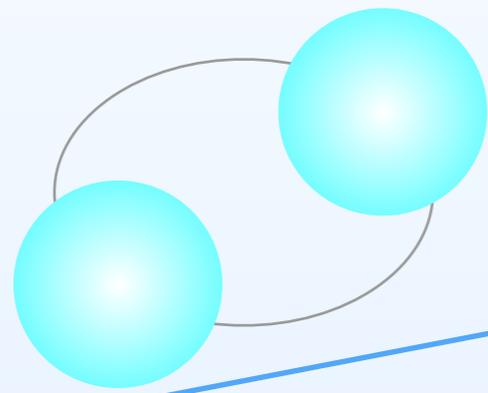


Orbital transformation is key in
formation of compact binaries

Common envelope interactions transform binary systems

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



**Common
Envelope
Phase**



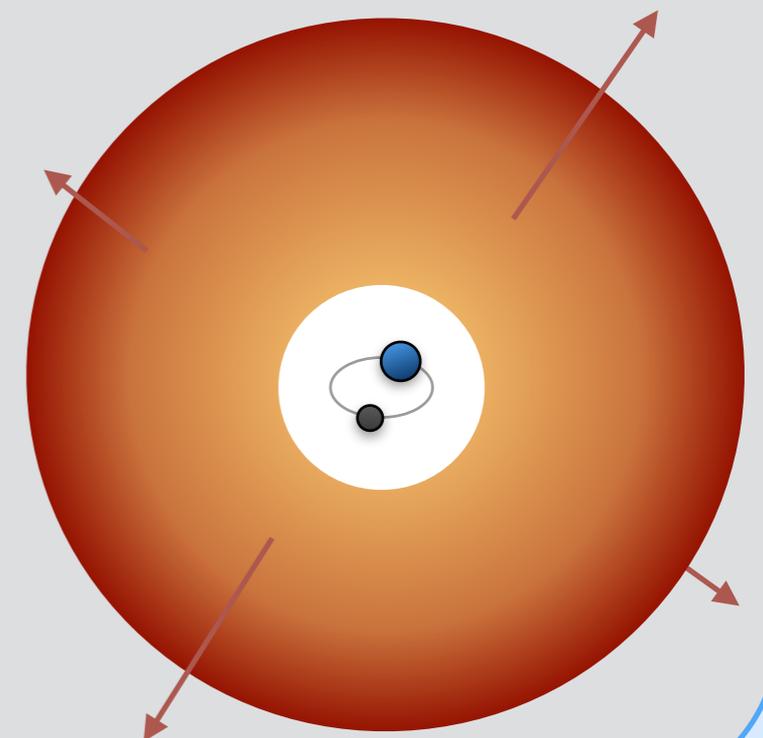
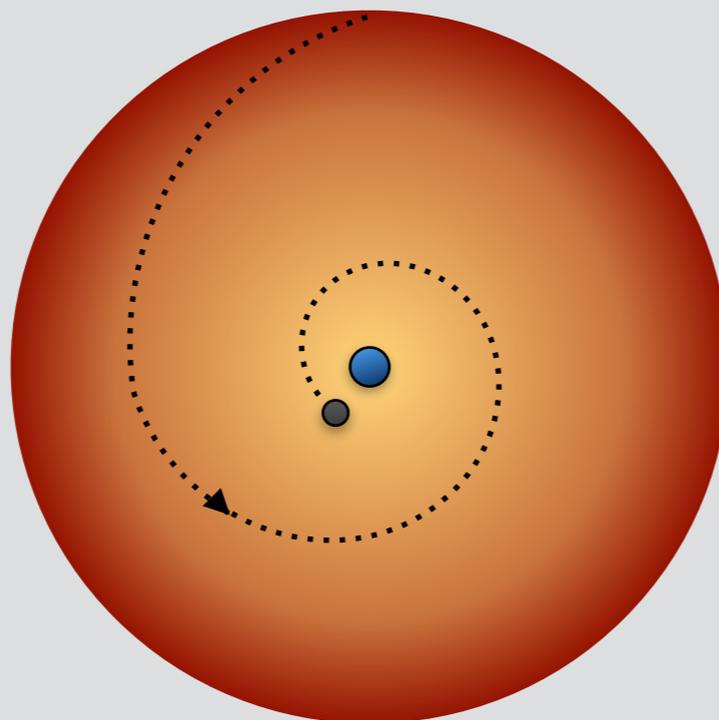
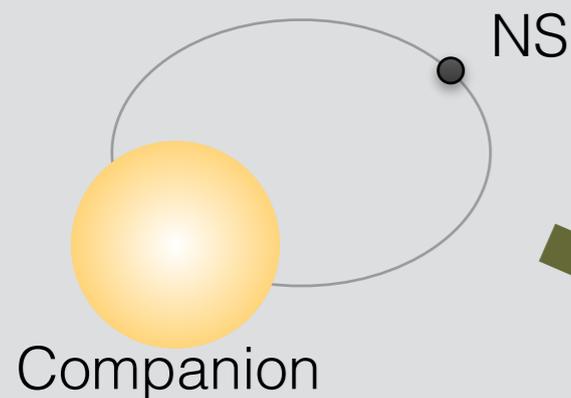
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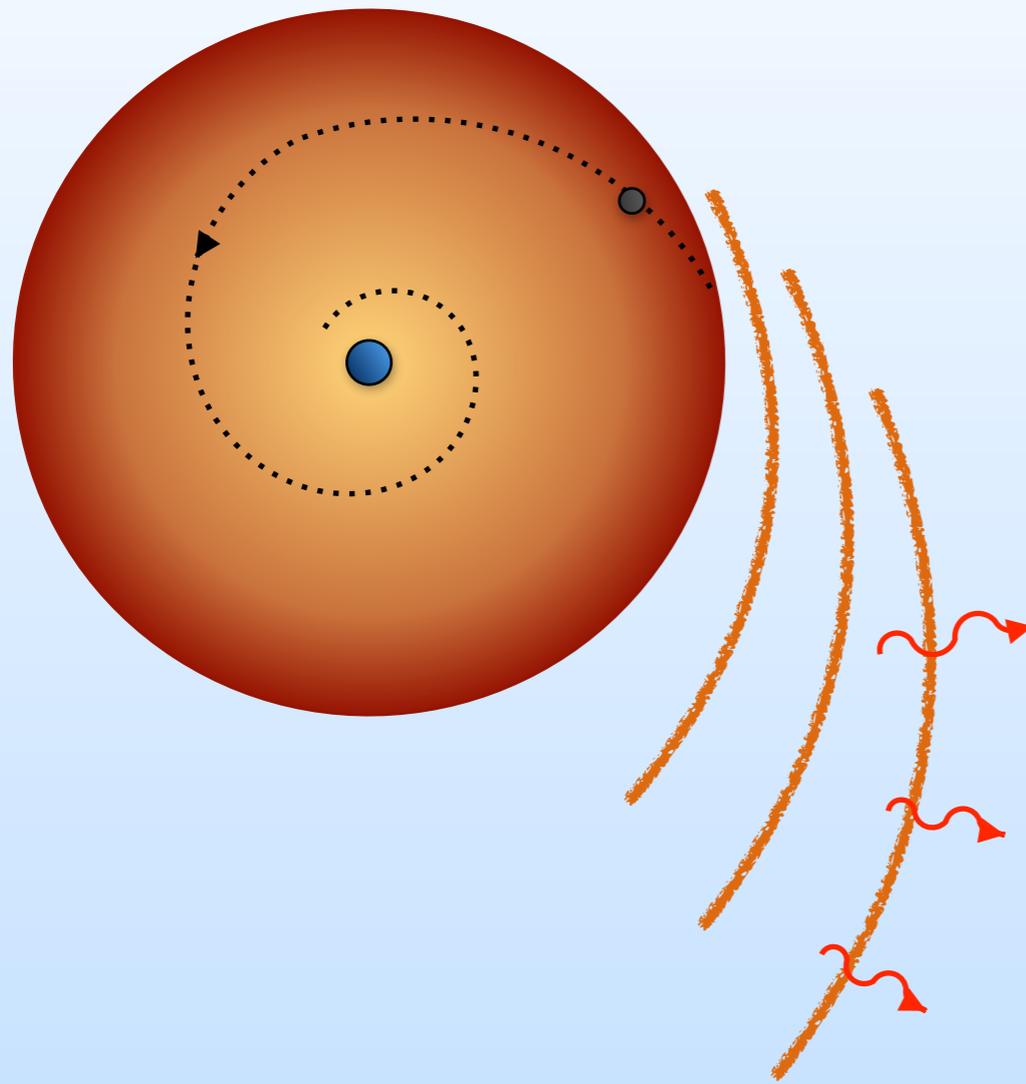
Drag on surrounding
gas tightens the orbit

Orbit stabilizes as
envelope is ejected

Evolution to contact

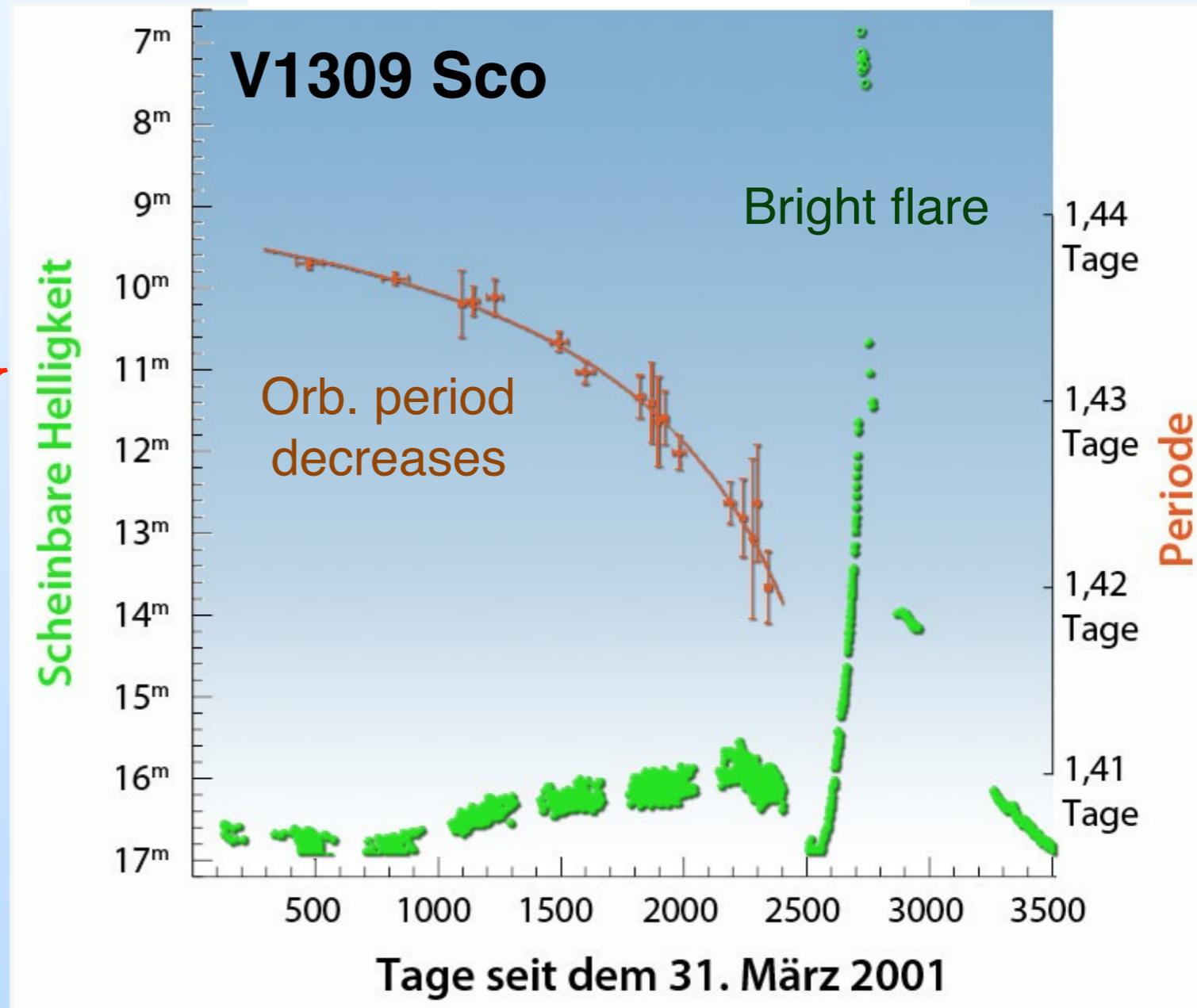


CE transients



hot ejecta radiate
as they cool

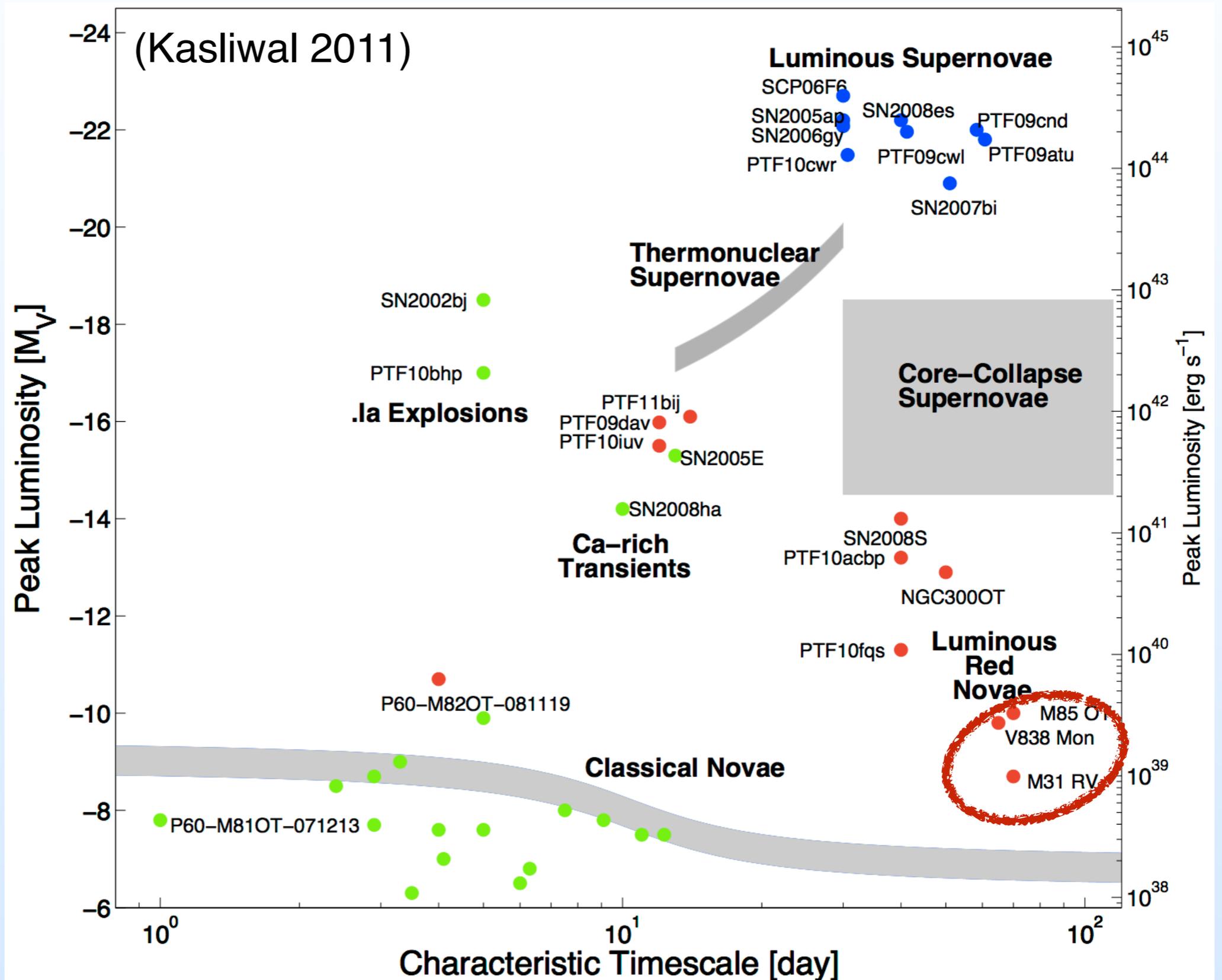
Luminous Red Novae:



(Mason+ 2010, Tylanda+ 2011)

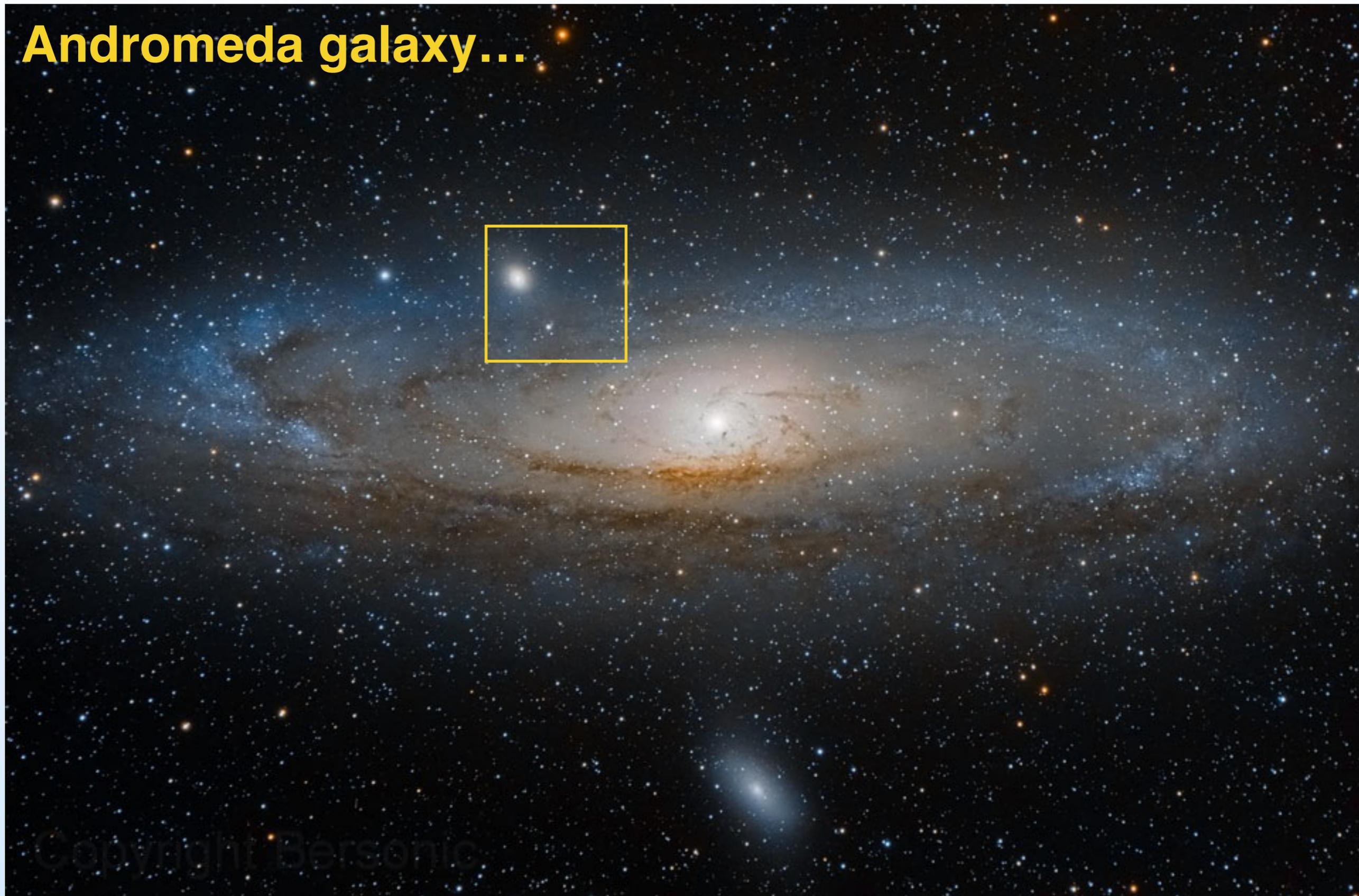
CE transients

Luminous Red Novae?



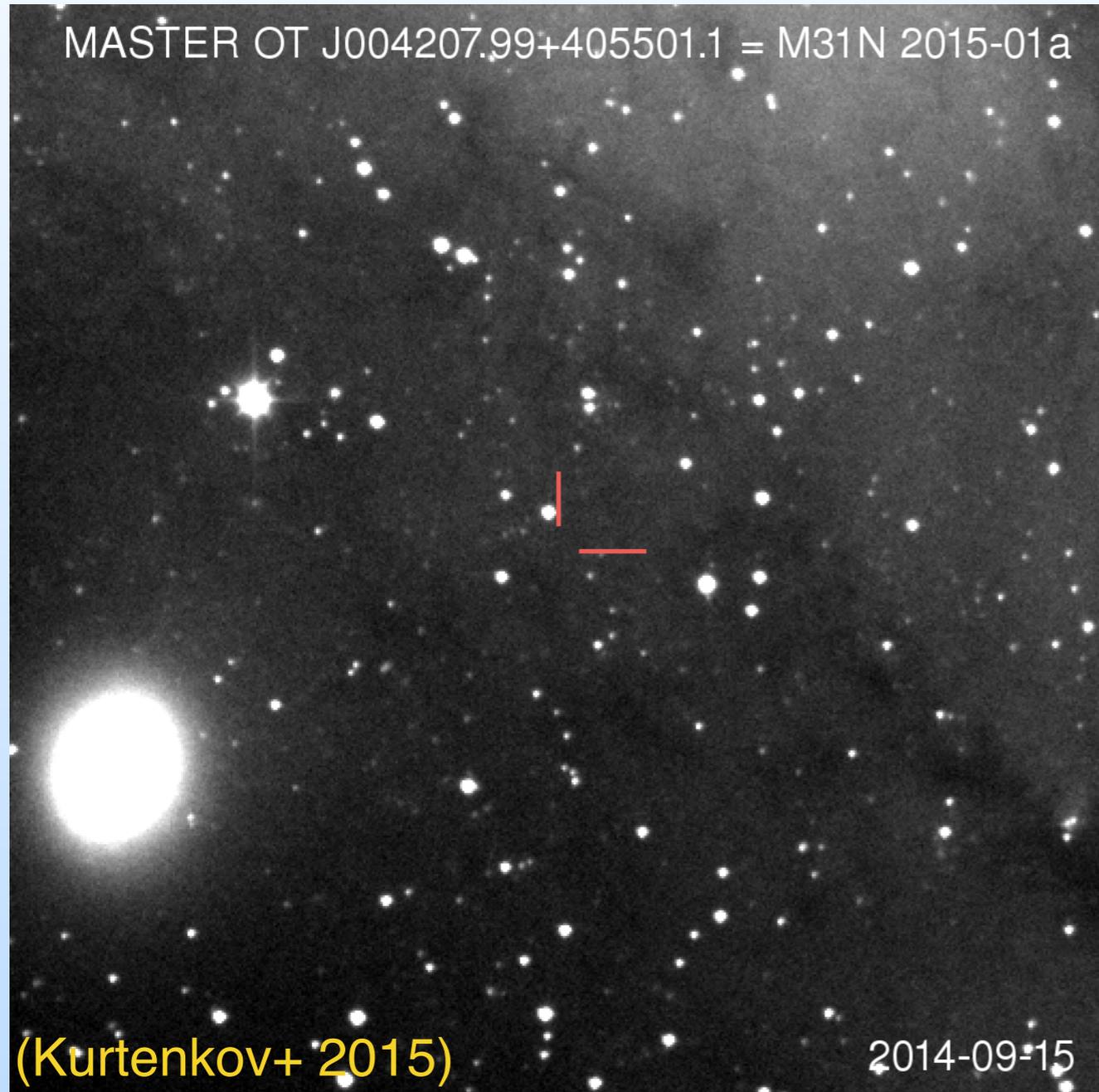
CE transients

Andromeda galaxy...

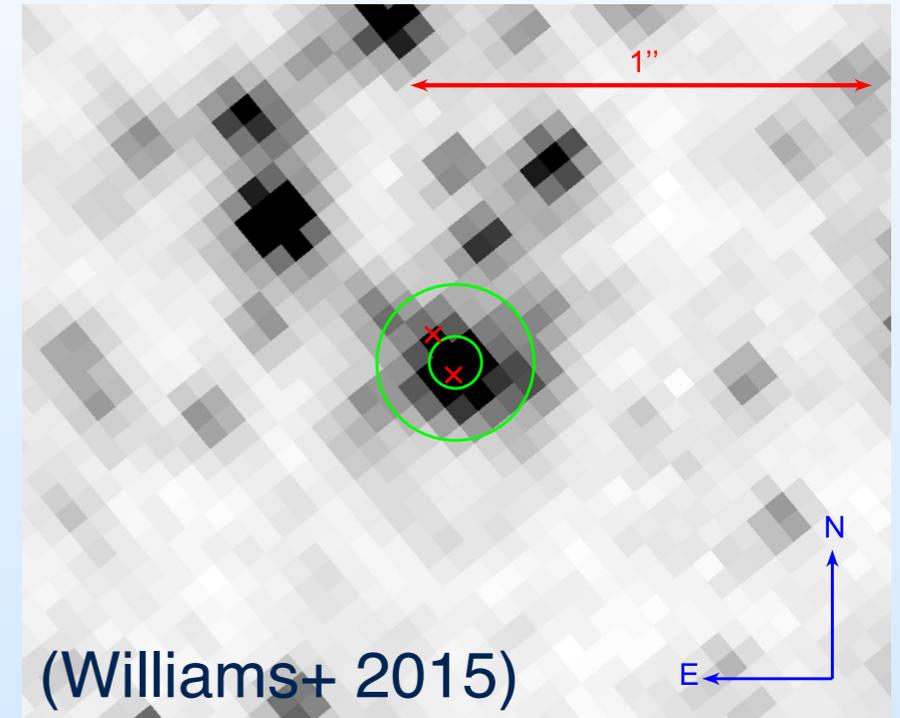


CE transients

M31 LRN 2015



Outburst in Andromeda galaxy in Jan 2015

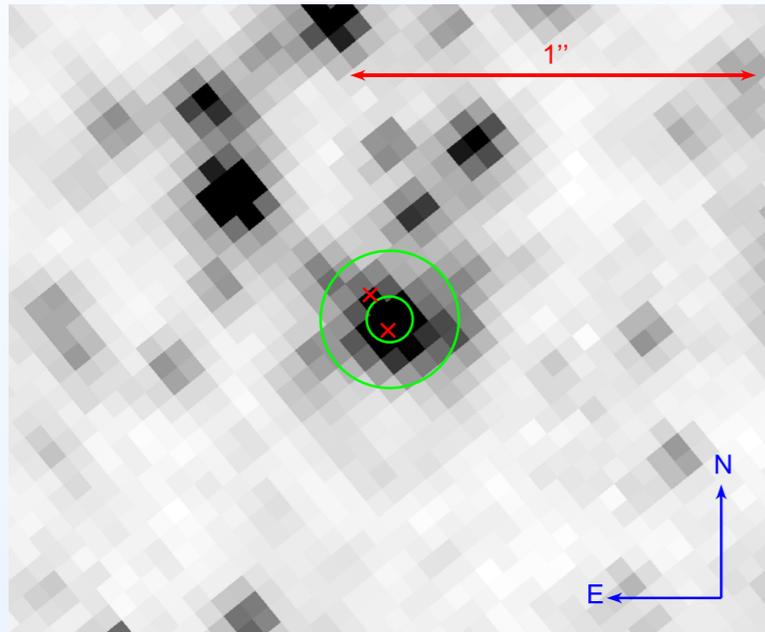


Pre-outburst source in *HST* imaging



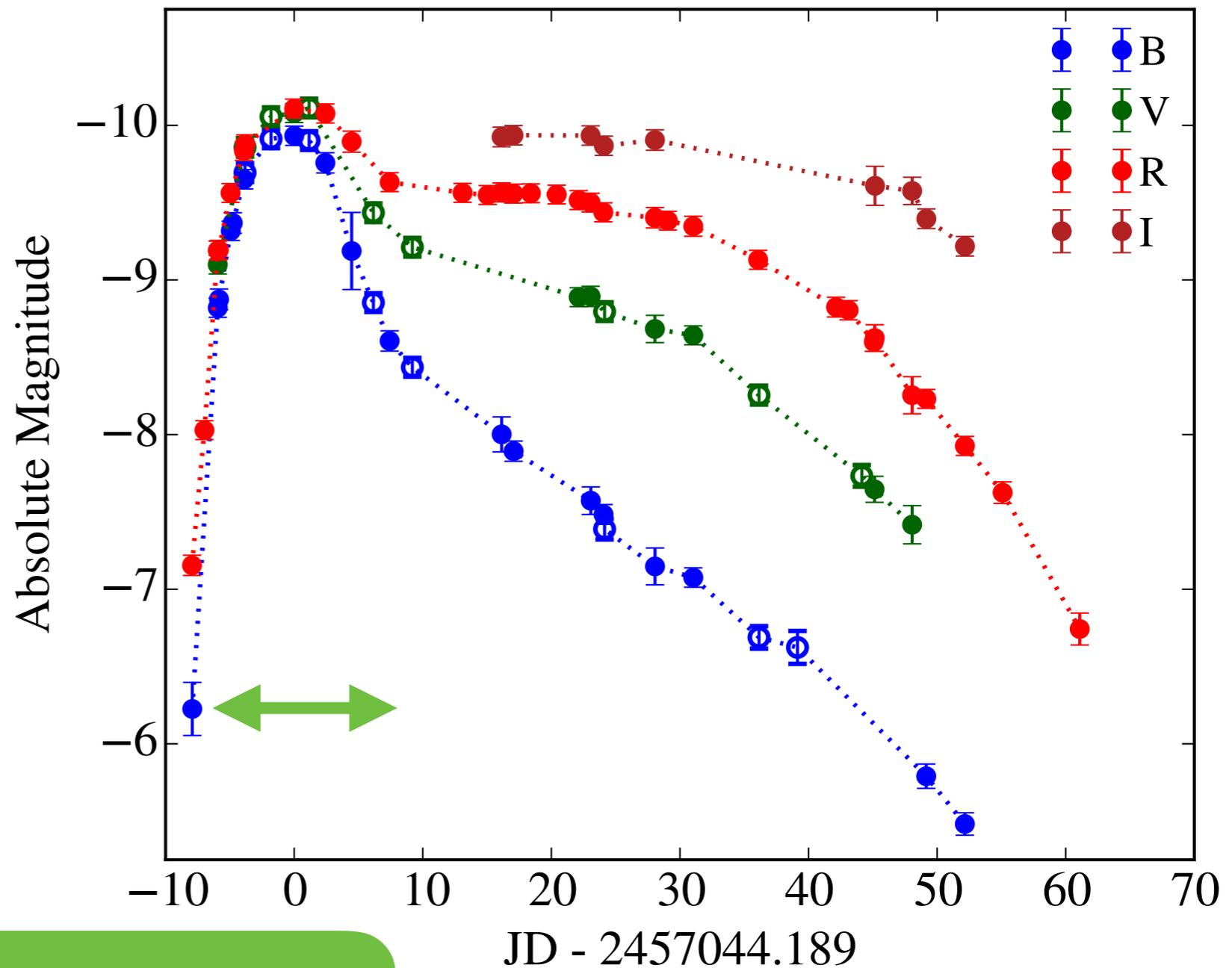
CE transients

M31 LRN 2015



sub-giant primary star

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

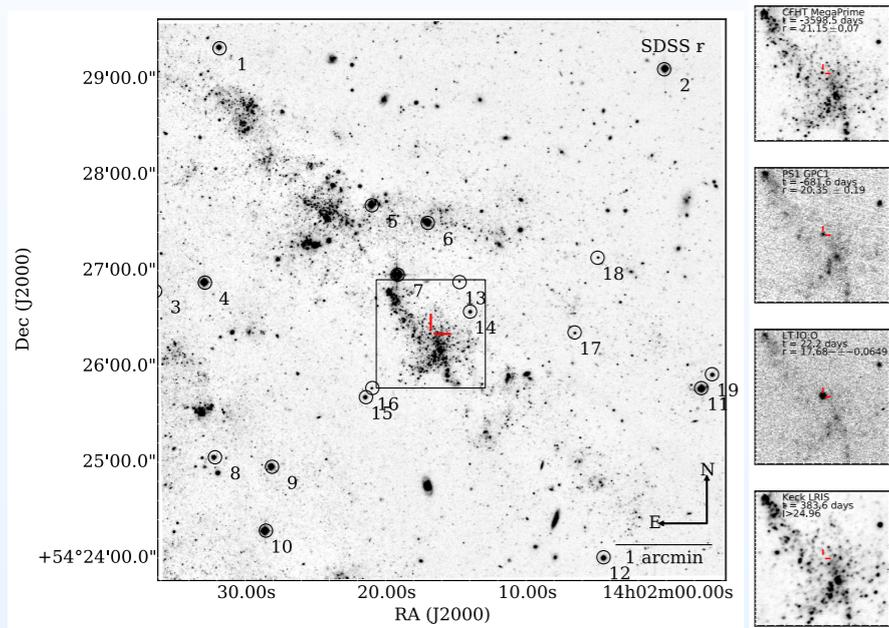


$$\Delta t_{\text{peak}} \sim t_{\text{orb}}$$

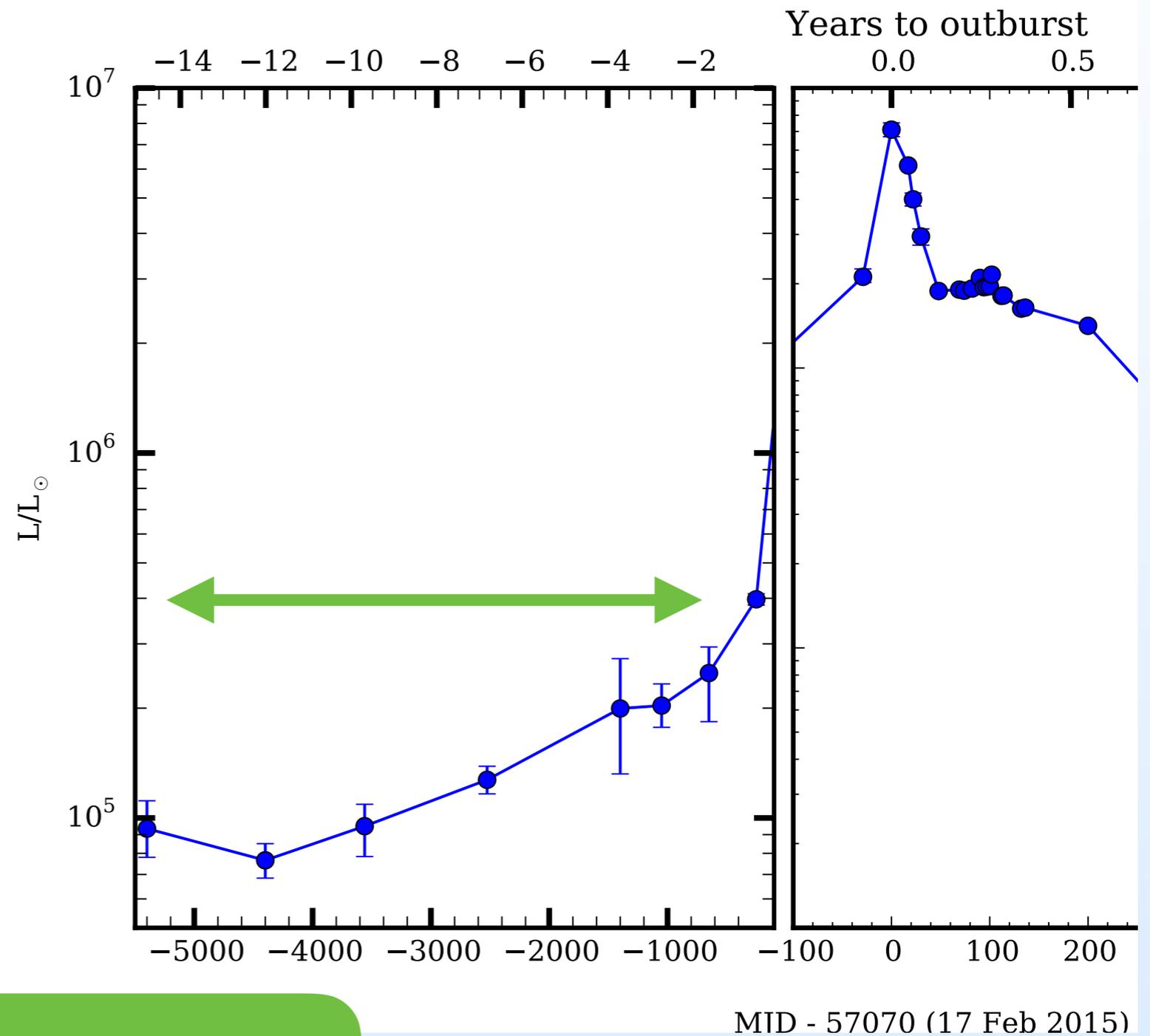
transient rise time similar
to orbital period

CE transients

M101 OT2015-1



~18 solar mass primary star

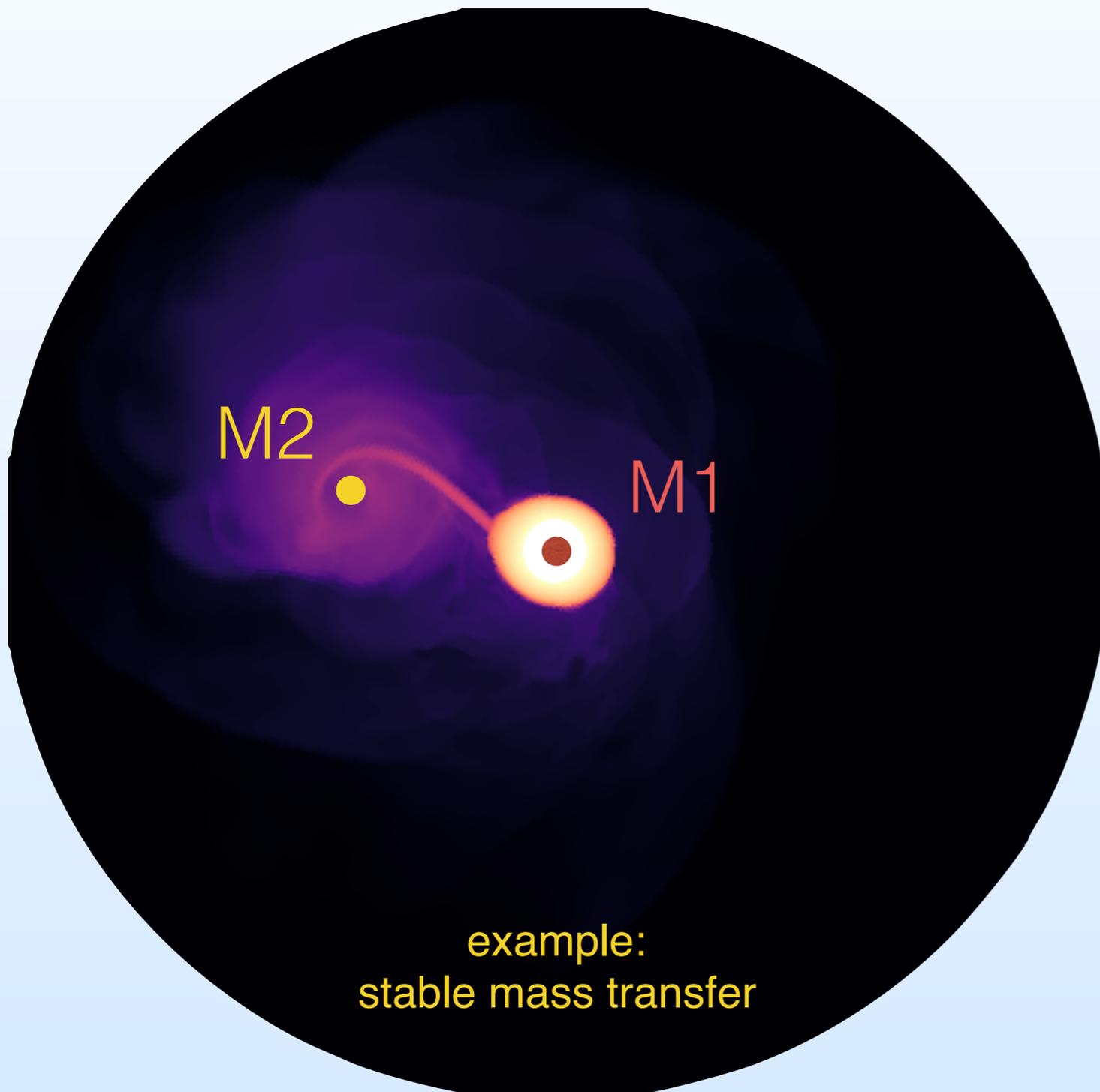


extended 'precursor'
brightening

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

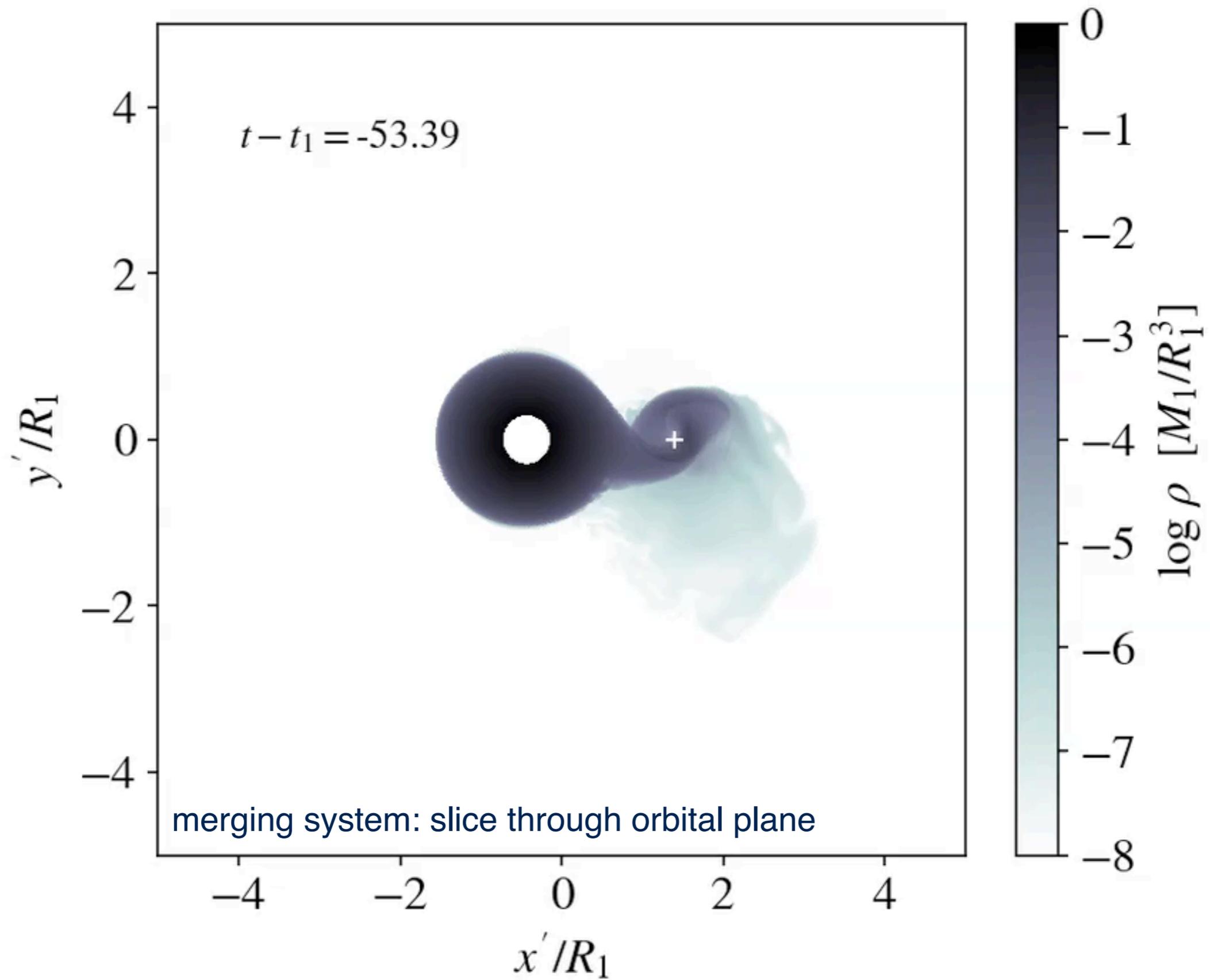
CE ejection modeling

A new setup to study interacting binaries in Athena++



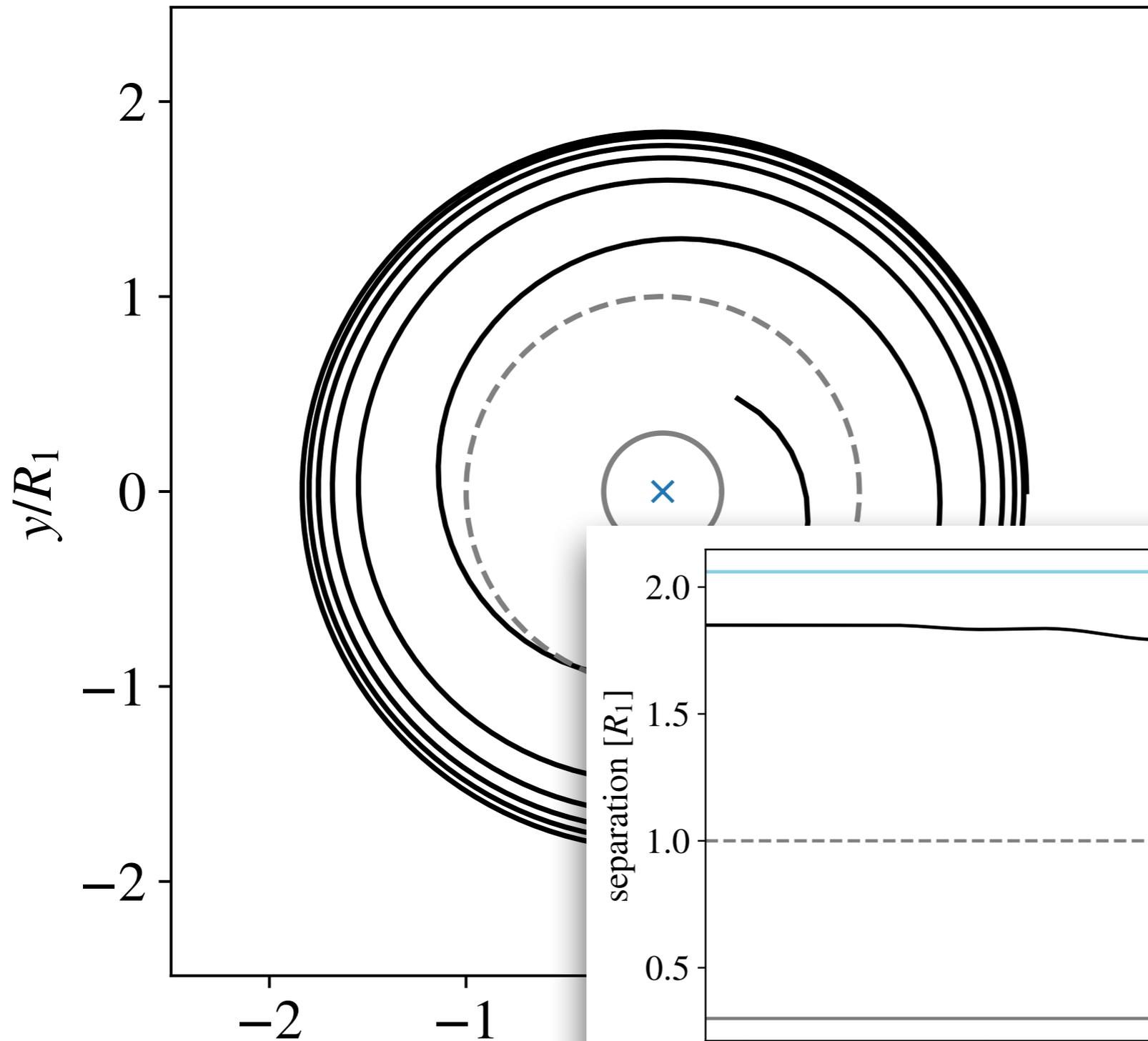
- Athena++ is a grid-based, magnetohydrodynamics code
- spherical coordinate system centered on the giant star
- gas in the domain interacts with two point masses
- in the reference frame of orbiting star

CE ejection modeling

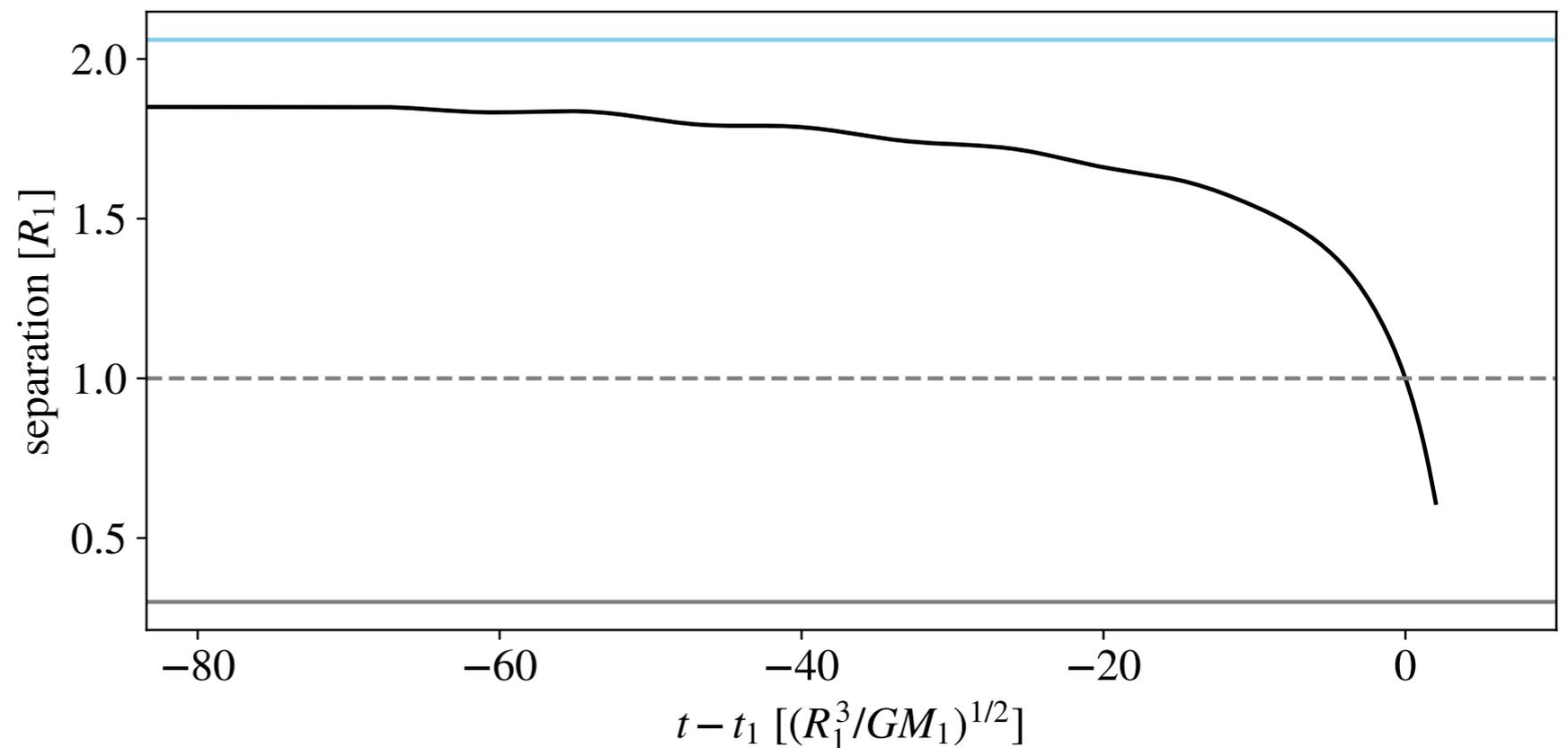


CE ejection modeling

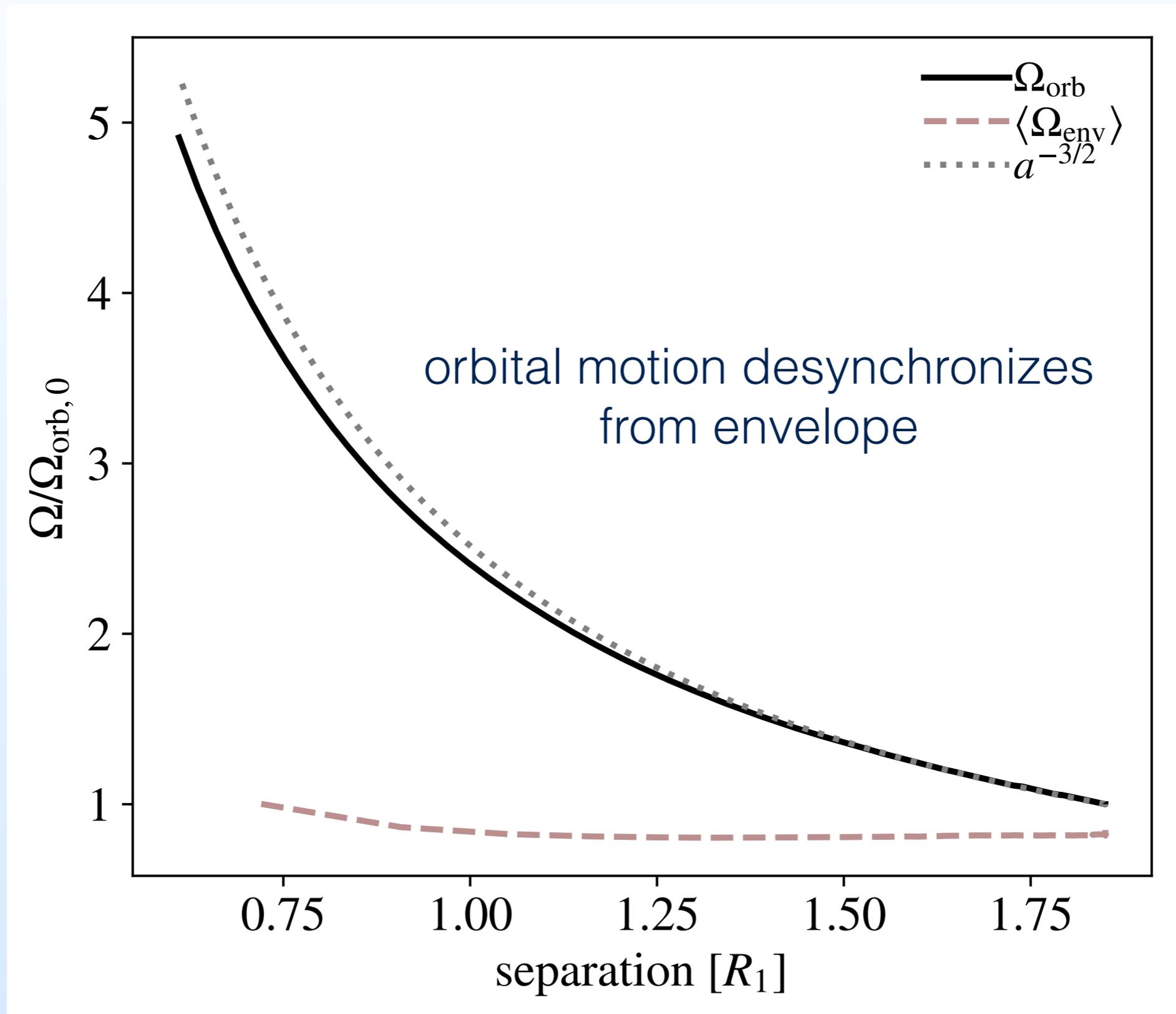
Simulation frame



orbital decay starts out gradual, then runs away



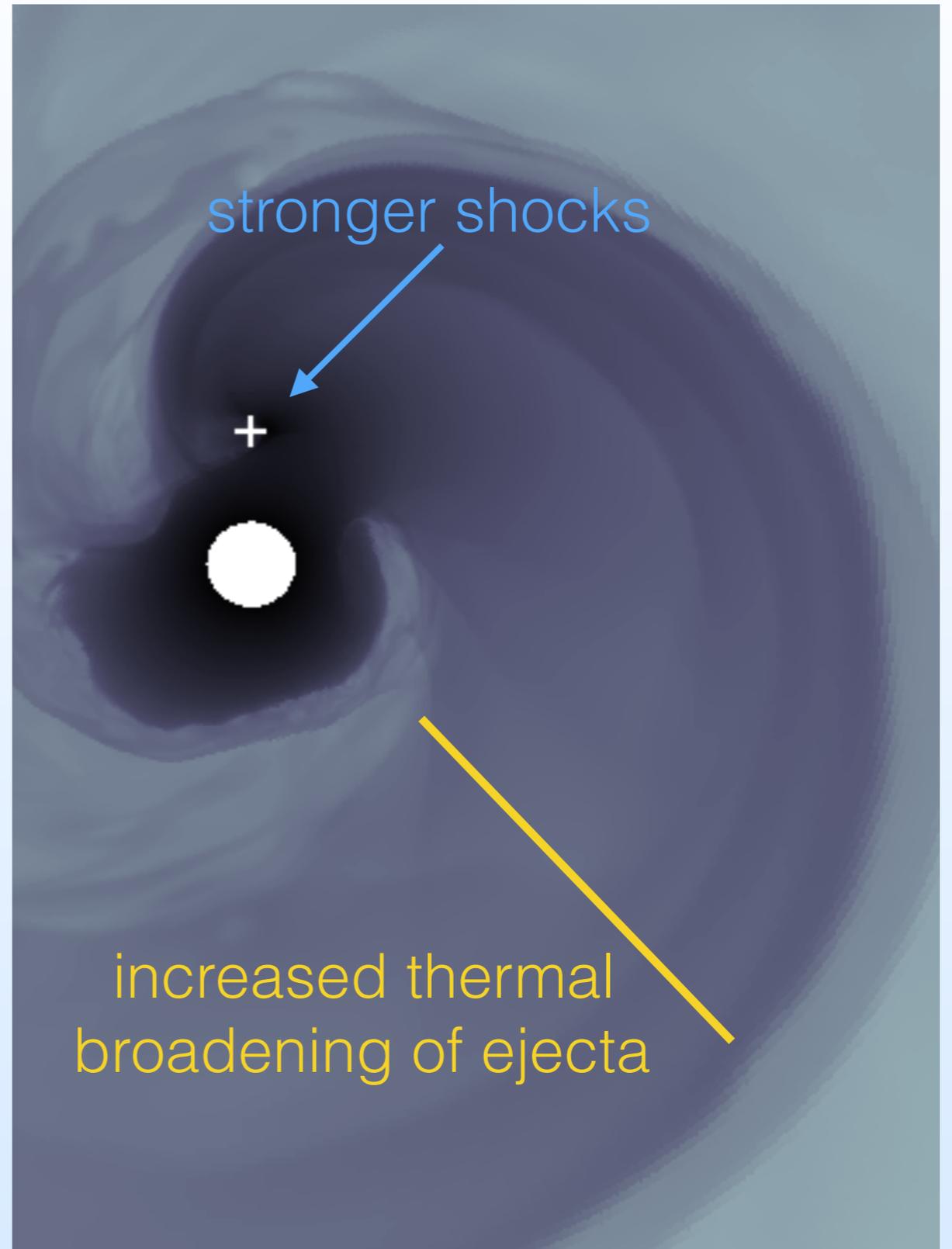
CE ejection modeling



CE ejection modeling



→
~5 orbits

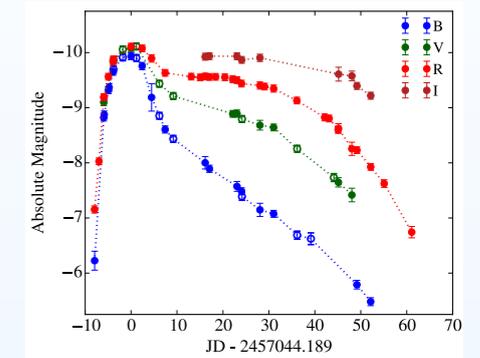


precursor

outburst

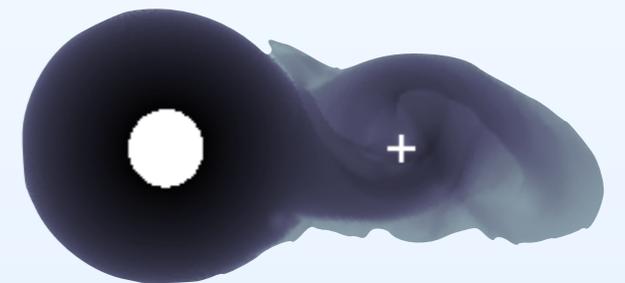
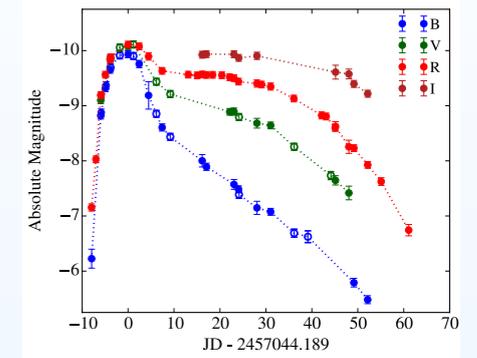
CE events illuminate the transient night sky

- 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.



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- 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.

