

SYSTEMATIC ERRORS IN THE DETERMINATION OF STELLAR ROTATIONAL VELOCITIES

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ABSTRACT

Using our new updated and enlarged catalogue of stellar rotational velocities (containing about 39 000 data), we estimate errors of determination of $V \sin i$ values for different techniques of measurements. Individual errors evaluated by comparison of published values of $V \sin i$ for a given star are always higher than that claimed by the observers. Additionally, we find systematic errors in some numerous determinations (e.g. Coravel data), and therefore we suggest list of standards for unification of $V \sin i$ scale.

Key words: Stars: rotation

1. INTRODUCTION

The distribution of rotational velocities as a function of spectral type and luminosity yields important constraints for models of angular momentum history of stars. For majority of stars information about their rotation is obtained from Doppler broadening of spectral lines. The most frequently used methods of analysis of rotational broadening are the following: cross-correlation technique (C-C), full width at half maximum (FWHM), convolution and Fourier transform of line profile (FTLP). Results depend critically on the adopted templates and standards used for calibration of line broadening as a function of $V \sin i$. Because of the aspect factor – $\sin i$, values of equatorial rotational velocities (V) for a given group of stars can be obtained only for statistically significant sample of data. To enable such analysis we have prepared catalogue of all published $V \sin i$ values.

2. RANDOM AND SYSTEMATIC ERRORS

Our catalogue contains more than 39000 data for about 28000 stars. This is updated and corrected catalogue of Głębocki et al. (2001) CDS III/226. Before making an analysis of $V \sin i$ distribution on H-R diagram, we have looked at errors of $V \sin i$ determinations. Intrinsic errors for a given method (especially for a given instrument and author) are slightly dependent on the method of analysis. Highest accuracies are obtained by FTLP method, slightly lower by cross correlation and they amount to about 5

to 10%. FWHM and convolution determinations usually achieve 10 to 15% accuracy. Details will be discussed in the paper under preparation.

Much more serious is the problem of systematic errors. This type of errors, resulting mainly from the use of different standards, led Uesugi & Fukuda (1982) to re-reduction of all published values of $V \sin i$ to one system, so called “old Slettebak system”. In our paper we suggest that values of $V \sin i$ presented by Slettebak (1982, 1985), Gray (18 papers 1979-1997), and Reiners & Schmitt (2003) should be used as standards for $V \sin i$ calibration. In Table 1 we display details of papers used for establishing list of standards. We have chosen Slettebak data for obvious reason; they are up to now most frequently used by different authors for calibration of stellar rotational scale. David Gray very accurate method of Fourier analysis is the only method separating macroturbulence from rotation. Recently, Reiners & Schmitt (2003) used more sophisticated FTLP analysis to measure differential rotation. Certainly, their results can be used as standards. Table of 659 Standards as well as the catalogue of all $V \sin i$ data can be obtained from: <http://www.iftia.univ.gda.pl/~pg/prace/StellarRotation.tar.gz>

Careful analysis of all data from this catalogue revealed systematic differences in four cases. The most numerous uniform data are those obtained by CORAVEL (about 14500 measurements). It turns out that they are systematically higher than other determinations. It is illustrated in fig. 1a. In case of Royer et al. (2002a,b) FTLP measurements, $V \sin i$ are also systematically too high (fig. 1b). For large sample of data (about 3000) given by Abt et al. (1995, 2002) $V \sin i$ are systematically lower (fig. 1d). The same is found for Stoeckley, Carroll & Miller (hereafter SCM) - fig. 1c. The differences shown in fig. 1 are of the order of 12%, but because of their systematic character they have to be reduced before starting any statistical analysis.

Uesugi & Fukuda (1982) values are too high by about 15% because they have reduced $V \sin i$ to the “old Slettebak system”, while we propose (in accordance with many recent authors) the new Slettebak system as the reference values.

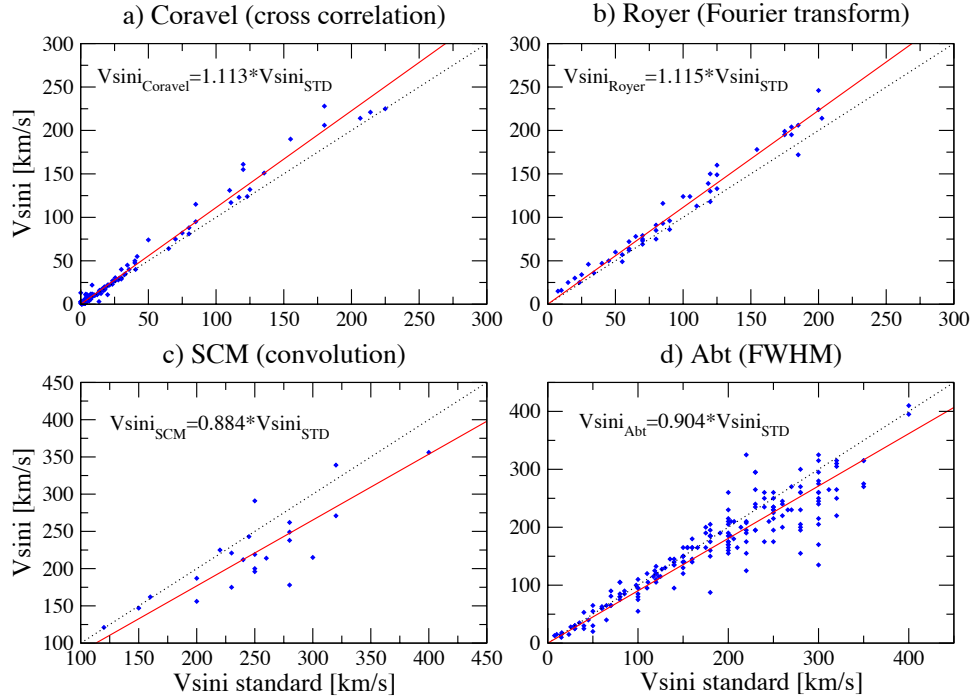


Figure 1. Comparison of V_{sini} from literature with standards for four cases displaying systematic differences.

3. CONCLUSIONS

Increasing number of V_{sini} determinations allows for more sophisticated analysis of changes of stellar rotation with time. Unfortunately, errors of V_{sini} measurements are relatively high, and we show that systematic errors are also present. It seems to us that, like in stellar photometry, it is necessary to impose standards for calibration of V_{sini} scale. In our new catalogue we present list of proposed standards. We also include table of weighted mean values of V_{sini} for each star, using weights proportional to an individual intrinsic accuracies estimated for particular methods, and correcting for systematic errors shown in fig. 1 and 2.

ACKNOWLEDGEMENTS

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 Abt H.A. and Morrell N.I., 1995, ApJS, 99, 135
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 Reiners A. and Schmitt J.H.M.M., 2003, A&A, 396, 647
 Royer F., Gerbaldi M., Faraggiana R., and Gomez A.E, 2002, A&A, 381, 105

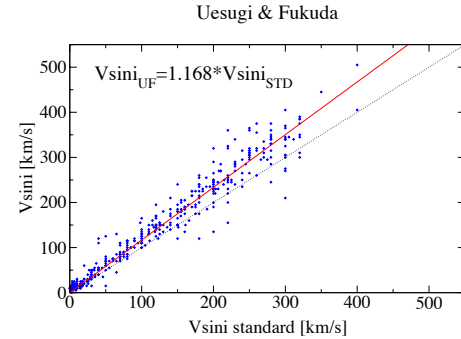


Figure 2. Comparison of the Uesugi & Fukuda data with standards.

- Royer F., Grenier S., Baylac M.-O., Gomez A.E. and Zorec J., 2002, A&A, 393, 897
 Slettebak A., Collins II G.W., Boyce P.B., White N.M. and Parkinson T.D., 1975, ApJS, 29, 137
 Stoeckley Th.R., Carroll R.W. and Miller R.D., 1984, MNRAS, 208, 459
 Uesugi A. and Fukuda I., 1982, CDS III/63B

Table 1. List of publications with rotational velocities proposed as standards for $V \sin i$ calibration.

Author(s)	Bibcode	No. of data
Gray D.F.	1979ApJ...231..139G	8
Gray D.F.	1980PASP...92..154G	1
Gray D.F.	1980PASP...92..771G	22
Gray D.F.	1981ApJ...245..992G	1
Gray D.F.	1981ApJ...251..152G	1
Gray D.F.	1981ApJ...251..155G	5
Gray D.F.	1982ApJ...258..201G	7
Gray D.F.	1982ApJ...262..682G	23
Gray D.F.	1984ApJ...281..719G	18
Gray D.F.	1984PASP...96..537G	2
Gray D.F.	1986PASP...98..319G	12
Gray D.F.	1989ApJ...347.1021G	76
Gray D.F. and Baliunas S.L.	1997ApJ...475..303G	1
Gray D.F. and Endal A.S.	1982ApJ...254..162G	6
Gray D.F. and Nagar P.	1985ApJ...298..756G	24
Gray D.F. and Pallavicini R.	1989PASP...101..695G	18
Gray D.F. and Toner C.G.	1986ApJ...310..277G	37
Gray D.F. and Toner C.G.	1987ApJ...322..360G	30
Reiners A. and Schmitt J.H.M.M.	2003A&A...396..647R	142
Slettebak A., 1982	1982ApJS...50...55S	197
Slettebak A., 1985	1985ApJS...59..769S	70