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Decoding the lack of fast rotators in Cygnus OB2

3D modelling of non-spherical massive stars

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Departamento de Astrofísica
Universidad de La Laguna





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Massive blue star credit: ESO/M. Kornmesser

Principal Characteristics

- $M_* \geq 8 M_{\odot}$
- Most powerful & luminous phenomena
- Rapid evolution

Crucial role in cosmos
Mechanical & radiative feedback

Langer (2012); Geen et al. (2015)



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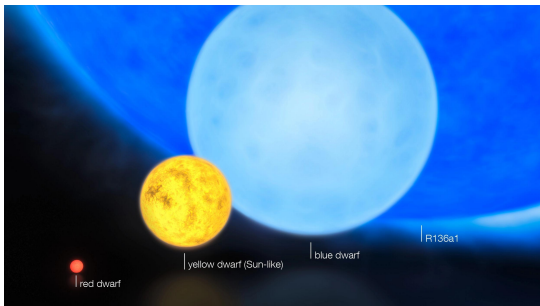
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Importance of rotation

- Rotation key element

– Evolution

– Fate

- Similar

– Stellar mass

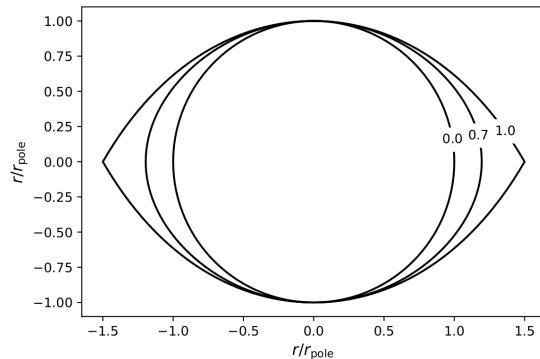
– Metallicity

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– Non spherical

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Maeder & Meynet (2000)



Massive rotating star credit: M. Abdul-Masih



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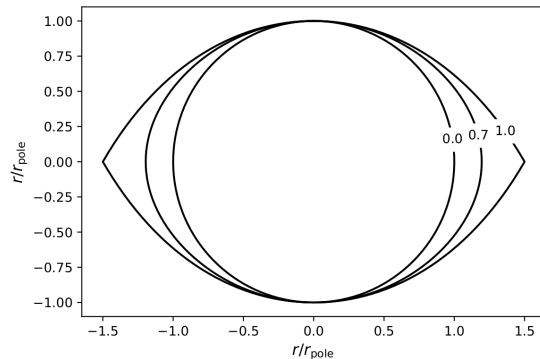
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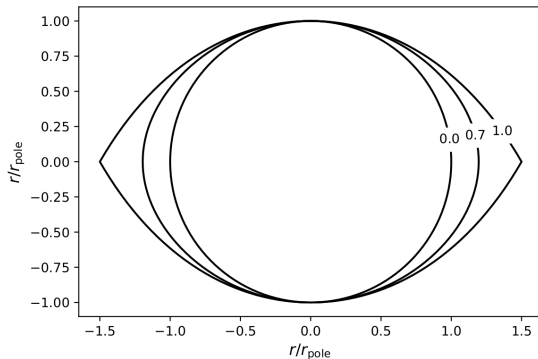
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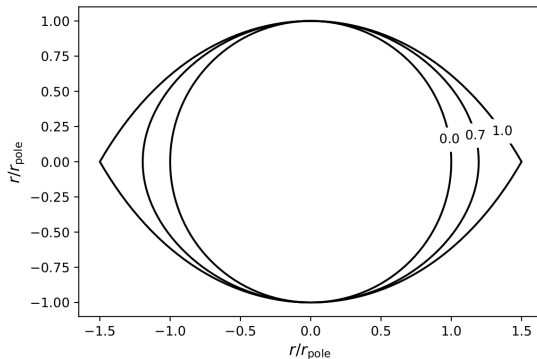
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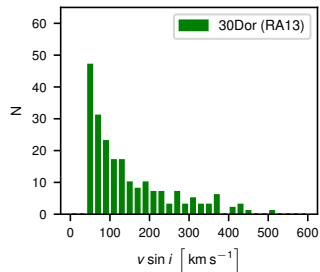
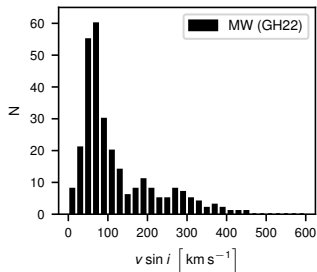
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Distributions of rotational velocities

- O-type stars

– Milky Way Holgado et al. (2022)

– 30 Doradus Ramírez Agudelo et al. (2013)

- Bimodal distribution

– Peak slow rotators ($v \sin i \sim 80 \text{ km s}^{-1}$)

– Tail fast rotators ($v \sin i > 200 \text{ km s}^{-1}$)



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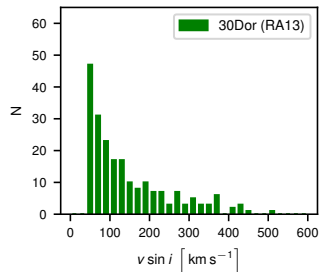
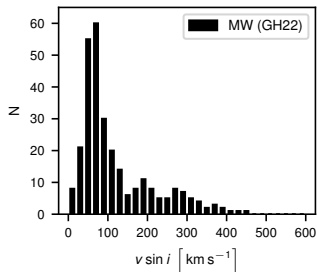
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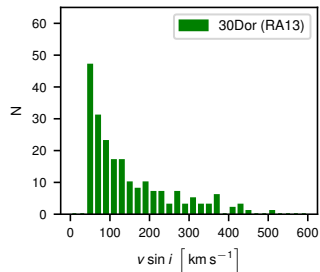
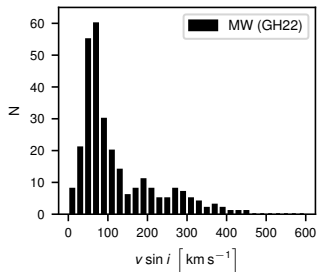
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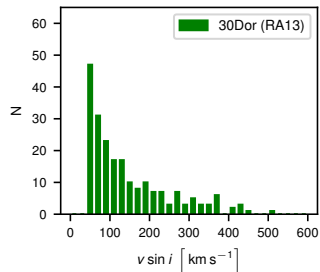
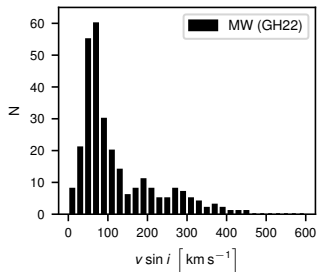
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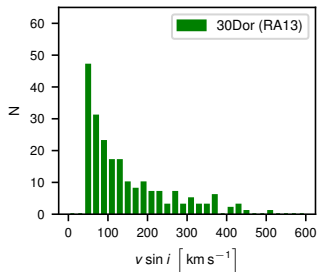
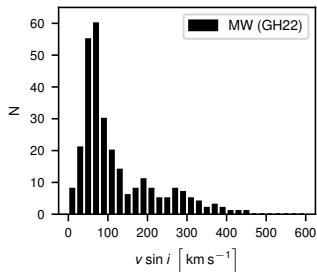
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VFTS 352 animation credit: SPAMMS, M. Abdul-Masih

Massive stars systems

- Most found in multiple systems
- Interaction between members

– Evolution & Fate

Sana et al. (2014)

Interactions in massive stars systems

- Different interactions
 - Tides & mass-exchange
- Rotation rate change

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Key Region

- One of the richest areas of massive star formation in MW
- Nearest from Earth (~ 1.7 kpc)
- Understanding of massive stars
 - formation and evolution of massive stars
 - dynamics of star clusters
 - feedback processes



Cygnus OB2 image credit: X-ray: NASA/CXC/SAO/J. Drake et al; H-alpha: Univ. of Hertfordshire/INT/IPHAS; Infrared: NASA/JPL-Caltech/Spitzer



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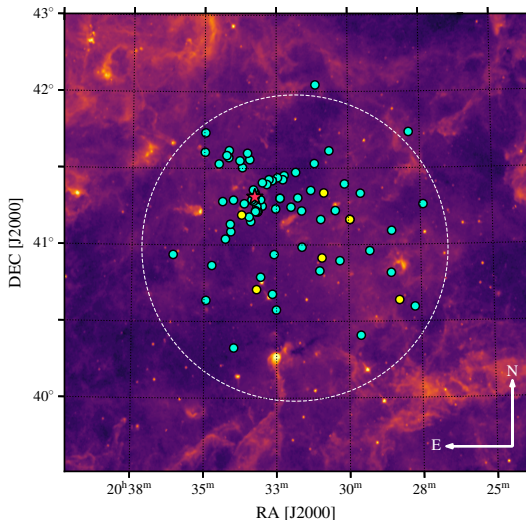
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Berlanas et al. (2020) + Galán-Diéguez et al. (prep)

- O-type stars
 - ~ 100 stars
- ORM Observations
 - 10.4-m GTC
 - 4.2-m WHT
 - 2.56-m NOT
 - 2.54-m INT
- $v \sin i$ distribution



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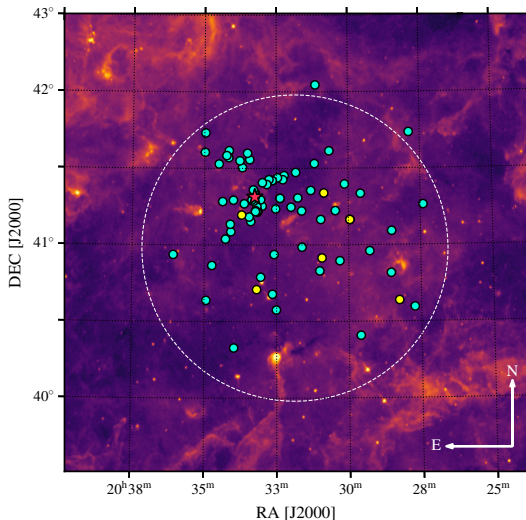
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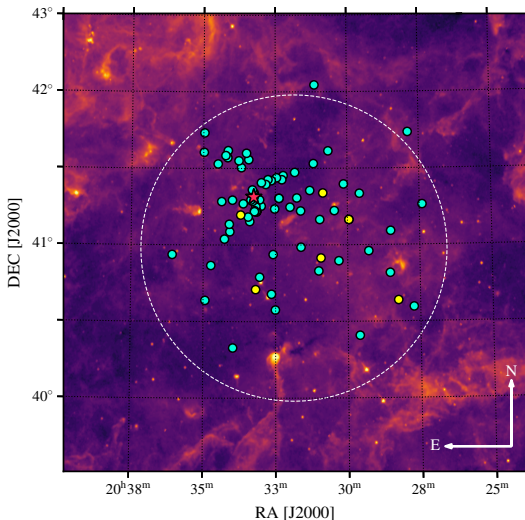
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$v \sin i$ Distribution in Cygnus OB2

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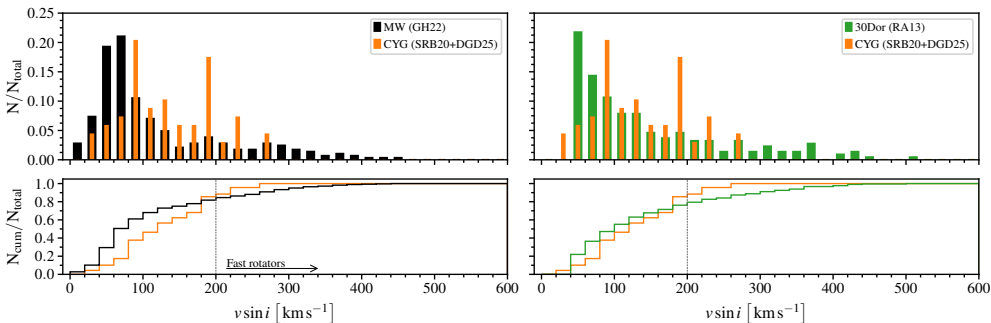
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– 30 Doradus [Ramírez-Agudelo et al. \(2013\)](#)

• Lack of fast rotators

– $v \sin i \geq 200 - 250 \text{ km s}^{-1}$

[Borlante et al. \(2020\); Galán-Díez et al. \(prep\)](#)



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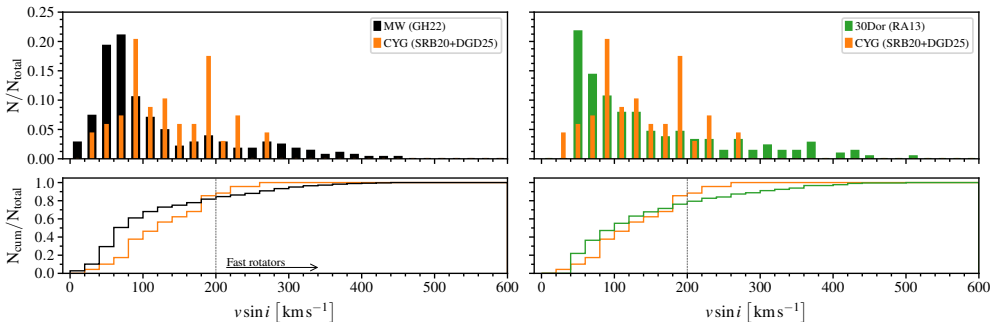
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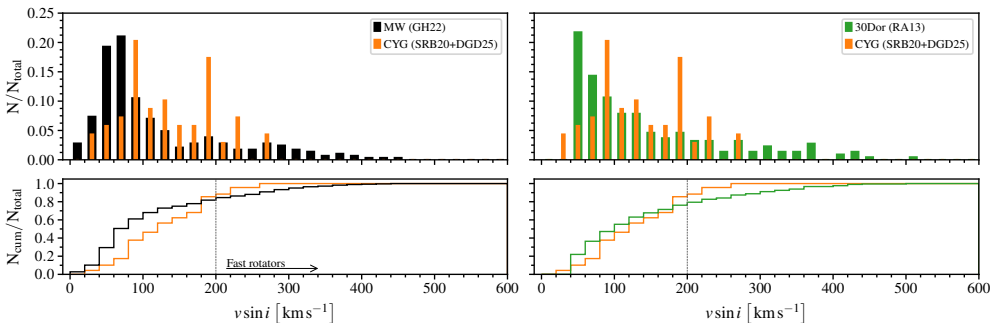
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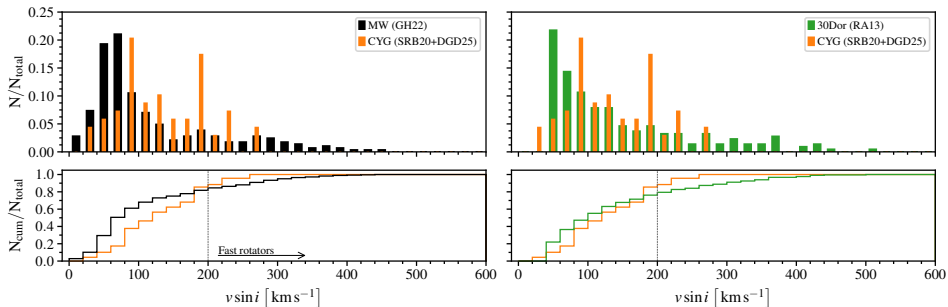
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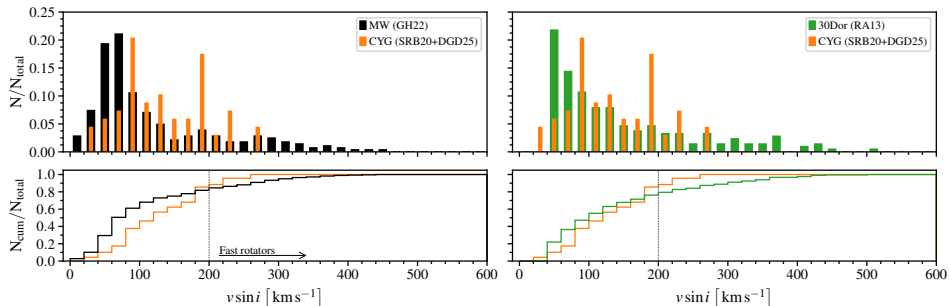


Lack of fast rotators!

- **Problem:**
 - Multiple systems
 - Binary interactions → fast rotators
- Fast-rotators expected: 13-18



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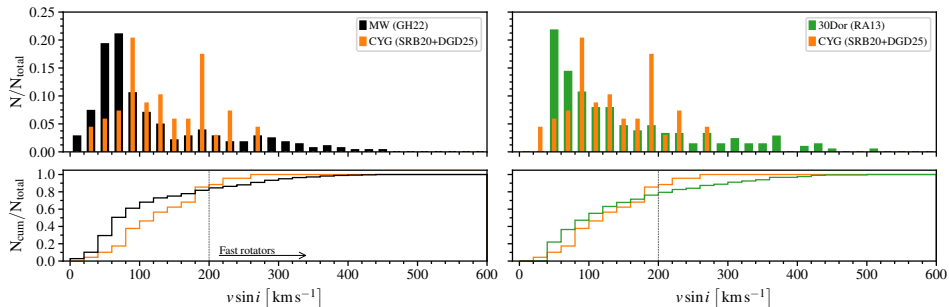


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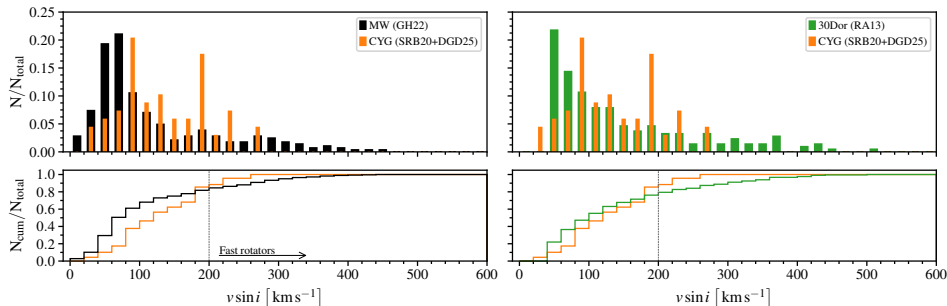
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Possible explanations

- **Runaways**
 - Fast-rotators ejected by SN explosion

Galán-Diéguez et al. (prep)





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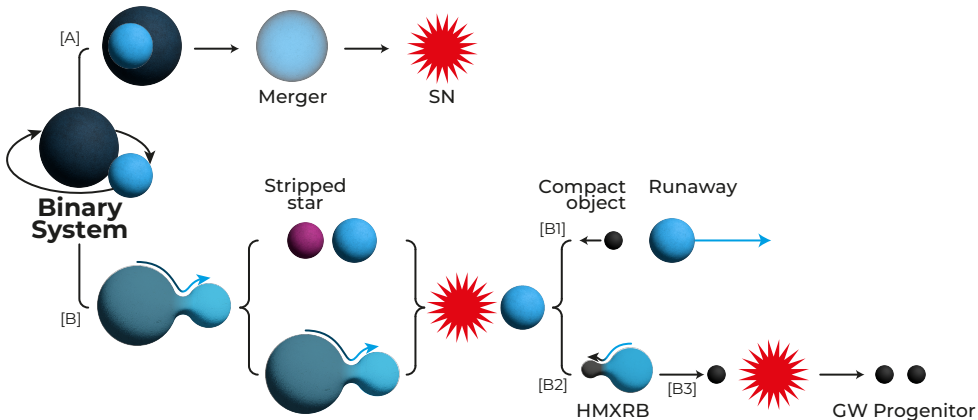
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Massive binary system credit: D. Galán-Diéguez & A. Baamonde Cordal



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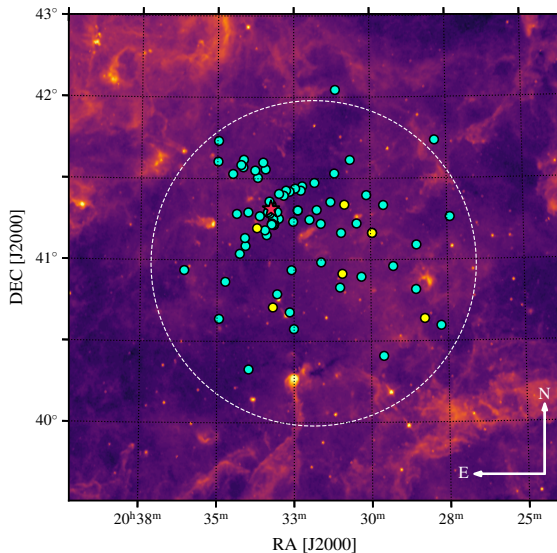
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Possible explanations

- **Evolutionary stage**
 - No enough time for binary interactions
 - 1–6 Myr [Berlanas et al. \(2020\)](#)





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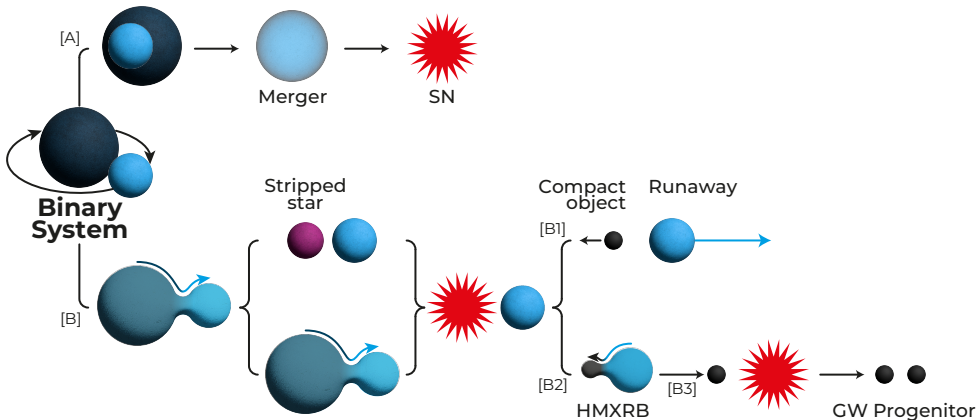
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Massive binary system credit: D. Galán-Diéguez & A. Baamonde Cordal



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- **Spin rotation direction**
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Galán-Diéguez et al. (prep)





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- **Environmental properties**
 - No formation enough binary systems
 - Low initial rotation





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On going!

- **Runaways**
 - Fast-rotators ejected by SN explosion
- **Evolutionary stage**
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- **Spin rotation direction**
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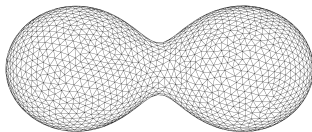
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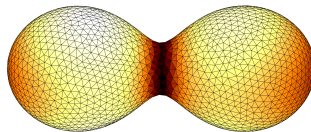
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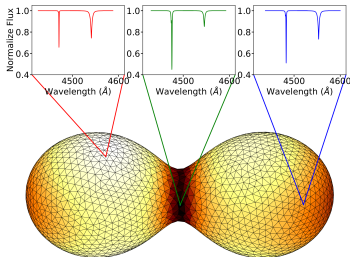
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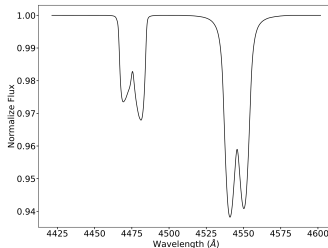
2)



3)



4)





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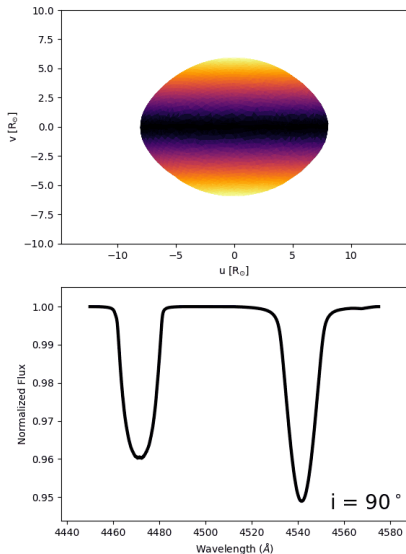
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Ongoing projects

- Field extension

- $1^\circ \rightarrow 2^\circ$ using high-resolution WEAVE

- Spectra analysis

- High-resolution WEAVE + SPAMMS + genetic AI

- SPAMMS

- $v \sin i \rightarrow v/v_{crit}$
- No inclination

- Binary fraction

- High-resolution WEAVE survey
- Multiepoch spectra



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Have a look into my work!



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