Constraints on Rotational Mixing from Magellanic Clouds B-Stars

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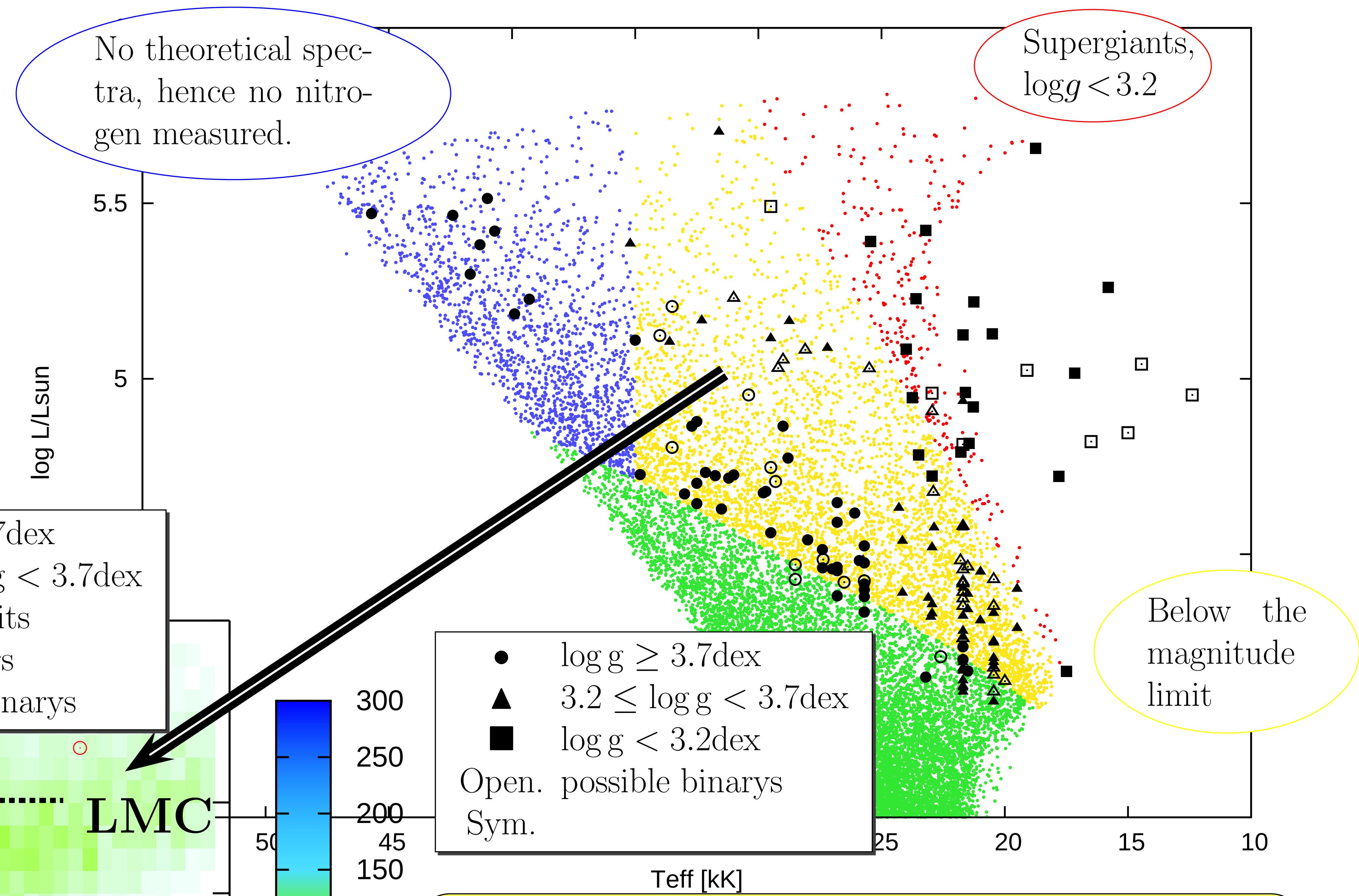
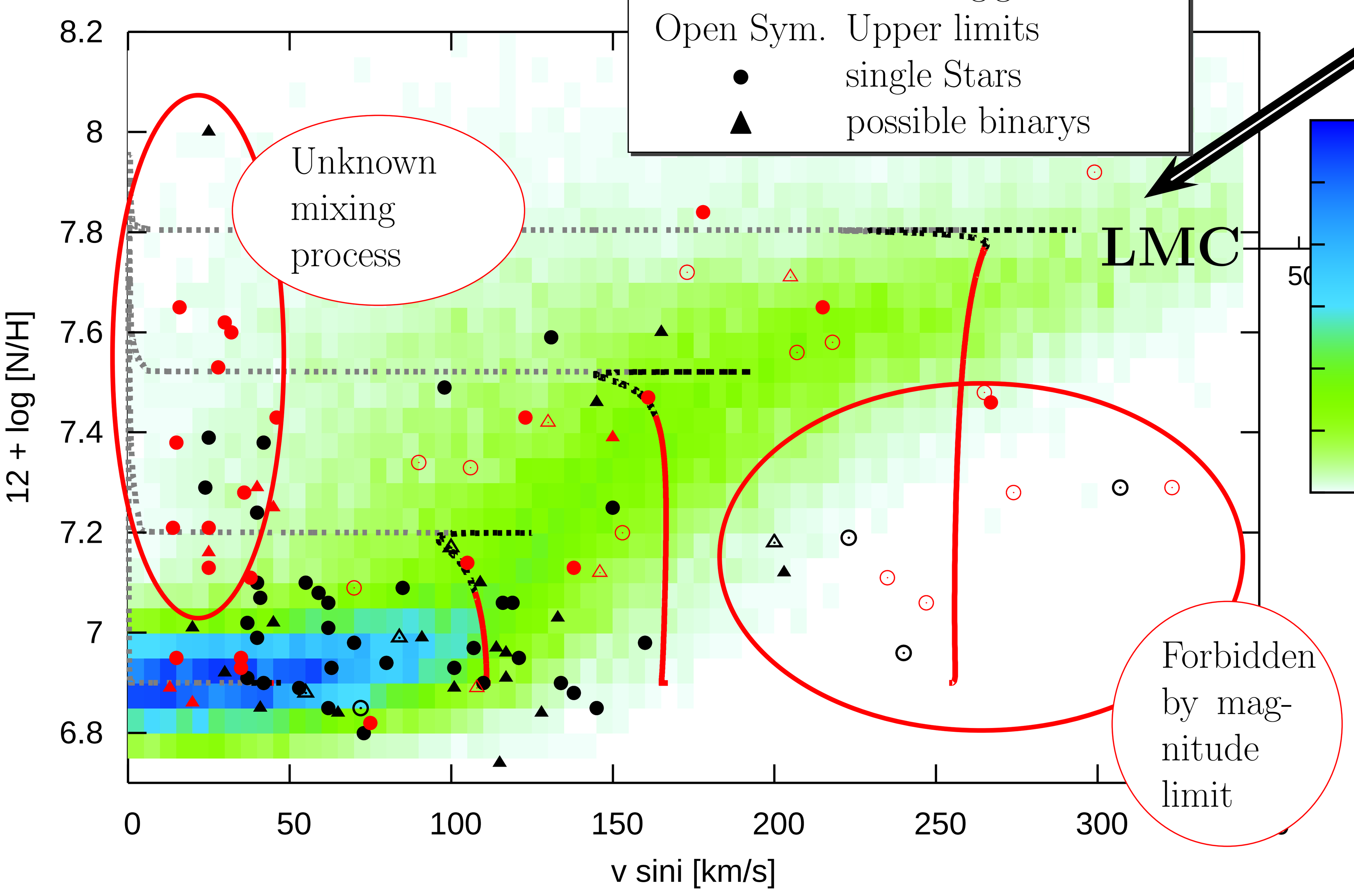
Introduction

Nitrogen is an easily observed tracer element for rotational mixing. It is produced in the stellar core and can be mixed gradually to the surface over the main sequence lifetime. So, in fast rotating stars one expects N enhancement towards the end of the main sequence, while slow rotators should not show any N enhancement at the surface.

The VLT FLAMES Survey of O and B Stars provided nitrogen abundances for stars with rotational velocities up to $v \sin i \sim 300$km/s, which we used to constrain the uncertain physics of rotational mixing in our stellar evolution code.





LMC / SMC

Population simulated with 10^6 Stars, of which $\sim$4.1% (LMC)/ $\sim$4.9%(SMC) passed the selection criteria.

LMC: Two groups can not be explained by our simulated single star population

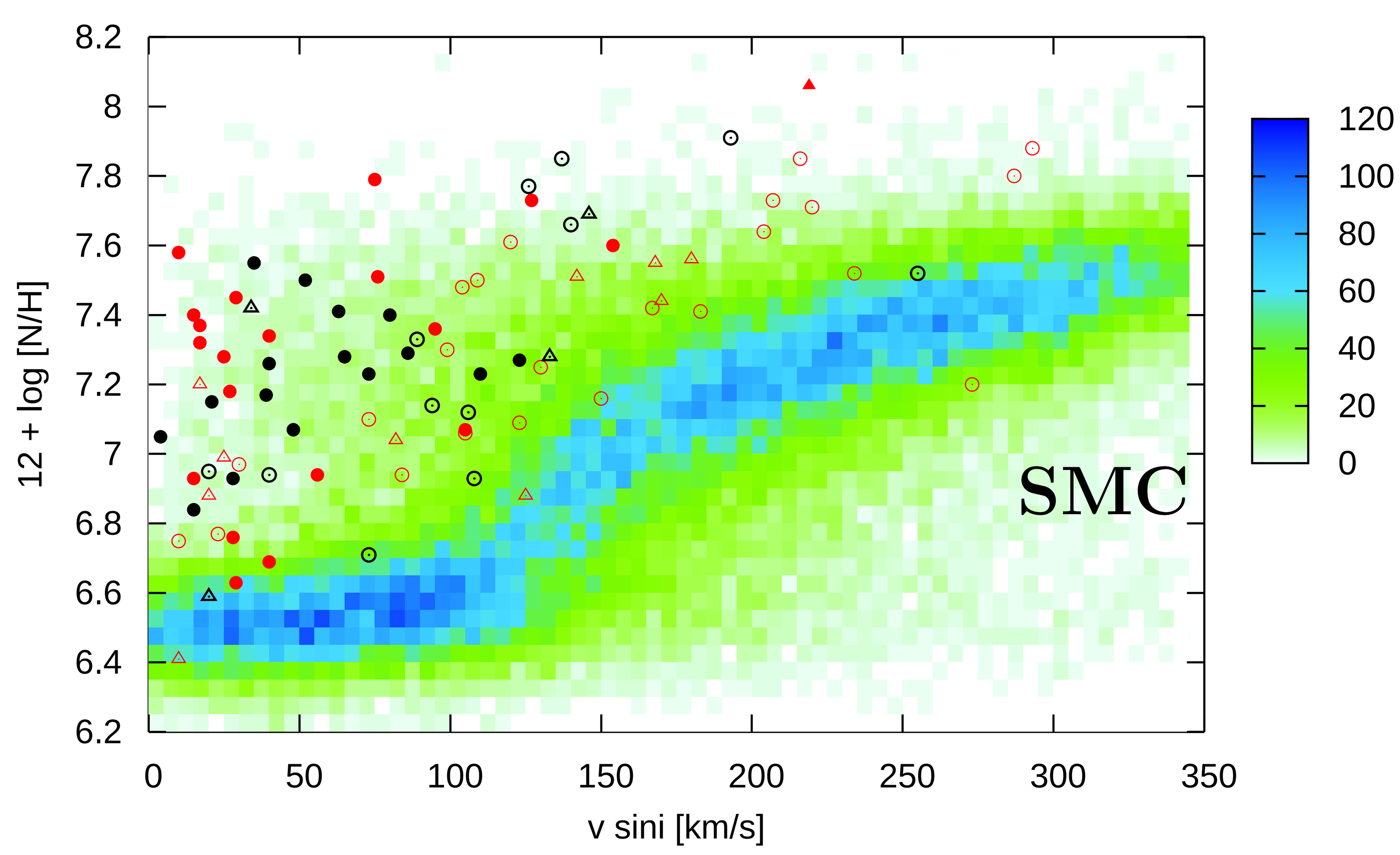
- N-enhanced slow rotators: fossil magnetic fields (Morel et al. 2007) or binaries
- unenriched fast rotators: region is forbidden by the magnitude cut-off. Only young/fast rotating single star models populate the region, but have too low luminosities. Previous binary interaction might give an explanation.

SMC: highly enriched fast rotators only have upper limits, hence do not allow interpretation. Do enhanced slow rotators belong to the same group as found in the LMC?

Models and Simulations

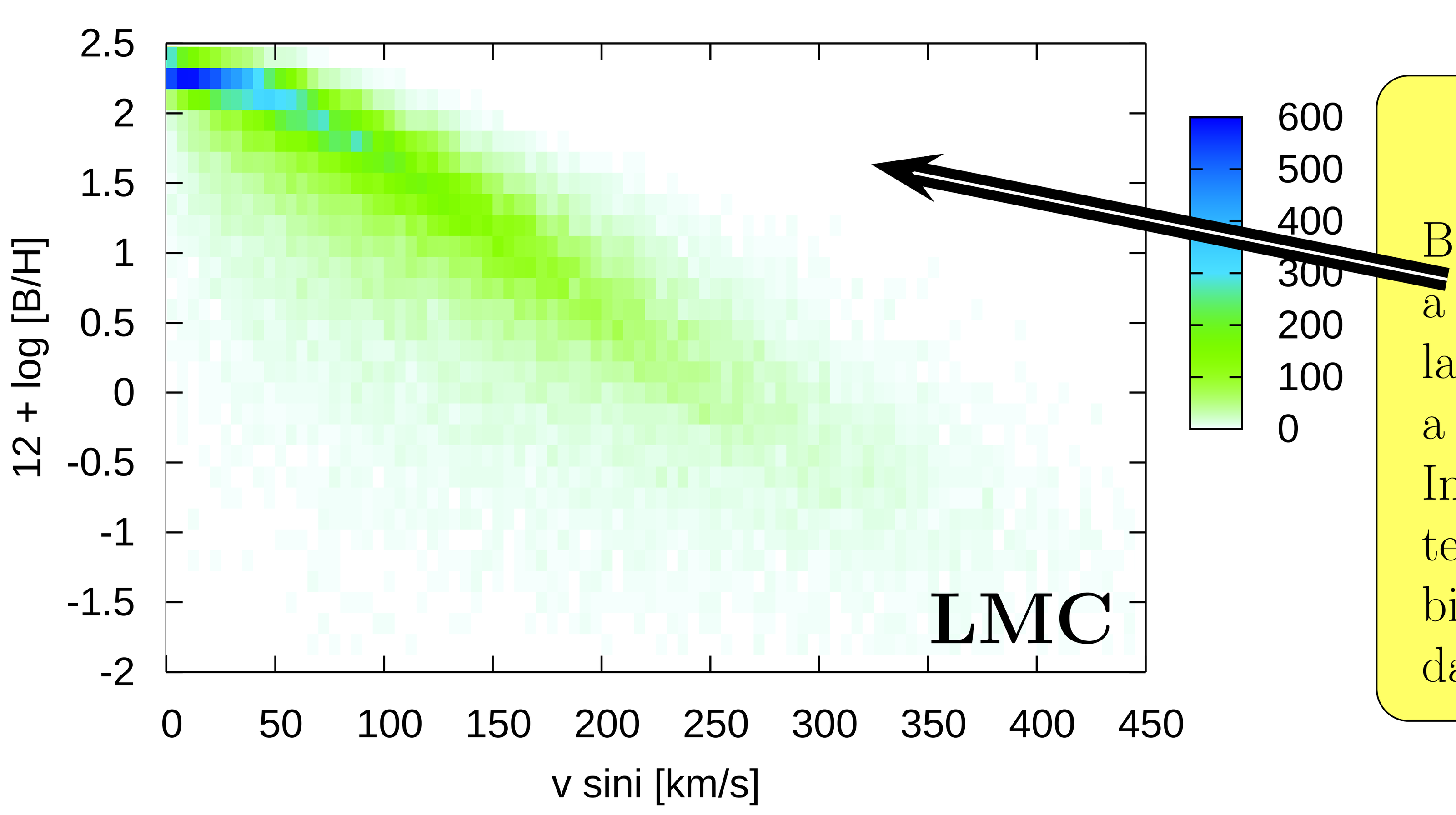
Evolutionary tracks for masses between 5 $M_\odot$ and 50 $M_\odot$ and rotational velocities between 0 and 500 km/s. We used a code based on the code of Heger et al. 2000 and Yoon et al. (2006). It includes angular momentum transport by magnetic fields (Spruit 2002). To fit the observations we

- used specific chemical compositions for LMC, SMC based on a (scaled) solar Asplund-composition but modified by HII-region observations for C,N,O and average values of unenriched B-stars for Mg, Si and Fe. (Brott et al., in prep. & Hunter et al. 2008)
- calibrated rotational mixing efficency and overshooting with the LMC sample and applied this also to the SMC.
- simulated the population, assuming constant star formation and the observed rotational velocity distribution (Hunter et al. 2007, Dufton et al. 2006)
- took the effect of random inclinations into account.
- applied the FLAMES Survey selection effects and added observational error on the simulated abundances.



Selection Effects

- magnitude limit
- no nitrogen measurement for stars with $T_{eff} < 35$kK (no theoretical spectra)
- Supergiants ($\log g < 3.2$) where analyzed separately and are not discussed here.



Boron as Binarity Test

Boron can only exist in the coolest outermost layers of a star. In rotating stars it is gradually mixed to deeper layers and destroyed. On the left: the expectation for a sample of single stars in the LMC.

In a mass transfer scenario practically boron-free material is dumped on the mass gainer. Thus, in a pure binary sample, boron is either almost at its initial abundance or it is significantly depleted by mass transfer.