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

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

Evolution to contact

Drag on surrounding gas tightens the orbit

Orbit stabilizes as envelope is ejected
CE transients

hot ejecta radiate as they cool

Luminous Red Novae:

V1309 Sco

Bright flare

Orb. period decreases

(Mason+ 2010, Tylenda+ 2011)
CE transients

Luminous Red Novae? (Kasliwal 2011)
CE transients

Andromeda galaxy...
CE transients

M31 LRN 2015

Outburst in Andromeda galaxy in Jan 2015

Pre-outburst source in HST imaging

Binary System

Transient Outburst

(Kurtenkov+ 2015)

Outburst in Andromeda galaxy in Jan 2015

(MASTER OT J004207.99+405501.1 = M31N 2015-01a)

(Williams+ 2015)
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

(MacLeod+, 2017)
CE transients

M101 OT2015-1

~18 solar mass primary star

extended ‘precursor’ brightening

(Blagorodnova+ 2017)
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

example: stable mass transfer
CE ejection modeling

$\frac{t-t_1}{t_1} = 53.39$

merging system: slice through orbital plane
CE ejection modeling

Simulation frame

orbital decay starts out gradual, then runs away
CE ejection modeling

orbital motion desynchronizes from envelope
CE ejection modeling

precursor

~5 orbits

stronger shocks

outburst

increased thermal broadening of ejecta
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.