ESPECTROSCOPIA ESTELAR

COMUNICACIONES

Comments on the statistics of stellar rotation

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Abstract: With the data provided by the Catalogue of Stellar Rotational Velocities by Bernacca and Perinotto, some aspects of the rotational velocity statistics are review.

Introduction

The main purpose of this paper is to review some statistical aspects of stellar rotational velocities. A number of authors has done statistics of one kind or another, but usually the number of stars was small and/or taken from heterogeneous sources. (see for instance: Huang (1953), Slettebak (1955), Boyarchuk and Kopylov (1958), etc.). In view of the recent completition of the Catalogue of Stellar Rotational Velocities by Bernacca and Perinotto (1970-1971) which provides the most accurate and homogeneous set of data, it was considered useful to repeat some of the existent statistics.

Material

As mentioned above, the Catalogue of Bernacca and Perinotto (1970-1971) was used. In order to increase the number of southern stars, a recent list of Vsin i values by the author Levato (1972) was also used. This list lies also in the system of the Bernacca and Perinotto Catalogue.

Discussion

I. Average rotational velocity as a function of spectral type.

In order to derive this function for single, field dwarfs, the average rotational velocity was computed for samples

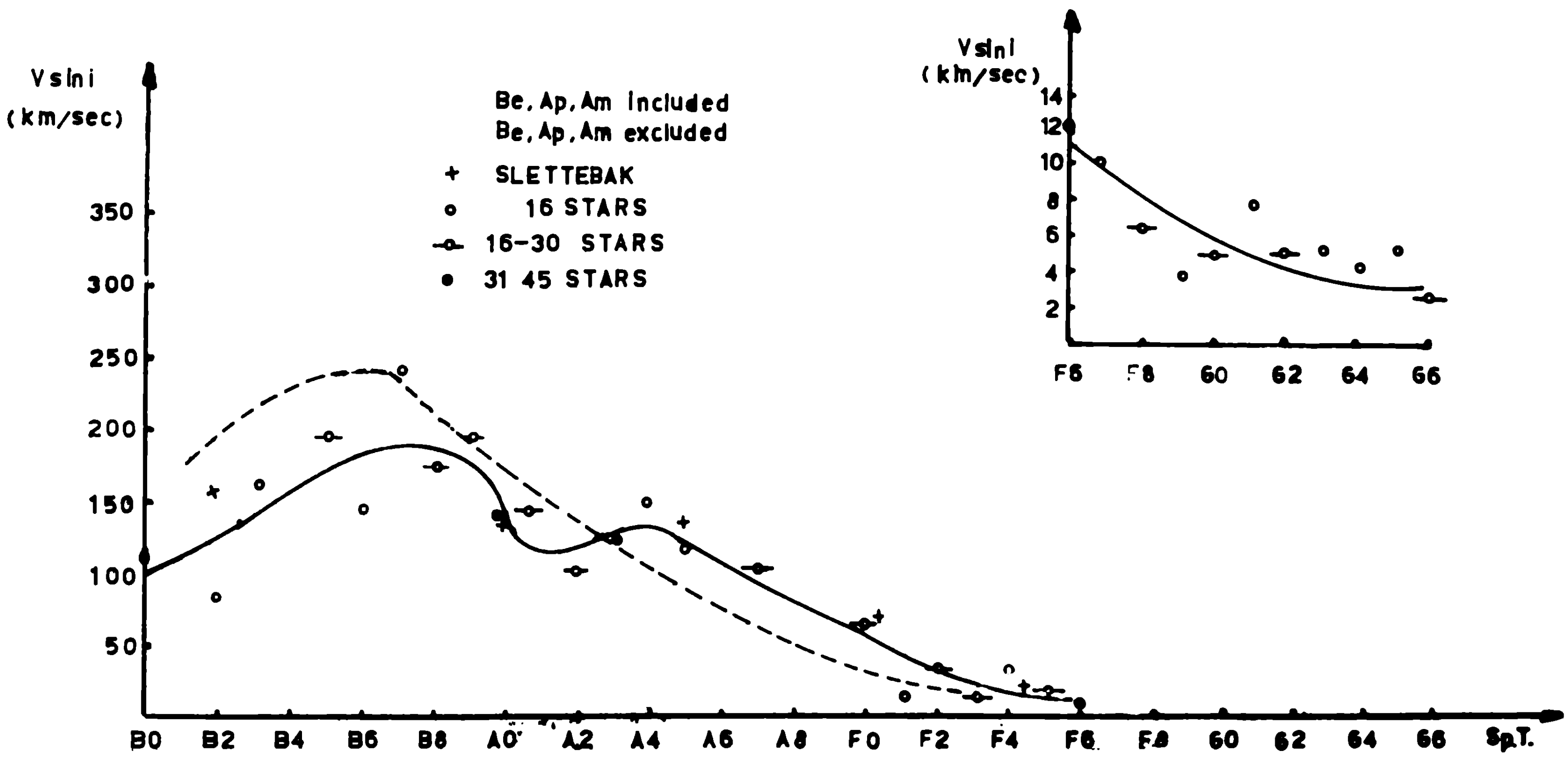

Fig. 1: *Relation between < V sin i > and the spectral type for single field main sequence stars.*

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of stars with the same spectral type. The number of objects in each group oscillates between 10 and 40. The Vsin i values were plotted against the spectral types as shown in figure 1. Two different relations are indicated, one in which Am, Be and Ap stars were excluded and another with them included. This last relations shows that the minimum near A0 and the maximum at A3 disappeared. This confirms the earlier results of Van den Heuvel (1965, 1968) and Jaschek (1970), in the sense that from a rotational point of view the Am and Ap stars cannot be treated separately from the A-type main sequence stars. The Be and shell stars were included because they are simply the B stars with largest rotational velocities.

In order to compare the < Vsin i > values with the ones obtained by Slettebak (1955), the stars were divided in the following spectral ranges: B1-B3, B5-B7, B8-A2, A3-A7, A9-F2, F3-F6, F7-G0 and G1-G8. The < Vsin i > values computed for each group are shown in table I, II and III were Slettebak's values for some groups are also indicated. For each of the groups the percentages of stars in each velocity interval were computed and the results are plotted in figure 2. The values include Am, Ap and Be stars are also shown. It is clear that the relations and percentages here computed for single, field dwarf stars are biassed in the sense that they include the undiscovered spectroscopic binaries.

TABLE I

AVERAGE ROTATIONAL VELOCITIES OF SINGLE, FIELD DWARFS

SPECTRAL RANGE	< VSIN I > (km/sec) Ap, Am, Be excluded	< VSIN I > (km/sec) Ap, Am, Be included	SLETTEBAK < VSIN I > (km/sec)
B1-B3	125(24)	198(66)	157
B5-B7	190(51)	237(101)	203
B8-A2	150(163)	135(228)	139
A3-A7	138(88)	—	136
A9-F2	48(52)	—	68
F3-F6	17(91)	—	24
F7-G0	6(68)	—	20
G1-G8	5(59)	—	—

The numbers between brackets represent the number of stars included in each average.

TABLE II

AVERAGE ROTATIONAL VELOCITIES OF Am AND Ap STARS

	< VSIN I > (km/sec)	NUMBER OF TARS
Am	52	94
Ap	44	46

TABLE III

AVERAGE ROTATIONAL VELOCITIES OF Be AND SHELL STARS

SPECTRAL RANGE	< VSIN I > (km/sec)	NUMBER OF STARS
B1-B3	240	42
B5-B7	286	50
B-?-A2	234	19

II. < Vsin i > as a function of galactic longitude and latitude.

This was studied for dwarfs of different spectral types. The stars were divided into the following spectral ranges: B0-B9, A0-A9, F0-F9 and G0-G9. These ranges are a compromise between the number of stars and the variation of the rotational velocity along the main sequence. In order to test the possible variation of < Vsin i) with the galactic longitude this quantity was computed for 60 degrees intervals and this was done for all the spectral ranges. The dispersion σ (Vsin i) was also computed and the results are plotted in figure 3 in the form of histograms.

The same procedure was used to test the possible variation of < Vsin i > with the galactic latitude. The latitude interval was chosen of 18° except for the range B0-B9 in which a 9° interval was chosen because of the strong concentration of B-type stars toward the galactic plane. The results are shown in figure 4. Despite of the small number of stars in some intervals, one can say that a random distribution represents well the data in figure 3 and 4. This is supported by a chi square test at a 50 % level.

III. Correlation between duplicity and rotational velocity.

This correlation was found by Abt and Hunter (1962) in galactic clusters. The binary stars are more frequent between stars of low rotational velocity. This can be regarded as an observational evidence of the influence of one component upon the other. Later on Jaschek (1970) found this was true also for main sequence field stars.

This correlation was redone here again for field stars. First of all, the percentages of binary stars in given rotational velocity intervals were computed. This was done for the B0-B9- and A0-A9 spectral ranges. The results of these computations are shown in tables IV and V and in figure 5, where the percentages of normal (single) stars are also indicated for comparative purposes.

It must be kept in mind that between the normal single stars there are, of course, undetected spectroscopic binaries. In spite of this bias the tables and figure are very conclusive in the sense that spectroscopic binaries are more frequent between low rotational velocity stars which is interpreted as showing the action of the secondary component on the rotational behaviour of the primary.

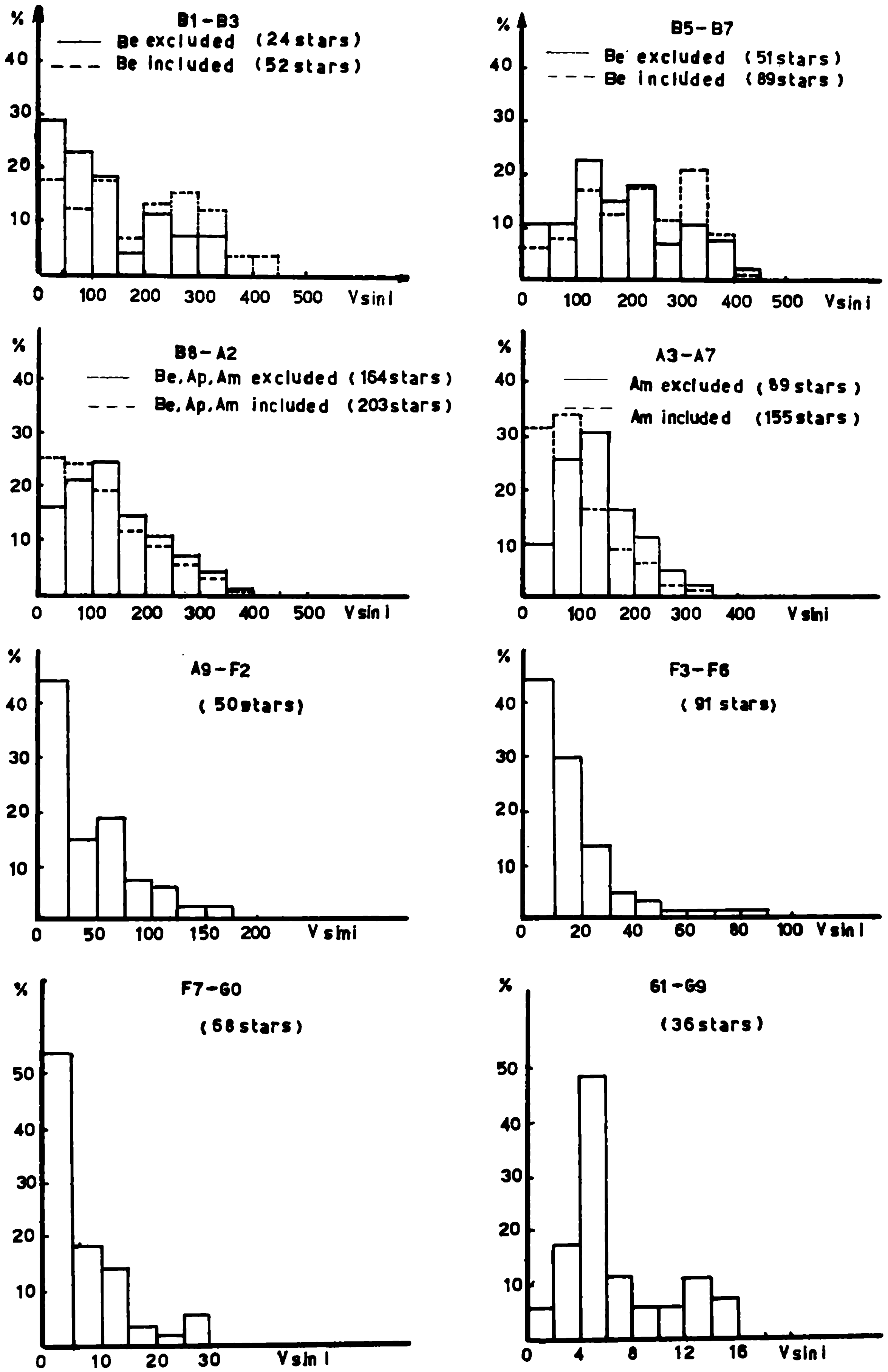

Fig. 2: *Distribution of V sin i for single field dwarfs.*

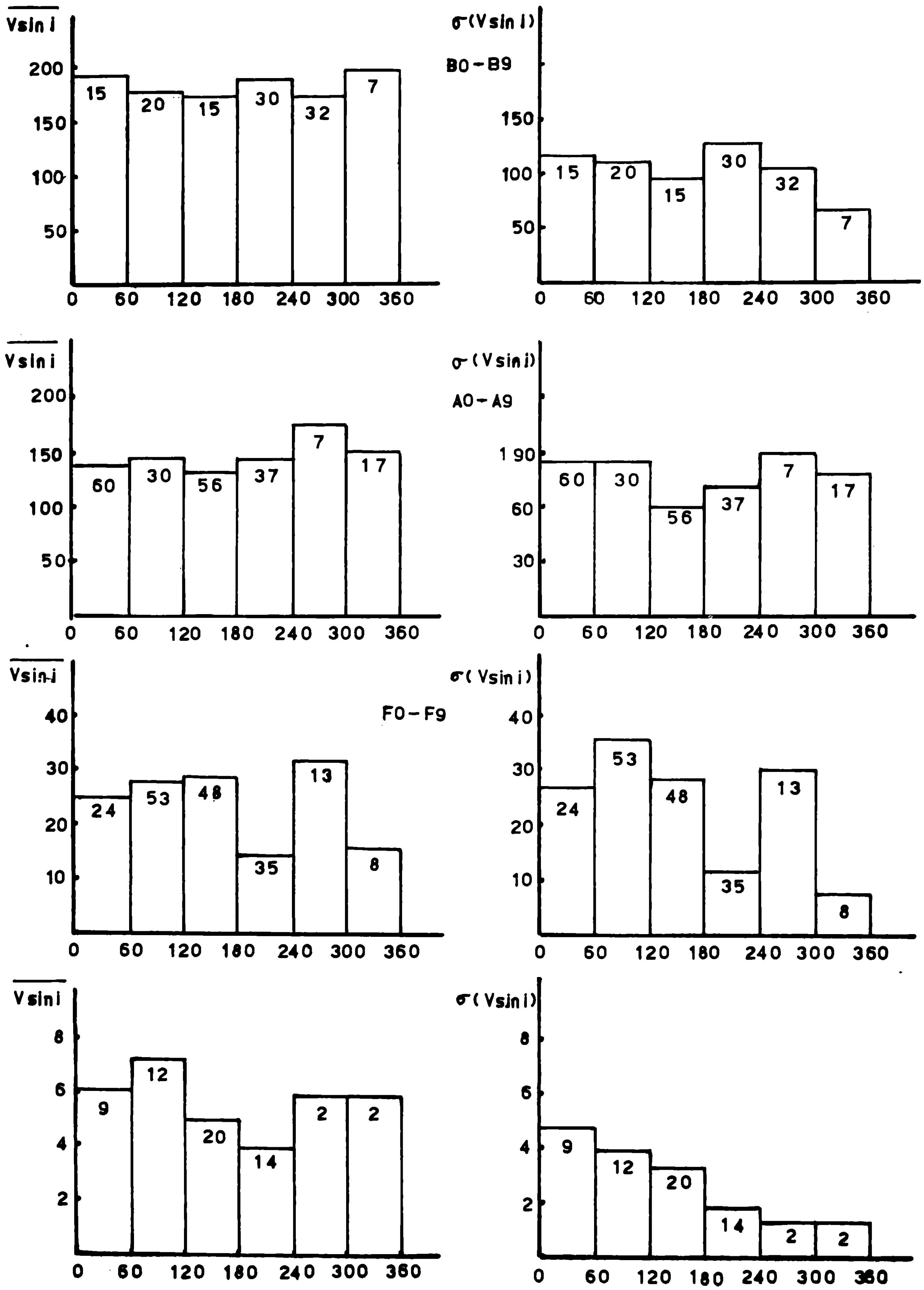

Fig. 3: *Variation of $< V \sin i >$ and σ $(V \sin i)$ with the galactic longitude. The numbers at the top of each block represent the number of stars included in each longitude interval.*

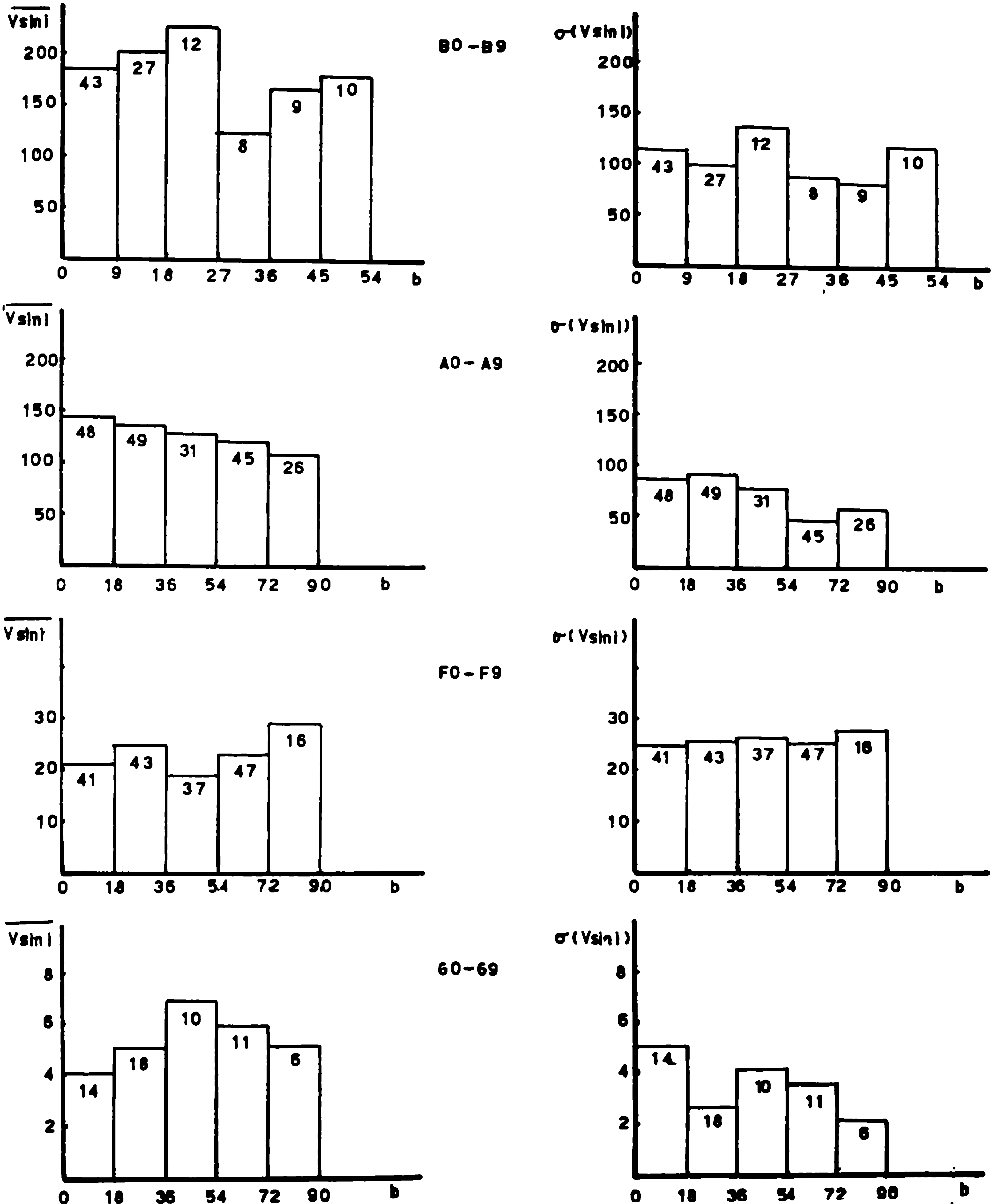

Fig. 4: *Variation of < V sin i > and σ (V sin i) with the galactig latitude. The numbers at the top of each block represent the number of stars included in each latitude interval.*

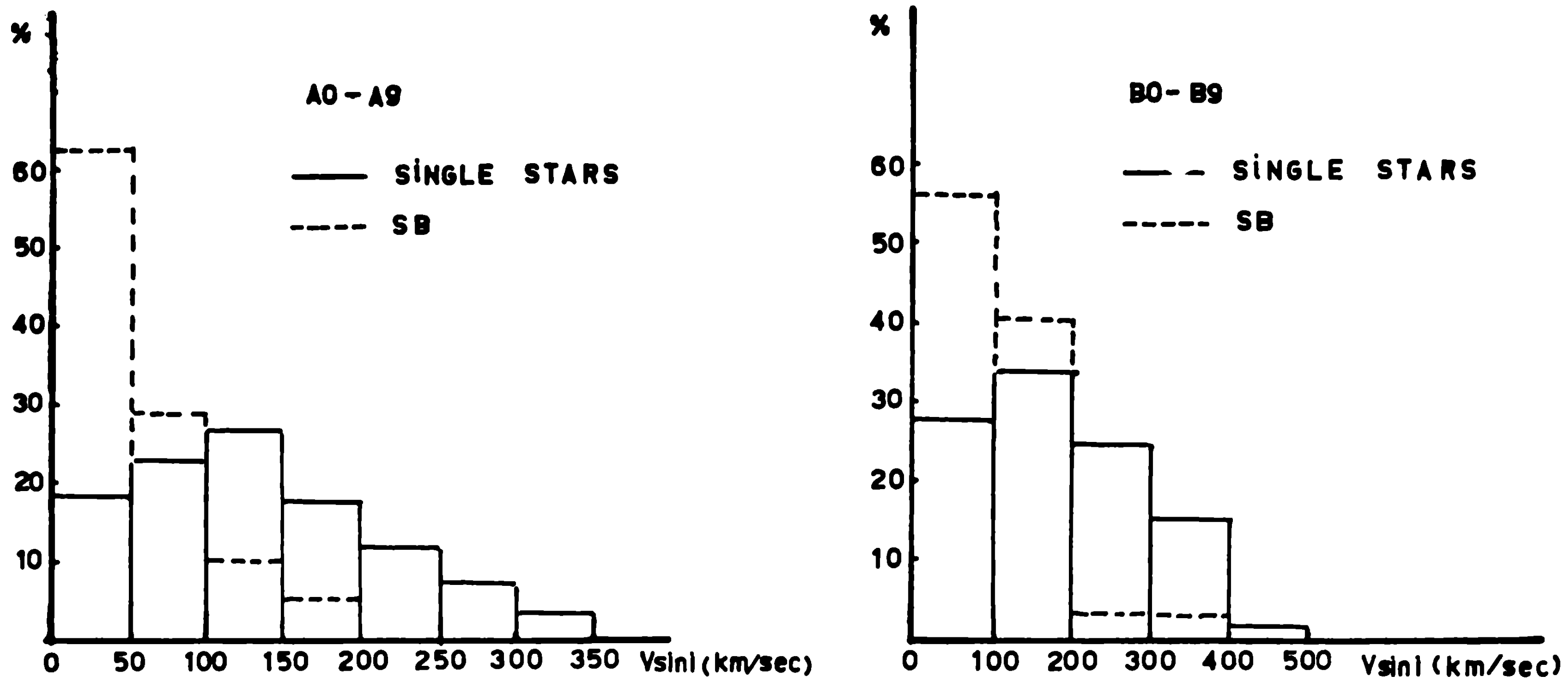

FIG. 5: *Distribution of V sin i for single field stars and for spectroscopic binaries.*

TABLE IV

DISTRIBUTION OF VSIN I FOR SPECTROSCOPY BINARIES AND SINGLE FIELD MAIN SEQUENCE STARS

SPECTRAL RANGE: A0 - A9

VSIN I (km/sec)	SB (P 10^d)	SB (P 5^d)	SINGLE STARS
0-50	61 %	65 %	17 %
51-100	28 %	35 %	22 %
101-150	8 %		26 %
151-200	3 %		17 %
201-250			10 %
251-300			6 %
301-350			2 %
NUMBER OF STARS	38	28	173

TABLE V

DISTRIBUTION OF VSIN I FOR SPECTROSCOPY BINARIES AND SINGLE FIELD MAIN SEQUENCE STARS

SPECTRAL RANGE: B0 - B9

VSIN I (km/sec)	SB (P 20^d)	SB (P 10^d)	SINGLE STARS
0-100	51 %	55 %	28 %
101-200	37 %	41 %	33 %
201-300	8 %	2 %	24 %
301-400	4 %	2 %	14 %
401-500	0 %	0 %	1 %
NUMBER OF STARS	60	49	119

VI. Zonal distribution in clusters and associations.

In some clusters and associations an anomalous rotational velocity for stars situated in a particular region of them was found. Examples are the Pleiades (Struve (1945)) and Sco-Cen (Slettebak (1968)). This author found that in the region of higher density the rotational velocity of the B stars was higher than in the lower density region. Revising the data on clusters and associations contained in Bernacca and Perinotto Catalogue of Stellar Rotational Velocities, the opposite result was found in the I Ori association. In the higher density region the rotational velocities of the B stars are lower than for B type field stars and in the lower density region the rotational velocities are higher than for field stars. This result is shown in table VI where the region $l > 207$ is the higher density zone.

TABLE VI

AVERAGE ROTATIONAL VELOCITIES OF B-TYPE STARS IN I ORI ASSOCIATION

GALACTIC LONGITUDE	$<$ VSIN I $>$ (km/sec)		NUMBER OF STARS	
	B0-B3	B5-B9	B0-B3	B5-B9
$l > 207°$	65	141	19	13
$l < 207°$	144	182	24	14
SINGLE FIELD DWARFS	119	187	29	91

As can be seen from the table, the number of stars on which the average rotational velocities are based are rather small and one can think that these fluctuations have statistical origin.

Conclusión

At the light of the best available data, the main features of the rotational velocity statistics are confirmed. However it must be emphasized that the number of stars with Vsin i measured is small even now, and that the lack of good observational data specially in cluster and binaries constitutes the greatest difficulty for a good statistics.

I would like to thank Dr. Carlos Jaschek for reading the manuscrit and for his valuable advice.

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Estrellas F con espectros anómalos

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Astract: A description of the criteria adopted to detect the various grups of peculiar objects is provided. The material comprises 372 spectra of southern F stars. The complete list will be published elsewhere.

El objeo del presente trabajo es reportar una serie de estrellas con espectros anómalos, tales como estrellas Am tardías, espectros compuestos, δ Delphinis, espectros peculiares, etc., encontradas en el curso de un proyecto de clasificación sistemática de estrellas de tipo espectral F.

El material observacional comprende:

a) 173 placas en 110 Å/mm tomadas con el reflector de La Plata (80 cm);

b) 132 placas en 110 Å/mm tomadas con el reflector de Cerro Tololo (40 cm) y

c) 67 placas en 40 Å/mm tomadas con el reflector de Bosque Alegre (152 cm).

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Parte de este material fue tomado para programas de clasificación espectral. En todos los casos los espectros utilizados tienen más de 0.4 mm de alto y una ranura proyectada sobre la placa de 18 μ.

Todo el material fue clasificado en el sistema MK con ayuda de estrellas patrones.

Se analizarán a continuación los distintos tipos de objetos peculiares encontrados.

Estrellas con líneas metálicas:

Se encontraron ocho Am nuevas, lo cual no altera el porcentaje encontrado por Cowley et al (1970) de estrellas Am en función del color B-V. No se encontraron objetos Am con tipo metálico más tardío que F6 y con tipo de hidrógeno más tardío que F2. Además la revisión del material en 40 Å/mm mostró que todas ellas tienen el ScII muy debilitado o ausente. Dado que el ScII tiene un efecto de luminosidad muy pronunciado, para identficar estrellas Am con este criterio hay que tomar como estrellas patrones sólo estrellas A enanas. Esta precaución no se ha tenido en cuenta por otros autores, lo que produjo metálicas espúreas.

Estrellas peculiares:

No se buscaron objetos Ap clásicos. Solo mencionaremos HD77258, que tiene un espectro de hidrógeno alrededor de F5, un espectro metálico F8 y un espectro de calcio alrededor de F0. La banda G responde a F8, el ScII está débil o ausente y λ 4226 (CaI) es normal para F8, pero el Sr II (λ 4077) está normal para una enana. Salvo el SrII, normal, esta descripción correspondería a la de un Am clásica, con espectro metálico muy tardío. Se tratará de determinar en un próximo trabajo si la estrella es una Am clásica o corresponde a un nuevo grupo de estrellas peculiares con banda G intensificada.

Estrellas tipo δDelphini:

Se encontraron seis nuevos miembros. Definimos espectroscópicamente a una δ Delphini como una estrella F fuera de secuencia principal con H y K de CaII iguales en intensidad, pero mucho más finos de lo que corresponde al tipo espectral deducido de las líneas metálicas y de hidrógeno. Se están analizando fotométricamente estas estrellas para decidir si son variables de luz.

La lista de objetos será publicada in extenso en otro lugar.

Deseamos agradecer al Observatorio Interamericano de Cerro Tololo por el tiempo de observación puesto a disposición de uno de los autores y al Dr. J. Landi Dessy por el préstamo de su material de estrellas F, tomado en Bosque Alegre para el Atlas de Clasificación Espectral.

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