An overview of the rotational behavior of metal-poor stars

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(Based on Cortés et al. 2009, ApJ, 704, 750)

IAU Symposium 266

Abstract: We describe the behavior of the rotational velocity in metal-poor stars ([Fe/H]≤-0.5), in different evolutionary stages, based on vsini values from the literature. Our sample is comprised of stars in the field and some Galactic globular clusters, including stars on the MS, the RGB, and HB.The metal-poor stars are, mainly, slow rotators, and their vsini distribution along the HR diagram is quite homogeneous. Nevertheless, a few moderate to high values of vsini are found in stars located on the MS and on the HB. We show that the overall distribution of vsini values is basically independent of metallicity for the stars in our sample. In particular, the fast-rotating main sequence stars in our sample present similar rotation rates as their metal-rich counterparts, suggesting that some of them may actually be fairly young, in spite of their low metallicity, or else that at least some of them would be better classified as blue straggler stars. We do not find significant evidence of evolution in vsini values as a function of position on the RGB; in particular, we do not confirm previous suggestions that stars close to the RGB tip rotate faster than their less evolved counterparts. While the presence of fast rotators among moderately cool blue HB stars has been suggested to be due to angular momentum transport from a stellar core that has retained significant angular momentum during its prior evolution, we find that any such transport mechanisms must likely operate very fast as the star arrives on the zero-age HB (ZAHB), since we do not find a link between evolution off the ZAHB and vsini values.

Method:

We have compiled the vsini values available in the literature for stars with [Fe/H] ≤ -0.5. The stars are located in the field and in some Galactic GCs. These stars are located in the MS, RGB, and HB phases. The sample of stars in GCs is restricted to HB stars. Several blue HB stars in metal-poor GCs present [Fe/H] > -0.5 as a consequence of radiative levitation.

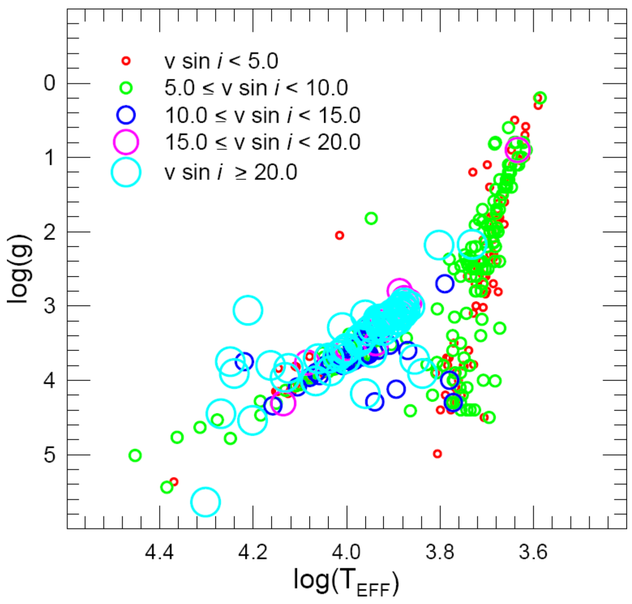


Fig.1: The vsini distribution along the HR diagram. The slow rotators can be found throught the HR diagram, whereas the fast rotators are found almost exclusively over a restricted range in HB temperature.

Results

The Figure 1 shows that most metal-poor stars are slow rotators, and that they are located from the MS to the HB. There are some stars with high vsini, and they are located in the HB and at high temperatures along the MS. Also, we note that RGB stars present low rotation.

We did not find a dependence of vsini with metallicity for the stars in our sample. In fact the stars in our sample present a wide range in [Fe/H], but this does not produce important differences in rotational behavior (Fig. 2).

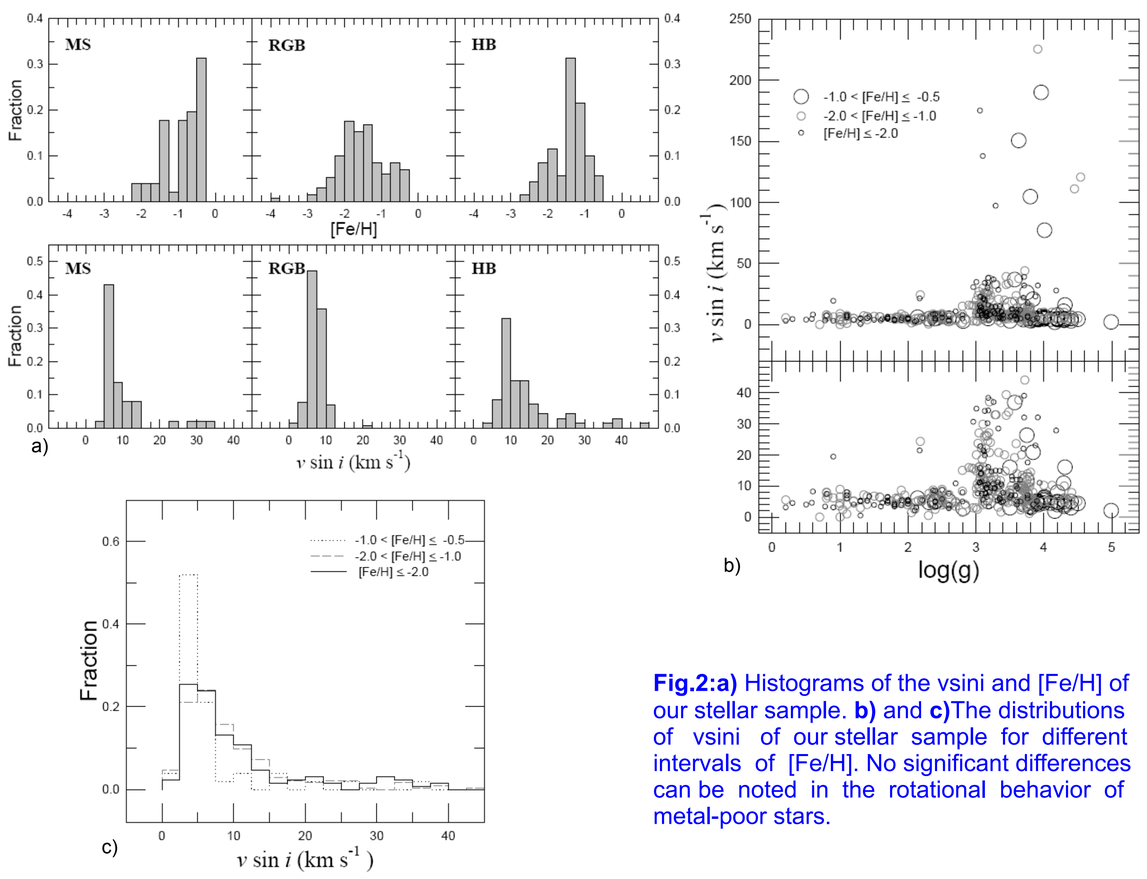


Fig.2:a) Histograms of the vsini and [Fe/H] of our stellar sample. **b)** and **c)**The distributions of vsini of our stellar sample for different intervals of [Fe/H]. No significant differences can be noted in the rotational behavior of metal-poor stars.

Metal-poor MS stars present similar patterns as metal-rich MS stars, and there is a link between the rotation rates and the stellar mass in the MS (Fig. 3a).

The RGB stars present a constant rotation along their evolution up to the tip of this stage, as was reported in several open clusters. Why these stars do not slow down with the expasion of their outermost layers? In addition there are no differences in the rotational rates of single stars and those that form binary systems (Fig. 3b).

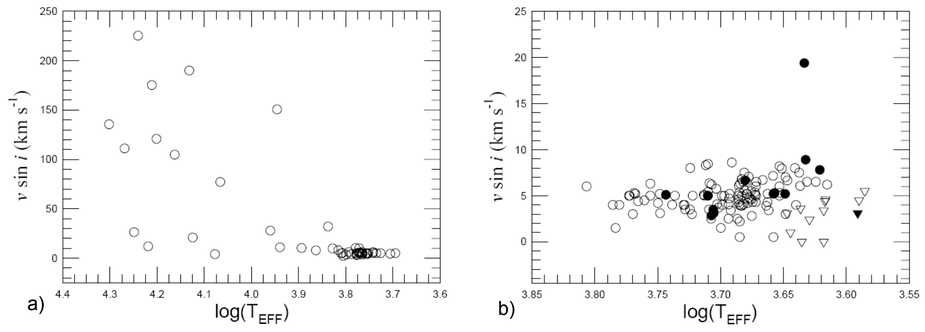
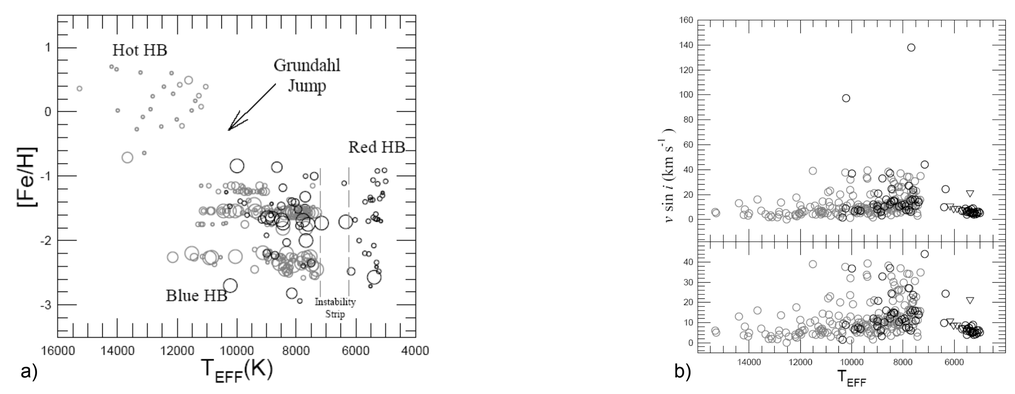


Fig.3: a) vsini as a function of Teff of MS stars. **b)** vsini as a function of Teff n for RGB stars. Open circles and triangles represent single stars, filled circles and triangles represent binary systems.

The rotation of HB stars show different features as a function of the temperature. A spread of vsini values is found in HB stars with Teff≤11,500K, whereas the stars with Teff>11,500K only present low rotation rates (Fig. 4a,b). No important differences can be noted in the rotational features between stars in the field and Galactic GCs. Also, there is no correlation between the evolutionary stage and the rotation in HB stars (see Fig. 4c).



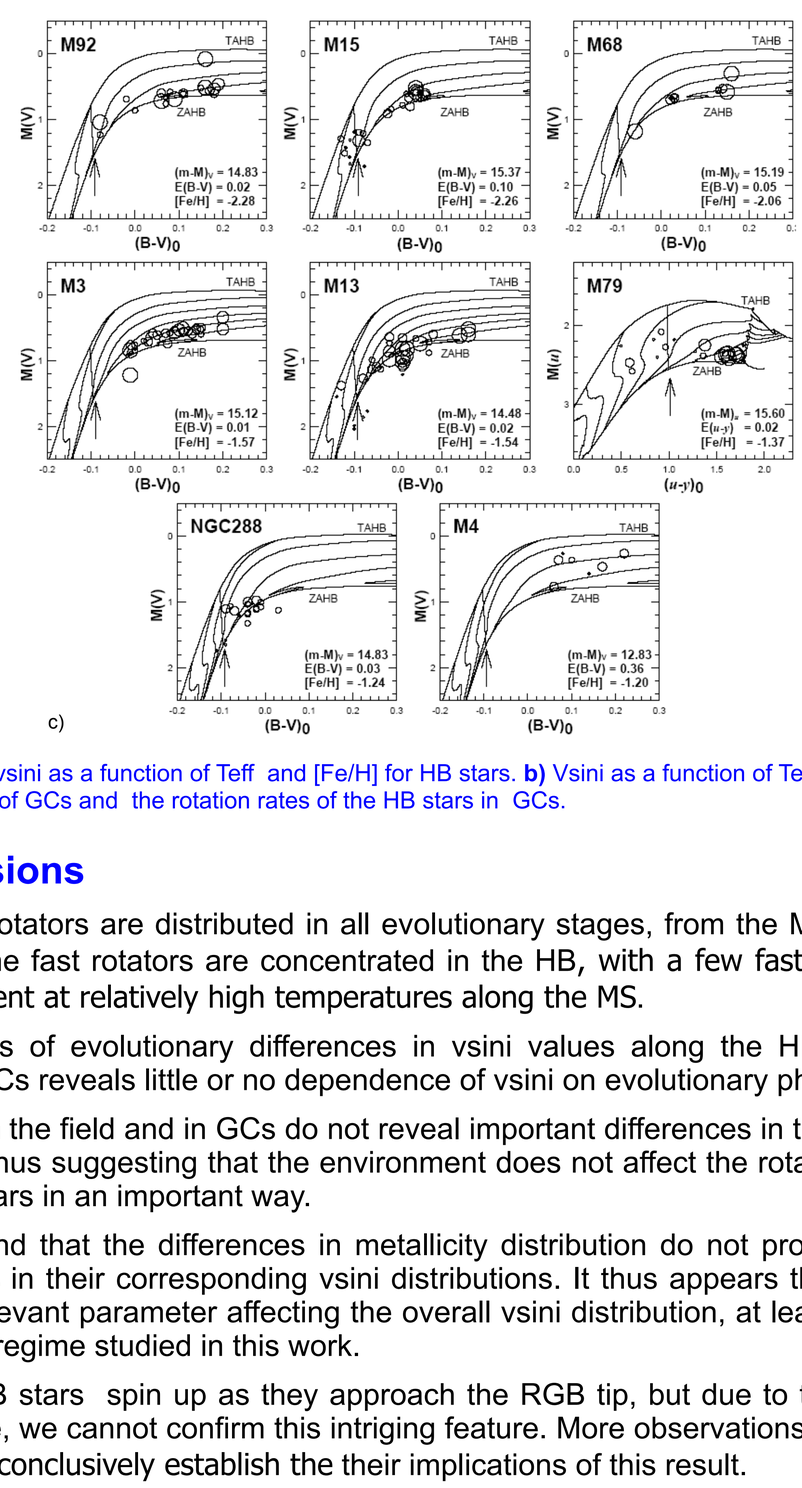


Fig.4: a)vsini as a function of Teff and [Fe/H] for HB stars. **b)** Vsini as a function of Teff for HB stars. **c)** CMD of GCs and the rotation rates of the HB stars in GCs.

Conclusions

- The slow rotators are distributed in all evolutionary stages, from the MS to the HB, whereas the fast rotators are concentrated in the HB, with a few fast rotators also being present at relatively high temperatures along the MS.
- An analysis of evolutionary differences in vsini values along the HB phase for different GCs reveals little or no dependence of vsini on evolutionary phase.
- HB stars in the field and in GCs do not reveal important differences in their rotational behavior, thus suggesting that the environment does not affect the rotation behavior of these stars in an important way.
- We also find that the differences in metallicity distribution do not produce marked differences in their corresponding vsini distributions. It thus appears that metallicity is not a relevant parameter affecting the overall vsini distribution, at least in the low-metallicity regime studied in this work.
- Some RGB stars spin up as they approach the RGB tip, but due to the pancity of our sample, we cannot confirm this intriging feature. More observations are requiried in order to conclusively establish the their implications of this result.