The nearest young moving groups

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ABSTRACT

The latest results in the research of forming planetary systems have led several authors to compile a sample of candidates for searching for planets in the vicinity of the sun. Young stellar associations are indeed excellent laboratories for this study, but some of them are not close enough to allow the detection of planets through adaptive optics techniques. However, the existence of very close young moving groups can solve this problem. Here we have compiled the members of the nearest young moving groups, as well as a list of new candidates from our catalogue of *late-type stars possible members of young stellar kinematic groups*, studying their membership through spectroscopic and photometric criteria.

Subject headings: associations and clusters: moving groups — stars: kinematics — stars: stellar activity — stars: lithium abundance — stars: planets

1. Introduction

In recent years, a series of young stellar kinematic groups (clusters, associations, and moving groups) of late-type stars with similar space motion and ages ranging from 8 to 50 Myr (see Zuckerman & Song 2004, and references therein) has been discovered in our neighbourhood: TW Hya, β Pic, AB Dor, η Cha, ϵ Cha, Tucana and Horologium associations. In addition, several more distant young associations such as MBM 12 (Hearty et al. 2000), Corona Australis (Quast et al. 2001), and possibly the group of stars with a motion similar to that of HD 141569 (Weinberger et al. 2000) have also been identified. In the Galactic velocity space, they situate inside the boundaries of the Local Association (see Fig. 1), a mixture of young stellar complexes — OB and T-associations — and clusters with different ages (Eggen 1975, 1983a,b; Montes et al. 2001). These associations of very young stars are excellent laboratories for investigations of forming planetary systems (Zuckerman et al.

2004). Nevertheless, they are generally situated at distances above 50 pc, which makes them less accessible to adaptive optics systems even on large telescopes.

It is well-known that tightly bound, long-lived open clusters can account for only a few per cent of the total galactic star formation rate (cf. Wielen 1971). Therefore, either most clusters and associations disperse very quickly after star formation has started or most are born in isolation (Wichmann et al. 2003). The existence of very young moving groups (MGs) with a few dozens of stars showing the same spectroscopic properties — i.e. age, metallicity, level of magnetic activity — is in agreement with the first explanation. Small associations of stars may be dispersed by galactic differential rotation since they are not gravitationally bounded enough, taking into account that their nucleus consist of only a few stars as in the case of the Ursa Major MG (see King et al. 2003, for a recent review) or the recently discovered AB Doradus MG (Zuckerman et al. 2004). The location of these young MGs inside the Local Association and its proximity in the UV-plane can be explained as the result of the juxtaposition of several star forming bursts in adjacent cells of the velocity field (see Montes et al. 2001, and references therein) or dynamical perturbations caused by spiral waves (De Simone et al. 2004; Famaey et al. 2005; Quillen & Minchev 2005). Thus, one expects to find groups of coeval stars with similar space motion in our neighbourhood.

In 2001, the β Pic MG (Zuckerman et al. 2001) — a group of stars with an age of $\sim$ 12 Myr (Zuckerman et al. 2001; Ortega et al. 2004) at a mean distance of $\sim$ 35 pc co-moving with the well-known young star β Pic — was confirmed to be the closest kinematic group up to date. More recently, Zuckerman et al. (2004) have identified a new group of stars co-moving with the also well-known young star AB Dor, at a mean distance of $\sim$ 30 pc, and with an age of $\sim$ 50 Myr. Nevertheless, the existence of a nearer association of a few stars was proposed by Gaidos (1998) and studied in detail by Fuhrmann (2004), though its existence is quite controversial. Here we discuss about the fact of the nearest MGs using both spectroscopic and photometric criteria of membership for a sample of stars that includes the proposed members from the literature and our list of young cool stars possible members of young stellar kinematic groups (Montes et al. 2001; López-Santiago 2005).

2. The Hercules-Lyra Association

Based on the kinematics of young solar analogues in the solar neighbourhood, Gaidos (1998) confirmed the existence of a group of four stars (marked with † in Table 1) co-moving in the space towards the constellation of Hercules. Recently, Fuhrmann (2004) has extended the sample of late-type stars of this MG up to 15 nearby (d $<$ 25 pc) candidates, proposing the name Hercules-Lyra since several members show a radiant "*evenly matched*" with this constellation. Comparing the level of chromospheric activity of the stars of his sample with that of the members of the Ursa Major Association and looking for the existence of lithium in their spectrum, he notices that several candidates of Hercules-Lyra appear to be coeval of the Ursa Major stars, for which he gives an age of $\sim$ 200 Myr. On the contrary, other candidates seem to be older (e.g. HD 111395) or younger (HD 17925, HD 82443, and HD 113449), questioning the existence of Hercules-Lyra as an entity independent of the Local Association. However, he considers unlikely that the majority of his sample can originate from the Pleiades alone, or other clusters of the Local Association since "*they are poorer and more distant*" as pointed out by Jeffries (1995). Thus, he confirms "*the bulk*" of the sample — formed by the stars HD 166, HD 96064, HD 97334, HD 116956, HD 139777, HD 139813 and HD 141272 (see his Table 1) — to be an entity on its own.

Here we discuss the possible existence of the Hercules-Lyra MG as an independent association using kinematic (space motion), spectroscopic (lithium abundance) and photometric (isochrone fitting) criteria. A total of 12 possible members (stars marked with *a* in Table 1) have been added to the initial sample of Fuhrmann (2004) from our catalogue of *Late-type Stars Possible Members of Young Stellar Kinematic Groups* (Montes et al. 2001). The candidates have been chosen by their kinematics assuming a total dispersion of $\pm$ 6 km s^{-1} in U and V, respectively; that is, an average position of (U, V) = (-15.4, -23.4) km s^{-1} has been determined using the stars given by Fuhrmann (2004), and every star in our catalogue in a radius of $\pm$ 6 km s^{-1} has been selected. The value of the dispersion has been chosen equal to that of the $\sim$ 200 Myrs old Castor MG (Montes et al. 2001), coeval of the Hercules-Lyra Association. No restriction in the W component has been imposed in this first selection.

In Table 1 we summarize the results obtained by us. From the whole sample of 27 candidates, eight stars have been discarded as members by their space motion: HD 25457, located inside the B4 subgroup (see Fig. 1); HD 96064, HD 112733, HIP 67092, the binary system made up of the F-type star HD 139777 and HD 139813, and HD 207129 all them with a value in W higher than that of the rest of the candidates (see Fig. 2); and HD 113449, classified as member of the AB Dor MG by Zuckerman et al. (2004) (see Table 1 and § 3 for a more detailed discussion) and questioned by Fuhrmann (2004) because of its relatively high lithium abundance. We have also studied the lithium abundance — measured as the equivalent width of the lithium line λ6707.8 Å, EW(Li I) — in each one of the candidates. The values of EW(Li I) have been taken from López-Santiago (2005) and compared with those of the members of well-known stellar clusters (see Fig. 3). The results appear to be consistent with an age of 150 – 300 Myr for seven candidates. However, several stars (HD 1466, HD 17295, 1E 0318.5-19.4, and HD 82443) show an EW(Li I) comparable to that of the members of the Pleiades while other five (HD 37394, HD 97334B, HD 111395, HD 116956 and HD 141272) are fully depleted or have a value lower than the expected for a member of the Hercules-Lyra Association. For isochrone fitting, we have adopted pre-main sequence models from Siess et al. (2000). For $T_{\rm eff} < 4000$ K, the models systematically underestimate the age when comparing with clusters of known age such as the Pleiades and IC 2391 in a $M_{\rm v}$ vs. $V - I$ diagram (López-Santiago 2005) due to the transformation from flux to colour. Bearing this in mind, the corrected transformation adopted by López-Santiago et al. (2003) and López-Santiago et al. (2006) for stars cooler than 4000 K has been used in this work. The values of $V - I$ have been taken from the Hypparcos Catalogue (ESA 1997). The result of comparing the position of the stars with the isochrones in the colour-magnitude diagram (CMD) (Fig. 4) is again in agreement with and age of $\sim$ 150 - 300 Myrs. Nevertheless, no conclusions can be inferred from the CMD alone since isochrones of more than 80 Myr converge for $V - I \leq 1.8$ mag., and ages larger than 300 Myr could be adopted.

From the combination of the three criteria, the total sample of candidates is reduced to 10 stars with EW(Li I) and position in the CMD compatibles with an age of $\sim$ 200 Myrs, which could form the bulk of the Hercules-Lyra Association, and other 15 definitively non members or with a doubtful classification (Table 1). The members show a deviation ($\sigma_{\rm U}$, $\sigma_{\rm V}$) = (2.46, 1.61) km s^{-1} from the centre ((U, V) = (13.19, 20.64) km s^{-1}) lower than that of other coeval MGs such as Castor and Ursa Major (see Montes et al. 2001, and references therein). A similar dispersion ($\sigma_{\rm W} \approx 3.4$ km s^{-1}) is found in W, confirming the results in U and V. In the same way, the shape of the MG in the velocity field is in agreement with the theory of the MGs (Eggen 1965; Agekyan & Belozerova 1979; Skuljan et al. 1999; Asiain et al. 1999b; López-Santiago 2005). According to this theory, not-gravitational bounded stars formed in the same forming region and with low sigmas in U, V and W are dispersed during their rotation around the Galactic centre, inducing a particular shape in both the space and the velocity field since some of the stars fall behind while others go ahead. The Galactic potential maintains the group bounded during several hundreds of years, in spite of the initial velocity dispersion in the molecular cloud, in both the UV-plane and the W component.

3. The AB Dor MG and subgroup B4

Very recently, Zuckerman et al. (2004) have identified a large group of stars with the same space motion than the well-known young K-dwarf AB Dor (d = 15 pc), a quadruple system (Close et al. 2005; Guirado et al. 2006) made up of three late-type stars — AB Dor A (HD 36705), AB Dor Ba and AB Dor Bb — and a very low mass companion which has recently been object of discussion because of the discrepancy between its dynamical mass and that predicted by evolutionary models (Close et al. 2005). All the stars listed in Table 1 of Zuckerman et al. (2004) are situated inside the Local Association (see Fig. 1) near the boundaries of the young disk stellar population (Eggen 1984), and have at least one indicator of youth. Taking the intensity of the Hα emission line of these stars and the position in a $V-K_{\rm s}$ diagram of three M-type members of the MG into account, they estimate an age of 50 ± 10 Myr for the AB Dor MG. Very recently, Luhman et al. (2005) and Luhman & Potter (2006) have showed that the components of AB Dor should have an age of 75 – 150 Myr based on the comparison of both their position in the $M_{\rm K}$ vs. $V-K_{\rm s}$ diagram with respect to the Pleiades and IC 2391 clusters, and the EW(Li I) of AB Dor A with that of rapidly rotating K dwarfs in the Pleiades. Moreover, with an age of $\sim$ 100 Myr the discrepancy between observations and models for the very low-mass companion (AB Dor C) would disappear (eg. Close et al. 2005). Taking this into account, they propose an age range of 75 – 150 Myr for all the MG.

To the initial sample of Zuckerman et al. (2004), we have added 13 stars (marked with b in Table 1) from our catalogue of *Late-type Stars Possible Members of Young Stellar Kinematic Groups* (Montes et al. 2001). These stars have been included to both searches: a) for other members of the group and b) to show the existence of two subgroups of different ages more clearly. They have been chosen because of their kinematics, assuming a total dispersion of ± 4 km s^{-1} in U and V respectively, around the centre of the AB Dor MG defined by Zuckerman et al. (2004). We have imposed no restriction to the W component for this first selection. The whole sample contains a total of 50 stars.

We have compared the EW(Li I) of every star in the sample with that of known members of young open clusters (Fig. 3), as well as their position in the $V-I$ diagram with the isochrones of Siess et al. (2000) (Fig. 4). The results reveal the existence of two subgroups with stars showing different spectroscopic and photometric features, mixed in the velocity field (see Fig. 2). The members of the first subgroup, that includes AB Dor and PW And — a very active young K2-dwarf (López-Santiago et al. 2003) — show EW(Li I) similar to that of the high-rotators in the Pleiades (upper continuous line in Fig. 3) which are above the values found in the low-rotators of IC 2602 (lower dashed line in Fig. 3). Their position between the 30 and the 80 Myr isochrones in the $V-I$ diagram, together with the first result, is compatible with an age of 30 - 50 Myr. Moreover, the stars from the sample of Zuckerman et al. (2004) belonging to this subgroup are situated above the sequence of the Pleiades in the $M_{\rm K}$ vs. $V-K_{\rm s}$ diagram in Luhman et al. (2005). Here we have obtained a dispersion $\sigma \approx 2$ km s^{-1} in the W component, quite similar to the one observed in other young stellar associations such as Tucana or ϵ Cha (see Zuckerman & Song 2004, and references therein). For determining the dispersion we have rejected the stars BD+07 1919A and B (marked with * in Table 1) since their radial velocities — used for calculating the Galactic velocity components — have not been corrected for binarity since no orbital solution has been found in the literature. Nevertheless, although the membership of this system is not completely reliable taking the value of their W component into account, it has been included in the sample as possible member because of the position of the A component in the CMD, which suggests an age of $\sim$ 30 Myr. The stars in the second subgroup show features, in terms of EW(Li I) values and position in the CMD, comparable with that of the members of the Pleiades cluster: in Fig. 3 they are situated slightly above the lower envelope of the Pleiades, while in Fig. 4 they situate on the (ZAMS) 80 Myrs isochrone. Its members could be considered as part of subgroup B4, one of the four subgroups found by Asiain et al. (1999a) inside the Local Association in their study of the space motion of OB associations using Hypparcos astrometric data. The authors find a mean age of $\sim$ 150 Myr for this subgroup using information from the photometry. The higher dispersion found for the stars of this second subgroup in the velocity space (Fig. 2) is in agreement with the age estimated by us.

On the other hand, the results about AB Dor MG indicate that this quadruple system has indeed $\sim$ 50 Myr. The value of EW(Li I) for AB Dor A is somewhat above the upper envelope of the Pleiades but not so high as the one of IC 2602 (Fig. 3). On the other hand, its $(V - I)$ colour situates it between the 30 and 80 Myr isochrones (Fig. 4). The same result is clearly visible in Fig. 1 of Luhman et al. (2005), where AB Dor is situated above the lower sequence of the Pleiades in the $M_{\rm K}$ vs. $V - K_{\rm s}$ diagram. With an age of 50 Myr, the discrepancy between observations and models for the AB Dor very low-mass companion (AB Dor C) shown in Close et al. (2005) continuous, although it can be solved if the very low-mass companion were indeed an unresolved binary system (Marois et al. 2005).

4. Discussion and conclusions

In Table 1 we list the stars belonging to the nearest moving groups: Hercules-Lyra Association and AB Dor MG, and those being part of the Local Association B4 subgroup. For the Hercules-Lyra Association, a division between certain members and candidates with doubtful classification or non members has been made. In the three groups, new candidates from our catalogue of *Late-type Stars Possible Members of Young Stellar Kinematic Groups* (Montes et al. 2001) have been selected because of their kinematics (see § 2 and § 3). A total of 75 stars including the known members and the new candidates selected by us have been analysed. Kinematic, spectroscopic and photometric criteria have been utilized to discriminate non members from the rest of candidates of the Hercules-Lyra Association, and to distinguish between the members of the AB Dor MG and those of the B4 subgroup.

In the velocity space, Hercules-Lyra is clearly distinguishable from the rest of the sample (see Figs. 1 and 2). The dispersion in U, V, and W is comparable with that of other coeval MGs such as Castor and Ursa Major (e.g. Montes et al. 2001), and compatible with its age (see § 2). On the other hand, AB Dor MG and B4 subgroup are mixed up and age-dating criteria are necessary to distinguish between the members of both groups. Nevertheless, the dispersion in W for AB Dor MG is quite smaller than the one of B4 subgroup. Age-dating criteria are also necessary to discriminate non members of Hercules-Lyra from the certain ones. The results of applying them are summarized in Table 1: the Hercules-Lyra Association is formed by 10 certain members situated at a mean distance of $\sim$ 20 pc and show values of EW(Li I) (Fig. 3) and a position in the $V - I$ CMD (Fig. 4) compatible with an age of 150 – 300 Myr; the members of AB Dor MG are situated at a mean distance of $\sim$ 30 pc and show lithium abundances typical of stars with 30 – 50 Myr (Fig. 3), which is in agreement with their position in the $M_{\rm V}$ vs. $V - I$ diagram (Fig. 4); finally, a set of stars with EW(Li I) and positions in the CMD compatible with an age of 80 – 120 Myr are mixed with Hercules-Lyra and AB Dor MG, and have been classified as other members of the Local Association B4 subgroup (see § 3). Note that the age estimated using the position of the members of Hercules-Lyra in the CMD is a lower limit since the 80 Myrs isochrone is overlapped with the ZAMS for spectral types earlier than about K5. On the other hand, the age estimated using the equivalent width of the Li I line λ6707.8 Å is more robust since the 50% of the stars classified as members have measurements of the EW(Li I): the Li indicator is useful only for spectral type later than G0, but only three of the 25 candidates of the initial sample are F stars.

Stars in these three subgroups form an excellent list of young cool stars for studying how planets are formed, since they cover a range of ages between 30 and 200 Myr, characteristic of the period during which the Solar System was formed, and they are close enough to be accessible to adaptive optics. In addition, they can be taken as targets for direct imaging detection of sub-stellar companions — brown dwarfs and extra-solar giant planets — (Neuhäuser et al. 2000; Martín 2003; Masciadri et al. 2005; Lowrance et al. 2005) and for cold dust, debris disks (Gaidos & Koresko 2004; Metchev et al. 2004; Liu et al. 2004; Chen et al. 2005).

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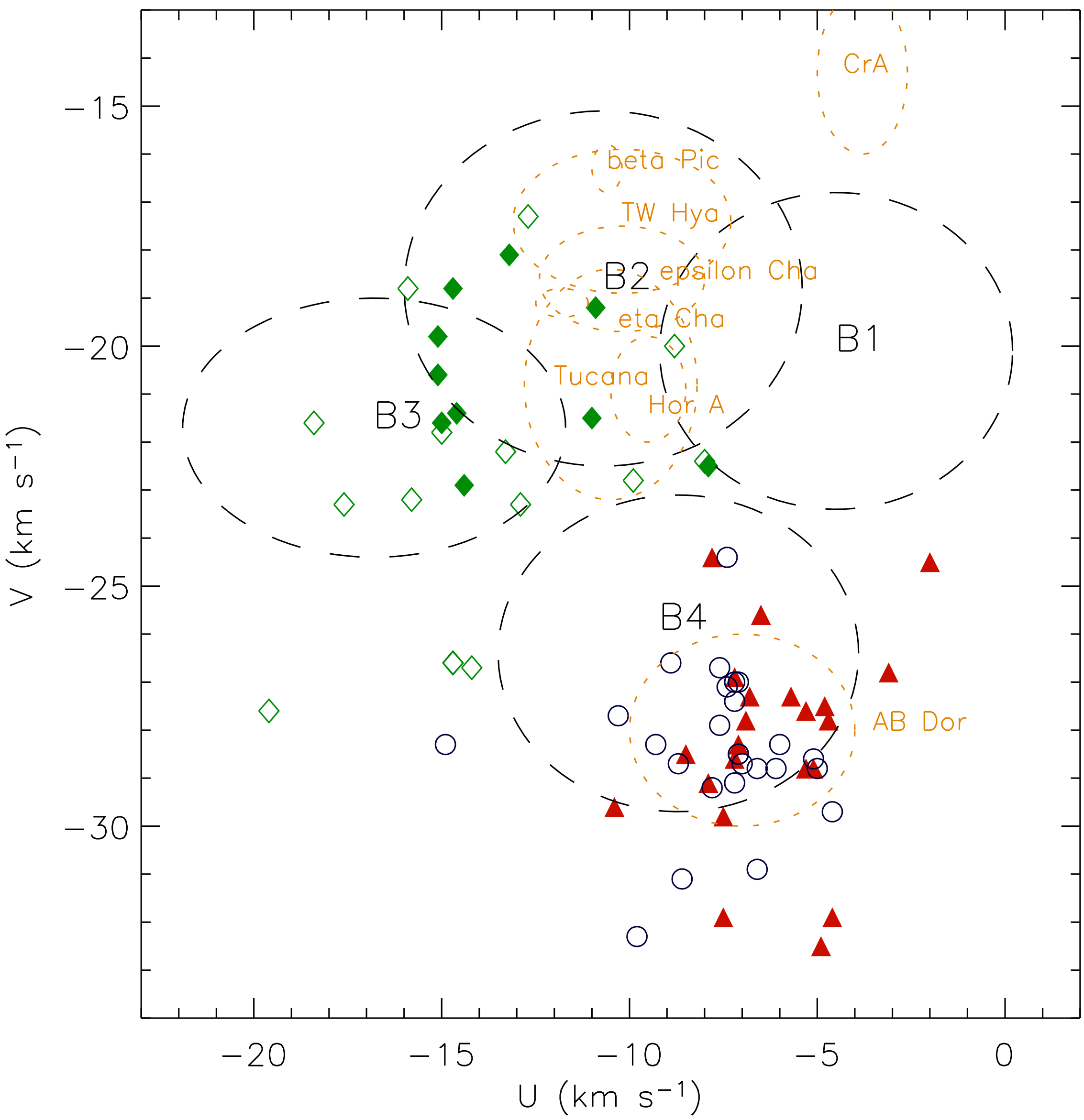

Fig. 1.— Position in the UV-plane of the stars listed in Table 1 and young stellar associations. Symbols are used as follows: filled diamonds for Hercules-Lyra members; open diamonds for non members of Hercules-Lyra or stars with doubtful classification; triangles for AB Dor MG; and circles for other Local Association members (members of the subgroup B4).

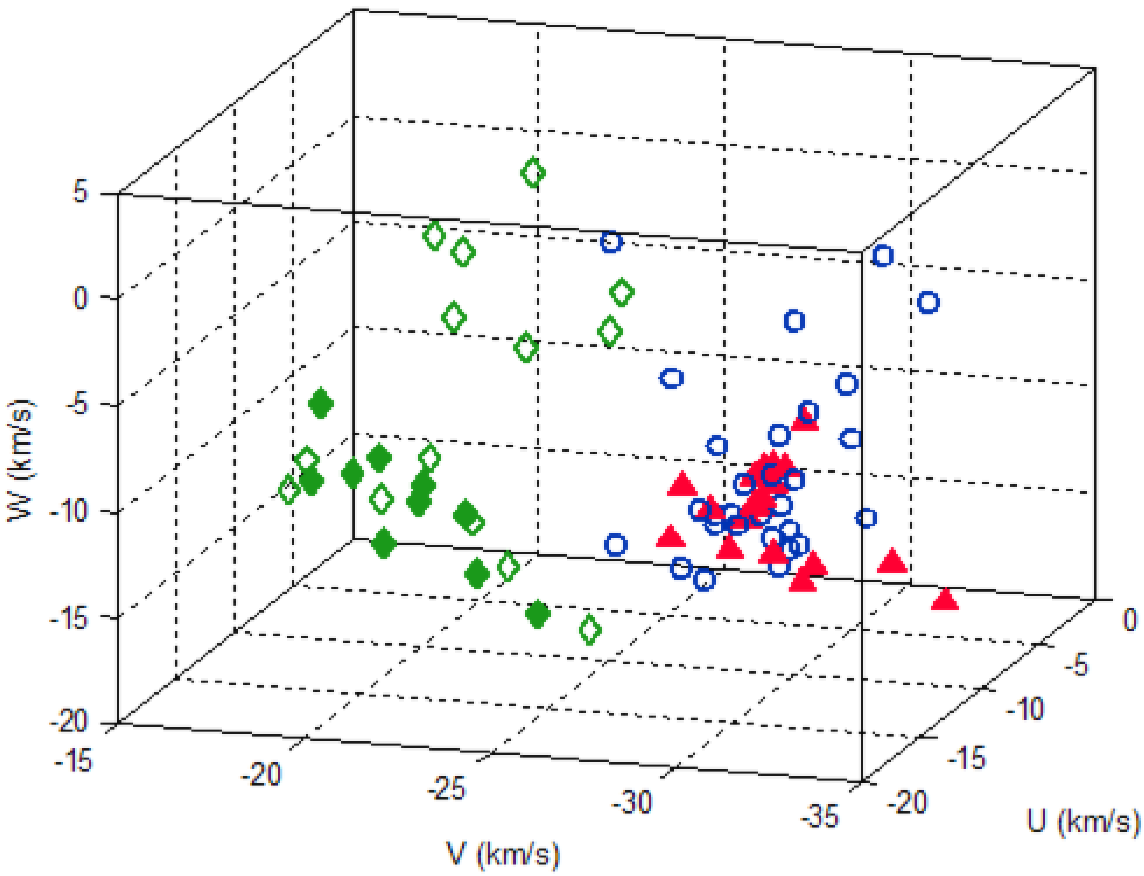

Fig. 2.— Position in the 3D velocity space of the stars in Fig. 1. Candidates of Hercules-Lyra with values of W different from that of the rest of the group are clearly distinguishable.

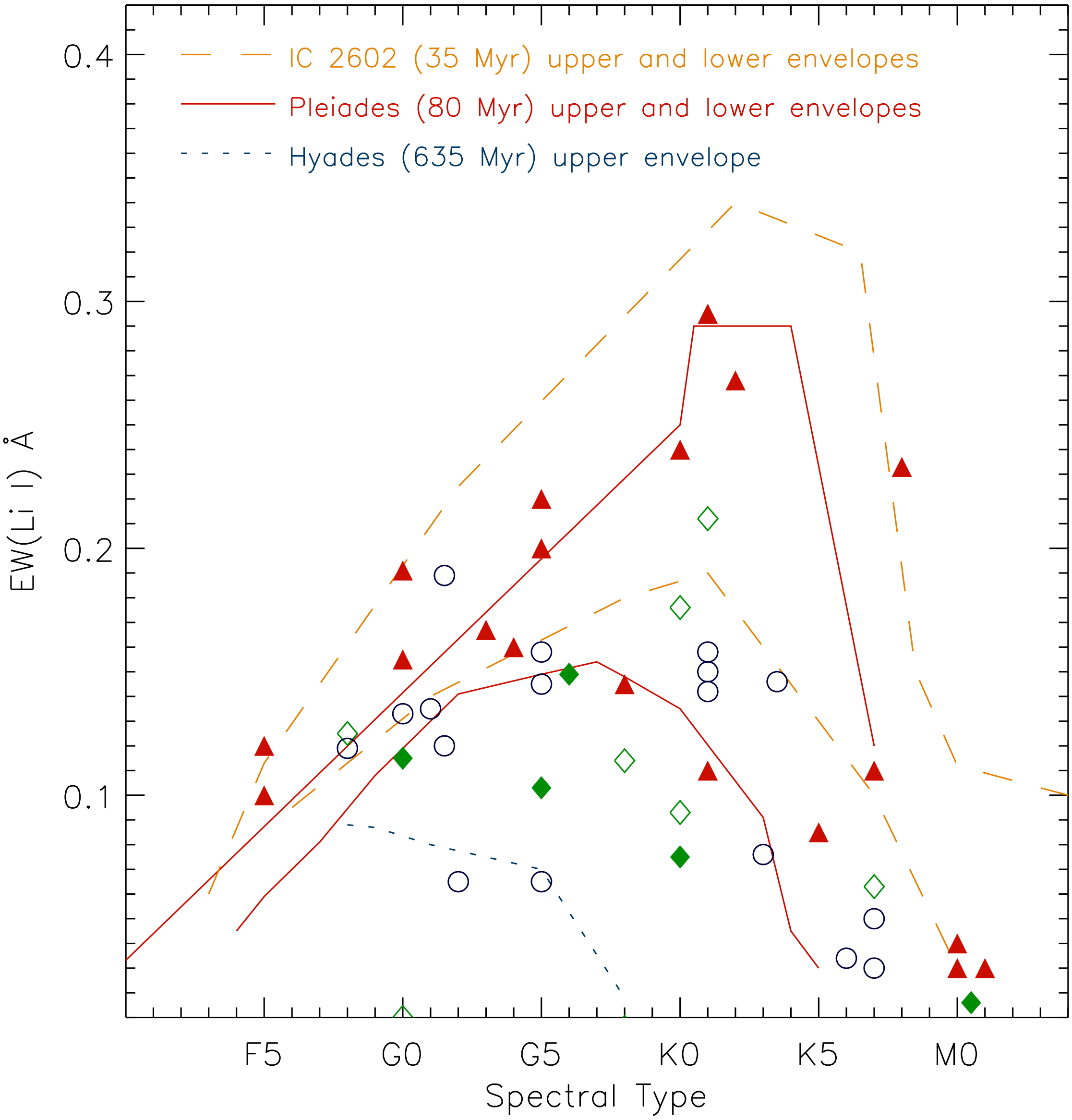

Fig. 3.— Equivalent width of Li I 6707.8 Å as a function of spectral type for the stars in Table 1, compared with the envelopes of well-known stellar clusters. Symbols as in Fig. 1.

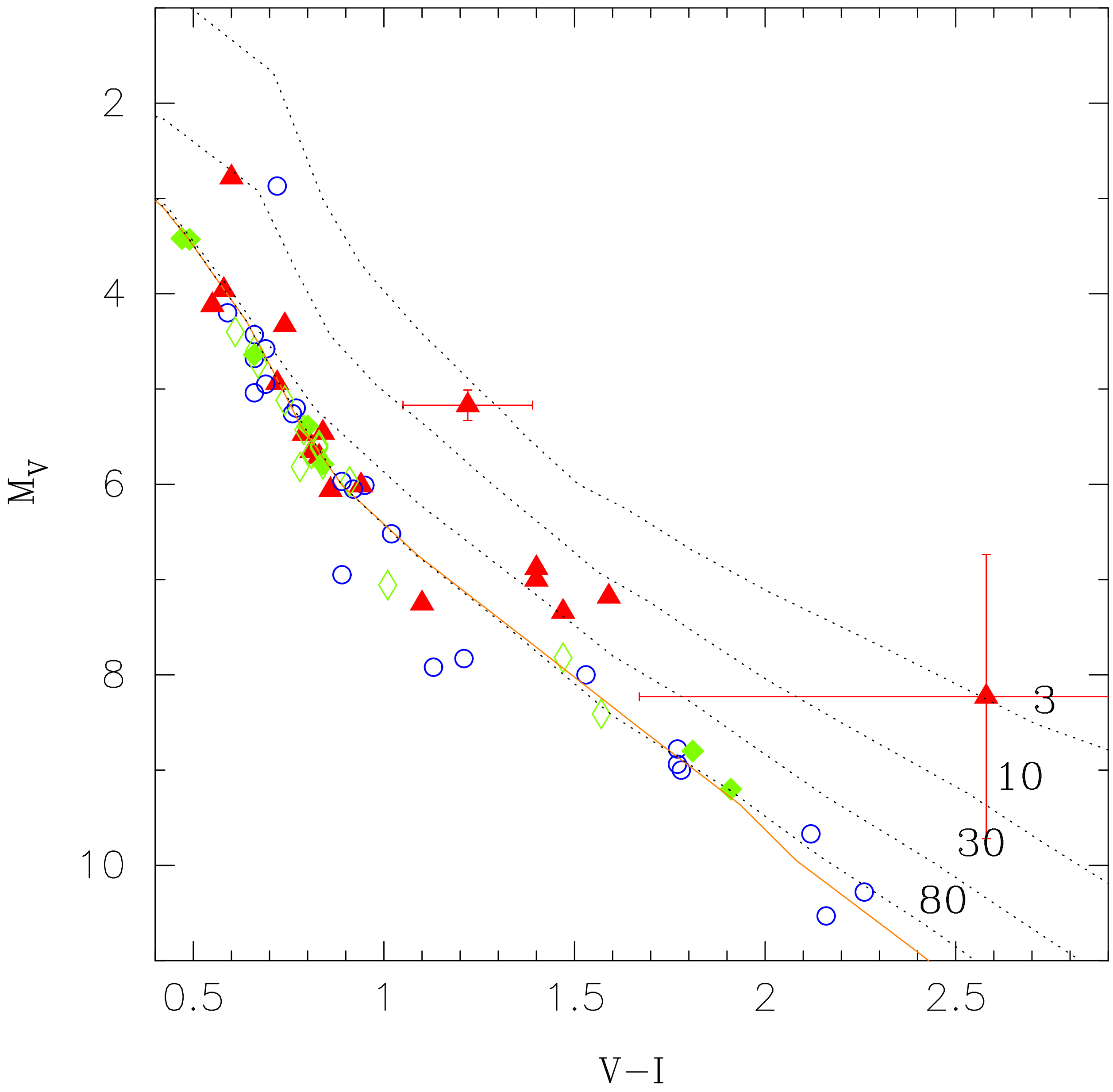

Fig. 4.— M_V vs. $V - I$ for the stars of the Hercules-Lyra Association, AB Dor MG and Local Association subgroup B4. Symbols as in Fig. 1. The member of AB Dor MG situated under the ZAMS is LO Peg, which photometry is probably affected by dark spot-type features. Isochrones of 3, 10, 30 and 80 Myr from Siess et al. (2000) are plotted as well as ZAMS (continuous line).

Table 1. Stars members of near MGs.

HD/ other name	R.A. (J2000.0)	Dec (J2000.0)	SpT	D (pc)	$V_{\rm hel} \pm \sigma_{V_{\rm hel}}$ (km s^{-1})	U (km s^{-1})	V (km s^{-1})	W (km s^{-1})	$B-V$ (mag)	$V-I$ (mag)	EW(Li I)[c] (mÅ)
Hercules-Lyra Association: members											
166[†]	00 06 36.78	29 01 17.41	K0 V	13.7	-6.9 0.2	-15.0	-21.6	-10.0	0.75	0.80	75
10008	01 37 35.47	-06 45 37.52	G5 V	23.6	11.6 0.6	-13.2	-18.1	-11.1	0.80	0.84	103
233153[a]	05 41 30.73	53 29 23.28	M0.5	12.5	1.9 1.0	-14.4	-22.9	-14.3	1.40	1.91	16
HIP 37288[a]	07 39 23.04	02 11 01.18	K7	14.9	18.5 5.0	-11.0	-21.5	-13.1	1.38	1.81	-
70573[a]	08 22 49.95	01 51 33.55	G6 V	45.7	19.5 1.0	-14.7	-18.8	-6.7	0.59	-	149
HIP 53020[a]	10 50 52.06	06 48 29.34	M4	12.9	-2.0 0.1	-7.9	-22.5	-19.1	1.68	2.81	-
GJ 560B[a]	14 42 30.42	-64 58 30.50	K5 V	16.4	7.0 4.0	-10.9	-19.2	-10.8	1.15	-	-
139664[a]	15 41 11.38	-44 39 40.34	F5 V	17.5	-5.4 2.0	-15.1	-19.8	-9.7	0.41	0.47	-
206860[†]	21 44 31.33	14 46 18.98	G0 V	18.4	-16.9 2.0	-14.6	-21.4	-11.0	0.58	0.66	115
213845[a]	22 34 41.64	-20 42 29.56	F7 V	22.7	-1.9 0.9	-15.1	-20.6	-12.9	0.45	0.49	-
Hercules-Lyra Association: non members or doubtful classification											
1466[a]	00 18 26.12	-63 28 38.97	F8 V	40.9	0.54 2.0	-8.8	-20.0	-1.2	0.54	0.61	125
17925	02 52 32.13	-12 46 10.97	K1 V	10.4	17.5 0.1	-15.0	-21.8	-8.7	0.88	0.91	212
1E 0318.5-19.4[a]	03 20 49.50	-19 16 10.00	K7 V	27.0	20.8 1.0	-12.7	-17.3	-11.8	-	-	63
37394	05 41 20.34	53 28 51.81	K1 V	12.2	0.3 0.2	-12.9	-23.3	-14.5	0.84	0.88	2
82443[†]	09 32 43.76	26 59 18.71	K0 V	17.7	8.1 0.1	-9.9	-22.8	-5.6	0.78	0.78	176
96064	11 04 41.47	-04 13 15.91	G8 V	24.4	18.3 0.8	-14.2	-26.7	-0.6	0.77	0.81	114
97334B[†]	11 12 32.35	35 48 50.69	G0 V	21.7	-3.6 1.0	-15.8	-23.2	-11.2	0.60	0.67	10
111395	12 48 47.05	24 50 24.81	G5 V	17.7	-8.6 1.0	-18.4	-21.6	-9.2	0.70	0.74	0
112733[a]	12 58 31.97	38 16 43.55	K0 V	22.5	-3.4 0.1	-17.6	-23.3	-0.8	0.74	0.79	93
116956	13 25 45.53	56 58 13.77	G9 V	21.8	-13.1 0.3	-15.9	-18.8	-8.8	0.80	0.83	0
HIP 67092[a]	13 45 05.33	-04 37 13.25	K5	25.7	4.6 0.5	-8.0	-22.4	1.8	1.49	1.57	-
139777	15 29 11.20	80 26 55.00	F0 V	22.1	-15.8 0.5	-14.7	-26.6	-2.2	-	-	-
139813[‡]	15 29 23.60	80 27 01.00	G5 V	21.7	-15.8 0.5	-14.7	-26.6	-2.2	0.80	0.83	-
141272	15 48 09.46	01 34 18.26	G8 V	21.4	-27.2 0.3	-19.6	-27.6	-14.0	0.80	0.84	6
207129[a]	21 48 15.75	-47 18 13.01	G0 V	15.6	-6.5 1.3	-13.3	-22.2	0.3	0.60	0.66	-
AB Doradus Moving Group											
1405	00 18 20.90	30 57 22.03	K2 V	30.6	-11.2 0.1	-5.3	-28.8	-17.8	1.04	-	268
HIP 6276	01 20 32.27	-11 28 03.74	(G8)	35.1	9.9 1.0	-4.7	-27.8	-13.6	0.79	0.83	145
13482	02 12 15.41	23 57 29.54	K1 + K5	32.3	-1.3 0.3	-7.1	-28.3	-11.8	1.13	1.22	110
17332	02 47 27.42	19 22 18.56	G0 + G5	32.6	4.1 1.3	-8.5	-28.5	-12.9	0.68	0.74	155
19668[b]	03 09 42.29	-09 34 46.59	G0 V	40.2	14.6 0.7	-5.1	-28.8	-10.3	0.81	0.84	191
21845	03 33 13.49	46 15 26.54	(G5)	33.8	-6.0 0.3	-6.5	-25.6	-15.7	0.70	0.81	200
HIP 16563B	03 33 14.00	46 15 19.00	M0	33.8	-6.1 1.1	-6.5	-25.6	-15.7	-	-	30
25457	04 02 36.74	-00 16 08.12	F5 V	19.2	17.0 0.3	-7.2	-28.6	-11.6	0.52	0.58	100
25953	04 06 41.53	01 41 02.08	F5	55.3	17.6 0.6	-6.9	-27.8	-14.3	0.48	0.55	120
36705	05 28 44.83	-65 26 54.85	K1	14.9	33.0 3.0	-7.5	-29.8	-16.0	0.83	0.94	295
37572	05 36 56.85	-47 57 52.87	K0 V	23.9	31.0 1.0	-7.2	-26.9	-13.9	0.84	0.86	240
BD+20 1790[b]	07 23 44.00	20 25 06.00	K5 V	31.6	19.9 0.1	-4.9	-32.5	-18.5	1.07	-	85
89744[b]	10 22 10.56	41 13 46.31	F7 V	39.0	-6.5 1.3	-10.4	-29.6	-14.2	0.53	0.60	-
139751	15 40 28.39	-18 41 46.19	(K7)	42.6	-8.9 0.4	-7.5	-31.9	-15.6	1.24	1.40	110
160934	17 38 39.63	61 14 16.12	M0	24.0	-35.6 0.7	-5.3	-27.6	-14.5	1.30	2.58	40
HIP 106231	21 31 01.71	23 20 07.37	K8	25.1		-5.7	-27.3	-15.0	1.03	1.10	233
217343	23 00 19.29	-26 09 13.50	G3 V	32.1	6.3 1.5	-3.1	-26.8	-14.1	0.65	0.72	167
217379	23 00 27.96	-26 18 42.80	(K8)	30.0	8.4 1.5	-2.0	-24.5	-15.4	1.34	1.59	0
HIP 114066	23 06 04.84	63 55 34.36	(M1)	24.9	-23.7 0.8	-6.8	-27.3	-15.9	1.21	1.77	30
218860	23 11 52.05	-45 08 10.63	(G5)	50.5	10.3 1.2	-7.9	-29.1	-11.3	0.71	0.76	220
HIP 115162	23 19 39.56	42 15 09.82	(G4)	49.4	-19.7 0.2	-4.8	-27.5	-14.3	0.75	0.79	160
Members of subgroup B4											
4277	00 45 50.89	54 58 40.17	F8 V + K3	48.5	-15.4 0.5	-8.9	-26.6	-15.8	0.52	0.59	119
6569	01 06 26.15	-14 17 47.11	K1 V	50.0	6.0 1.2	-8.6	-31.1	-9.3	0.91	0.95	150
HIP 12635	02 42 20.97	38 37 21.20	(K3.5)	49.6	-4.1 0.3	-8.7	-28.7	-13.1	0.88	0.89	146
16760	02 42 21.31	38 37 07.20	G5	49.6	-3.3 0.2	-9.3	-28.3	-13.4	0.71	0.77	158
HIP 14807	03 11 12.34	22 25 22.77	(K6)	49.8	4.1 0.3	-5.1	-28.6	-16.1	-	-	34
HIP 14809	03 11 13.84	22 24 57.11	G5	49.8	5.2 0.2	-6.0	-28.3	-16.7	0.71	0.66	145
HIP 17695	03 47 23.35	-01 58 19.93	M3	16.3	16.0 1.7	-7.4	-27.1	-10.6	1.51	2.16	-
25457	04 02 36.74	00 16 08.13	F6 V	19.2	15.3 0.4	-6.0	-28.3	-10.5	0.52	0.58	118
35650	05 24 30.17	-38 58 10.76	(K7)	17.7	30.9 1.0	-7.1	-27.0	-14.5	1.25	1.21	0
HIP 26369	05 36 55.07	-47 57 47.99	(K7)	23.9	31.1 1.1	-7.2	-27.0	-13.9	1.17	1.13	30
45270	06 22 30.94	-60 13 07.15	G1 V	23.5	30.0 0.7	-7.6	-26.7	-13.6	0.61	0.66	135
GSC 8894-426	06 25 55.39	-60 03 29.20	M2	(22)	31.8 2.0	-10.3	-27.7	-15.6	-	-	0
48189	06 38 00.36	-61 32 00.19	G1.5 V	21.7	33.4 1.0	-7.1	-28.5	-15.0	0.62	0.69	120
HIP 31878	06 39 50.02	-61 28 41.52	(K7)	21.9	30.5 0.7	-7.2	-27.4	-13.9	1.26	1.53	50
HIP 36349[b]	07 28 51.37	-30 14 48.54	(M3)	15.6	26.6 1.0	-7.4	-24.4	-15.7	1.44	1.78	0
BD+07 1919A[b,*]	08 07 09.09	07 23 00.13	K5 V	40.2	19.1 0.1	-4.6	-31.9	-4.5	1.24	1.40	-

Table 1—Continued

HD/ other name	R.A. (J2000.0)	Dec (J2000.0)	SpT	D (pc)	$V_{\rm hel} \pm \sigma_{\rm V_{hel}}$ (km s^{-1})	U (km s^{-1})	V (km s^{-1})	W (km s^{-1})	$B-V$ (mag)	$V-I$ (mag)	EW(Li I)[c] (mÅ)
BD+07 1919B[b,*]	08 07 08.78	07 22 58.39	K7 V	40.2	18.7 0.1	-7.8	-24.4	-1.2	1.15	-	-
HIP 51317[b]	10 28 55.55	00 50 27.58	M2	26.1	8.3 0.5	-7.8	-29.2	-15.1	1.50	2.26	-
92945[b]	10 43 28.27	-29 03 51.43	K1 V	21.6	23.2 0.6	-14.9	-28.3	-4.0	0.87	0.92	158
GJ 466[b]	12 25 58.58	08 03 44.03	M0 V	39.9	10.0 0.1	-9.8	-32.3	0.1	1.46	1.47	-
113449	13 03 49.66	-05 09 42.52	(K1)	22.1	2.0 0.5	-5.0	-28.8	-9.8	0.85	0.89	142
129333[b]	14 39 00.22	64 17 29.84	G1.5 V	33.9	-20.6 0.3	-7.2	-29.1	-4.6	0.63	0.69	189
HIP 81084	16 33 41.61	-09 33 11.95	M0.5	31.9	-15.0 0.4	-7.0	-28.7	-13.4	1.44	1.77	0
152555	16 54 08.14	-04 20 24.66	G0	47.6	-17.1 0.5	-6.1	-28.8	-12.6	0.59	0.66	133
199065A[b]	20 57 22.44	-59 04 33.46	G2 V	50.9	11.0 2.0	-7.1	-28.5	-12.0	0.66	0.72	65
199065B[b]	20 57 21.86	-59 04 34.23	G5 V	50.9	11.0 2.0	-4.6	-29.7	-8.6	-	-	65
GJ 856A	22 23 29.09	32 27 33.47	M0 V	16.1	-24.0 3.0	-6.6	-30.9	-13.9	1.57	2.12	-
GJ 856B[b]	22 23 30.00	32 27 00.00	M1 V	16.1	-21.7 1.0	-6.6	-28.8	-14.7	1.49	-	-
224228	23 56 10.67	-39 03 08.40	K3 V	22.1	12.1 0.5	-7.6	-27.9	-12.3	0.97	1.02	76

Note. — [†] Co-moving group (Gaidos 1998). [‡] $V_{\rm r}$ and (U, V, W) from the A component (HD 139777). [a] New candidates of Hercules-Lyra Association. [b] Stars added to the initial sample of Zuckerman et al. (2004). [c] EW(Li I) from López-Santiago (2005) and López-Santiago et al. (2006) for the stars in the Hercules-Lyra Association, for the stars marked with [b] in AB Dor MG and B4 subgroup and for HD 1405 (PW And) and HIP 106231 (LO Peg). For the rest of stars we have adopted the values of Zuckerman et al. (2004). [*] Doubtful members of the AB Dor MG.