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Proper motions of pre-main sequence stars in southern star-forming regions⋆,⋆⋆

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Abstract. We present proper motion measurements of pre-main sequence (PMS) stars associated with major star-forming regions of the southern hemisphere (Chamaeleon, Lupus, Upper Scorpius - Ophiuchus, Corona Australis), situated in the galactic longitude range $l = 290°$ to $l = 360°$. A list of PMS stars as complete as possible was established based on the Herbig and Bell catalogue and many new catalogues like the PDS survey, the catalogue of Herbig Ae/Be stars by Thé et al. (1994), X-rays surveys, etc. The measurements made use of public material (mainly $\mathrm{AC2000}$ and $\mathrm{USNO-A2.0}$ catalogues) as well as scans of SERC–J Schmidt plates with the MAMA measuring machine (Paris) and Valinhos CCD meridian circle observations (Brazil). We derived proper motions for 213 stars, with an accuracy of 5 to 10 mas/yr depending mainly on the difference of epochs between the position sources. The main characteristics of the sample are discussed. We show that systematic motions of groups of stars exist, which are not explained by the reflex solar motion.

Key words: astrometry – stars: kinematics – stars: pre-main sequence – Galaxy: open clusters and associations: general

1. Introduction

Analysis of the motion of pre-main sequence (PMS) stars and of related groups of young stars provide essential tests of star formation models. Different space velocities and velocity gradients of the stellar associations can be derived from the major star formation scenarios, like sequential star formation, star formation by high-velocity clouds, Gould's Belt models, etc. Proper motion measurements of the members of these associations provide one way to discriminate among these predictions. The PMS stars are supposed to be sufficiently young to be very close to their birthplaces and to have velocities still very similar to the initial ones, so that one can get clear constraints on the birth mechanism.

In this work, we investigated the PMS stars of an extended region of aligned molecular clouds and OB associations that includes the Chamaeleon, Lupus, Upper Scorpius - Ophiuchus and Corona Australis regions. This selected area is specially interesting because the associations are close enough to the Sun (100-150 pc), so that a refined kinematical study can be made.

The HIPPARCOS mission (ESA 1997) provided accurate measurements of positions, parallaxes and proper motions, for OB stars brighter than V=10 mag, allowing to study the kinematics of the same regions (de Zeeuw et al. 1999). Proper motions of PMS stars associated with these star-forming complexes, based on HIPPARCOS data, were recently obtained (Frink et al. 1998, Neuhäuser & Brandner 1998, Wichmann et al. 1998, Bertout et al. 1999), providing a first comparison of space velocities of different groups of stars. However, since most PMS stars are fainter than the limiting magnitude of HIPPARCOS, the total number of measured PMS stars is still small.

In this work, we present proper motion determination for 213 PMS stars as faint as V∼16 mag lying in the galactic longitude range $l = 290°$ to $l = 360°$.

In the following sections, we present the method used to derive proper motions based on different combinations of first and second epoch measurements, we discuss the quality of our results and present a first analysis of this large sample of proper motions obtained for the PMS stars.

2. Data

For this work, we collected a list of well known and candidate T Tauri and Herbig Ae/Be (hereinafter HAeBe) stars as exhaustive as possible for the studied regions in the literature (Alcalá 1994; Alcalá et al. 1995; Bertout et al. 1999; Brandner et al. 1996; Casanova et al. 1995; Feigelson & Kriss 1989; Feigelson et al. 1993; Gauvin & Strom 1992; Gregorio-Hetem et al. 1992; Hartigan 1993; Herbig & Bell 1988; Krautter et al. 1997; Malfait et al. 1998; Marraco & Rydgren 1981; Martín et al. 1998, Preibisch et al. 1998; Schwartz 1977; Thé et al. 1994; Torres et al. 1995; van den Ancker et al. 1997; van den Ancker et al. 1998; Walter et al. 1997; Wichmann et al. 1997; Wilking et al. 1992). With these data, we constructed an input catalogue

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⋆ Based on observations made at VALINHOS CCD Meridian Circle. Based on measurements made with MAMA automatic measuring machine

⋆⋆ Table 4 is only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html containing about 680 stars with their approximate positions and magnitudes. In this set of stars, we could identify and measure proper motions of 213 PMS stars as faint as V∼16 mag. We also present, separately, measurements for 29 stars that were previously considered as PMS, but subsequently classified differently by Covino et al. (1997) and Wichmann et al. (1999), who did not confirm their PMS nature. These authors obtained high resolution spectra, and compared the Li line equivalent widths to those of the Pleiades stars, considered by them as a frontier between PMS and non-PMS stars.

The proper motions were obtained from the comparison between several sources including current epoch CCD meridian observations performed at Valinhos Observatory (Viateau et al. 1999) and old SERC–J Schmidt plates measured with MAMA automatic measuring machine (Guibert et al. 1984). These data were combined with published positions extracted from the following catalogues: AC2000 (Urban et al. 1998a), USNO–A2.0 (Monet 1998), HIPPARCOS and Tycho (ESA 1997). One star had its proper motion obtained from a combination of CCD meridian observation and a Digitized Sky Survey[1] (DSS) image.

2.1. CCD meridian observations

The most recent observations used here were obtained with the Valinhos CCD meridian circle (Dominici et al. 1999) in 1998 and 1999. This instrument is installed in Valinhos at the Abrahão de Moraes Observatory (Latitude $-23°00'06''$, Longitude $+46°58'03''$) which belongs to the São Paulo University – Brazil.

The CCD detector has 512x512 square pixels of 19μm (1 pixel = 1.5″ square) and works in drift scan mode. In this mode, the telescope is fixed and the electric charges are moved along the columns of the CCD with the same velocity as the transit, which depends on the declination. For $\delta = 0°$ the integration time interval is 51 seconds. The observed field has therefore an arbitrary length in right ascension (typically one hour) and is 13′ wide in declination. The magnitude limit is about V=16.0 mag. The astrometric and photometric observational precisions depend on the magnitude and in the best interval ($9.0 <$V< 14.0) are, respectively, approximately $0.050''$ in both coordinates and 0.05 magnitudes. At the detection limit, positional measurements are less accurate and the mean square error may reach $0.100''$. Observations are carried out with a filter CG495+BG38 (bandpass from 5200 to 6800 Å), which is wider than Johnson filter. Notwithstanding, the resulting magnitudes are close to the visual standard magnitude system (Dominici et al. 1999). The final positions are obtained by a global reduction procedure (Benevides-Soares & Teixeira 1992; Teixeira et al. 1992) using the ACT (Urban et al. 1998b) as the reference catalogue. The data treatment is made by means of a software package developed and maintained by J.F. Le Campion (Bordeaux Observatory).

[1] The Digitized Sky Survey was produced at the Space Telescope Science Institute under US Government grant NAG W–2166.

Table 1. Valinhos CCD meridian observations strips (1998-1999)

α_{min} [h m]	α_{max} [h m]	δ [° ′]	Nobs.
15 38	16 25	−39 06	9
15 39	16 18	−38 56	6
16 11	16 51	−24 04	3
15 50	17 20	−24 12	6
10 39	11 27	−76 39	3
10 39	11 27	−76 25	3
12 43	13 19	−76 39	8

Table 2. Schmidt SERC–J plates measured

Number	Epoch	α [J2000]	δ [J2000]
038	1976.255	11 00 53	−75 17 43
039	1976.252	12 08 42	−75 16 42
040	1980.531	13 15 53	−75 15 50
387	1975.268	15 15 09	−35 11 07
388	1974.474	15 39 15	−35 11 51
329	1978.331	15 39 19	−40 09 43
330	1975.422	16 05 22	−40 08 07
517	1978.578	16 33 03	−25 06 17
519	1976.411	17 16 57	−25 02 46
521	1974.558	18 01 04	−25 00 02
396	1974.460	18 51 23	−34 58 16
337	1974.561	19 07 27	−39 55 16
397	1977.528	19 15 16	−34 54 52

In this work, we observed seven strips in the Chamaeleon, Lupus and Upper Scorpius - Ophiuchus regions containing many PMS stars identified in the literature. The length in R.A. of the fields presented in Table 1 was defined to ensure a minimum of 20 reference stars in each strip, necessary for an accurate astrometric reduction, and their coordinates were defined to have the largest number of PMS stars. In this table, we also present the central declination and the number of observations of each strip.

Each star considered here was observed at least three times.

2.2. Schmidt plate material

Thirteen SERC–J $6.5° \times 6.5°$ Schmidt plates have been digitized at the MAMA measuring machine (Guibert et al. 1984), which provides at the present time the most accurate measurements (repeatability of $0.4\mu m$). For each plate, a catalogue of (x,y), flux and area has been produced for about 1 000 000 objects detected.

Each plate was then astrometrically reduced from (x, y) to (α, δ) with reference stars from the ACT catalogue (Urban et al. 1998b). The mean residual of these reductions was about 0.25″ in both coordinates. We give in Table 2 the list of the SERC–J plates used in this work to derive proper motions for the known PMS stars. In this table are shown the numbers of the plates, their observation epochs and their central coordinates.

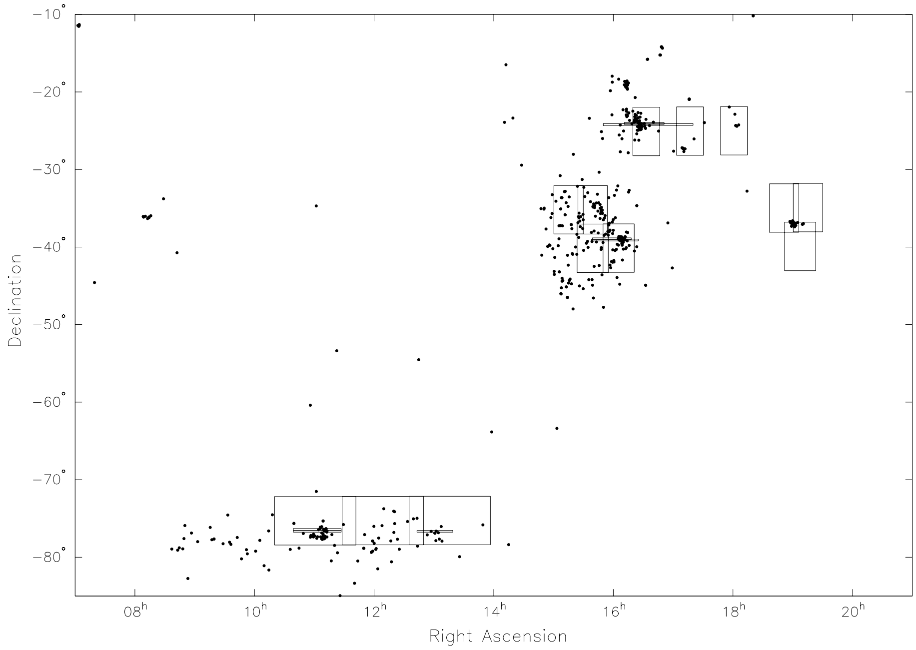

Fig. 1. Survey area. Rectangles = Schmidt plates, Strips = transit circle frames

The Schmidt plates and Valinhos strips distribution in the studied region of the sky are given in Fig. 1, along with the searched PMS stars from our input catalogue.

2.3. Other data

For a good determination of proper motions, observations from well separate epochs are needed. Unfortunately, the catalogue with the oldest mean epoch (AC2000, Urban et al. 1998a), gives positions for stars essentially brighter than V=12 mag. We included these positions in our calculations, when available. For fainter stars (V>12), proper motions have been determined over a shorter time interval and so with a degraded precision. One of these stars, Sz 108, although observed at the Valinhos observatory, could not be found in the other catalogues. Its position was determined from the DSS (plate identification: 02F8, region: S330), using the IRAF software packages.

We also included many other available astrometric data as from USNO−A2.0 Catalogue (Monet 1998), Tycho and HIPPARCOS positions (ESA 1997) to better constrain the proper motion determination and to provide a larger number of proper motions.

3. Proper motion determination

From our initial sample of about 680 stars, we could measure accurate proper motions for 242 of them. These stars have magnitudes within the range 6<V<16. Proper motions have been determined only when the time basis was longer than 20 years. In most cases this time basis was longer than 50 years, reaching in some individual cases more than 100 years. About 30 proper motions were determined with a time basis shorter than 50 years. The mean time basis was 80 years.

For the remaining stars, the main reasons of their absence in our final catalogue are that either their magnitudes laid outside the magnitude range covered by our data sources or the request of a time basis longer than 20 years was not fulfilled.

The proper motion calculation was performed in the usual way, via a weighted least squares method (Eqs. 1 to 5).

$$t_0 = \frac{\sum p_i t_i}{\sum p_i} \tag{1}$$

$$\alpha_0 = \frac{\sum \alpha_i p_i}{\sum p_i} \tag{2}$$

$$\mu_\alpha = \frac{\sum p_i \alpha_i (t_i - t_0)}{\sum p_i (t_i - t_0)^2} \tag{3}$$

$$\sigma^2_{\alpha_0} = \frac{1}{\sum p_i} \tag{4}$$

$$\sigma^2_{\mu_\alpha} = \frac{1}{\sum p_i (t_i - t_0)^2} \tag{5}$$

where $p_i = \frac{1}{\sigma_i^2}$, and t_i is the epoch of the position for a given star i. The same calculation holds for the declination.

We have assumed the following precisions for the various data : $\sigma = 0.25''$ for AC2000, USNO–A2.0 and SERC−J positions, $\sigma = 0.001''$ for HIPPARCOS, $\sigma = 0.030''$ for Tycho and $\sigma = 0.050''$ for Valinhos positions.

We present the precision of the derived proper motions with various material in Table 3, where Δt is the mean time basis for the groups of sources given in column one, and N stands for the number of stars whose proper motions were obtained from the combination of these sources.

We give in Tables 4 and 5 the derived mean positions and proper motions for the 213 PMS stars. In these tables, the objects were separated in T Tauri stars (Table 4) and HAeBe stars (Table 5). Table 6 lists the 29 non-PMS ROSAT stars in Chamaeleon

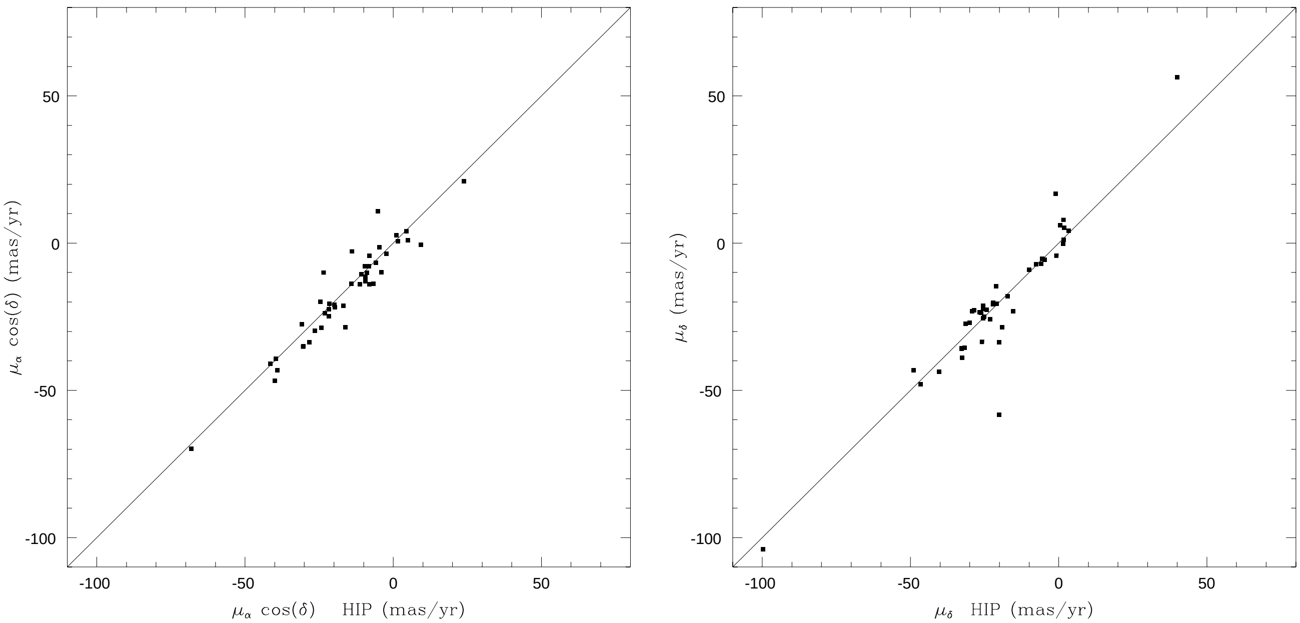

Fig. 2. Comparison of our proper motions in right ascension (left panel) and declination (right panel) with HIPPARCOS ones.

Table 3. Evaluation of the precision of the proper motions

Sources	Δt [yr]	t_0 [yr]	σ_{α_0} [$''$]	σ_μ [mas/yr]	N
AEU	75	1948.33	0.144	4	46
AU	70	1935.00	0.177	5	48
ATU	91	1989.68	0.030	3	42
EUV	28	1996.11	0.048	7	25
AHTU	91	1991.25	0.001	3	20
AETU	91	1989.47	0.029	3	22
AHT	91	1991.25	0.001	3	7
AEHTU	91	1991.25	0.001	3	7
AEUV	98	1992.68	0.047	2	3
AE	75	1937.50	0.177	5	3
AEHT	91	1991.25	0.001	3	2
AEHTUV	98	1991.25	0.001	2	2
UV	28	1996.92	0.049	9	2
AHU	81	1991.25	0.001	3	2
AEH	78	1991.25	0.001	3	2
AH	85	1991.25	0.001	3	2
AHTV	98	1991.25	0.001	3	1
AHTUV	98	1991.25	0.001	3	1
AETUV	98	1991.66	0.025	2	1
ATUV	98	1991.83	0.025	3	1
AUV	98	1996.23	0.025	3	1
AT	91	1989.31	0.030	3	1
DV	23	1997.98	0.050	17	1

In 1st column, A = AC2000, D = DSS, E = SERC–J, H = HIPPARCOS, T = Tycho, U = USNO–A2.0, V = Valinhos.

and Lupus (see Sect. 2). In addition, a traditional separation by region was adopted.

In the second column of these tables, magnitudes are taken preferably from Tycho catalogue (V_T). For the Valinhos non-Tycho stars, Valinhos visual magnitudes are used. Otherwise, magnitudes are taken from the literature, as indicated by the references (Column 3) explicited at the end of Table 6. For stars RX J1621.4–2332ab and RX J25.3–2402 we give the B magnitude from the AC2000. Magnitudes taken from reference [10] are also B magnitudes.

Out of the 213 PMS stars studied here, 101 had no previous determination of proper motion, as far as the consulted literature is concerned, 81 of them had known proper motions from the ACT and 41 from HIPPARCOS. In the last column of Tables 4, 5 and 6, additional references for other available proper motions are provided. The proper motions in common with the ACT and HIPPARCOS catalogues were used to externally evaluate the quality of our results.

A comparison of the obtained proper motions with HIPPARCOS ones is presented in Fig. 2. We can notice the good agreement between both sets of data. The mean dispersion of the differences is 6 mas/yr, which is the best estimate of the external errors of our catalogue, concerning the bright PMS stars. For the fainter stars, no catalogues for comparison were found available.

We also compared our proper motions to the ACT ones in order to evaluate the importance of the addition of SERC–J plates and meridian observations to the material used by ACT. The mean dispersion of differences is 3 mas/yr.

One should stress that the depicted comparison with HIPPARCOS and ACT is not completely independent, but is useful for a first estimation of the coherence of our results.

4. Discussion

We present in Fig. 3 a general view of the spatial distribution and proper motions in galactic coordinates of the measured PMS stars, and in Figs. 4, 5, 6 and 7 – upper panels – zooms of the

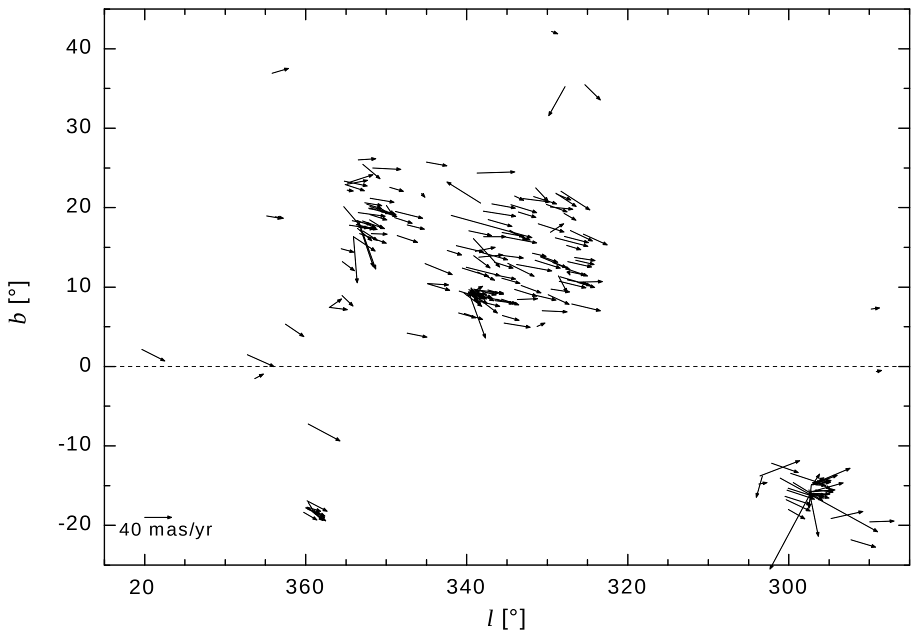

Fig. 3. Positions and proper motions of PMS stars depicted in Figs. 4 to 7 – upper panels.

4 main star-forming regions studied in this work. In all these regions, a dominant orientation of the proper motions towards smaller longitudes can be observed. This is in large part the effect of the reflex solar motion, as can be seen in the μ_b versus $\mu_l \cos b$ graphs of the same regions (Figs. 4, 5, 6 and 7 – lower panels). Since the effect of solar motion on the star proper motion depends on the distance of the stars, and the distances of PMS stars are usually poorly known, we present in these figures the reflex solar motion as a function of distance, from 50 to 200 pc. We assumed the basic solar motion, with components U = 9 km/s (directed towards the galactic center), V = 11 km/s, W = 6 km/s. The reflex solar motion depends also on the direction of the stars, and since some of the regions studied here have sizes of several degrees, we present it for two extreme directions in each field (except for Corona Australis, which is a small field).

In all groups, a number of stars are found to have proper motions that lie well outside the average distribution. Notice that some of these stars that can be seen in the (l, b) maps (for Upper Sco, Chamaeleon and Corona Australis) are absent from the $(\mu_l \cos(b), \mu_b)$ graphs, due to the scale that we adopted. We consider that these stars have a large probability of being recently formed runaway stars and a possible explanation for them is the disruption of multiple systems. We cannot exclude the possibility of errors, like a wrong identification during the proper motion determination process; however, note that some of the stars with anomalous proper motions are bright and were found in several sources (eg. HD 137727, HD 140637), which reduces the probability of an erroneous identification.

Disregarding the runaway stars, the groups of PMS stars present proper motion dispersions of the order of 10 mas/yr typically. This means that in a period of about one million years, the stars would move apart several degrees in the sky, and would look very dispersed. We must bear in mind, however, that part of this apparent dispersion may not be intrinsic, but due to the fact that the sun is approaching the group. For instance, most of the PMS stars of Upper Scorpius present negative radial velocities, while most of the stars in Chamaeleon present positive radial ones (e.g. Gregorio-Hetem et al. 1992; Torres et al. 1995; Covino et al. 1997).

Let us now comment on the average proper motion of the stellar groups. We already noticed that the average values are largely explained by the reflex solar motion. However, they are not entirely due to this effect or, in other words, intrinsic average proper motion of the groups are detected. For instance, in the case of Lupus (our largest sample, Fig. 5), the center of mass of the points in the $(\mu_l \cos(b), \mu_b)$ graph is about $(-30,-9)$, which suggests mean distance of about 85 pc, if we consider only the reflex solar motion. However, the average distance of 14 stars of this group that have parallaxes from HIPPARCOS is 138 pc. This suggests that the Lupus PMS stars have a mean intrinsic proper motion in the longitude direction of about $\mu_l \cos(b)$ = -10 mas/yr.

The Chamaeleon group is peculiar, in that it seems to present two distinct kinematic groups, even after excluding the runaway stars. A group with proper motions close to about $\mu_l \cos(b)$ = -40 mas/yr, μ_b = -15 mas/yr, seems to be well behaved. Its observed proper motion could be explained by the the reflex solar motion, if its distance is of the order of 70 pc. And indeed, some of the stars of this group have distances determined by HIPPARCOS, and are not too different from this value (T Cha, 66 pc, RX J1158.5-7754a, 86 pc, RX J1159.7-7601, 92 pc, HD 104237, 116 pc). This group was already discussed by Terranegra et al. (1999); notice, however, that Bertout et al. (1999) consider that the HIPPARCOS distance of T Cha is incorrect. Another group of stars presents positive values of μ_b, considerably different from the reflex solar motion. Among these, only HD97300 has parallax measured by HIPPARCOS (187 pc).

Finally, we remark that in the studied regions, no systematic differences between the proper motions of T Tauri stars and

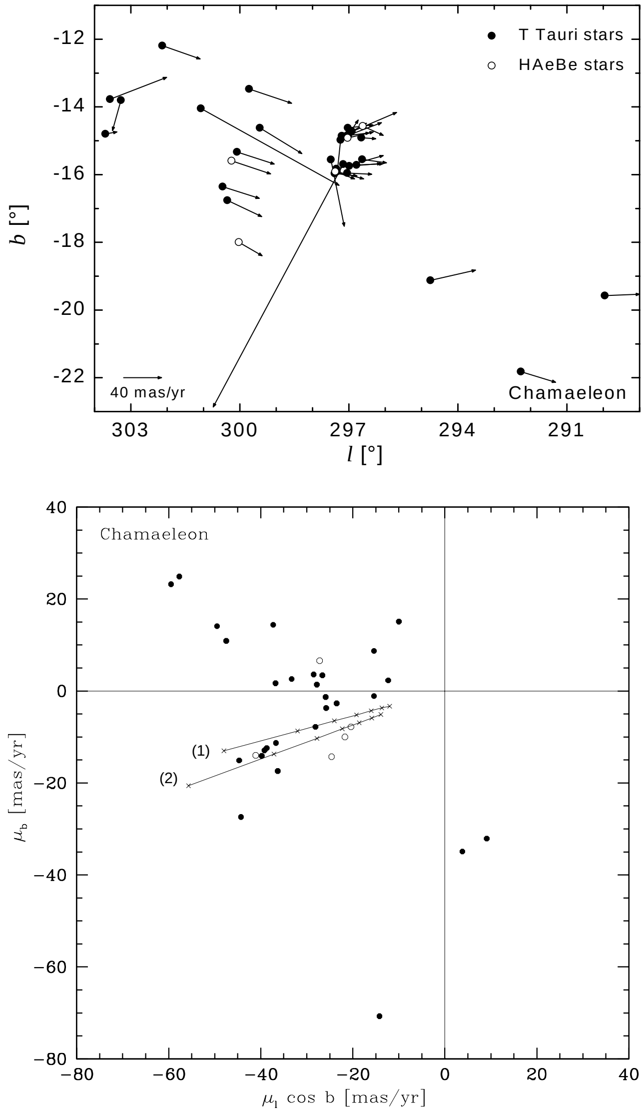

Fig. 4. Upper panel: Positions and proper motions of PMS stars in Chamaeleon. Lower panel: Components of proper motions of PMS stars in Chamaeleon, in galactic coordinates. The reflex solar motion is presented for two directions – (1): $l = 289°$, $b = -20°$ and (2): $l = 303°$, $b = -13°$ – for distances ranging from 50 pc to 200 pc, in steps of 25 pc, from left to right. The open symbols represent HAeBe stars, the filled ones T Tauri stars.

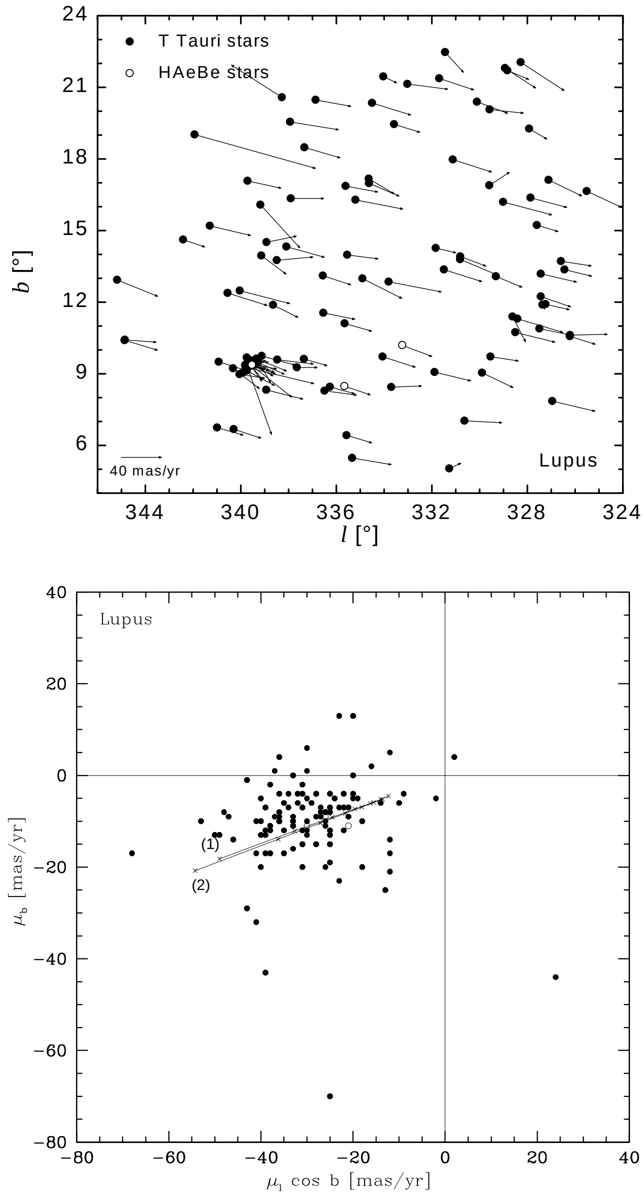

Fig. 5. Upper panel: Positions and proper motions of PMS stars in Lupus. Lower panel: Same as Fig. 4 – lower panel – for Lupus. (1): $l = 325°$, $b = 35°$ and (2): $l = 344°$, $b = 10°$

HAeBe stars can be observed. Our results favour the PMS nature of the candidates HAeBe stars included in our list.

A deeper analysis of the proper motion of the groups of PMS stars, in connection with the ages of the subgroups, will be presented in a separate paper, where our results are compared with the models proposed in the literature for the mechanisms that might have triggered the star formation.

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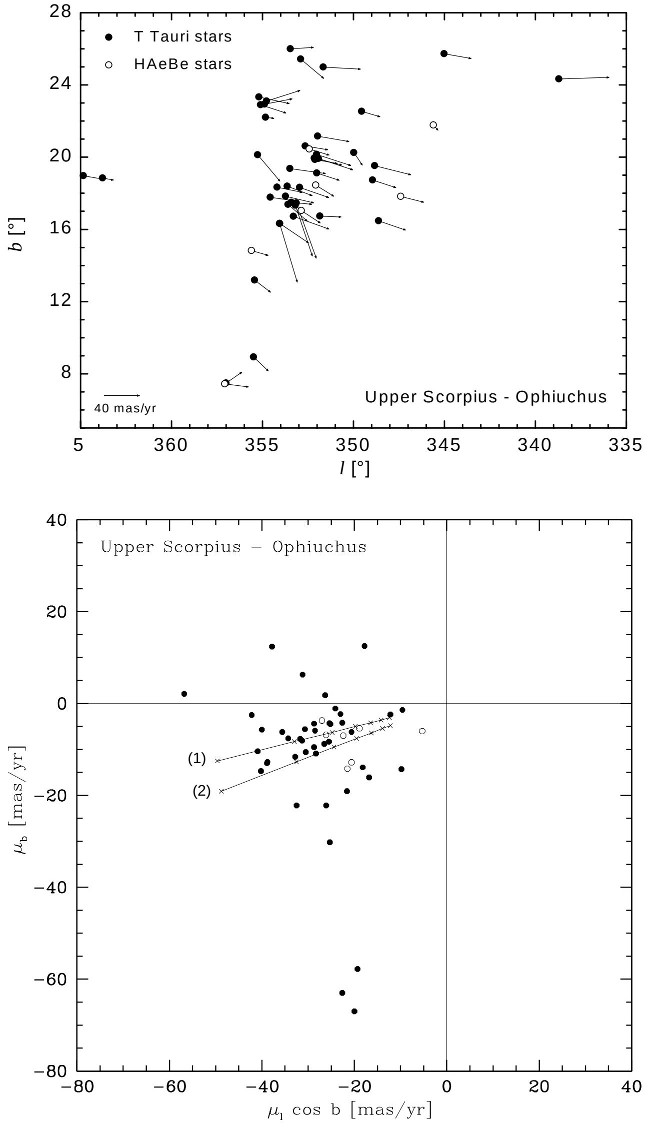

Fig. 6. Upper panel: Positions and proper motions of PMS stars in Upper Scorpius – Ophiuchus. Lower panel: Same as Fig. 4 – lower panel – for Upper Scorpius – Ophiuchus. (1): $l = 345^{o}$, $b = 25^{o}$ and (2): $l = 355^{o}$, $b = 10^{o}$

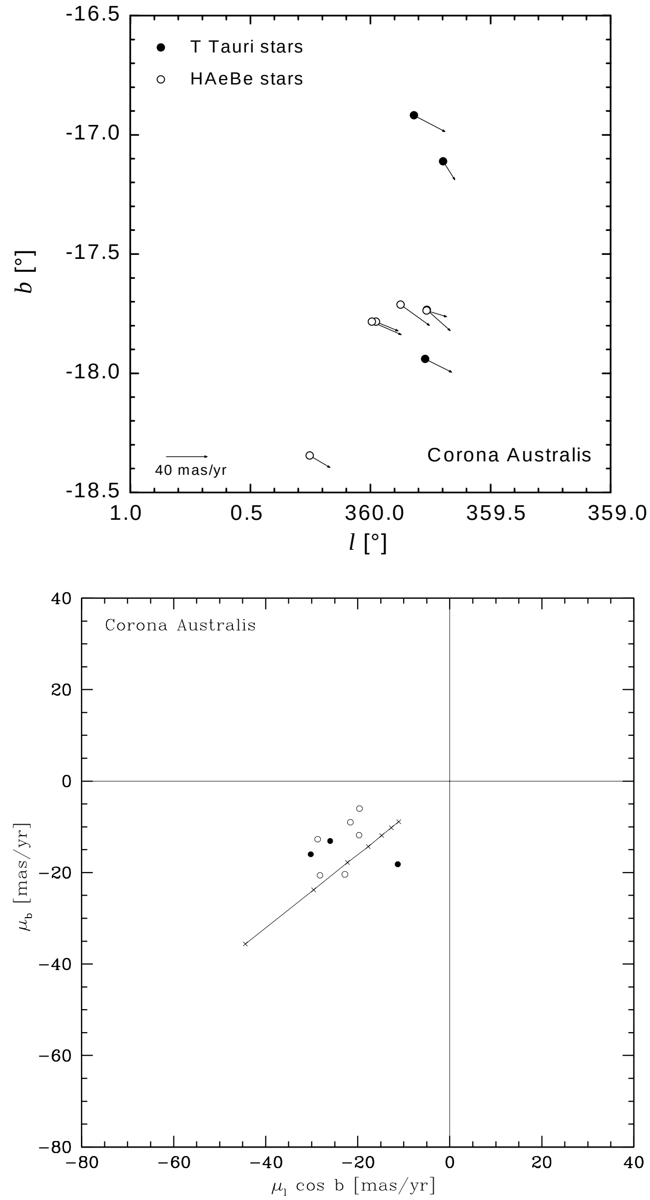

Fig. 7. Positions and proper motions of PMS stars in Corona Australis. Lower panel: Same as Fig. 4 – lower panel – for Corona Australis. $l = 359.8^{o}$, $b = -17.75^{o}$

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Table 5. Proper motions for the HAeBe stars

Name	Mag	Ref.	Sources	Epoch	α [J2000] [h m s]	δ [° ′ ″]	$\mu_\alpha \cos\delta$ [mas/yr]	μ_δ	$\mu_l \cos b$	μ_b	Other PM's
Chamaeleon											
HD 96675	7.7	[T]	AEHT	1991.248	11 05 57.865	−76 07 48.89	−24	0	−22	−10	1,2,3
CU Cha	8.5	[T]	AHT	1991.249	11 08 03.372	−77 39 17.50	−22	+1	−20	−8	1,2,3
HD 97300	9.0	[T]	AHTUV	1991.252	11 09 50.073	−76 36 47.71	−22	+17	−27	+7	1,2,3
HD 102065	6.6	[T]	AHTU	1991.248	11 43 37.057	−80 29 00.47	−28	−7	−25	−14	1,2,3
HD 104237	6.6	[T]	AHTU	1991.248	12 00 05.196	−78 11 34.51	−43	−5	−41	−14	2,3
Lupus											
HD 139614	8.3	[T]	AETU	1988.539	15 40 46.400	−42 29 53.24	−17	−27	−30	−11	1,3
HD 142527	8.4	[T]	AHT	1991.249	15 56 41.899	−42 19 23.06	−14	−24	−26	−9	1,2,3
V856 Sco	7.0	[T]	AHTV	1991.252	16 08 34.294	−39 06 18.13	−8	−23	−21	−11	2,3
U–Sco - Oph											
PDS 144 N,S	12.8	[14]	AU	1946.483	15 49 15.425	−26 00 52.48	0	−8	−5	−6	
HD 144432	8.2	[T]	AHTU	1991.249	16 06 57.962	−27 43 09.55	−14	−23	−26	−7	1,2,3
HD 145718	8.9	[T]	AHTU	1991.249	16 13 11.597	−22 29 06.42	−10	−21	−22	−7	1,2,3
CD-23 12840	11.3	[V]	AUV	1996.228	16 18 37.302	−24 05 22.51	−5	−24	−21	−12	
HD 147889	8.0	[T]	AHTU	1991.249	16 25 24.318	−24 27 56.34	−4	−26	−22	−14	1,2,3
HD 150193	8.9	[T]	AEHTU	1991.249	16 40 17.927	−23 53 45.03	−8	−18	−19	−5	2,3
KK Oph	10.3	[3]	AEU	1956.790	17 10 08.065	−27 15 18.24	−13	−24	−27	−4	
Corona Australis											
HD 176269	6.7	[T]	AHTU	1991.249	19 01 03.251	−37 03 39.06	+11	−29	−23	−20	1,2,3
HD 176270	6.4	[T]	AHTU	1991.249	19 01 04.301	−37 03 41.42	−1	−21	−20	−6	2,3
S CrA	11.6	[9]	AEU	1956.056	19 01 08.570	−36 57 19.41	+9	−34	−28	−20	
HD 176386	7.3	[T]	AHTU	1991.249	19 01 38.929	−36 53 26.31	+1	−23	−22	−9	1,2,3
TY CrA	9.5	[T]	AT	1989.313	19 01 40.826	−36 52 33.55	+2	−31	−29	−12	3
HD 177076	8.2	[T]	AHTU	1991.245	19 04 44.412	−36 50 40.72	+4	−23	−20	−11	1,2,3
Other regions											
GG Car	8.8	[T]	AHT	1991.248	10 55 58.924	−60 23 33.47	−7	+5	−8	+2	2,3
HD 98922	6.8	[T]	AHT	1991.248	11 22 31.683	−53 22 11.46	−11	+6	−13	+2	1,2,3
HD 141569	7.1	[T]	AHT	1991.254	15 49 57.759	−03 55 16.17	−21	−15	−25	+8	1,2,3
AK Sco	9.2	[T]	AHT	1991.249	16 54 44.855	−36 53 18.31	−14	−27	−30	−6	1,2,3
51 Oph	4.8	[T]	AHTU	1991.249	17 31 24.951	−23 57 45.29	+1	−34	−28	−19	1,2,3
HD 163296	6.9	[T]	AHT	1991.249	17 56 21.293	−21 57 21.53	−4	−44	−40	−18	1,2,3
LkHα 118	11.1	[3]	AE	1942.841	18 05 49.698	−24 15 20.66	−13	−8	−13	+7	

See references in Table 6.

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Table 6. Non-PMS ROSAT stars in Chamaeleon (Covino et al. 1997) and Lupus (Wichmann et al. 1999)

Name	Mag	Ref.	Sources	Epoch	α [J2000] [h m s]	δ [° ′ ″]	$\mu_\alpha \cos\delta$ [mas/yr]	μ_δ	$\mu_l \cos b$	μ_b	Other PM's
Chamaeleon											
RX J0849.2-7735	9.0	[T]	ATU	1988.877	08 49 11.130	−77 35 58.80	−8	+20	−21	+5	1,3,4,6
RX J0853.1-8244	11.7	[1]	AU	1940.627	08 53 05.137	−82 43 59.17	+7	−20	+20	−5	4
RX J0917.2-7744	10.7	[T]	ATU	1988.664	09 17 10.495	−77 44 02.17	−34	+13	−32	−17	1,4,6
RX J0919.4-7738S	9.4	[T]	ATU	1988.652	09 19 24.359	−77 38 45.84	−104	+69	−120	−33	
RX J0919.4-7738N	8.0	[T]	ATU	1988.652	09 19 25.033	−77 38 37.13	−107	+66	−120	−37	2,3,4,6
RX J0936.3-7820	8.7	[T]	AHTU	1991.248	09 36 18.035	−78 20 42.02	−72	+51	−87	−15	2,3,4,6
RX J1007.7-8504	8.8	[T]	AHTU	1991.248	10 07 33.366	−85 04 36.45	−555	+390	−677	−52	2,6
RX J1039.5-7538N	11.0	[1]	AEU	1956.371	10 39 31.496	−75 37 53.27	+10	+0	+8	+5	
RX J1039.5-7538S	9.4	[T]	AETU	1988.762	10 39 31.623	−75 37 56.67	+31	+36	+9	+47	2,4
RX J1120.3-7828	11.0	[1]	AU	1941.851	11 20 19.444	−78 28 25.22	+15	+71	−12	+71	4
RX J1140.3-8321	11.6	[1]	AU	1938.801	11 40 18.106	−83 21 02.24	−45	+27	−51	+13	4
RX J1207.9-7555	10.2	[T]	AETU	1988.336	12 07 51.663	−75 55 16.06	−157	−7	−153	−34	1,4,6
RX J1209.8-7344	11.6	[1]	AEU	1950.581	12 09 42.925	−73 44 41.28	−12	−4	−11	−6	4,6
RX J1217.4-8035	8.6	[T]	ATU	1988.674	12 17 26.902	−80 35 06.73	−1	−11	+1	−11	1,3,4,6
RX J1220.6-7539	10.5	[T]	AETU	1988.340	12 20 34.736	−75 39 28.78	−117	+4	−116	−11	1,4,6
RX J1223.5-7740	8.3	[T]	AETU	1988.362	12 23 29.268	−77 40 51.51	−63	+10	−64	+2	1,3,4,6
RX J1225.3-7857	10.8	[T]	ATU	1988.669	12 25 13.515	−78 57 34.52	−24	−23	−21	−25	1,3,4,6
RX J1233.5-7523	9.6	[T]	AEHTU	1991.248	12 33 30.002	−75 23 11.38	−96	+16	−97	+9	2,3,4,6
RX J1325.7-7955	11.5	[1]	AU	1938.285	13 25 41.842	−79 55 16.24	−5	−1	−5	0	4
RX J1349.2-7549	9.7	[T]	AETU	1988.454	13 49 13.108	−75 49 47.12	−63	−30	−68	−15	1,3,4,6
Lupus											
RX J1507.2-3505	10.8	[T]	AETU	1988.777	15 07 14.842	−35 04 59.26	−32	−28	−42	−7	1
RX J1507.9-4515	10.8	[T]	ATU	1988.871	15 07 54.472	−45 15 21.15	+26	−2	+21	−15	1
HD 134974	10.4	[T]	AHTU	1991.248	15 14 07.559	−41 03 35.93	−21	−27	−32	−12	1,2
RX J1518.4-3738	10.3	[T]	AETU	1988.765	15 18 26.946	−37 38 01.87	−16	−28	−29	−14	1
RX J1524.5-3652	11.3	[7]	AEU	1956.311	15 24 32.435	−36 52 01.66	−21	−24	−31	−8	
HD 137059	9.2	[T]	ATU	1989.094	15 25 17.041	−38 45 25.55	−31	−33	−44	−9	3
RX J1534.1-3916	10.6	[T]	AETU	1988.727	15 34 07.378	−39 16 17.04	−26	−28	−38	−6	1
RX J1604.5-3207	11.0	[T]	ATU	1989.023	16 04 30.576	−32 07 28.50	−19	−25	−31	−5	1
HD 143978	9.2	[T]	AEHTUV	1991.252	16 04 57.094	−38 57 15.29	−30	−48	−54	−15	1,2,3

• References for the magnitudes (3rd column): [1] Alcalá et al. (1995); [2] Appenzeller et al. (1980); [3] Bastian & Mundt (1979); [4] Gauvin & Strom (1992); [5] Herbig & Rao (1972); [6] Hughes & Hartigan (1992); [7] Krautter et al. (1997); [8] Lawson et al. (1996); [9] Marraco & Rydgren (1981); [10] Preibisch et al. (1998) (B magnitudes); [11] Rydgren (1980a); [12] Rydgren (1980b); [13] Schwartz & Noah (1978); [14] Torres (1998); [15] Walter (1986); [16] Walter et al. (1997); [17] Wichmann et al. (1997); [A] AC2000 (B magnitudes); [H] HIPPARCOS; [T] Tycho; [V] Valinhos.

• Other available proper motions (last column): 1 = ACT; 2 = HIPPARCOS; 3 = PPM (Bastian & Röser 1993); 4 = Frink et al. (1998); 5 = Preibisch et al. (1998); 6 = Terranegra et al. (1999)