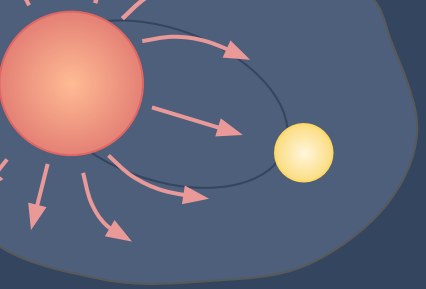
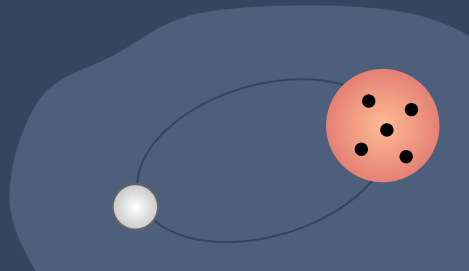
13th Torino Workshop on AGB Stars
23/06/2022

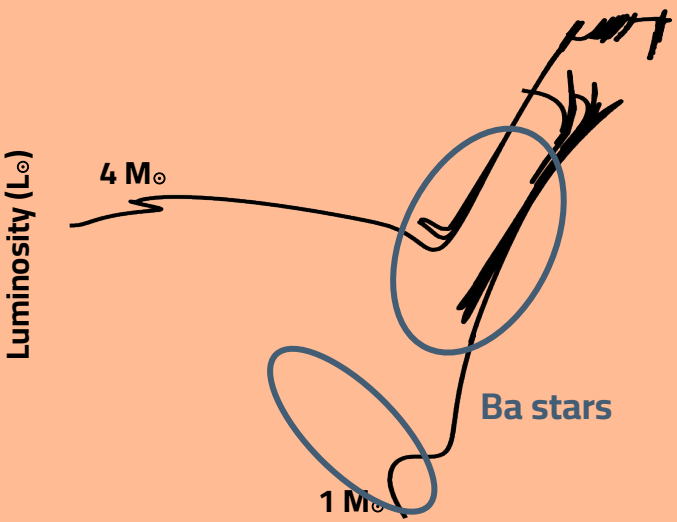
Nucleosynthesis and binarity in AGB stars: the Barium star perspective





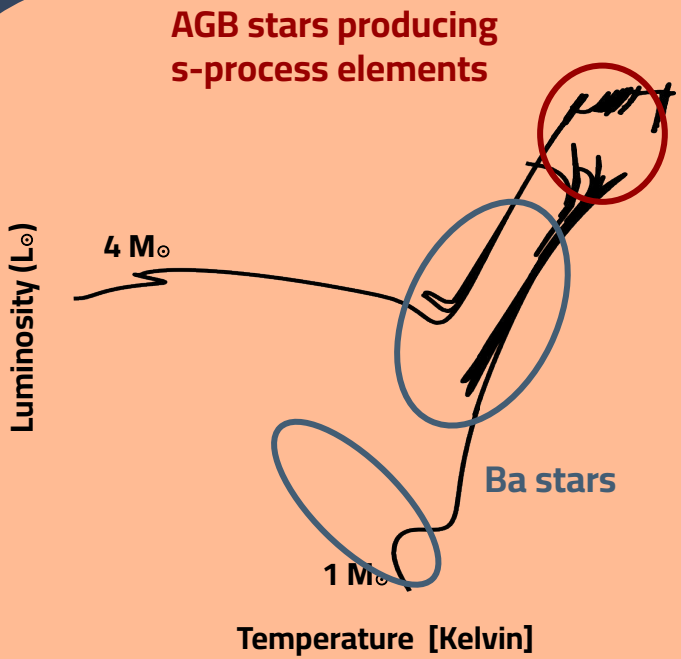
Ana Escorza

Barium stars



Ba stars were identified as main-sequence or red-giant stars with overabundance of s-process elements.

Barium stars



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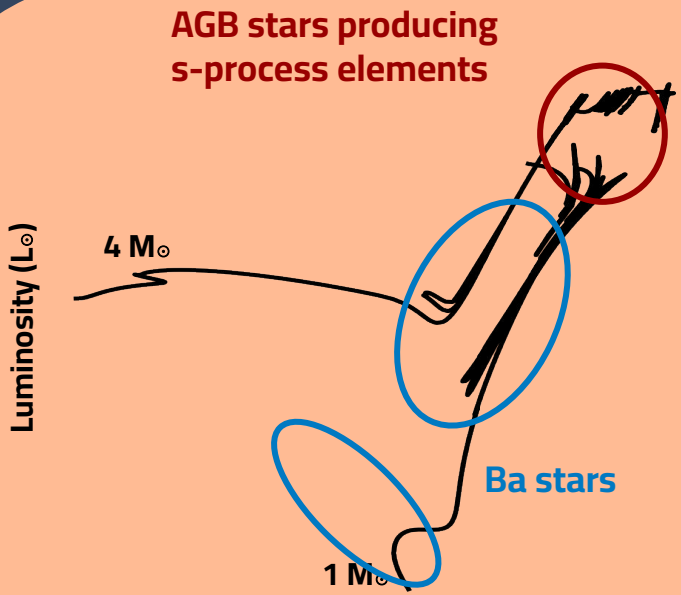
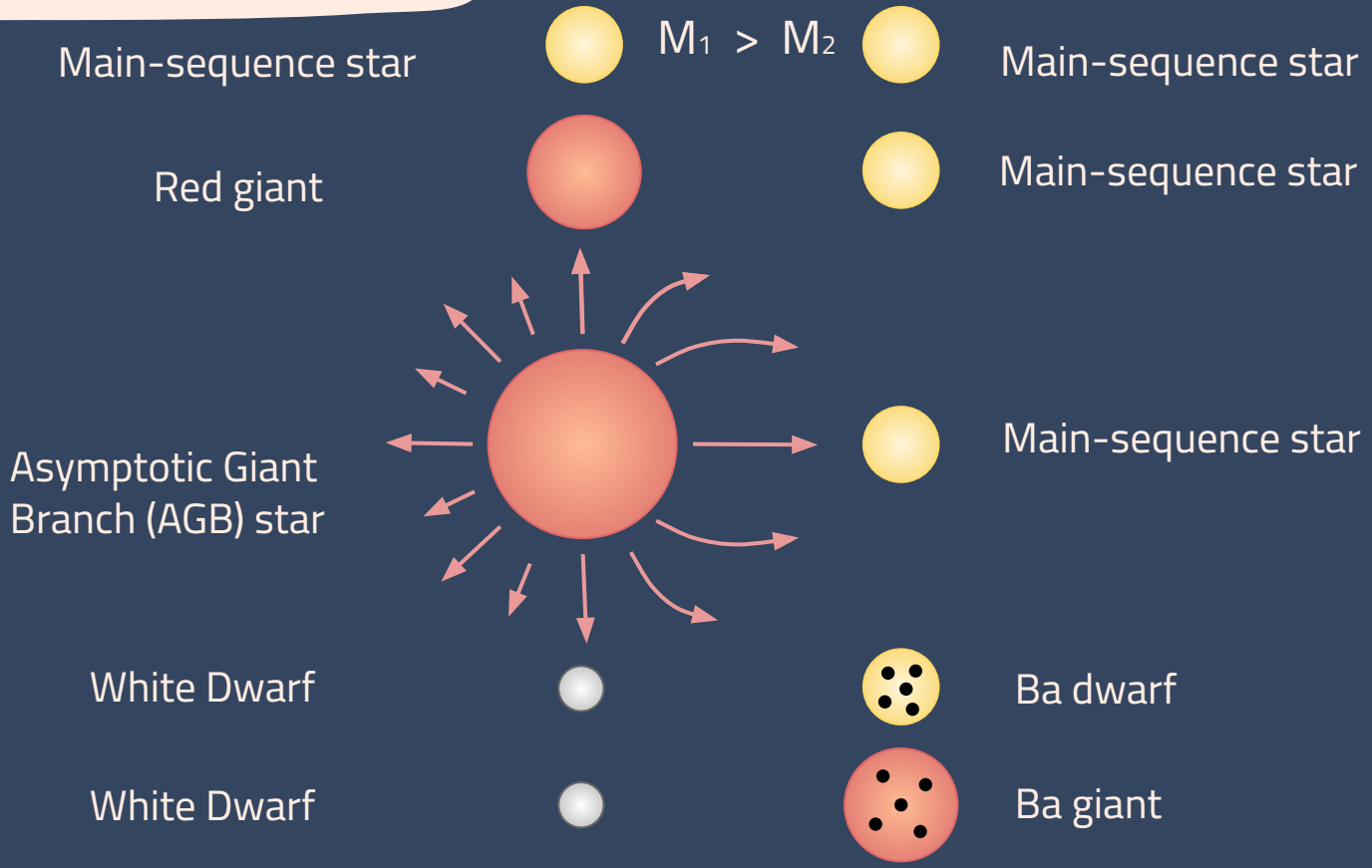


Ba stars were identified as main-sequence or red-giant stars with overabundance of s-process elements.

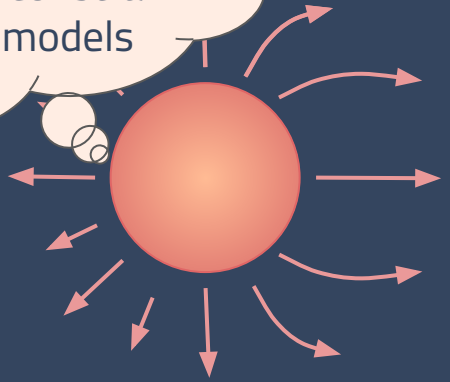
Ba stars form in binaries where a former AGB companion polluted them with s-process elements.

Barium stars



Why Should we care?

The stellar and chemical properties of the current components can constrain nucleosynthesis models



Asymptotic Giant Branch (AGB) star

Main-sequence star

White Dwarf

Ba dwarf

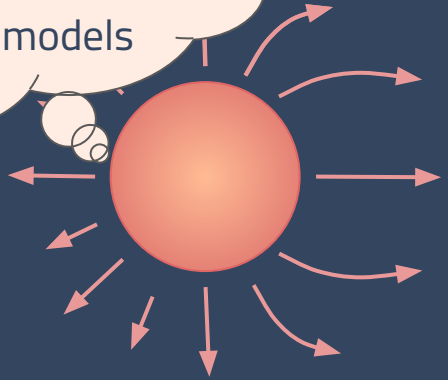
White Dwarf

Ba giant

Why Should we care?

The stellar and chemical properties of the current components can constrain nucleosynthesis models

AGB binary evolution models should reproduce the orbital properties of Ba stars.



Asymptotic Giant Branch (AGB) star

Main-sequence star

White Dwarf

Ba dwarf

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Outline

1. Stellar and chemical properties of Ba stars

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2. Orbital properties of Ba star systems

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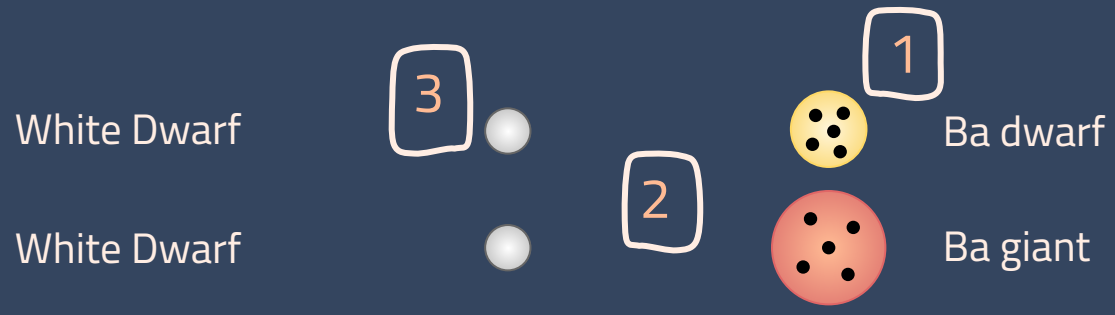
1. Stellar and chemical properties of Ba stars
2. Orbital properties of Ba star systems
3. The masses of the WD companions of Ba stars



1. Stellar and chemical properties of Ba stars

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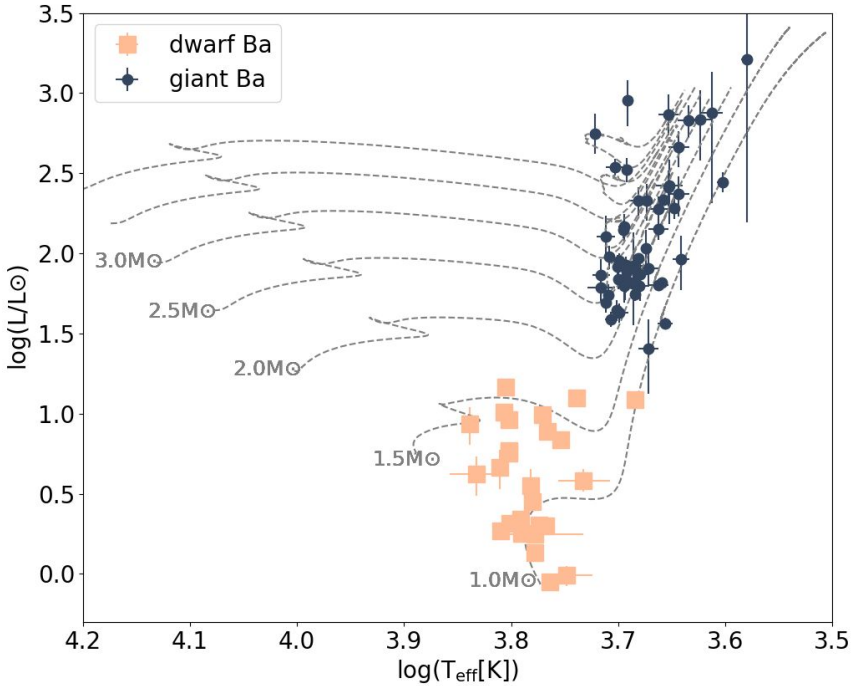


(Escorza+17, Jorissen+19, Escorza+19)

HERMES spectra

+

MARCS model atmospheres

+

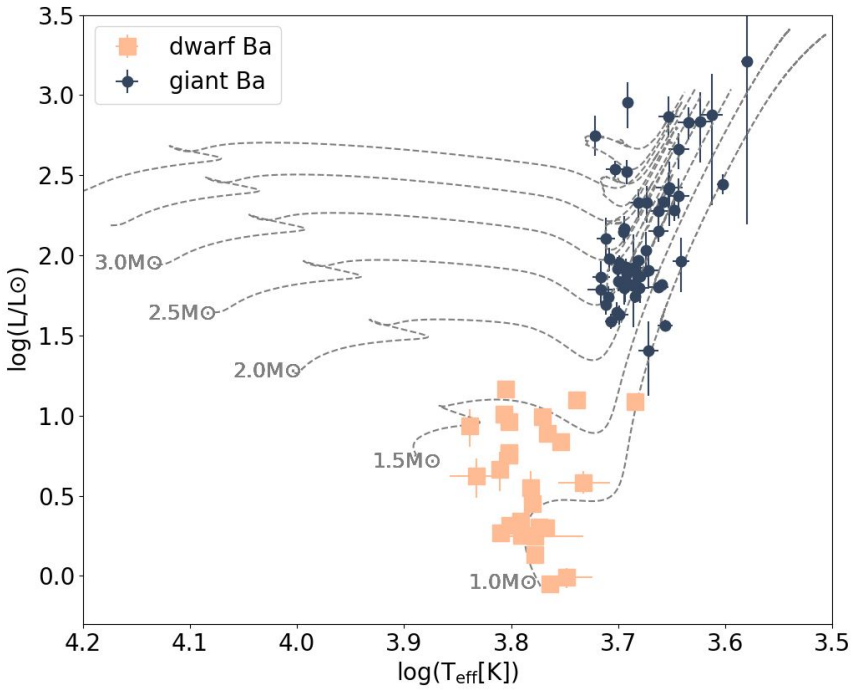
Gaia DR2 distances

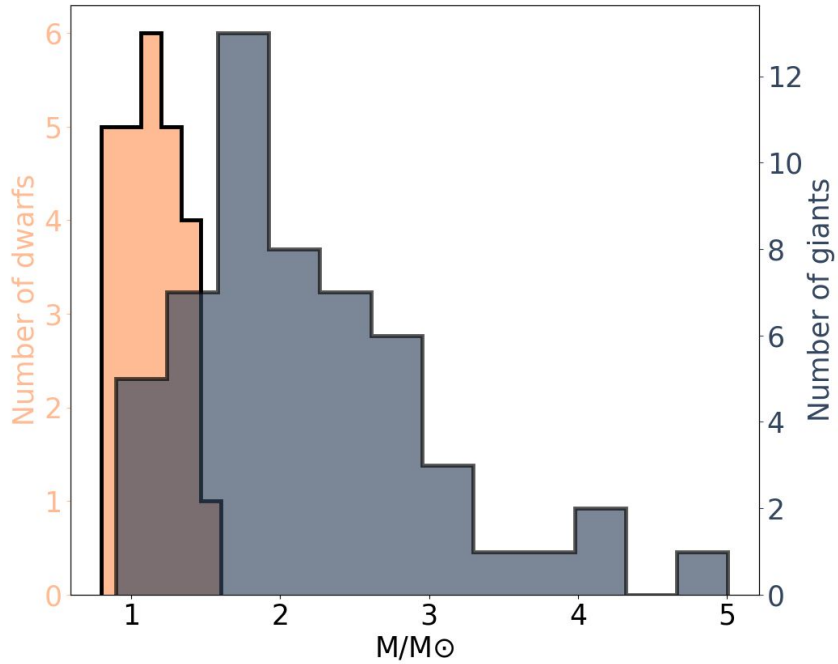
+

STAREVOL tracks

(Siess+00,06,08)

1. Stellar and chemical properties of Ba stars





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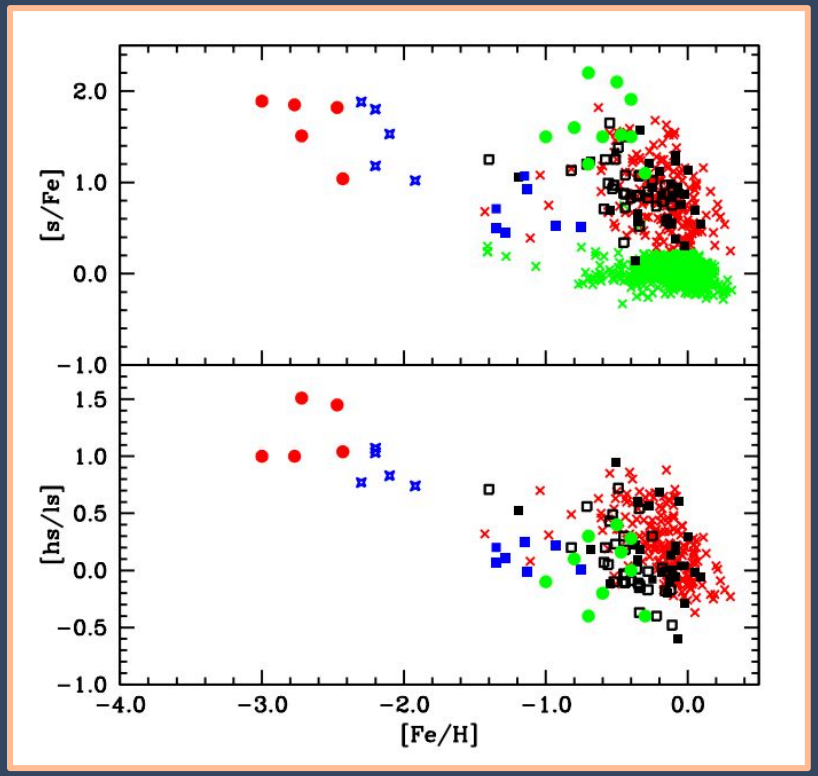

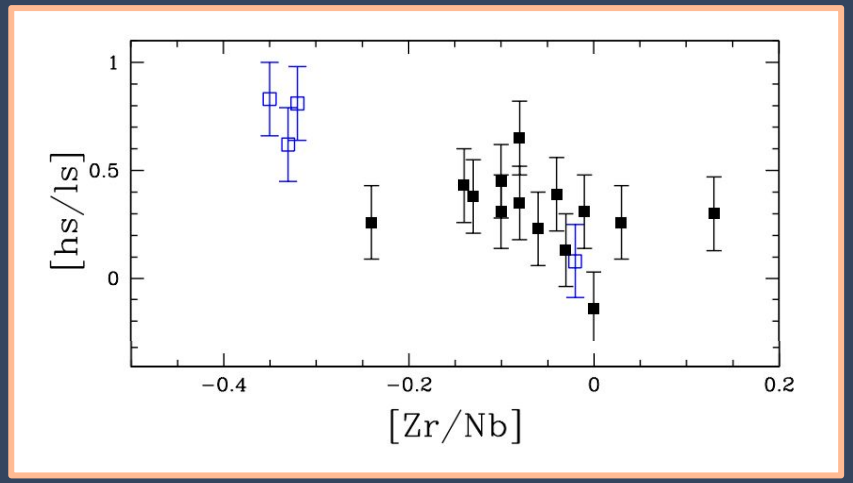

(Figures from De Castro et al. 2016 and Karinkuzhi et al. 2018)

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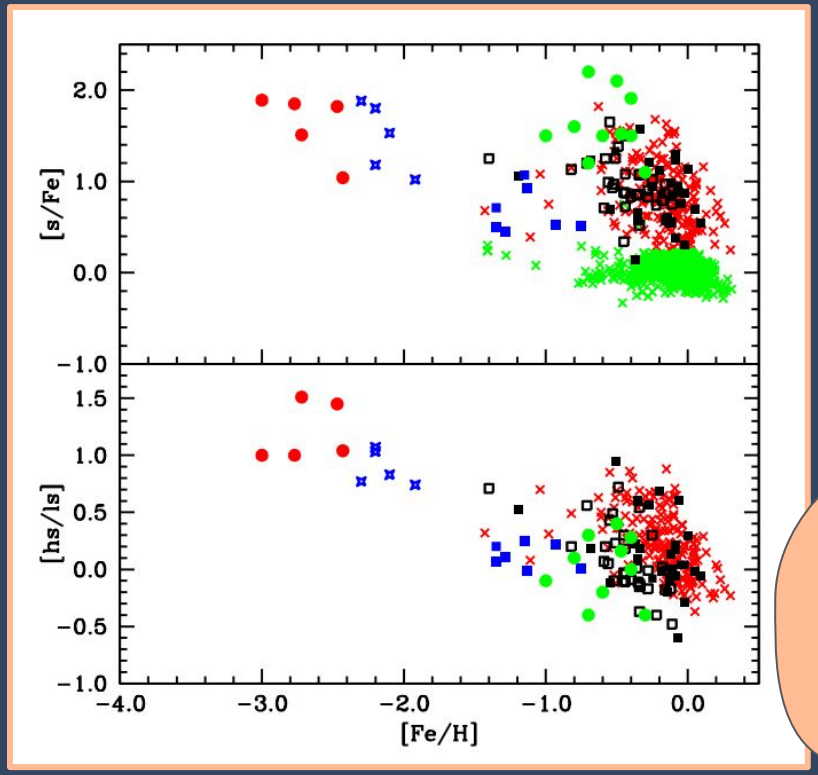

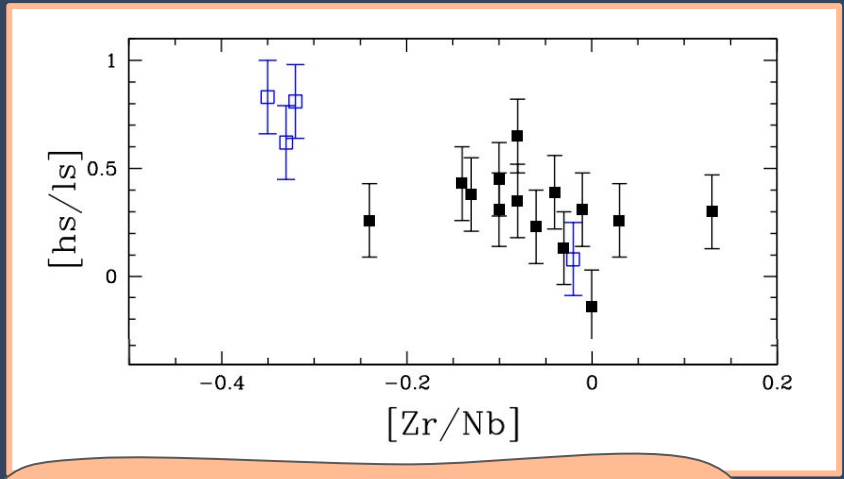

The ratio between the amount of heavy (Ba, La, Ce) and light (Sr, Y, Zr) s-process elements suggests that low-mass AGB stars (< 3 Msun) polluted Ba stars.
(e.g. Lugaro, Karakas, Karinkuzhi, Cseh…)

(Figures from De Castro et al. 2016 and Karinkuzhi et al. 2018)

2. Orbital properties of Ba stars

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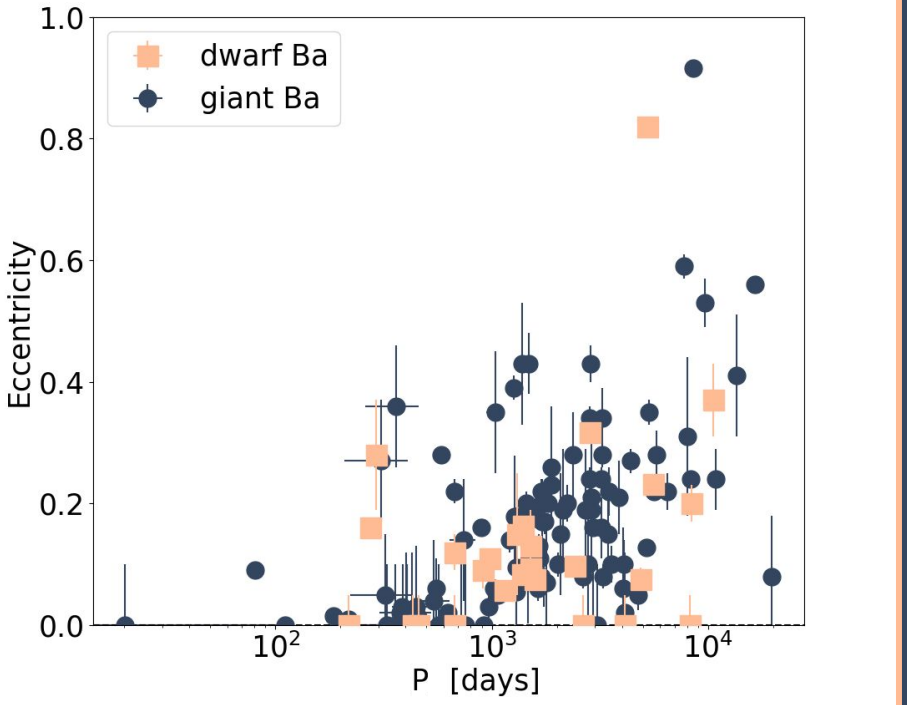
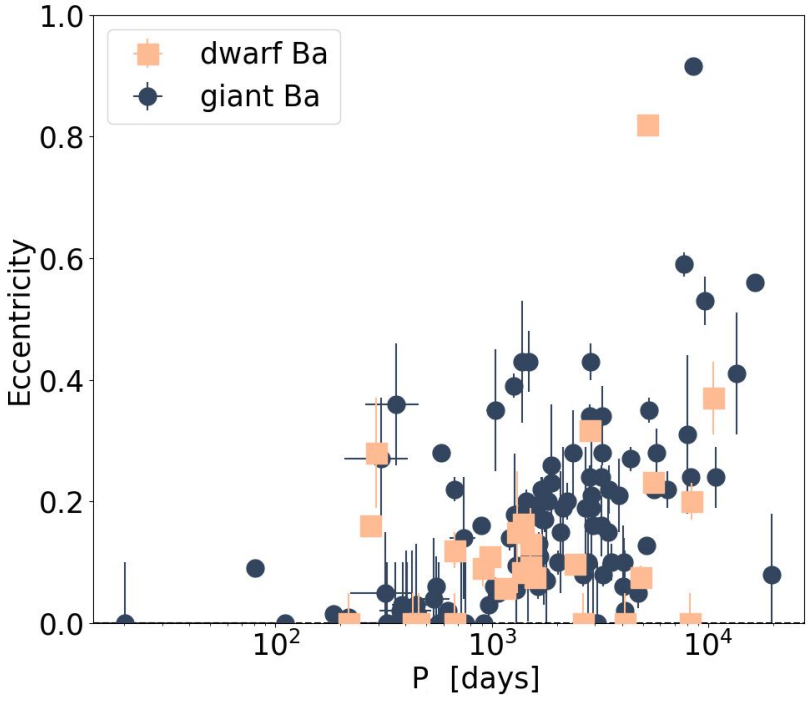


(Jorissen+19, Escorza+19)

HERMES
radial velocity monitoring
+
CORAVEL, CORALIE and ELODIE
radial velocity data
+
HRS@SALT spectra

2. Orbital properties of Ba



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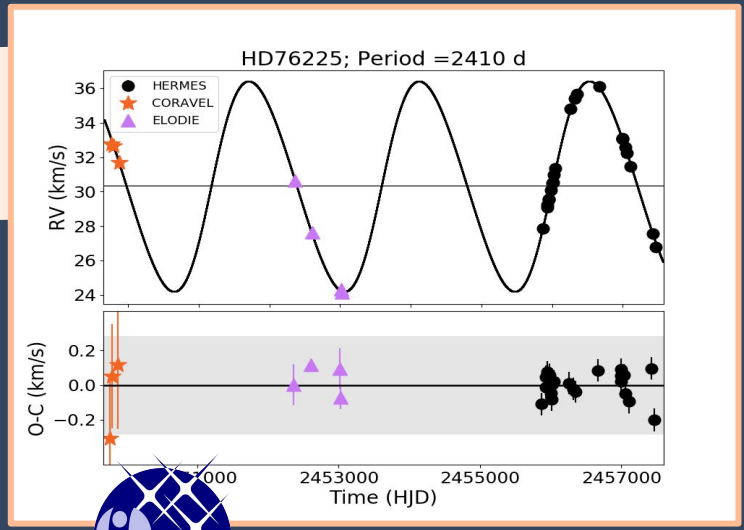

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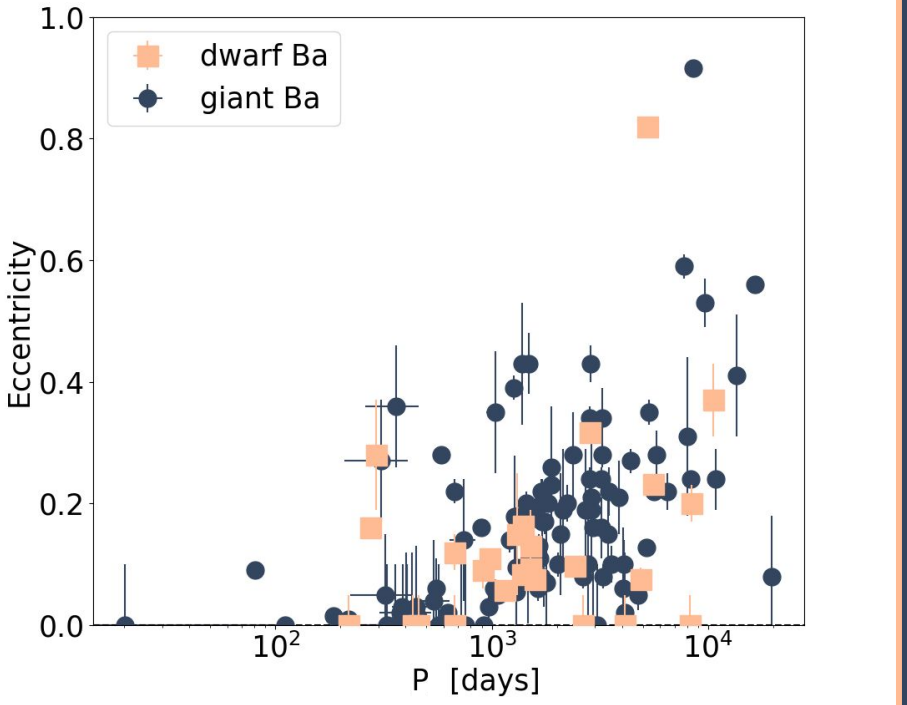

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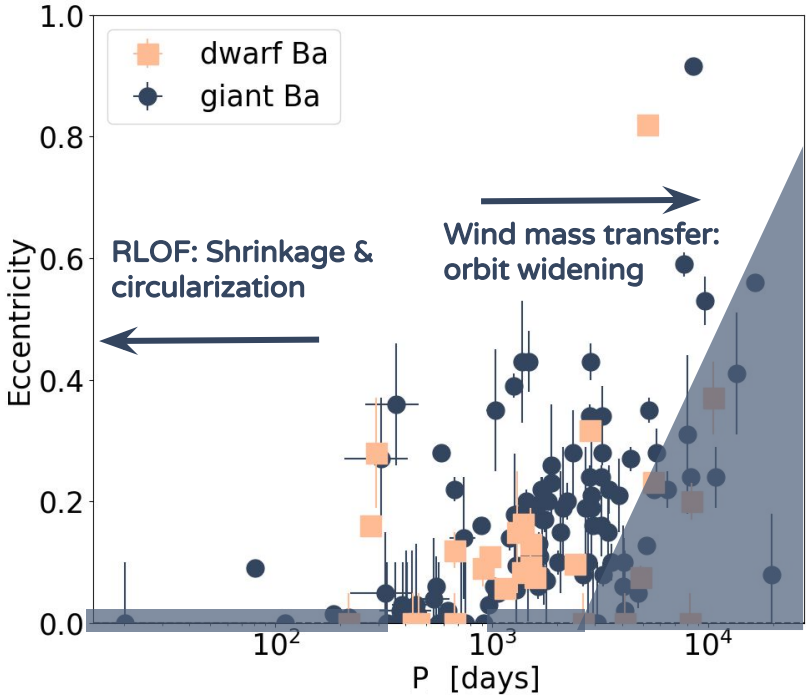

(Jorissen+19, Escorza+19 & Models from Izzard+10)

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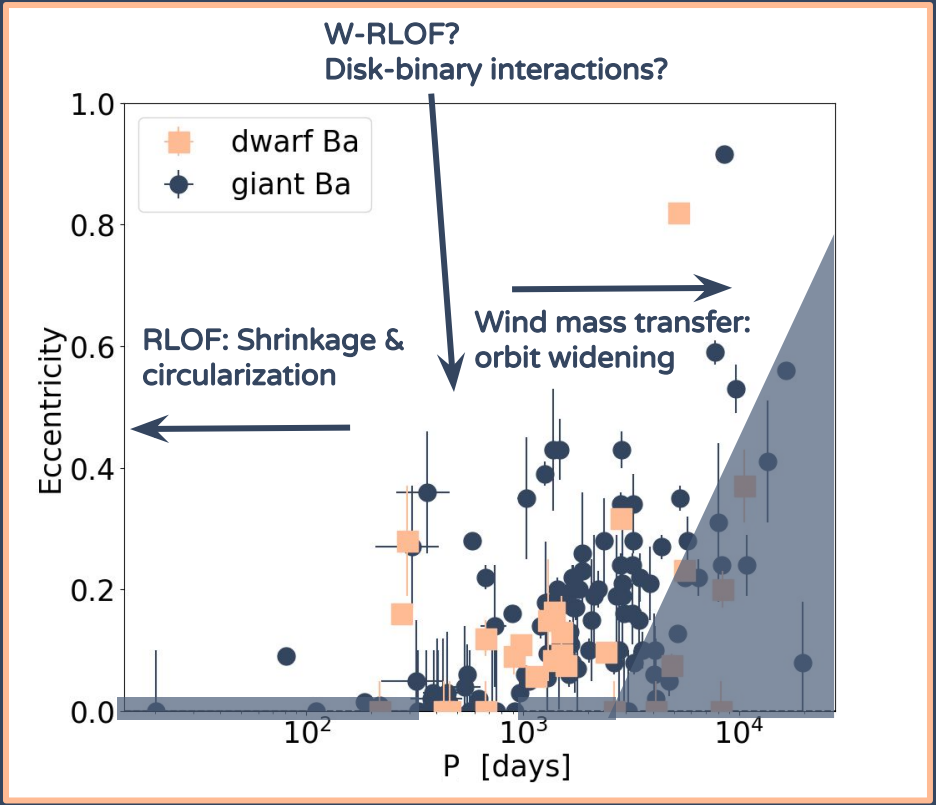

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(see Tout, Eggleton, Han, Soker, Pols, Bonačić Marinović, Mohamed, Izzard, Dermine, Nie, Abate, Oomen, Saladino, Stancliffe, Gao...)

3. The masses of the WD companions of Ba stars

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$$f(m) = \frac{m_2^3}{(m_1 + m_2)^2} \sin^3 i$$

$$= 1.0361 \cdot 10^{-7} \cdot (1 - e^2)^{3/2} K_1^3 P \quad [\mathrm{M}_\odot]$$

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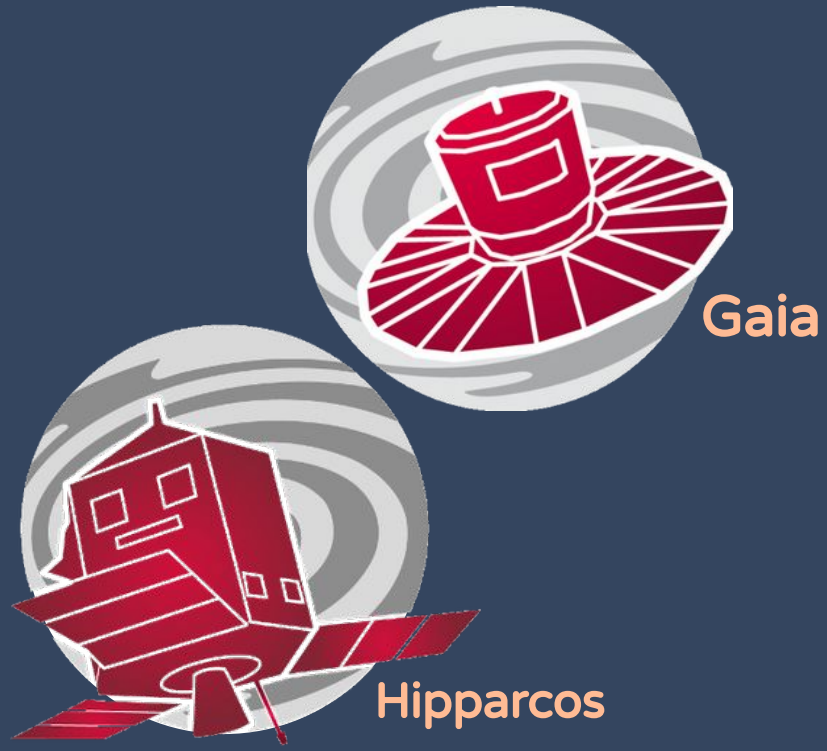
Combining RV data with Hipparcos and Gaia astrometry and the HG catalogue of accelerations, we could constrain orbital inclinations and secondary masses



3. The masses of the WD companions of Ba stars

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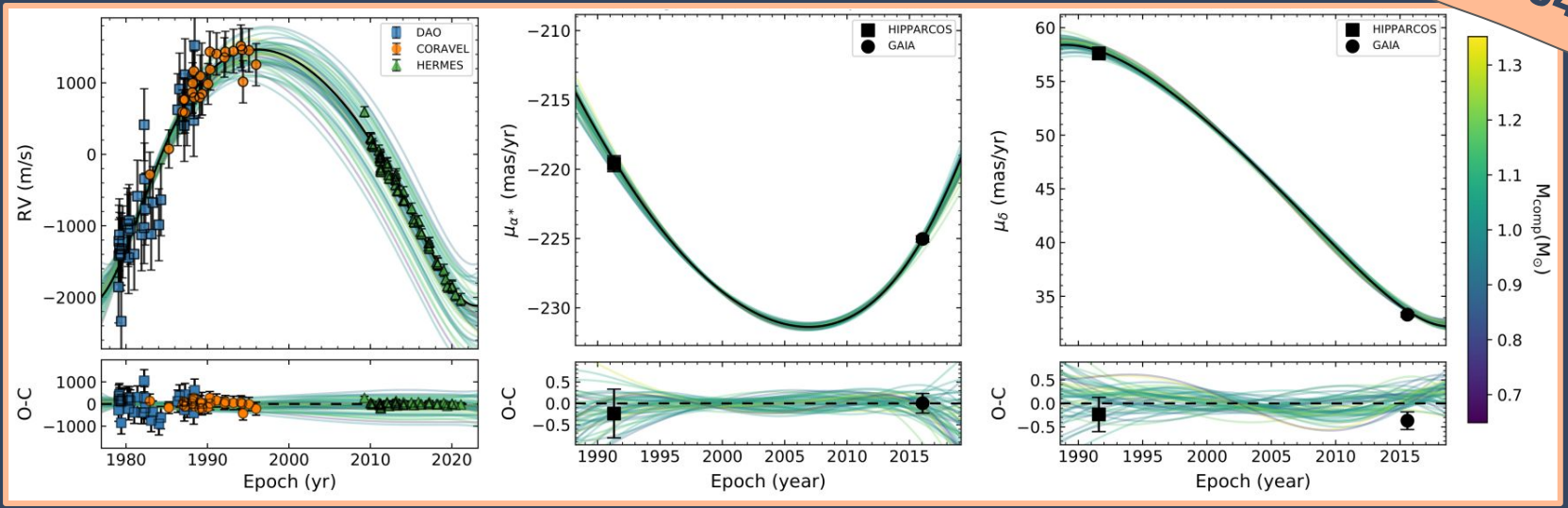
RV data + Hipparcos-Gaia acceleration

HD 104979



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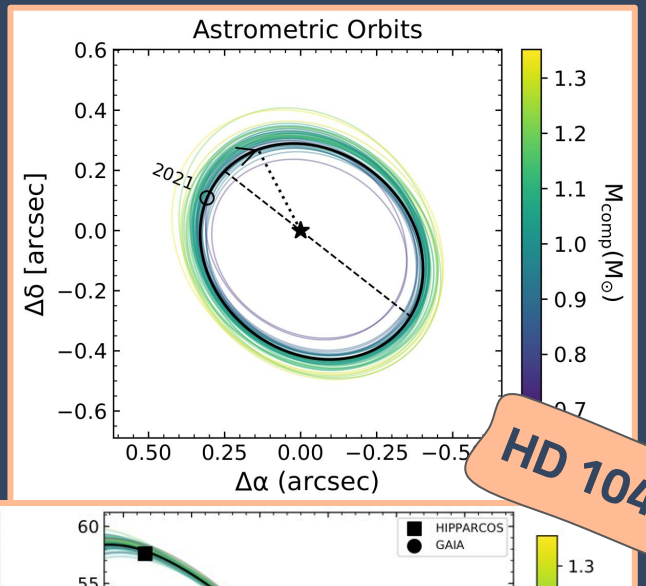
RV data + Hipparcos-Gaia acceleration

+ Hipparcos epoch astrometry



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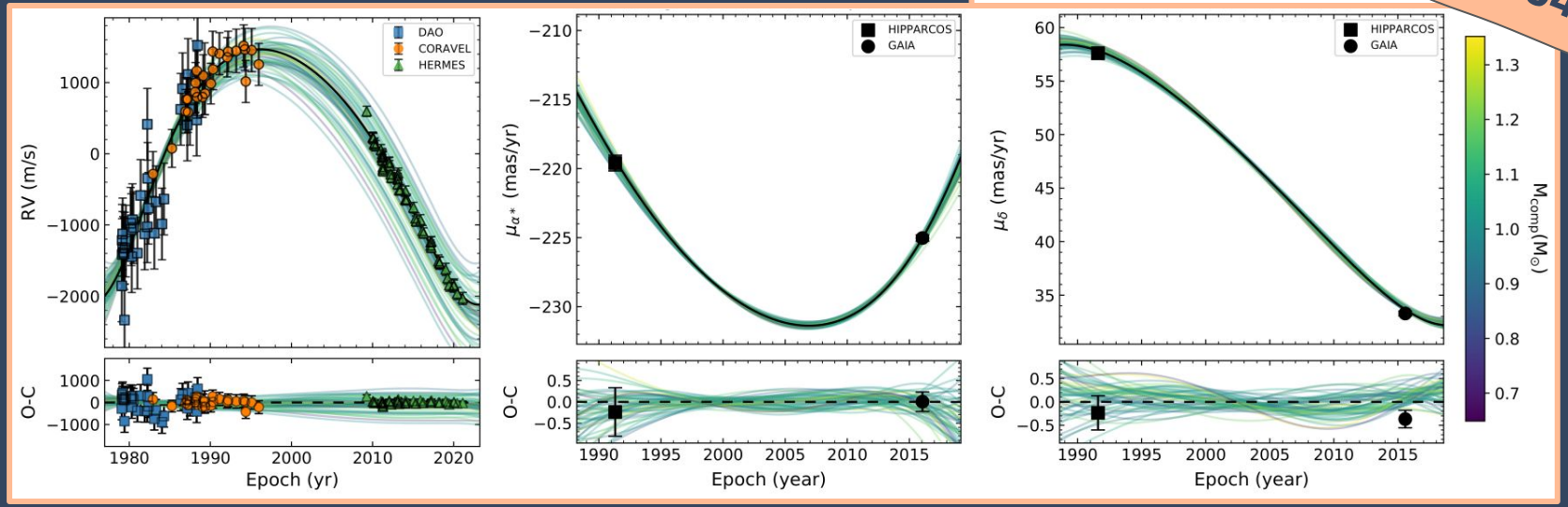
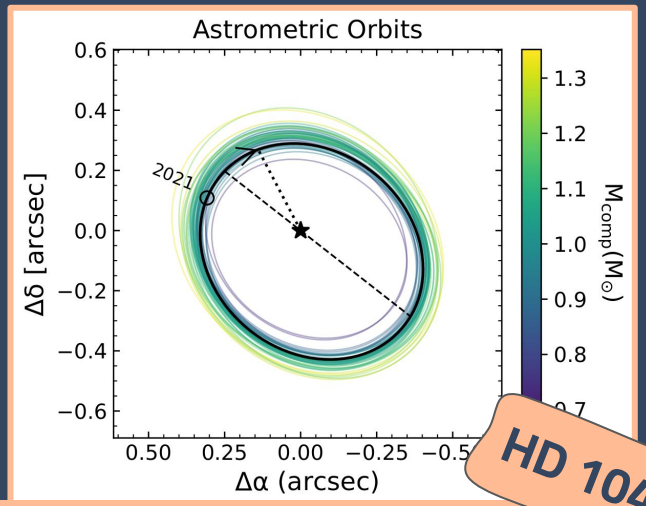


3. The masses of the WD companions of Ba stars

RV data + Hipparcos-Gaia acceleration

+ Hipparcos epoch astrometry

=> HD 104979 has a 1.02 ± 0.15 $M_\odot$ companion



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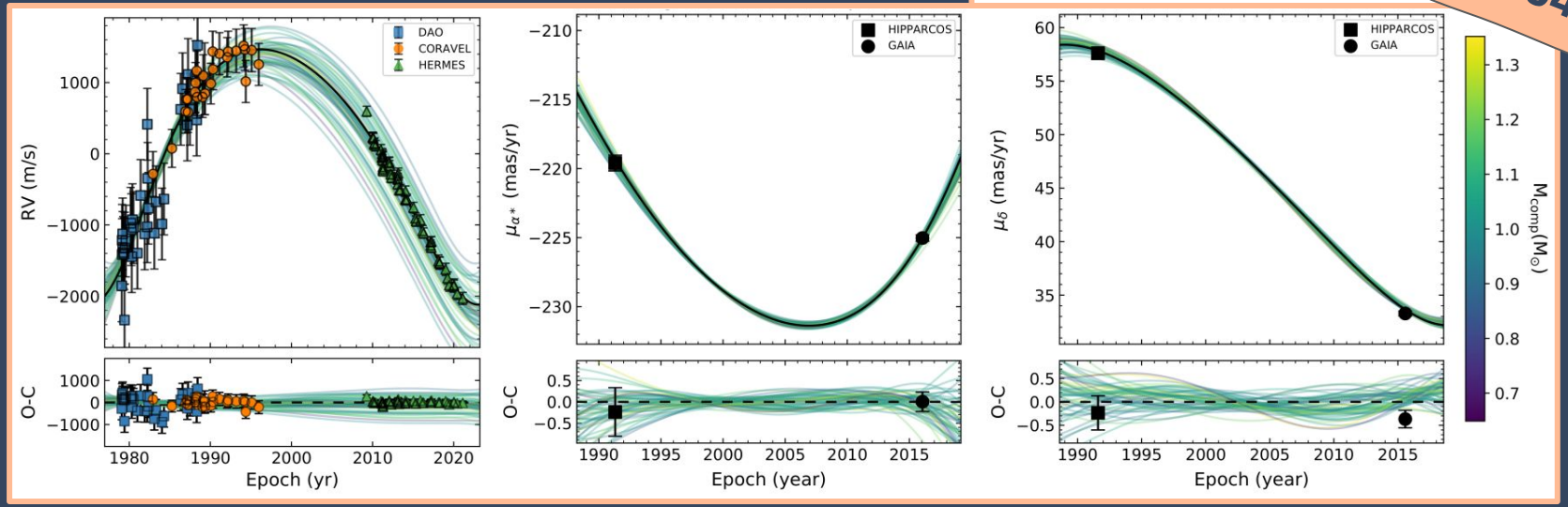
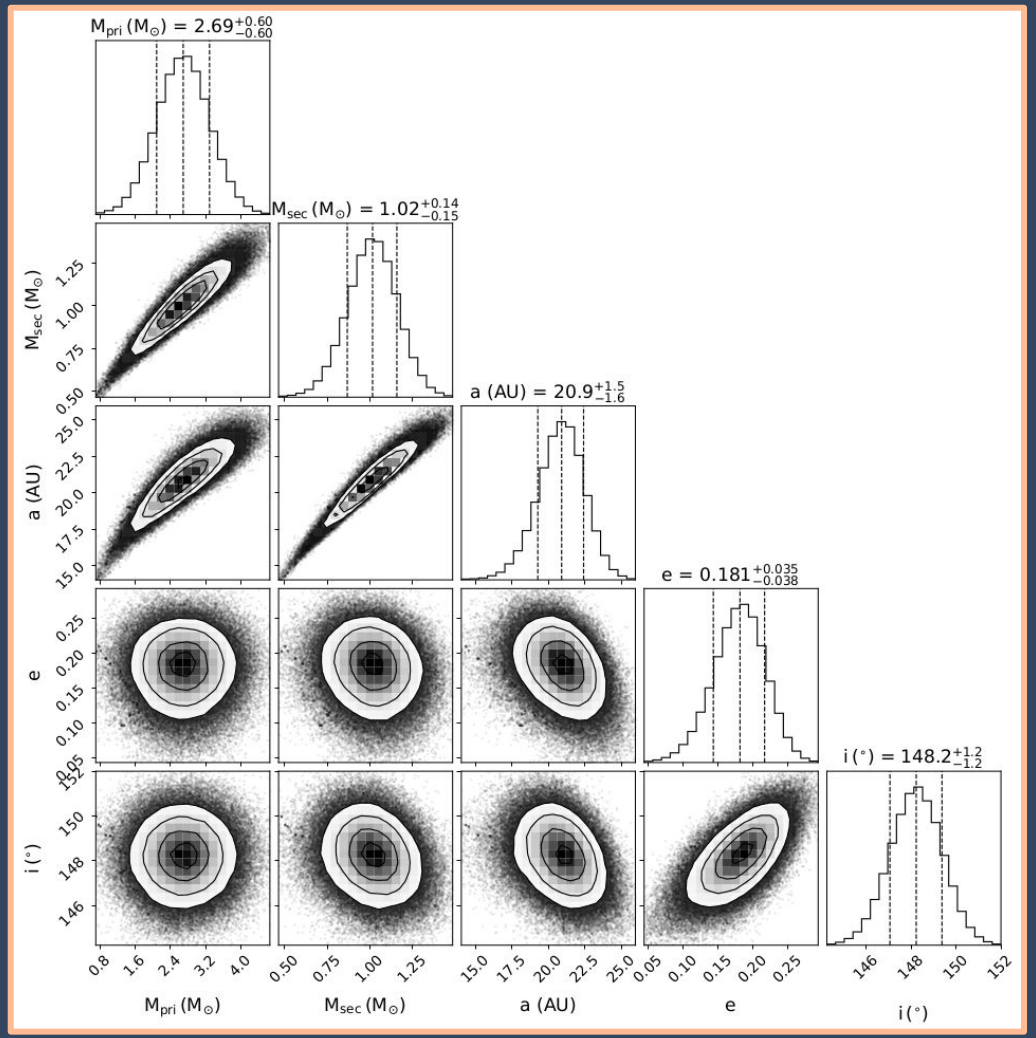
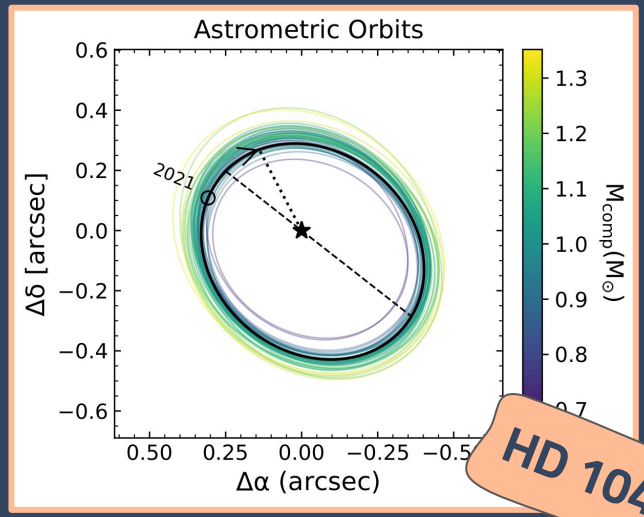


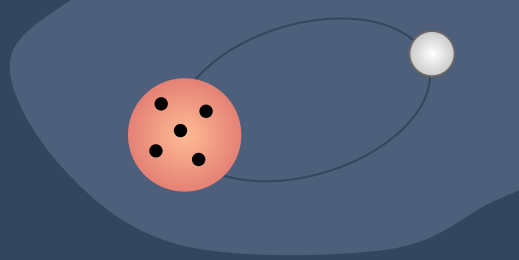




HD 104979

(Escorza & De Rosa, in prep)

3. The masses of the WD companions of Ba stars



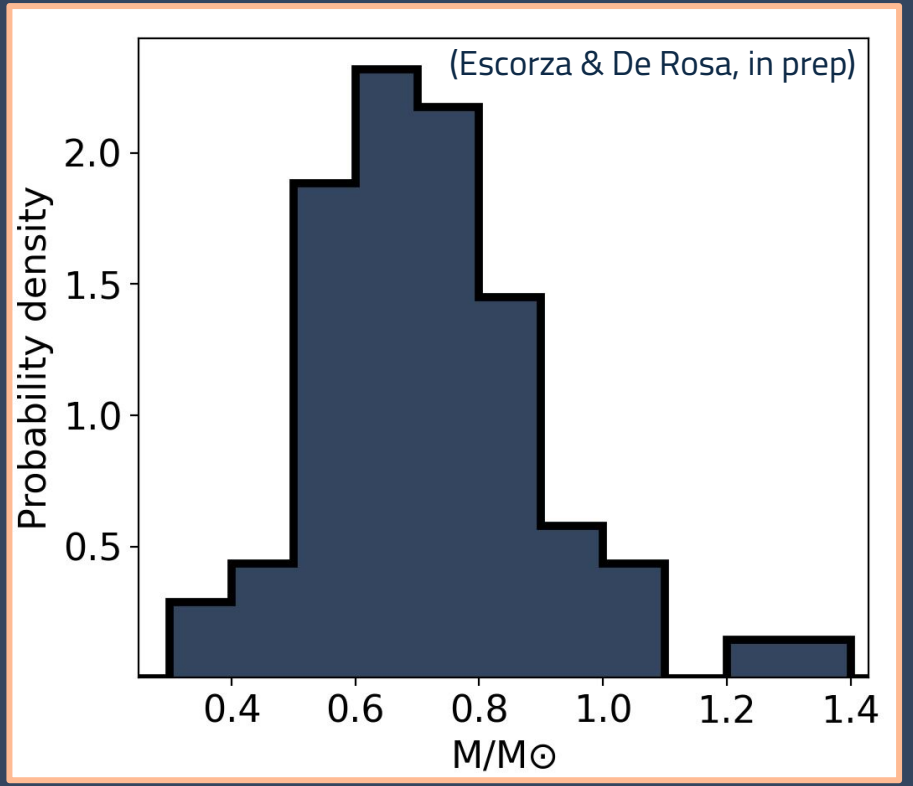
RV data + Hipparcos-Gaia acceleration

+ Hipparcos epoch astrometry

3. The masses of the WD companions of Ba stars

RV data + Hipparcos-Gaia acceleration
+ Hipparcos epoch astrometry

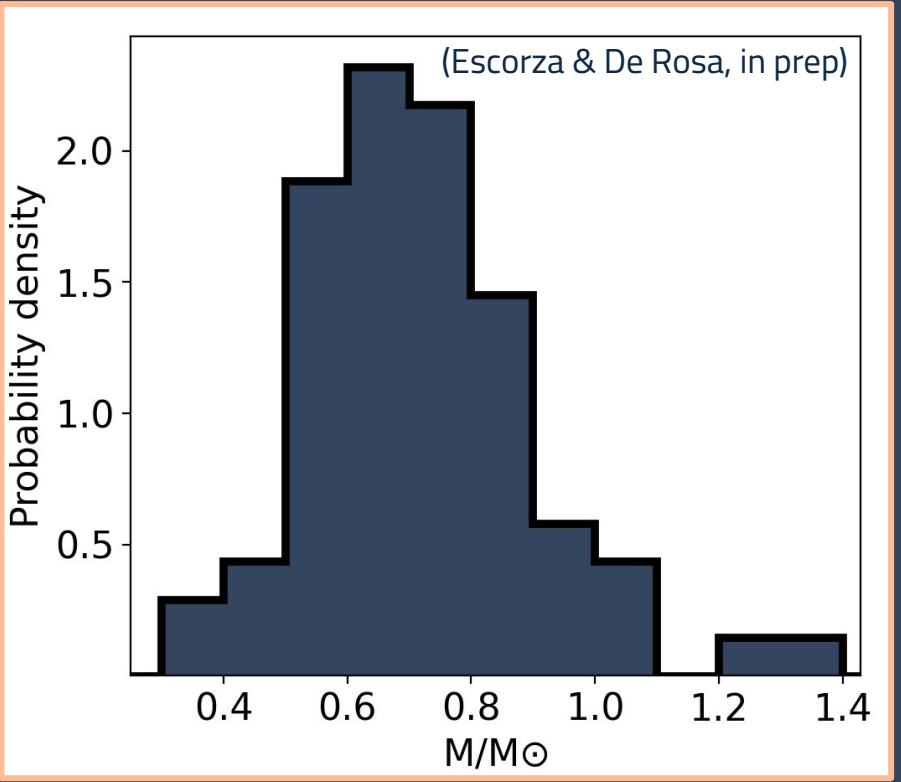
We determined the masses of 68 WD companions of Ba stars



(Escorza & De Rosa, in prep)

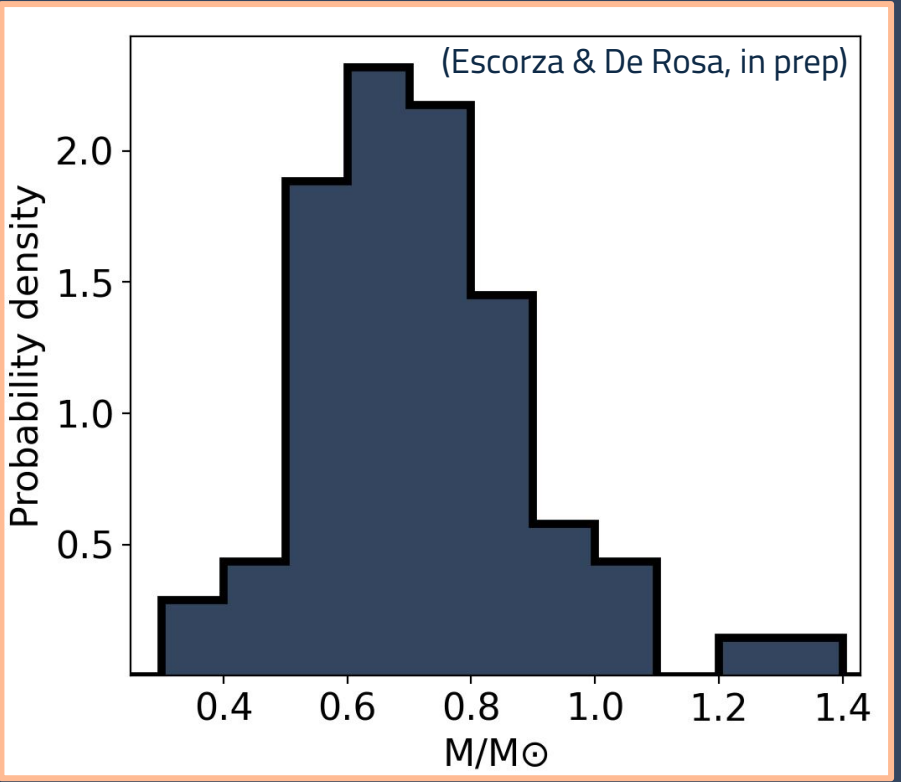
3. The masses of the WD companions of Ba stars

- On average, slightly more massive than field WD.



3. The masses of the WD companions of Ba stars

- On average, slightly more massive than field WD.
- Outliers at very low and very high masses.



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HD 95241 is not a Ba star

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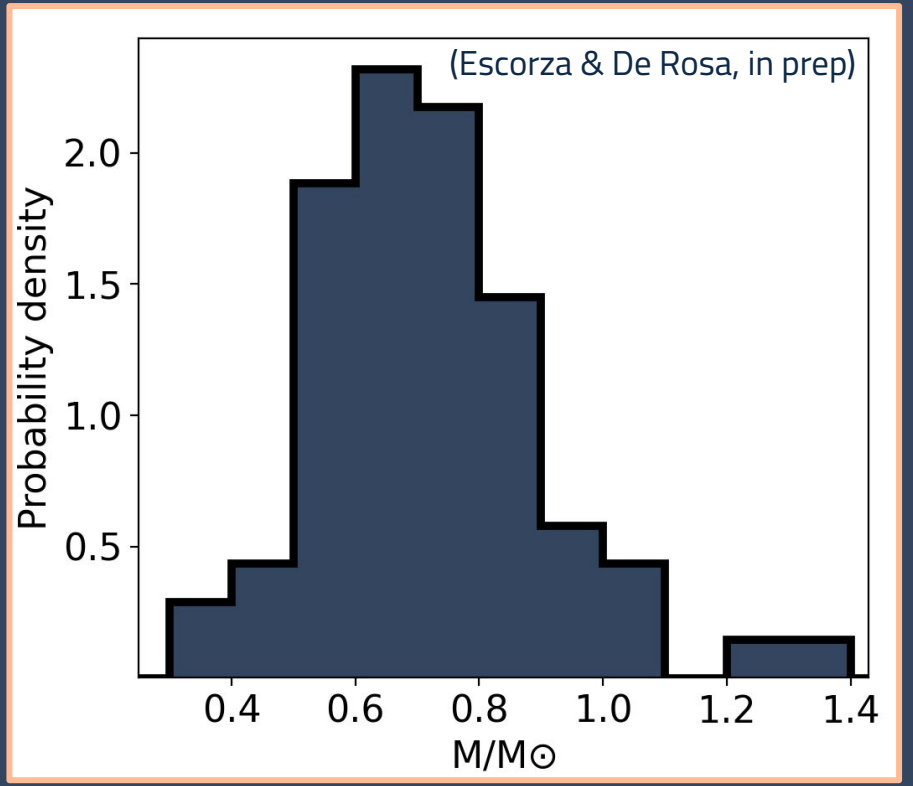

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- On average, slightly more massive than field WD
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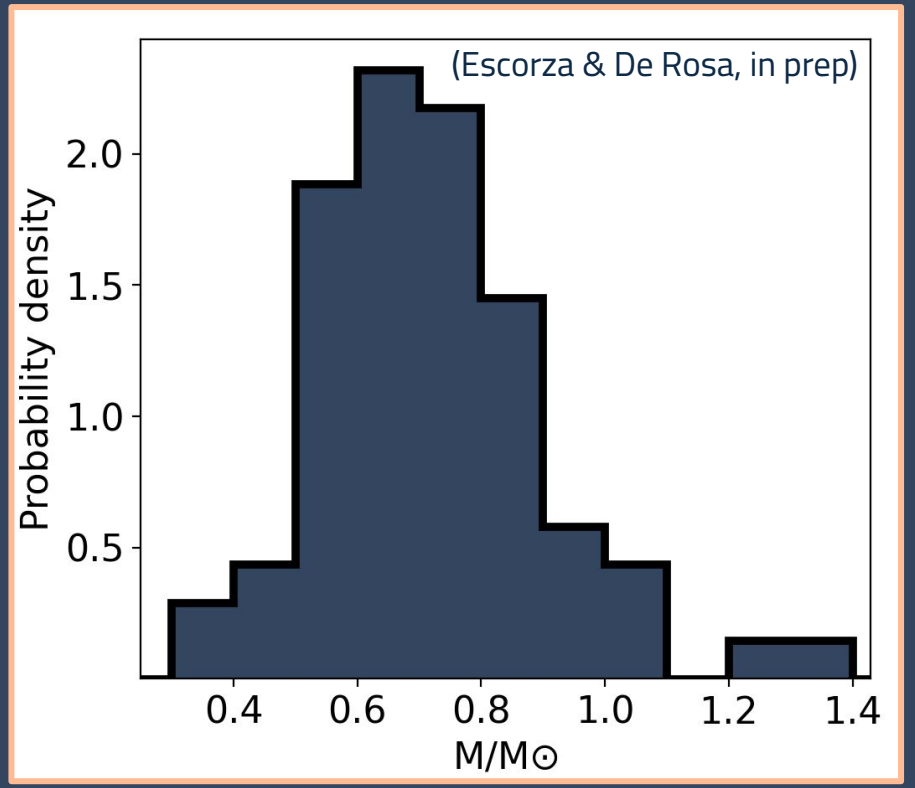
- Strong correlation between M_{Ba} and M_{WD} and a.



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- On average, slightly more massive than field WD
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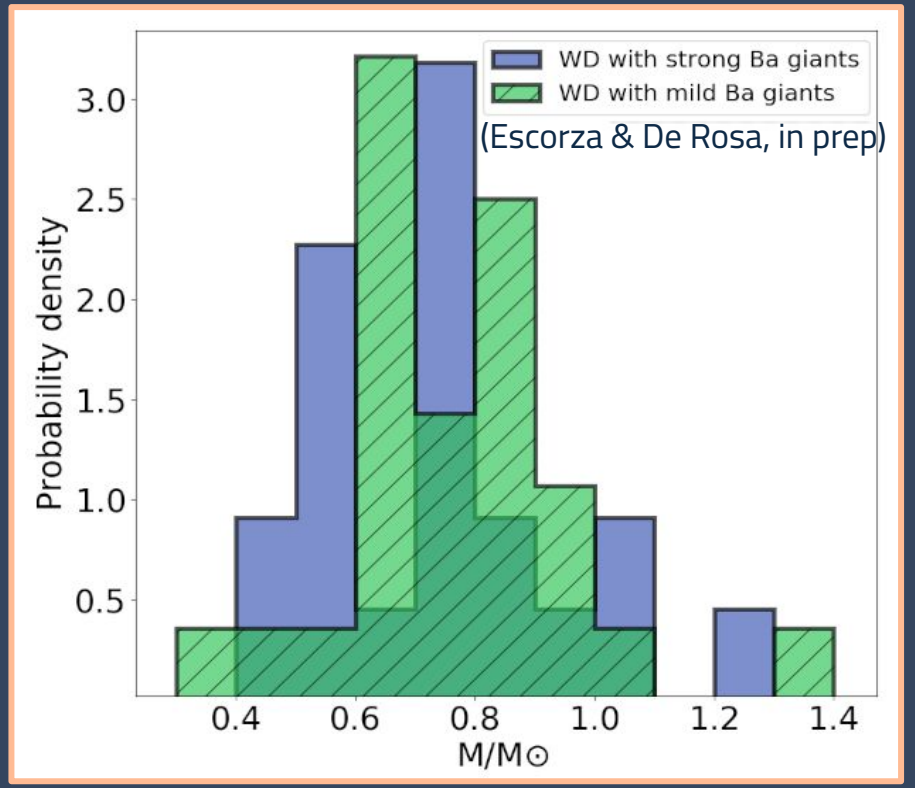
- Strong correlation between M_{Ba} and M_{WD} and a.
- Strong vs mild systems?



3. The masses of the WD companions of Ba stars

- On average, slightly more massive than field WD
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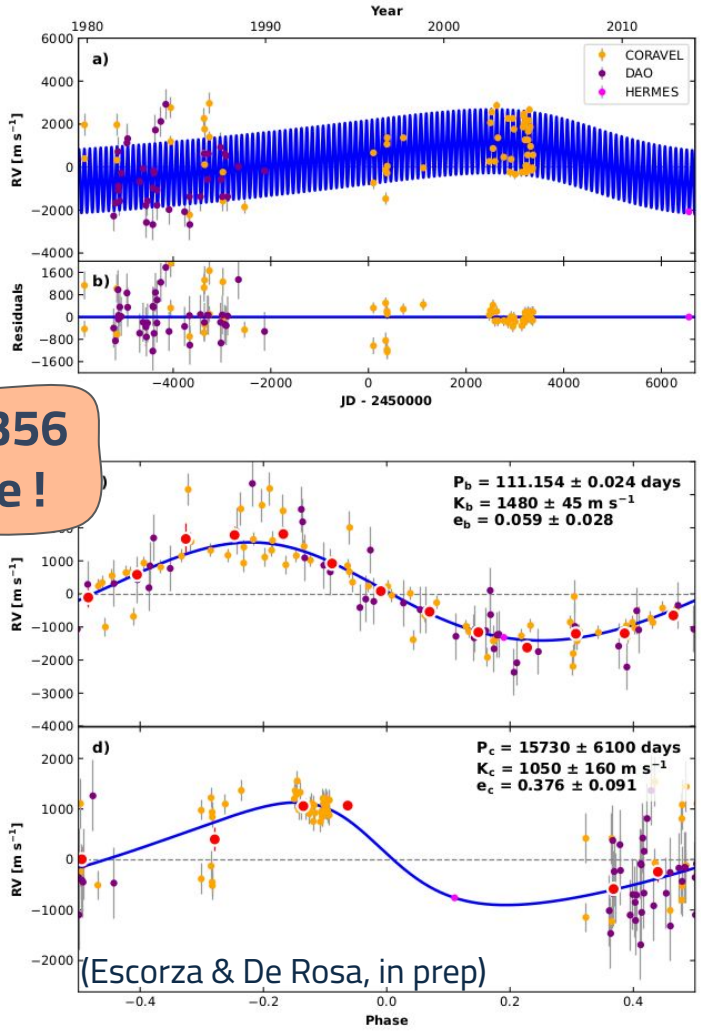
- Strong vs mild systems?
- Triple(s) !

HD 218356 is a triple !



(Escorza & De Rosa, in prep)

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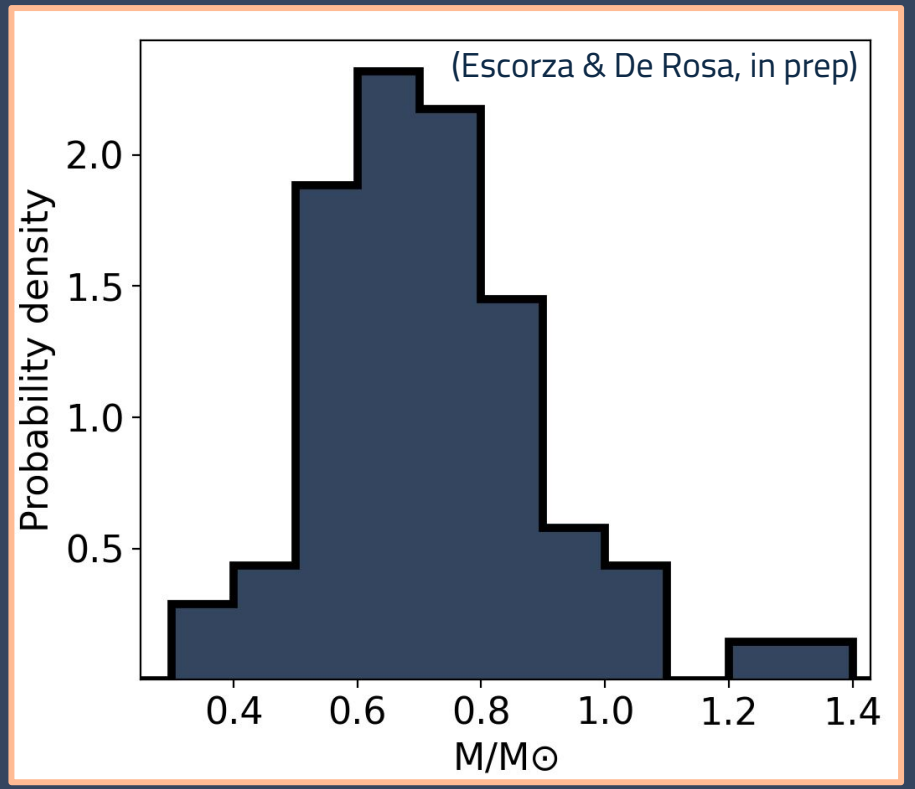
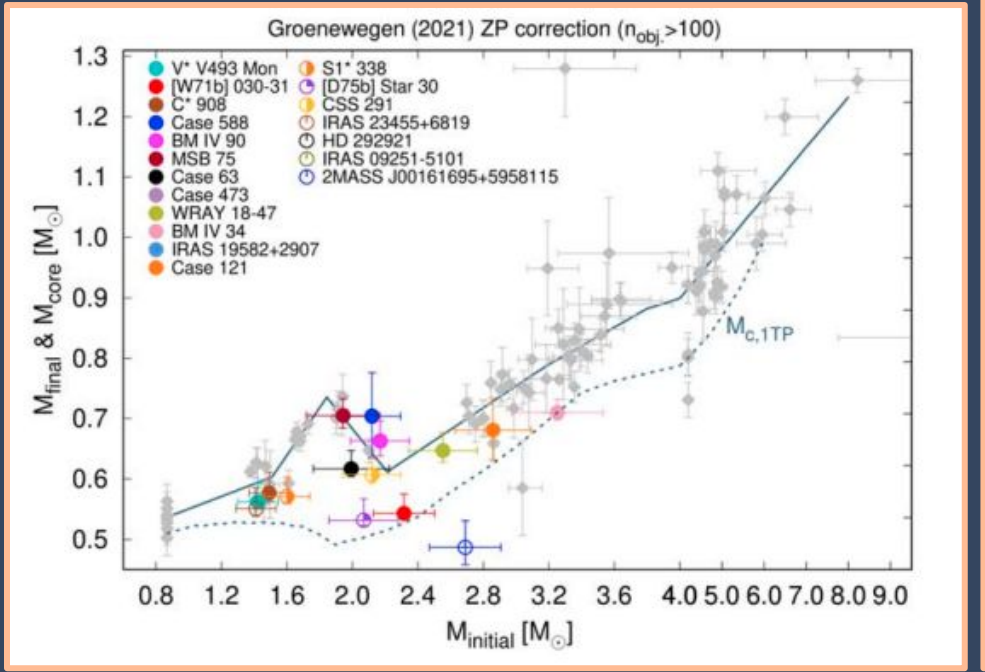
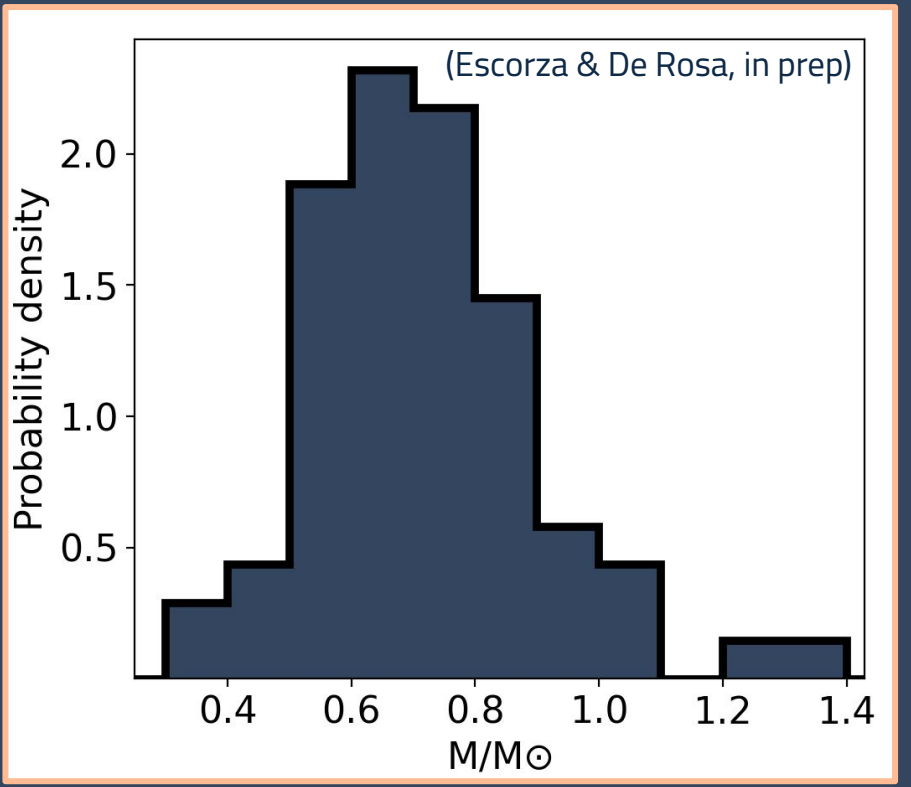


3. The masses of the WD companions of Ba stars

(Marigo et al. 2022)





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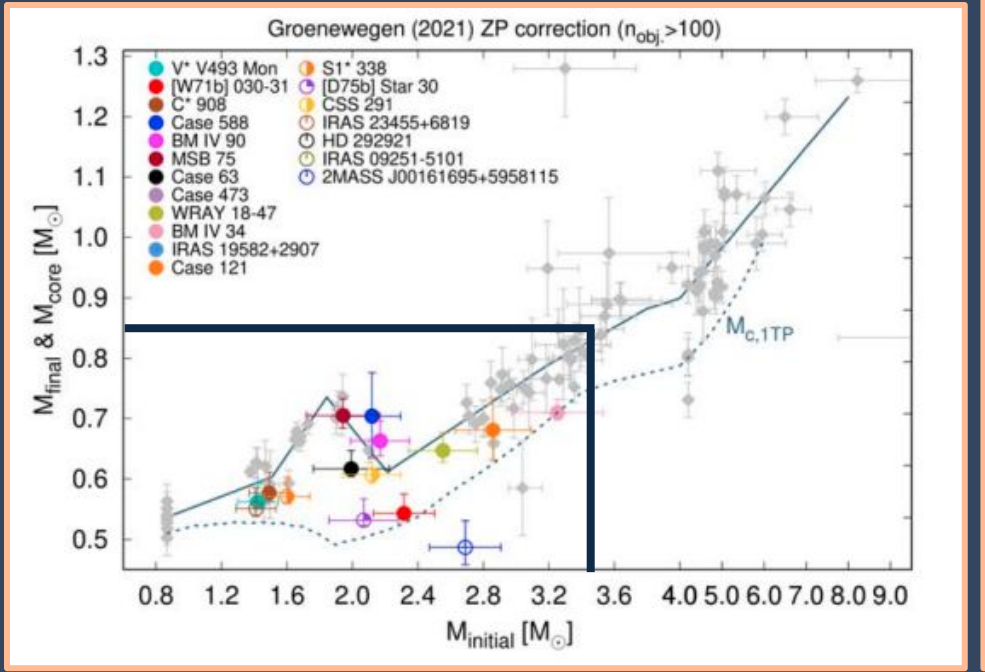

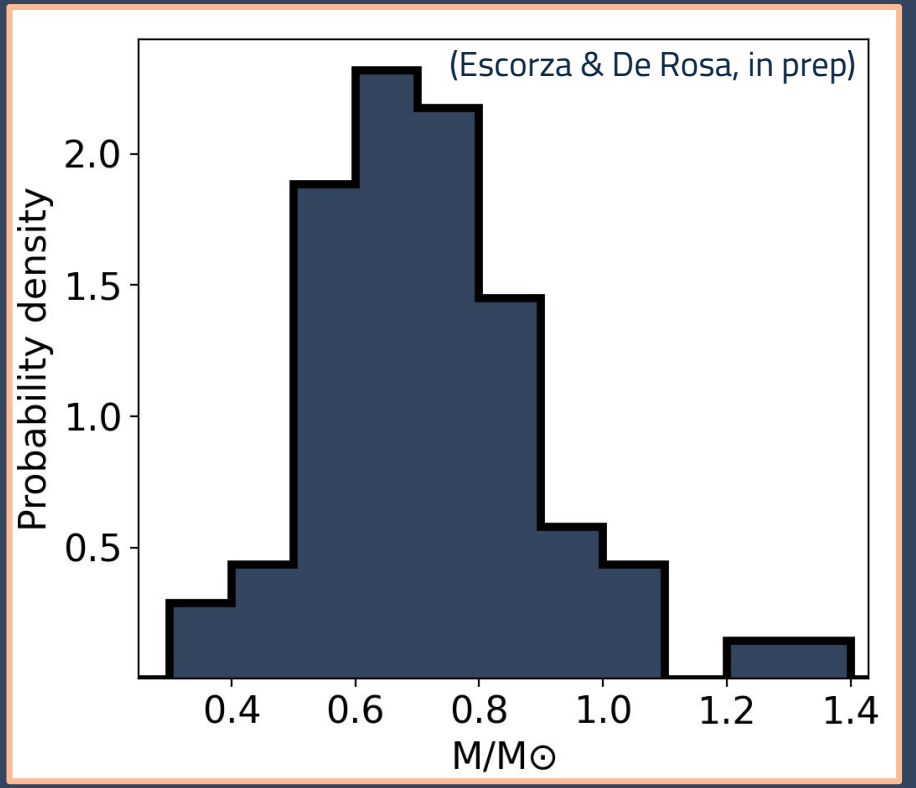

Summary & Conclusions

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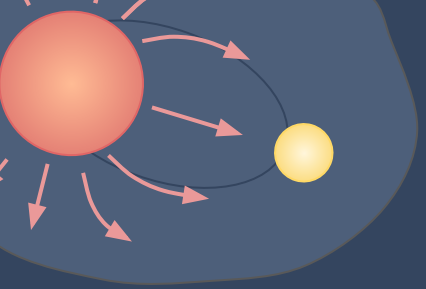
- **Word of caution!** Correlations M_{Ba} - M_{WD} and M_{tot} - a
  We are still relying on single-star parallaxes
  and evolutionary M_{Ba} values.

  But we have removed many strong assumptions !



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Thanks!

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