The eccentricity pumping effect of CB disks

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The Physics of Evolved Stars, 2015
Hot subdwarfs
Hot subdwarfs
Hot subdwarf evolution

- He Flash
- Envelope loss
- Core He burning
sdB formation

RG + MS Binary

Unstable RLOF

Common Envelope

Short period

Stable RLOF

Long period
Theoretical predictions

Adapted from Han et al. 2003; Chen et al. 2013

Based on our observations
sdB observing campaign

HERMES @ Mercator

- 8 targets
- 6 years of monitoring
- ~50 spectra/target
Radial velocity curves

PG 1104+243

Gravitational
Redshift

BD +29°3070

O-C (km/s)

RV (km/s)

Phase
Unexpected eccentricity
Eccentricity Pumping

Reintroduce eccentricity after circularisation on the RGB
Eccentricity Pumping

Reintroduce eccentricity after circularisation on the RGB

RLOF

Phase-dependent mass loss

Soker (2000)
Bonacic et al. (2008)
Eccentricity Pumping

Reintroduce eccentricity after circularisation on the RGB

RLOF

Phase-dependent mass loss
  - Soker (2000)
  - Bonacic et al. (2008)

CB disks

Lindblad resonances
  - Artymowicz & Lubow (1994)
  - Dermine et al. (2013)
Eccentricity Pumping

Reintroduce eccentricity after circularisation on the RGB

**RLOF**

- Phase-dependent mass loss
  - Soker (2000)
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**CB disks**

- Lindblad resonances
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  - Dermine et al. (2013)

min(e) = 0.001
MESA is a state-of-the-art, modular, open source suite for stellar evolution

- MESA stellar evolution code: mesa.sourceforge.net
- MESA instrument papers (Paxton et al. 2011, 2013)

Bill Paxton, father of MESA
Binary Module

- 2 stars evolved at the same time
- Implicit mass transfer (Ritter & Kolb)
- Tides (Zahn 1977)
- Circularisation (Hut 1981, Zahn 1988)
- Magnetic braking
- Gravitational waves
- Angular momentum accretion
RLOF mass-loss fractions

Mass takes away the angular momentum from where it is lost: donor, companion or L2

δ fraction feeds the CB disk
Circumbinary Disk parameters

The diagram illustrates the interaction and non-interaction regions of a circumbinary disk, with parameters such as distance and height. The graph shows the relationship between distance and mass fraction, with interaction and non-interaction regions clearly delineated. The distance is marked with critical points like CM, R_{in}, 6a, and R_{out} = 250 AU.
Circumbinary Disk edot

Eccentricity pumping depends on the orbital eccentricity

Figure taken from Dermine et al. 2013
Eccentricity evolution

- $M_{\text{disk}}$
- $\log(M)$
- $\log(\dot{M})$
- $\log(\dot{e})$
- $e$

- Tidal
- Mass loss
- Disk

Time:
- 7300 yr
- 310 yr
- 95000 yr
Parameter Effect - RLOF

Mass lost around Donor
$\alpha = 0.8 \beta = 0.0$

Mass lost around Accretor
$\alpha = 0.0 \beta = 0.8$

Mass lost to Disk
$\delta = 0.1-0.3$

Radius L2:
$\gamma = 0.9-1.3$
Parameter Effect – CB disk

Maximum Disk Mass

$M_{\text{disk}} = 10^{-2}M_\odot$

$\tau = 10^4 - 10^5$ yr

Disk Mass Distribution

$\sigma(r) \sim r^{-2}$

$\sigma(r) \sim r^{-1}$
Period – Eccentricity Disk & RLOF
Results & Conclusions

Created a small test sample for binary interaction mechanisms

Models allow for observed systems, but don't predict them.

Future prospects:

- Connection to He-WD and dust post-RGB binaries
- Population synthesis studies
- Search for evidence for CB disks