ON THE ROTATIONAL VELOCITIES DISTRIBUTION OF A-TYPE STARS OBSERVED BY HIPPARCOS

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1. Introduction

The study of the distribution of rotational velocities is related to the star formation and evolution. Projected rotational velocities ($v \sin i$) have been measured for 250 main-sequence A-type stars. These data have been merged with those of Abt & Morrell (1995). Thus, a sample of 650 stars, all observed by Hipparcos, has been gathered. Our aim is :

- to see whether there is multimodal distribution of $v \sin i$ (§3),
- to discuss the distribution of $v \sin i$ with galactic coordinates (l,b) (§4).

2. Observational data and statistical method

2.1. OUR SAMPLE

This work concerns stars in the spectral type range B9.5–A9, with luminosity class V to IV. In our sample all peculiar Am and Ap, known binaries and radial velocity variable stars were discarded. The studied spectra were obtained with the Echelec at La Silla or with the Aurélie spectrograph at Observatoire de Haute-Provence. The $v \sin i$ has been derived from the first zero of the Fourier transform of a chosen set of spectral lines (Ramella *et al.*, 1989). With the aim of increasing the sample, these data have been merged with those of Abt & Morrell (1995). The final sample contains 650 stars.

2.2. RECTIFICATION OF THE DISTRIBUTION

In order to obtain the distribution of equatorial velocities v, we have deconvolved the observed $v \sin i$ distribution (under the assumption of randomly oriented rotation axes) using Lucy-iteration technique (Lucy, 1974). We have deconvolved the probability density function Φ of the projected rotational velocities and obtained the distribution of equatorial velocities ($\Psi(v)$)

$$\Phi(v \sin i) = \int \Psi(v)\, P(v \sin i | v)\, dv$$

with $P(v \sin i|v) = \sin i(v^2 \cos^2 i)$ if i is randomly distributed.

3. Rotational velocities distributions

3.1. BINS OF SPECTRAL TYPE

The sample was divided into three groups of spectral types : B9.5–A1 (249 stars), A2–A3 (222 stars) and A4–A9 (186 stars). Spectral types come from the Hipparcos Catalogue (ESA, 1997). The $v \sin i$ distributions of the groups of stars are shown in Fig.1.

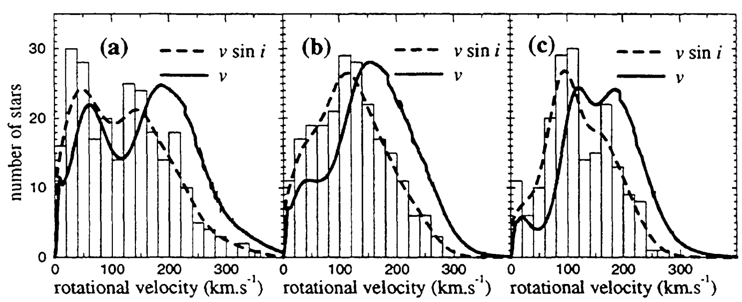

Figure 1. Distributions of the projected rotational velocities (dashed line) and equatorial velocities (solid line) for the three groups : (a) B9.5–A1 type stars, (b) A2–A3 type stars, (c) A4-A9 type stars

The histograms of $v \sin i$ were transformed to distributions of true rotational velocities v as explained in section 2.2. A bimodal distribution is clearly seen for the B9.5–A1 stars while such a behaviour is not clearly apparent for the other groups. A double peak in the $v \sin i$ of A0V-type stars was pointed out by Ramella *et al.* (1989).

3.2. BINS OF ABSOLUTE MAGNITUDE

We explore whether the observed bimodality in the distribution of $v \sin i$ for B9.5–A1 type stars is the result of a mass effect.

Since brighter absolute magnitudes will correspond, in our spectral range, to higher mass stars, we have considered three sub-groups of visual absolute magnitude M_V. The absolute magnitudes have been calculated using Hipparcos parallaxes. The visual apparent magnitude as well as the colour index $(B - V)$ for each star come from the Hipparcos Catalogue (ESA, 1997). If necessary, a reddening correction has been applied to the apparent magnitudes, using the Strömgren photometry and the code of Arenou (1993). An effect, attributed to the mass, can be seen by the comparison of the distributions of $v \sin i$ for the three absolute magnitude sub-groups (Fig.2) : each sub-group corresponding to a mass interval (mass range comes from Bertelli *et al.* (1994)).

"fainter" stars	$M_V > 0.8^{mag}$	$\sim$ 2–2.5 $M_\odot$	(95 stars)
"intermediate" stars	$0.8 > M_V > -0.2^{mag}$	$\sim$ 2.5–3 $M_\odot$	(103 stars)
"brighter" stars	$M_V < -0.2^{mag}$	$\sim > 3$ $M_\odot$	(51 stars)

In Fig.2, the different shapes of the distributions can be seen. In the interval of mass 2.5 and 3 $M_\odot$, two $v \sin i$ peaks are seen, whereas for the higher mass stars, there is less fast rotators.

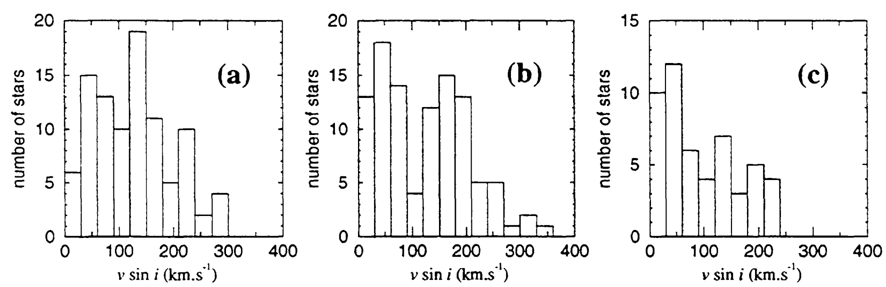

Figure 2. Distributions of the projected rotational velocities of the B9.5–A1 stars for the different sub-groups : (a) "fainter" stars , (b) "intermediate" stars, (c) "brighter" stars

The bimodal distribution of $v \sin i$ found in this study corresponds to normal A0-type stars. Guthrie (1982) studied the distribution of rotational velocities of B6-B9 stars. He found a one-peaked distribution for field stars which should be compared to the distribution for the higher mass stars shown in Fig.2) and a bimodal distribution for cluster stars. Let us remark that our sample does not include cluster members. Recently, Abt & Morrell (1995), studying the $v \sin i$ distribution of A-type luminosity class V stars, attributed the bimodality to the presence in their sample of A*m*-A*p* stars. These stars produce a small peak at low rotational velocities. In our sample known chemically peculiar stars were eliminated, though the small $v \sin i$ have a strong peak.

4. Dependence of $v \sin i$ distribution on galactic coordinates

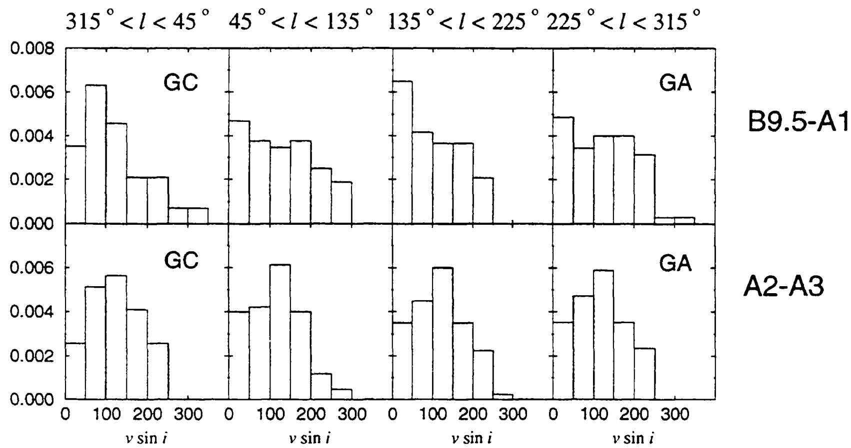

Figure 3. Distributions of the projected rotational velocities of the B9.5–A1 and A2–A3 stars for the different bins of galactic longitude l. GC and GA respectively stand for Galactic Centre and Galactic Anticentre.

The histograms in Fig.3 illustrate the fact that there is a lack of slow rotators toward the galactic centre. In previous works (Wolff *et al.*, 1982), (Burki & Maeder, 1977), concerning B-type stars, such a lack was attributed to an enhanced population of B*e* stars. It is worth noting that in our sample, there is no B*e* star. Therefore the same phenomenon also exists for objects of lower mass than B-type stars.

5. Conclusion

Using a larger sample, the bimodality in the rotational velocities distribution for A0-type stars is clearly observed. The A0 stars with the higher mass present a deficiency of high velocity objects. Nevertheless mass and evolutionary effects get entangled, and it is hard to separate both effects.

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