A comprehensive investigation of Galactic O-type fast rotators. Their current evolutionary status.

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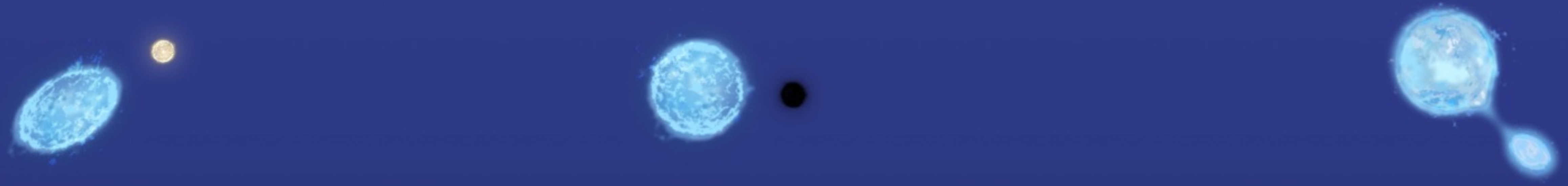


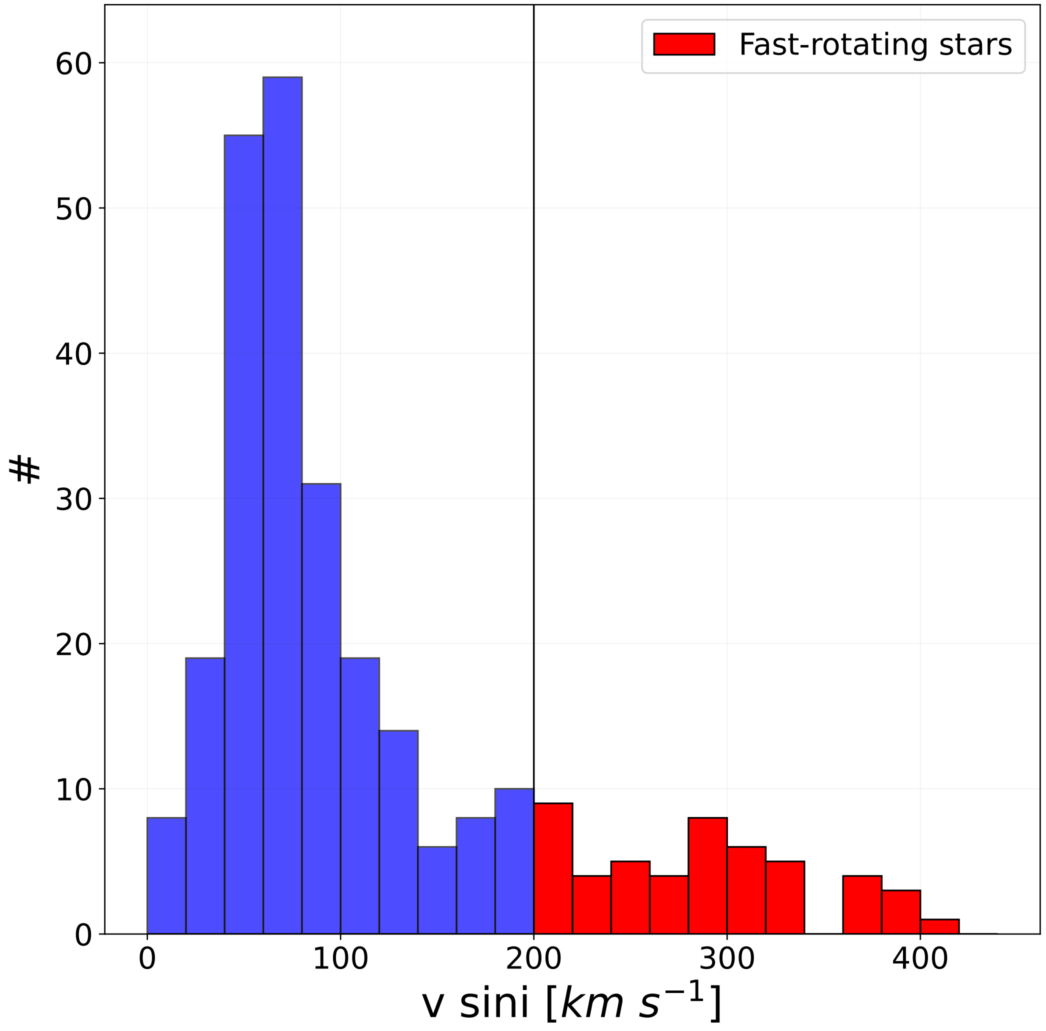
vsini distribution for O-type stars

Outline:

- Systematize the spectroscopic binary status, photometric variability, runaway status;
- Compare the results with a theoretical scenarios about the origin of fast-rotating stars;
- Empirically describe all channels from where do they come?

Based on the IACOB (PI: Sergio Simon-Diaz) data:

- 268 slow rotators (excluding SB2 systems);
- 54 fast rotators (including 4 SB2 systems);



Theoretical predictions:

de Mink et al. (2011, 2013)

1. Single star spin-up during the star formation process (???)

    product: effectively single fast-rotating star;

2. Binary interaction:

    a) mergers,

    product: effectively single fast-rotating star;

    b) short-period binaries (tides mechanism)

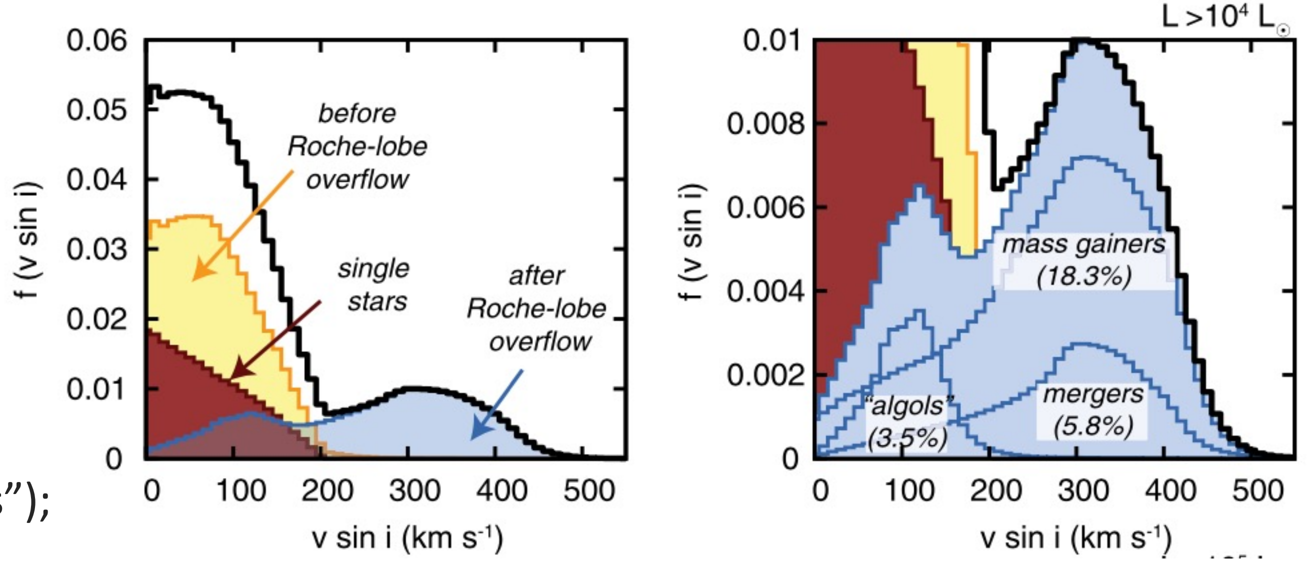
    P=2-3 days

    product: eclipsing binary system with a significant rotational mixing effect in the fast-rotating star ("Algols");

    c) post-interaction binaries (mass transfer)

    P=5 days – several months

    product: **(i)** a stripped helium star (donor) with fast-rotating gainer, **(ii)** the fast rotating gainer may become a walk/runaway star or **(iii)** the explosion may result a binary system with the fast rotating gainer and compact object (black hole or neutron star).



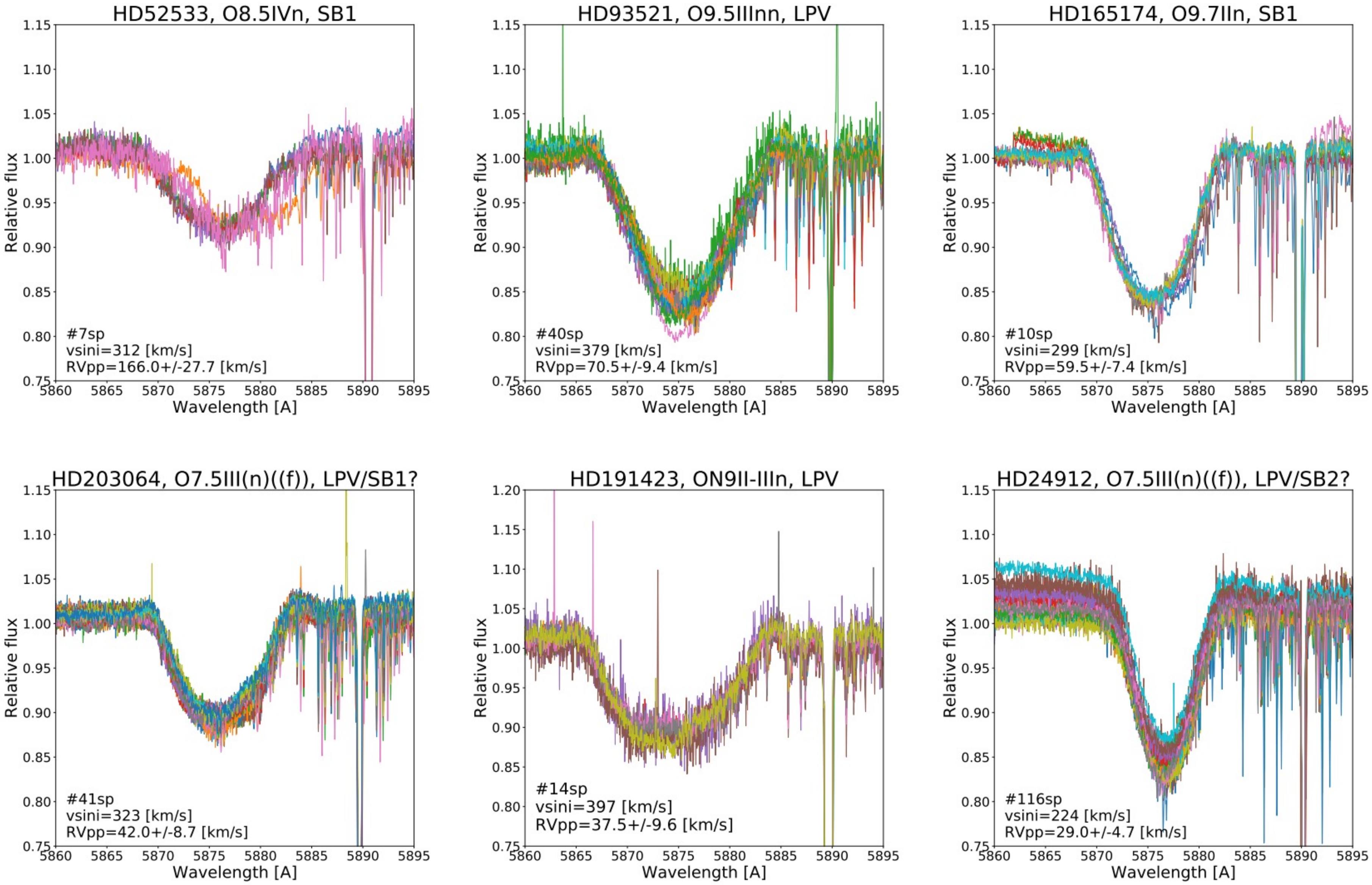
Analysis of fast-rotating stars:

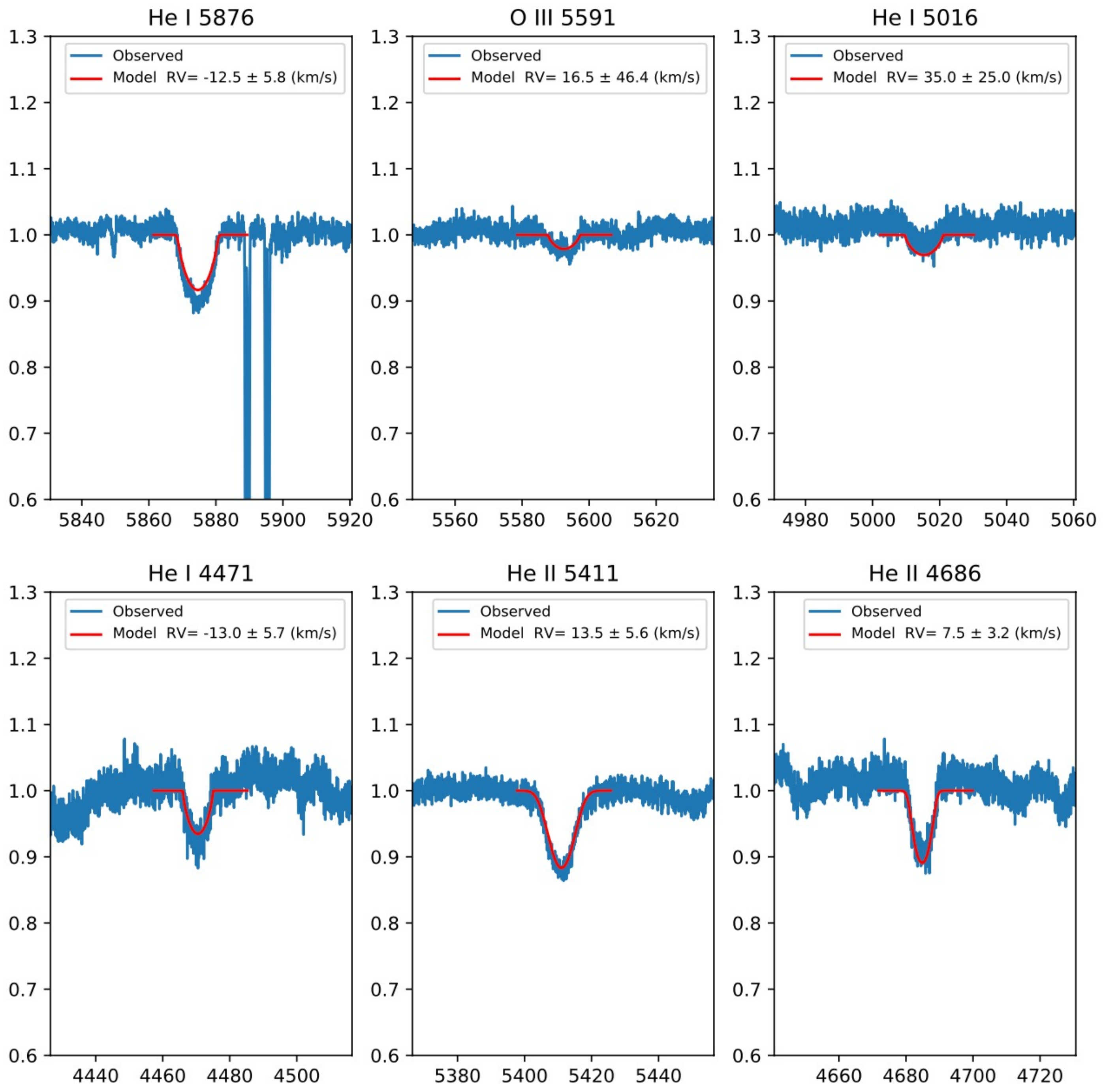
Britavskiy et al. (subm)

1. Multi-epoch spectroscopic observation of 54 fast-rotators;
2. RV analysis based on cross-correlation technique;
3. Visual inspection of the line profile variability in order to get info about binary status (LPV/SBs/etc);
4. Proper motion analysis in order to find runaways (GAIA EDR3, *Maíz Apellániz et al. 2018);*
5. Searching for eclipsing binary (EB) signatures based on TESS lightcurves;
6. Looking in literature (Washington Double Star Catalog, SMASH) for any information regarding existing of visual components within (0.1-2 arcmin).

Analysis of fast-rotating stars:

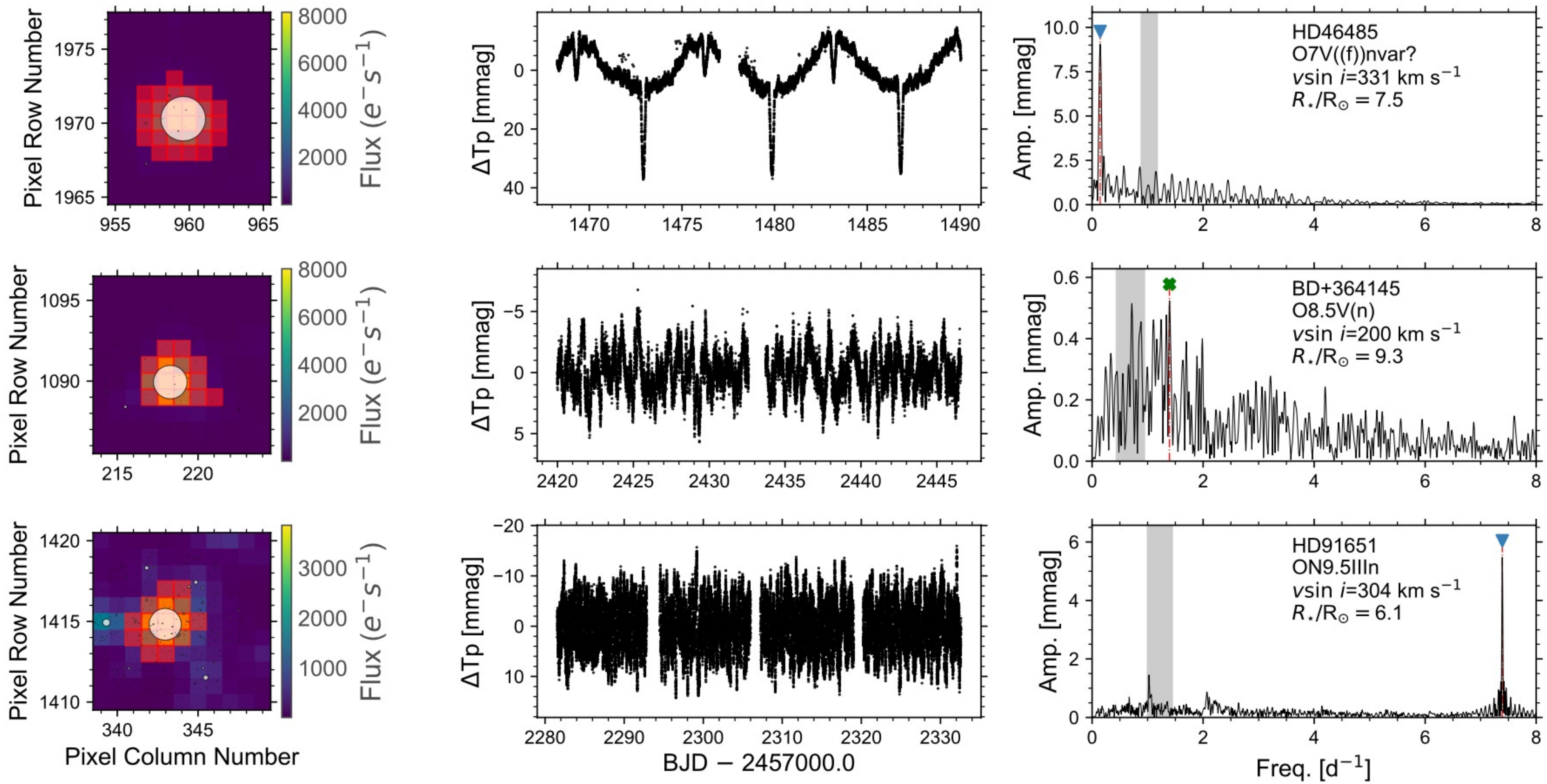
Britavskiy et al. (subm)





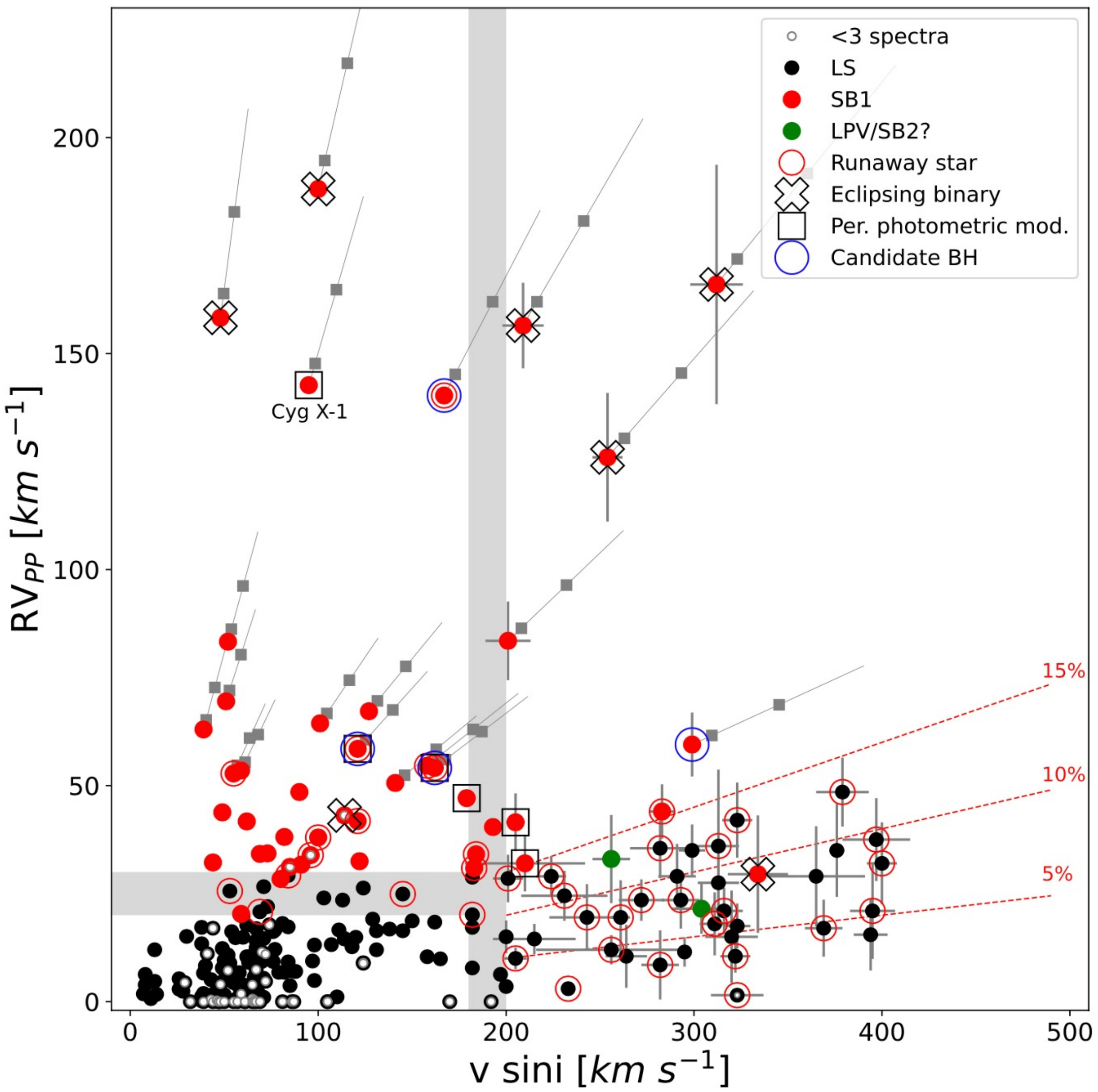
Britavskiy et al. (subm)

TESS data

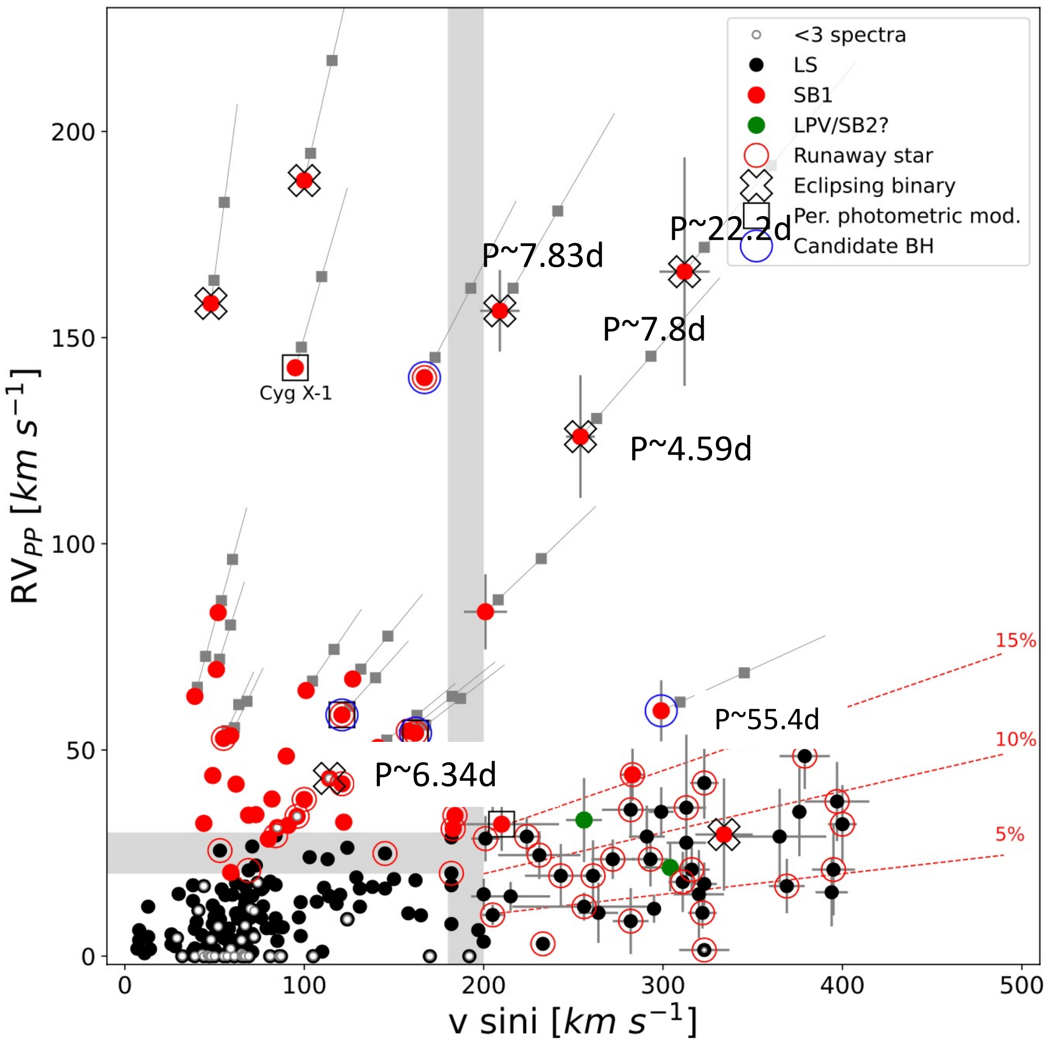


HD46485
O7V((f))nvar?
$v\sin i$=331 km s^{-1}
$R_\star/R_\odot = 7.5$
BD+364145
O8.5V(n)
$v\sin i$=200 km s^{-1}
$R_\star/R_\odot = 9.3$
HD91651
ON9.5IIIn
$v\sin i$=304 km s^{-1}
$R_\star/R_\odot = 6.1$
Pixel Row Number
Pixel Column Number
Flux (e^-s^{-1})
ΔTp [mmag]
BJD − 2457000.0
Amp. [mmag]
Freq. [d^{-1}]

RVpp vs vsini distribution of O-type stars

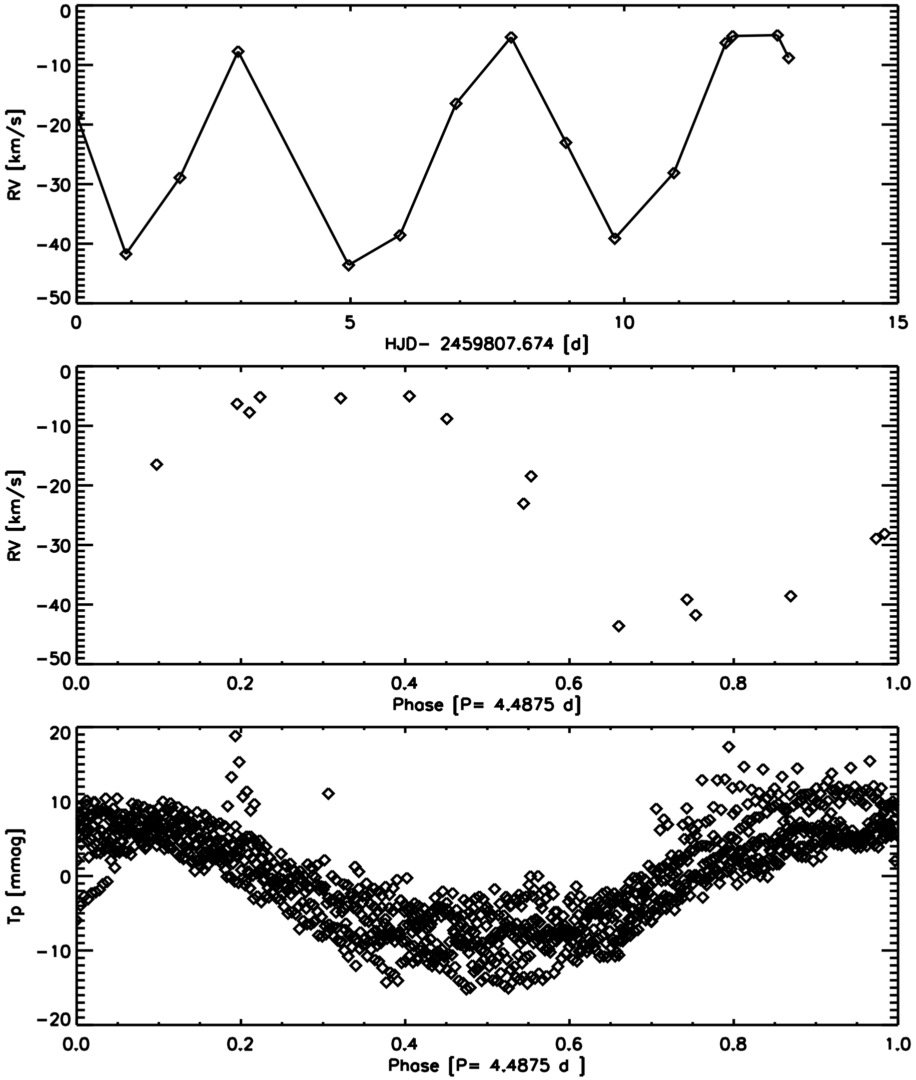


RVpp vs vsini distribution of O-type stars

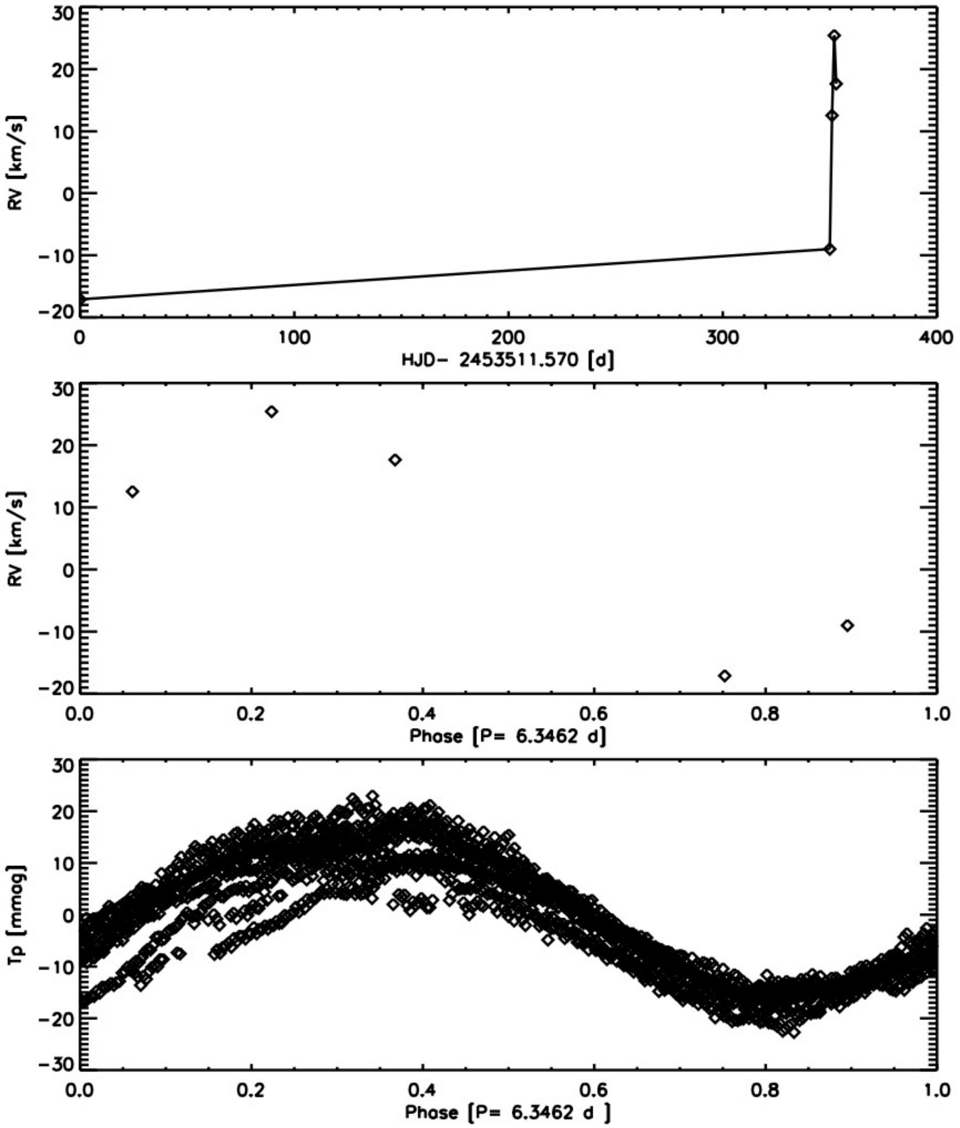


Our analysis	%	Possible origin of fast rotation	
Runaways	47%	O-type gainer which is ejected from system	
SB1 (P<5d)	4%	Tides?	
SB1 (P>5d)	14%	Secondary O-type gainer	
LPV	70% (incl Runaways)	Mergers/not detected companion (?)	

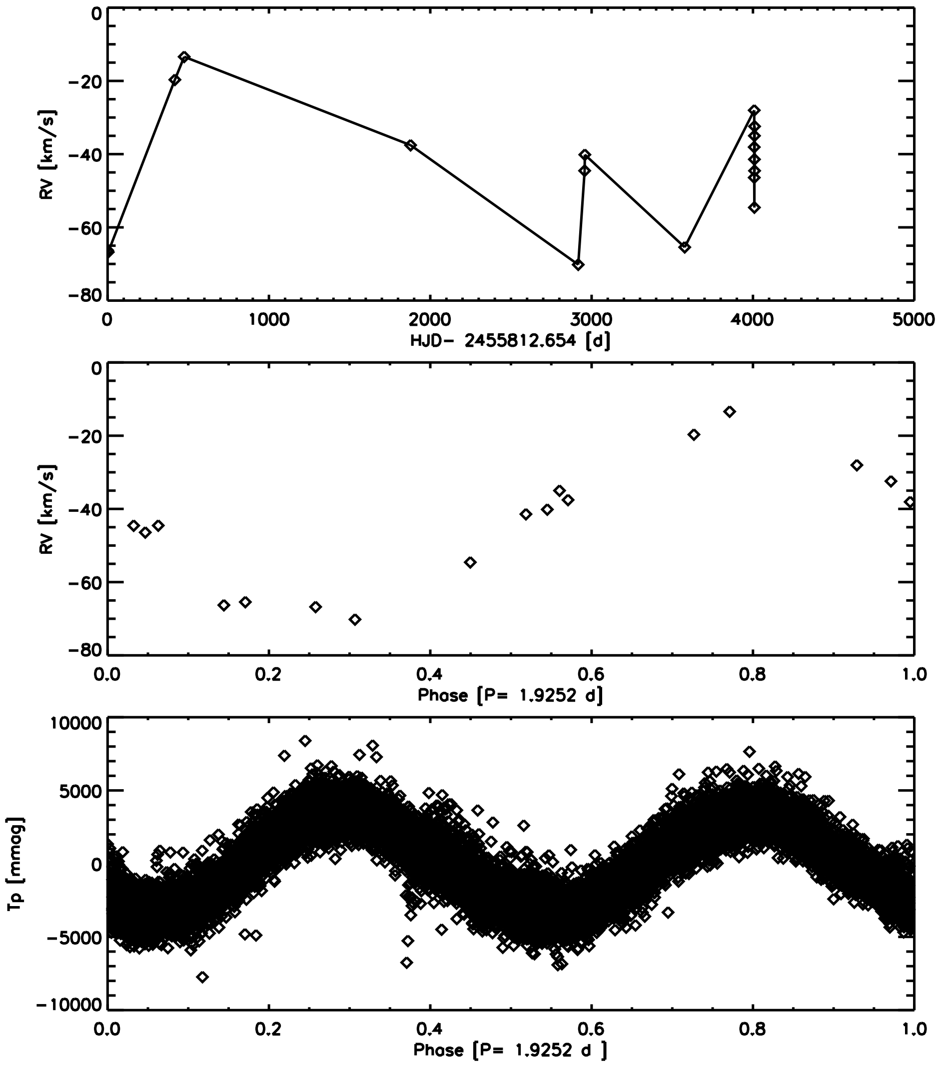
TESS data (HD152200 – periodic photometric modulation, reflection?)



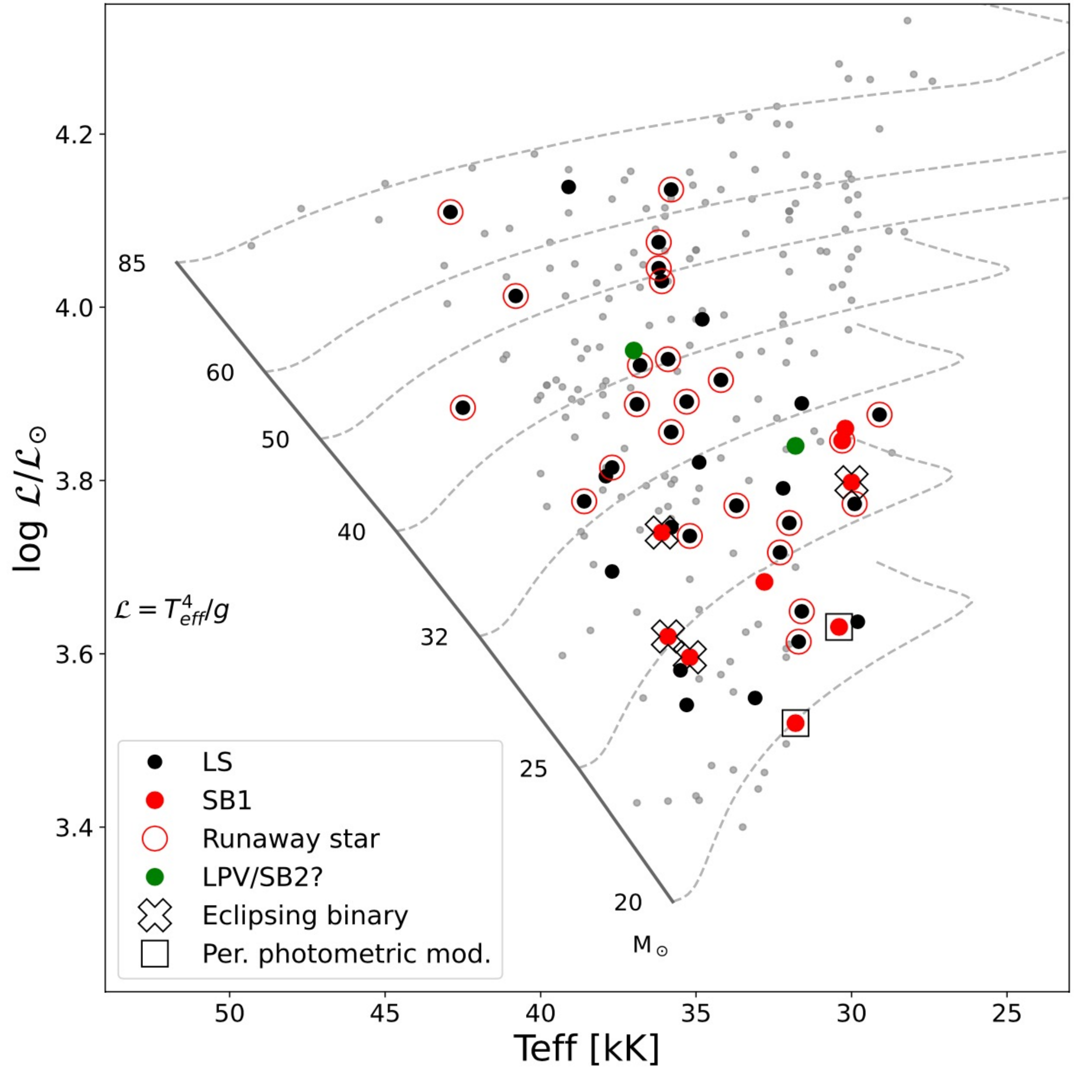
TESS data (HD308813 – periodic photometric modulation – really no idea what is this)

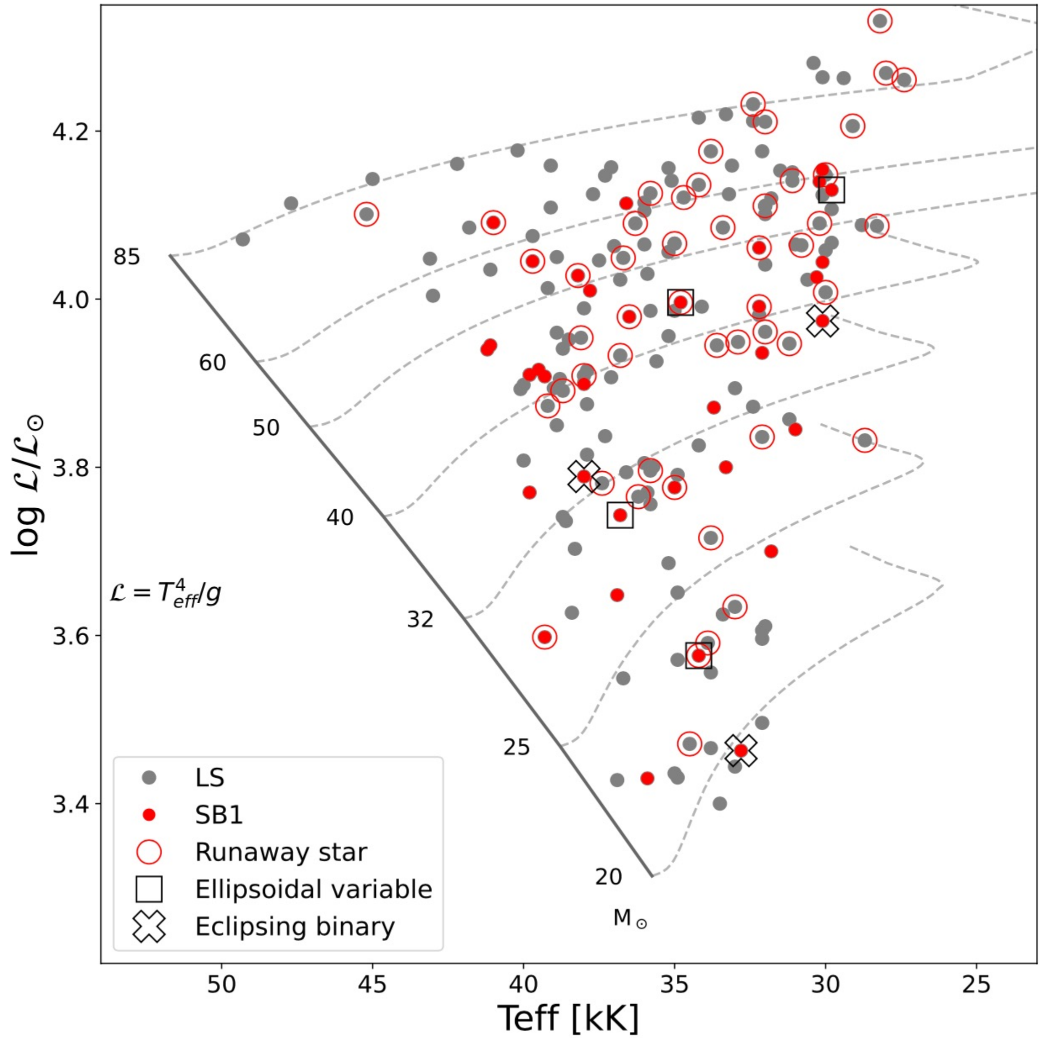


TESS data (HD12323 – ellipsoidal variable)



Spectroscopic H-R diagram for a sample of fast-rotating stars



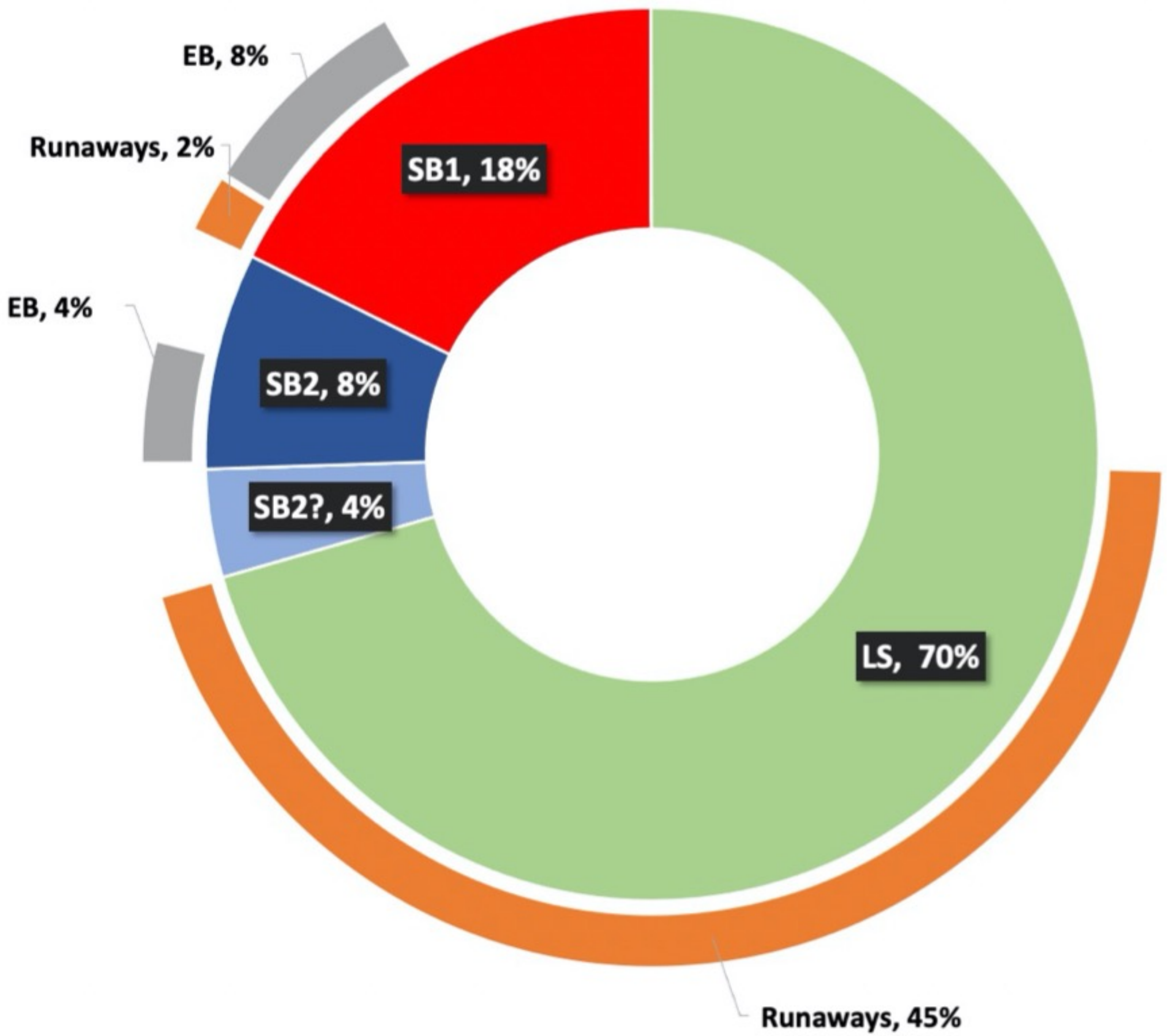


Statistics of SB systems in the slow- and fast-rotating domain

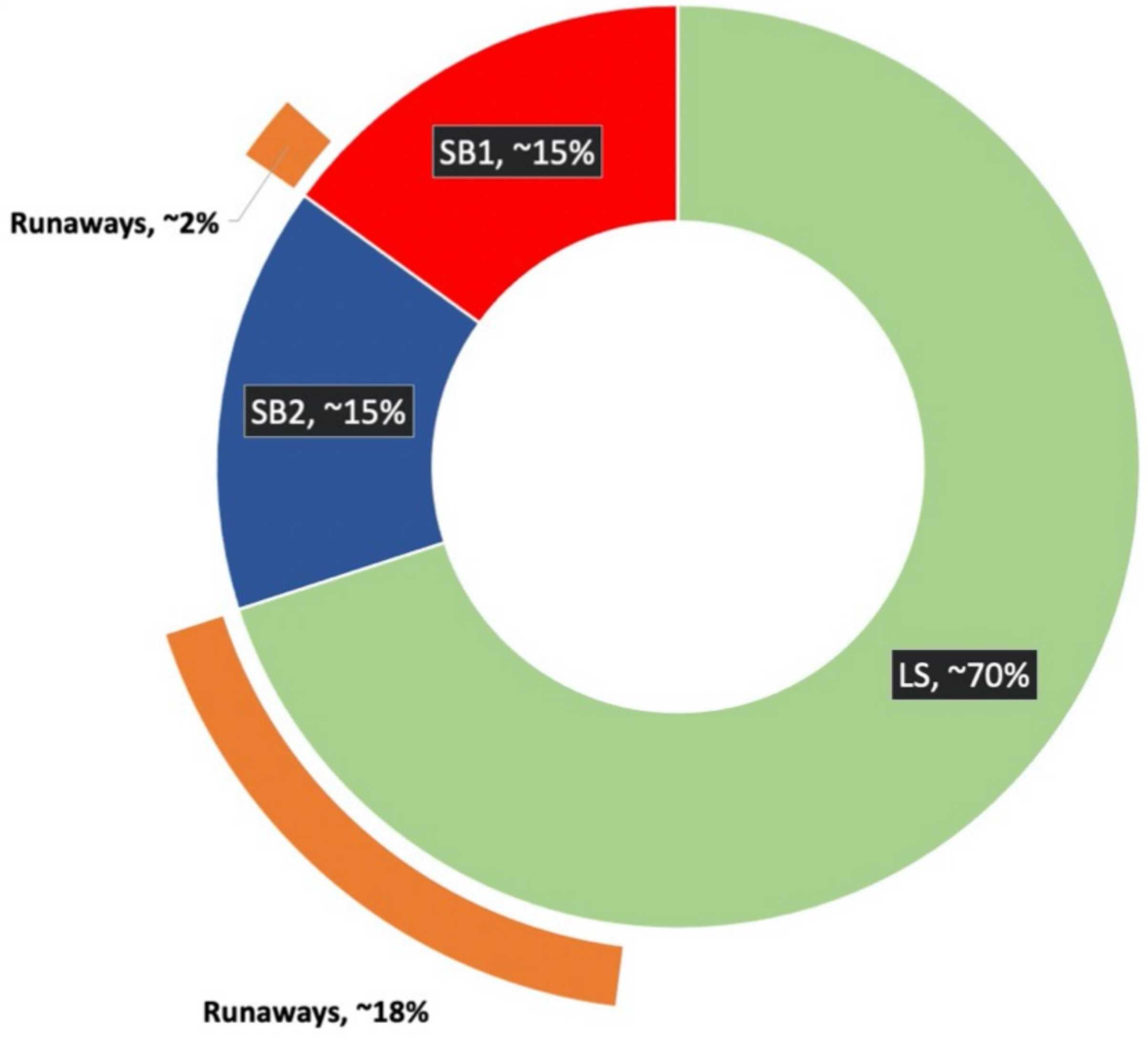
	SLOW	FAST
SB1	13%	18%
SB2	33%	10%
Runaways	20-30%	47%

- disrupted binary after supernova explosion (mmm.. Renzo et al. 2019 ?)
- dynamical ejection scenario from the clusters

Fast-rotating O-type stars
(vsini > 200 km/s; d < 3 kpc)



Fast-rotating O-type stars according to the BPASS models

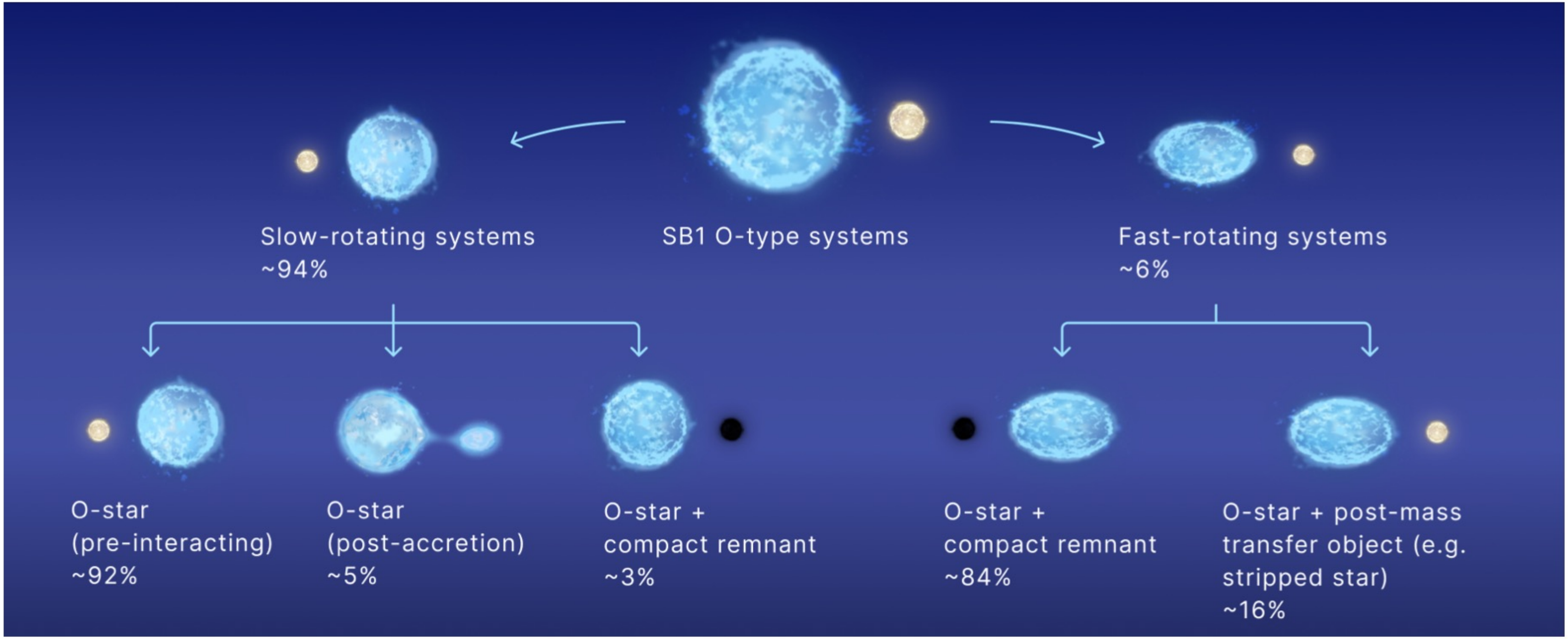


Appearance of fast-rotators (vsini > 200km/s) according to the BPASS

1. No effectively single stars!
2. Source of rapid rotation for O-type star: the star has accreted more then 5% of it’s initial mass (Z=0.014 to 0.020);
3. Mergers? (they would lose more mass than gain and spin-down relatively quickly);
4. We assume that the SB1 system is any system with only one O-type component;
5. No SB1 are primaries, they are all post mass transfer objects with a companions which are:
    - remnant star after supernova explosion;
    - stripped star/sdO which have undergone a binary interaction, the companion has became a fast-rotating O-type star (and not born like that!); This O-star can have a disk;

SB1 O-type systems according to BPASS:

N. Britavskiy et al.: Investigation of the binary nature of Galactic fast-rotating O-type stars



Next steps:

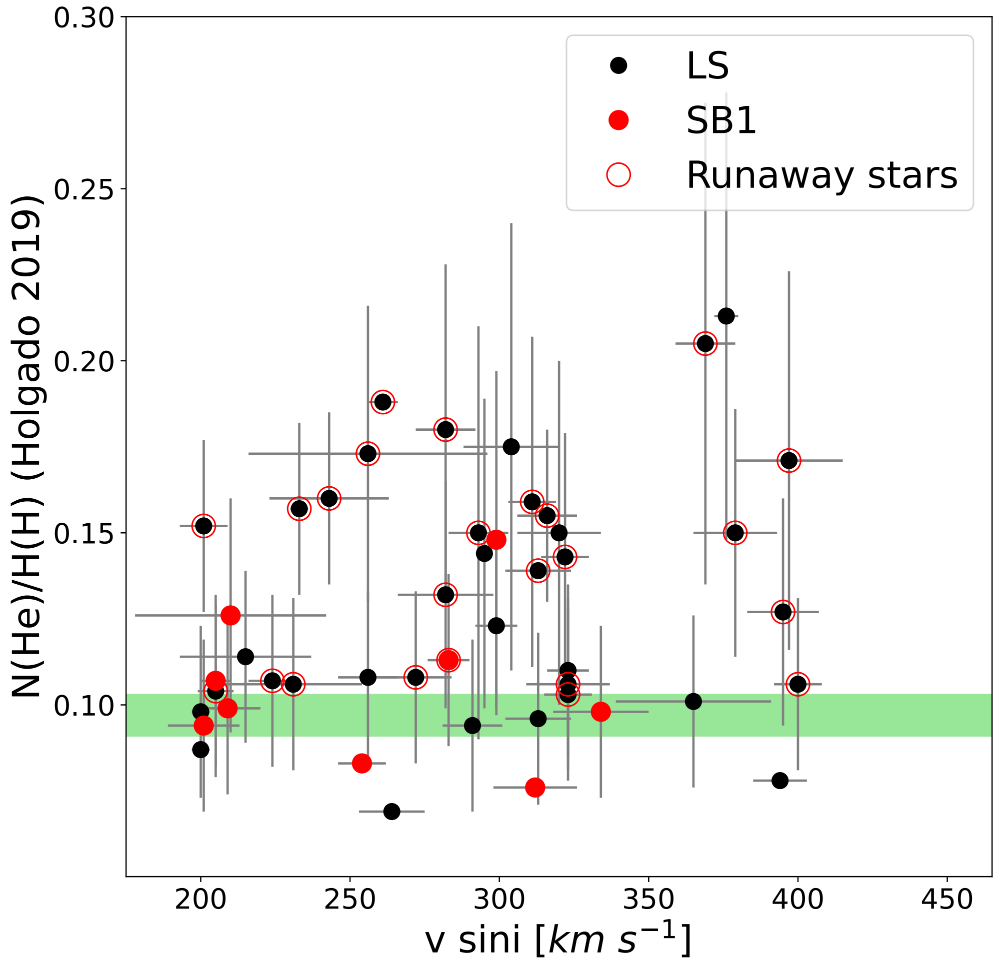
We have nice statistically significant observational data. Let’s do some fun with it!

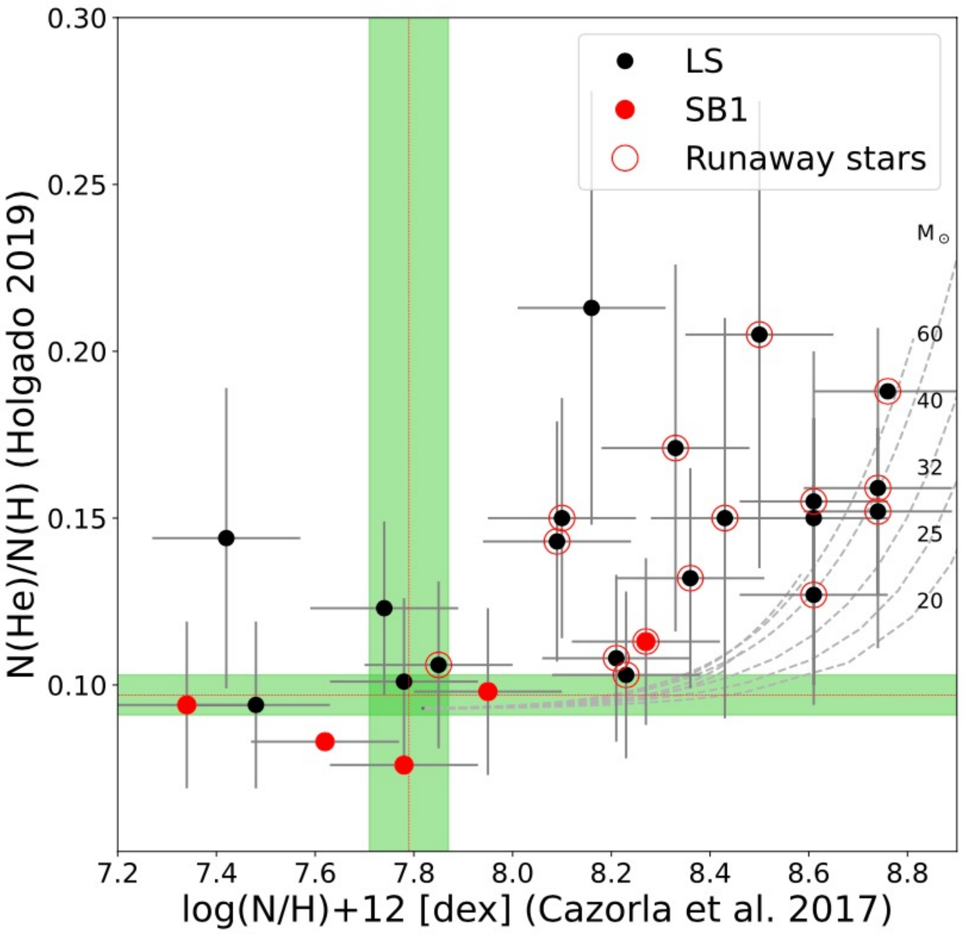
Some thoughts:

- reproduce the observed global properties of the fast rotator population;
- model individual objects (esp. SB1 systems)
  (e.g. Renzo & Götberg 2021, many others MESA related simulations);

1. What is the exact history of mass transfer in such systems ?
2. How do we get fast rotation ?
3. What are the impacts on surface abundances ?
4. What are the companions of fast-rotating stars (apart from BH)?

Chemical composition could be a hint…





Conclusions:

1. Among 51 fast-rotators: fraction of SB2~12%, fraction of SB1~18%, fraction of LPV runaways ~45% (disrupted binaries), fraction of LPV~70% (mergers?/hidden binaries);

2. The fraction of SB1 systems among O-type fast rotators is about 18% which are products of:
   - mass transfer
   - tidal interaction (?)

3. The fraction of runaway stars among O-type fast rotators is ~33-50%, which is significantly higher than for slow rotators ~20-30%;

4. Comparison of the CNO and helium abundances of our fast-rotators does not show any peculiar patterns that can characterize the different origins of fast rotators.