ROTATIONAL VELOCITIES OF STARS IN M39 AND THE URSA MAJOR CLUSTER

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ABSTRACT

Spectrograms of twenty-nine A-type stars in M39 and the Ursa Major cluster have been taken and measured for rotational velocities. The results indicate that there is no significant difference between the average velocity for the clusters and for field stars of the same type.

OBSERVATIONAL MATERIAL

The 60-inch Mount Wilson telescope was used in conjunction with the 8-inch camera of the X-spectrograph to obtain spectrograms of twenty-nine stars in M39 and the Ursa Major clusters. The plate dispersion was slightly over 40 A/mm at the 4481 line of Mg II. The plates were calibrated with a wedge-calibration spectrograph, and line profiles of the 4481 line were determined using the Caltech microphotometer.

Theoretical profiles of the 4481 line for different rotational velocities were derived in the usual manner (Shajn and Struve 1929) by distorting the profile of the line from an assumed zero-rotational velocity star (in this case α Lyrae). The apparent rotational velocities ($v \sin i$) of the cluster stars were then obtained by a comparison of the traced profiles with those derived from the standard star. A rough check on these velocities was made by means of a visual intercomparison of the stellar spectra. From internal evidence, the error in the estimated rotational velocity of an individual star seemed to be approximately 25 km/sec. This figure was checked by comparing the results with those of Slettebak (1954, 1955) for eight stars measured in common (Fig. 1). In view of this probable error, the rotational velocities were estimated only to the nearest 25 km/sec. As a rough rule, it can be said that the lowest rotational velocity (in km/sec), measurable with any accuracy, is of the order of the plate dispersion (in A/mm). In this paper, all rotational velocities less than 50 km/sec have been considered together and assumed to have an average value of 25 km/sec. Measurements of rotational velocity are particularly liable to systematic error. Of the various types of measurement normally used, the comparison of line profiles, as described above, is probably the most reliable. Even here, however, systematic errors can arise in fitting a symmetric standard profile to an asymmetric line profile.

RESULTS

The results of this investigation are given in Tables 1 and 2. Cluster membership and spectral type for the Ursa Major cluster are taken from Roman (1949) and for M39 from Johnson (1953), unless otherwise indicated. The stellar designations in M39 are due to Ebbighausen (1940).

In calculating the average value of $v \sin i$ from these observations, it is important that the stars considered should form a homogeneous group. For this reason only normal, main-sequence stars in the range B9.5–A7 have been used. Hence, in the Ursa Major cluster, 37 UMa, 78 UMa, HR 4867, and HD 115043 have been excluded as lying outside the spectral range and ϵ UMa and ζ UMa (B) have been excluded as being abnormal. Similarly, 23, 33, and 40a have been excluded in M39, as they belong to luminosity class

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IV, and 22, as it is abnormal. The resulting average, apparent rotational velocity for five stars in the Ursa Major cluster is 125 km/sec, and for fourteen stars in M39 it is 120 km/sec. The results for the two clusters were added together, giving a final average value of $v \sin i$ equal to 120 km/sec for nineteen stars. The justification for this step is that, although M39 contains many more members than the Ursa Major cluster, the two clusters have similar H-R diagrams and appear to be of approximately the same age. According to Slettebak (1954, 1955), the average $v \sin i$ for 106 field stars, in the range B9 V–A7 V, is 136 km/sec. In view of the probable error involved, it does not appear that $v \sin i$ for the cluster stars differs appreciably from that for the field stars, in the considered range of spectral types.

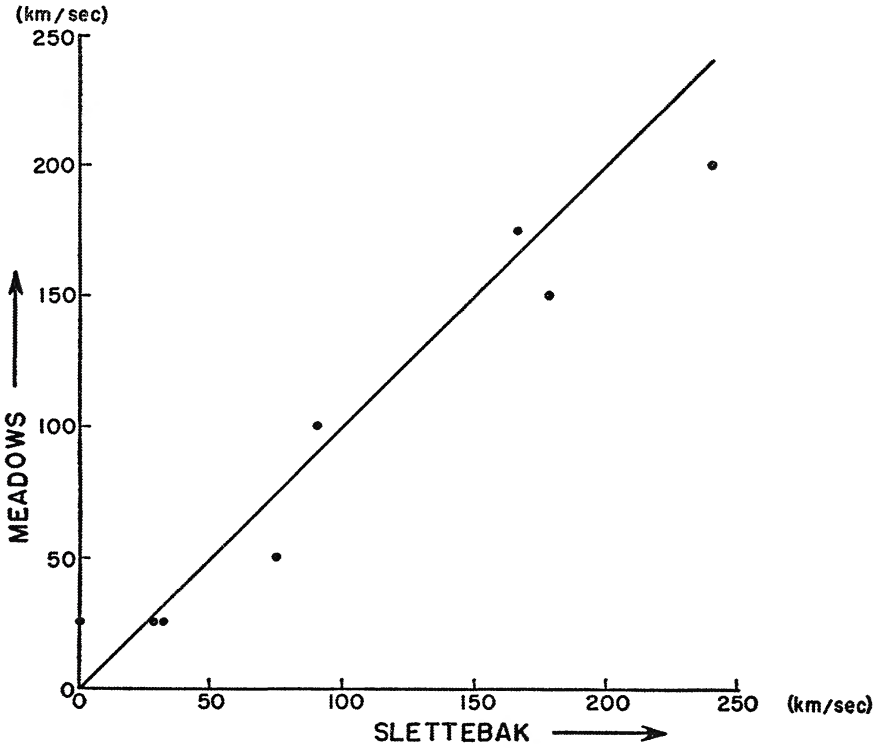

FIG. 1.—An intercomparison of measured rotational velocities in the Ursa Major cluster

TABLE 1

URSA MAJOR

Star	Spectral Type	Apparent Rotational Velocity ($v \sin i$) (km/sec)	Star	Spectral Type	Apparent Rotational Velocity ($v \sin i$) (km/sec)
β	A0 V	< 50	37	F1 V	100
γ	A0 V	175	78	F2 V*	100
δ	A3 V	150	80	A5 V	200
ϵ	A0p	< 50	HR 4867	F6 V	< 50
ζ(A)	A2 V	< 50	HD 115043	G2 V	< 50
ζ(B)	A2m	50			

* Roman also gives F0 V for this star.

It is of interest to compare this result with others available for A stars in clusters. Treanor (1960) has found $\langle v \sin i \rangle = 121$ km/sec for nine stars in the Hyades, in the spectral range A3–A9, and $\langle v \sin i \rangle = 128$ km/sec for fourteen stars in Praesepe, in the same spectral range. Struve (1945) suggested that the rotational velocities of A stars in the Pleiades were close to the average for A stars generally. (The values he quotes for the cluster stars are actually lower than the average now adopted for field stars. However, this would seem to be a systematic error, as his measures for the Hyades are low by about the same amount. Hence his original statement may well stand.) It thus seems that the average rotational velocity of A stars, in the five clusters for which measurements are available, does not differ by any appreciable amount from the average value for field stars.

TABLE 2

M39 (NGC 7092)

Star	Spectral Type	Apparent Rotational Velocity ($v \sin i$) (km/sec)	Star	Spectral Type	Apparent Rotational Velocity ($v \sin i$) (km/sec)
1	A0 V	125	23	A0 IV*	100
3	A2 V	150	26	B9 5 V*	100
4	A2 V	175	31	A0 V	75
5	A0 V	< 50	33	B9.5 IV*	150
8	A7 V	150	34	.....	250
17	A1 V	125	35	A2 V	100
19	A2 V	75	38	A1 V	50
20	A5 V	200	40a	B9 IV*	< 50
22	A1m	75	45	A7 V*	125

* Weaver (1953) gives: 23—A1p; 26—A0 III; 33—A1 III; 34—A3 V; 40a—A1 III; 45—A8m.

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