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Identification of moving groups from a sample of B, A and F type stars

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Abstract. An algorithm to find moving groups has been developed and applied to a sample of 1924 B, A, and F main sequence stars, basically extracted from the Hipparcos Input Catalogue. This algorithm uses a non-parametric kernel estimator to describe the stellar distribution in a 4-dimensional space of velocities and age, although it can be used to detect the real clustering structure in an n-dimensional space automatically.

Four moving groups near the Sun (Pleiades, Sirius, Hyades, IC2391) have been identified without assuming any *a priori* knowledge of moving groups, neither the velocity distribution nor other physical properties. This provides objective evidence of the existence of the moving groups, and we find that about 26% of our sample belongs to such stellar streams. For the remaining field stars we obtain a mean motion of the Sun respect to the Local Standard of Rest (U,V,W) = (13.4±0.4, 11.1±0.3, 6.9±0.2) km s^{-1}.

Key words: stars: early-type – stars: statistics – (Galaxy): solar neighbourhood – stars: kinematics

1. Introduction

According to Eggen (1994), superclusters are the result of clusters or associations that are in the process of dissociation. The members of a moving group are the stars still moving with similar velocities but distributed over a wide field. The confirmation of their existence, their identification and the separation of such stellar streams from the field stars is extremely interesting in many fields of galactic astronomy, because it may help us to clarify the process of star formation and stellar and kinematic evolution.

The study of moving groups goes back more than a century (e.g. Proctor 1869), although much of the recent work on this topic is due to O.J. Eggen. In 1963, this author compiled a catalogue of the space velocities of 750 stars of spectral type B8 or later and $B-V < 0^m3$, with visual magnitude brighter than $5^m.5$. He plotted all stars on the (U,V) plane, and claimed that A-type stars consist mainly of six stellar groups, four of them identified as Hyades, Pleiades, Ursa Major (also known as Sirius) and IC2391 superclusters from their kinematical similarity with these known open clusters.

Similar work was reported by Ogorodnikov and Latyshev (1968), who identified the members of the Hyades supercluster in the solar neighbourhood and investigated its density from a set of data including complete space-velocity vectors for 600 stars. Palouš & Hauck (1986) and Bubeníček et al. (1985) assumed that the supercluster velocity ellipsoid is a perturbation of the velocity ellipsoid of the field stars and that the former is important only in a limited region of the (U,V) velocity plane near the supercluster mean motion. They analyzed the Sirius and Hyades superclusters from Palouš's (1983) catalogue and investigated the age and the possible formation region of these star streams. More recently, Eggen identified the moving groups members from the FK5 catalogue. He chose some mean kinematic characteristics of the open cluster to define the members of Pleiades (Eggen, 1992a), Hyades (Eggen, 1992b), Sirius (Eggen, 1992c) and IC 2391 (Eggen, 1991).

Soderblom and Mayor (1993) used Coravel radial velocities and the indices of the strength of chromospheric emission – as an age indicator – to identify solar type candidate members of the Sirius moving group.

From a proper motion survey in a 5 square degree field in two selected areas, Méndez at al. (1993) showed the evidence for faint members of the Hyades and Sirius moving groups, estimating their densities and velocity dispersions. The large tangential velocity dispersion they found for both moving groups suggests that such stellar streams are not gravitationally bound.

Gómez et al.(1990) realized that the velocity field of young stars cannot be described as an ellipsoidal distribution; they used the SEM algorithm to decompose the sample into the sum of tridimensional gaussians in the (U,V,W) velocity space, and concluded that the observed distribution of the residual velocities can be explained as the sum of four independent distributions. These groups were kinematically related to several open clusters in the solar neigbourhood. They then suggested that

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each group may correspond to one burst of star formation, which took place at the epoch of birth of the associated open cluster.

The reality of these groups has been questioned by some authors. Ratnatunga (1988), using distance–independent kinematic observables and the Yale Bright Star Catalogue and Supplement, concluded that extended moving groups with the exact space velocities of Hyades and Sirius superclusters deduced by Eggen (1984) are not observed, although the presence of two extended moving groups with smaller space velocities relative to the Sun may be present in the data.

To confirm the existence of these large–scale stellar streams some problems must be overcome. First, the poor statistical significance of their identification –coming from the lack of robustness of the methods used, the scarcity of observational data and derived physical properties, among others–. Second, the fact that their members have usually been isolated taking into account the space velocities of an associated open cluster. In addition, we should bear in mind that the field star ellipsoidal velocity distribution hypothesis implies that a certain fraction of these stars should share the same space motion as the members of the moving groups. Thus, a definitive conclusion can only be derived from some objective, well-defined methods and large stellar samples.

Non-parametric techniques involve not only a change of mathematical tools, but a new approach that allows us to set up less restrictive astronomical hypotheses. Pisani (1993) established a new cluster analysis algorithm based on density estimation in one-dimensional space; Arenou (1993) uses Principal Component Analysis (PCA) to identify moving groups; Cabrera-Cano and Alfaro (1990) have used a kernel estimation to determine the probable physical members in open clusters; Chen et al. (1992) and Chen (1993) have used a kernel estimation to investigate the galactic structure parameters.

In this paper we use a non-parametric kernel approach to search for moving groups in a large stellar sample with well known individual physical properties. The most important difference between this study and previous works is that we identify the moving group members from pattern recognition theory without assuming any *a priori* knowledge of moving groups, either the physical properties or the velocity distributions. The rest of this paper is organized as follows. In Sect. 2, we describe our sample of B, A, and F stars. In Sect. 3, we investigate the distribution of these stars in the velocity space, and show that the local velocity field in the solar vicinity can be represented as an overlap of the field stars and the moving groups. In Sect. 4, we present our moving group–finding algorithm to isolate members of the moving group from the field stars. Results and discussion can be found in Sect. 5. In Sect. 6, we outline the principal conclusions of this investigation. In the appendix D [1], working with a set of simulated samples, we analyze the statistical significance of this moving group–finding algorithm.

[1] available by http://science.springer.de/aa/aa-main.htm

2. The sample

A large sample of 1924 main sequence stars of spectral types B, A, and F with uvbyH_β photometry, position, proper motion and radial velocity has been compiled basically from the Hipparcos Input Catalogue. The Strömgren photometric data come from the Hauck and Mermilliod (1990) compilation and the new observations performed by us (more than 700 stars: Figueras et al., 1991, Jordi et al., 1996). The U,V,W components of the space velocities, where U is directed towards the galactic center, V towards the galactic rotation direction and W towards the north galactic pole, have been corrected for differential galactic rotation. We have rejected the stars with residual velocities respect to Delhaye's centroid – (9,12,7) km s^{-1} – greater than 65 km s^{-1}, because they probably do not belong to the galactic disk. In order to eliminate stars with large space velocity error, those with a distance greater than 300 pc have been excluded. For kinematical reasons, we have also eliminated all stars known as members of galactic open clusters and associations. The detailed procedure to derive distances, effective temperatures, gravities and ages, together with a description of the spatial distribution of the sample and the error involved in velocities and ages is accessible by http://science.sspringer.de/aa/aa-main.htm.

In Table 1, we show the mean velocities and velocity dispersions for the whole sample and B, A, and F stars, respectively. For the complete sample, the mean velocity components relative to the Sun are in agreement with Delhaye's centroid (9,12,7) km s^{-1}. The ratio σ_v^2/σ_u^2 is 0.74, larger than the value 0.5, which corresponds to a flat rotation curve in the epicyclic approximation.

3. The uneven velocity field

The complicated pattern of the velocity distributions of young stars has been noticed, their uneven distribution makes it difficult to represent their space motion as a velocity ellipsoid (Palouš 1986). In Fig. 5, we show the space motion in the U and V plane for B, A and F stars, respectively. A box centered on the mean velocity components (U_0,V_0,W_0) =(-10.4,-10.5,-7.0) km s^{-1} $\pm$ 1 σ is plotted, where the σ is the standard deviation in Table 1 for B, A and F type stars respectively. As expected, the box size increases from B to F stars due to the age-velocity dispersion relation of disk stars in the solar neighbourhood. For the B type stars, we can see a concentration of stars below the box which, according to the literature, corresponds to the Pleiades moving group. For the A type stars, a significant concentration at the upper-right side corresponds to the Sirius moving group. For elder F stars, the Hyades moving group can be observed.

The principal components analysis (PCA, hereafter) has been applied to the whole sample to visualize the stellar distribution in the three dimensional space (U,V,W). The first main axis contributes 60% of the variance, and the first two main axes include 85 % of the variance. The relation between the new axes and the U, V, W is given in Table 2. The third main axis remains almost perpendicular to the galactic plane, and the first and second axes give us a vertex deviation of ϕ = 21^o.

Table 1. Mean velocities and velocity dispersion components for B,A, and F stars (Units: km s^{-1})

Sp. type	No.	U	V	W	σ_u	σ_v	σ_w
B, A and F	1924	-10.4 ± 0.4	-10.5 ± 0.3	-7.0 ± 0.2	17.4 ± 0.3	12.8 ± 0.2	9.1 ± 0.2
B	421	-11.3 ± 0.6	-14.4 ± 0.5	-7.2 ± 0.4	11.5 ± 0.4	11.0 ± 0.4	8.1 ± 0.3
A	1213	-9.5 ± 0.5	-8.7 ± 0.4	-6.9 ± 0.3	17.6 ± 0.4	12.5 ± 0.3	9.2 ± 0.2
F	290	-12.8 ± 1.3	-12.6 ± 0.9	-6.8 ± 0.6	22.7 ± 0.9	14.9 ± 0.6	10.2 ± 0.4

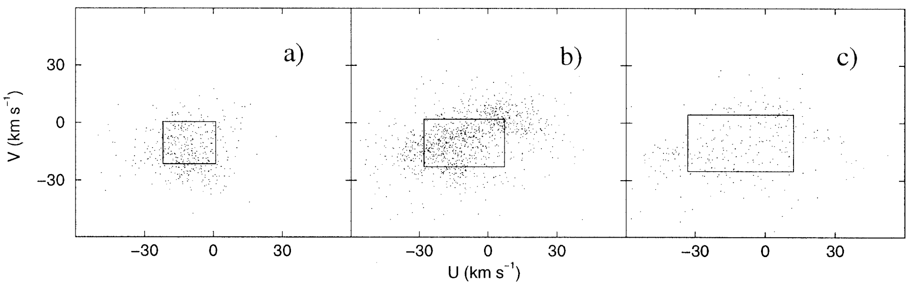

Fig. 5a–c. Distribution in the U, V plane. **a** B type stars **b** A type stars and **c** F type stars

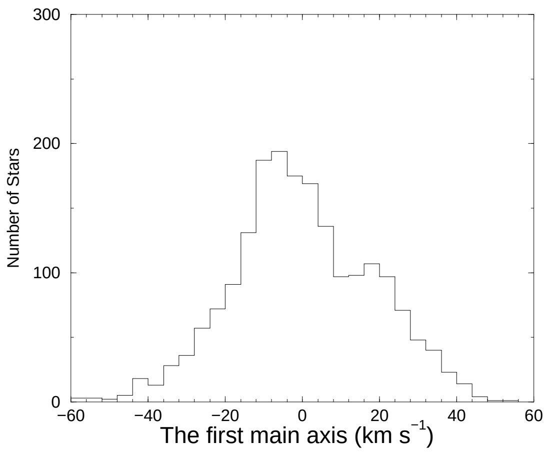

Fig. 6. Histogram of the first main axis of the velocity ellipsoid.

Table 2. The linear relation between the new axes and U,V,W components for the whole sample

	New1	New2	New3
U	0.92	0.38	0.01
V	0.38	0.92	-0.01
W	0.01	-0.01	1.00

The histogram of the first main axis is shown in Fig. 6. From it, we can see that the velocity field cannot definitively be represented by an ellipsoidal distribution. The peak around 20 km s^{-1} can be identified as the Sirius moving group.

4. The method

The moving group finding algorithm presented in this paper follows the general idea that the presence of moving groups in a data set is indicated by a concentration under the ellipsoidal velocity distribution of the field stars. This algorithm can be used to detect the real clustering structure in a d-dimensional space.

4.1. Multivariate kernel estimation

We use a non-parametric technique to represent the distribution of the observed parameters of our total sample. Each star is characterized by d variables regarded as a d-dimensional vector **x**. Suppose p(**x**) is the true density of probability, then a kernel estimator $p(\mathbf{x})$ of the density (Hand, 1982) is given by:

$$p(\mathbf{x}) = \frac{1}{nh^d} \sum_{i=1}^{n} K(\frac{\mathbf{x} - \mathbf{x}_i}{h}) \tag{1}$$

where n is the number of stars in the sample, $K(\mathbf{x})$ is a kernel function, h is the smoothing parameter, d is the dimension of the variables, and $\mathbf{x}_i (i = 1, ...n)$ is the sample set defined in a d-dimensional space. A more elaborated version can be accessible by http://science.springer.de/aa/aa-main.htm.

4.2. Identification of moving groups

The real probability density function (pdf) can be expressed as the sum of field stars and moving group members:

$$p_{real}(\mathbf{x}) = p_{field}(\mathbf{x}) + p_{mov}(\mathbf{x}) \tag{2}$$

After the adoption of a probability density function for the field stars (see Sect. 5.1), we can compare it with the estimated density of the real sample and isolate the moving group members from the field stars. Membership of the moving groups is determined by means of the two-hypothesis test using the thresholds parameters C1 and C2:

$$\frac{p_{real}(\mathbf{x})}{p_{field}(\mathbf{x})} > \text{C1} \tag{3}$$

$$p(\mathbf{x}) - p_{field}(\mathbf{x}) > \text{C2} \tag{4}$$

The first criterion (C1) allows us to detect the members in the low density regions of the background field, and the difference

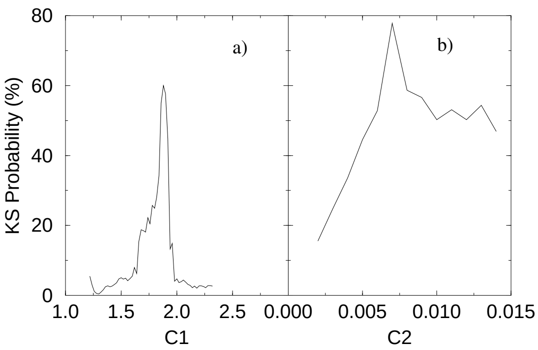

Fig. 8. a Kolmogorov-Smirnov probabilities of the remaining field as a function of C1; **b** The same as a function of C2.

(C2) is more useful for detection in the crowded regions, where the constrast between field and moving groups is low. Again two parameters, now C1 and C2, play an important role in our finding algorithm: if C1 and C2 are too large, only some of the moving group members are detected. On the other hand, if C1 and C2 are too low, too many field stars will be identified as moving group members.

The flow chart of our algorithm is shown in appendix C [2]. Since *a priori* we do not know the mean parameters defining the probability density function of the field stars, an iterative procedure has been followed. We first detect the moving groups in the low density region – using C1 – and, when the convergence is achived, we apply the second criterion to the remaining stars to detect possible moving-group members in the central region of the field (C2). In order to get rid of small-scale noise, we have considered as field stars those with a probability density function – given by Eq. 1 – less than 10% the mean density of the sample.

5. Results and discussion

For the application of the method described above, we have to choose which kinematical and physical parameters of the stars are to be taken into account. If a moving group is the result of the evaporation of a cluster of stars born from the same cloud, some properties, other than kinematics, should be shared by its members. For example, according to Soderblom and Mayor (1993), a moving group should contain stars of the same age and composition with minimal scatter, and similar velocity through space. Although we have Strömgren photometry for all stars of the sample, this photometric system does not allows us to determine the metallicity of stars with spectral type earlier than A3 – the index δm_1 is not directly related with $[Fe/H]$; so we will not use it as a discriminant parameter to isolate moving groups Once the groups have been defined we can analyze the chemical properties. Due to the well known lack of spatial cohesion of the stars belonging to a moving group, the position in the space has not been considered in our algorithm.

In our analysis we first apply the process to a 4-dimensional space: the three components of the velocity space and the age.

[2] available by http://science.springer.de/aa/aa-main.htm

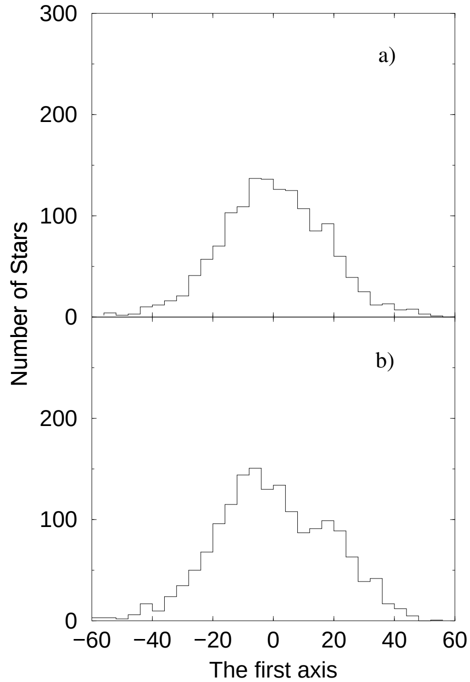

Fig. 9a and b. Histogram of the first main axis of the velocity ellipsoid for the remaining field stars. **a**: (C1,C2)=(1.85,0.0075); **b** (C1,C2)=(2.1,0.011)

We also apply our algorithm to the three dimensional space of the velocity components, which is a usual approach in the literature. The comparison between the four and three dimensional space results provides us interesting information about the role of the ages in the process of group identification.

5.1. On the 4-dimensional space of U,V,W and Age

In this section we apply the method described above to our 1924 B, A, and F stars. As commonly accepted for the field stars, we have considered a gaussian distribution for each velocity component (Mihalas & Binney, 1981). *A priori* we do not know the distribution of ages for the field stars in our sample. In Fig. 3 [3] we show the histogram of the log (age) of our real sample. As a first approximation we will assume that the logarithm of the age of field stars follows a gaussian distribution. The log-normal distribution has been widely used in many fields. We show in the appendix D [4] that this assumption is not very strong, although it can be improved if a more detailed form is adopted for the age distribution.

The pdf of the field stars at a point $\mathbf{x}$ has been expressed by a multivariate gaussian function with unknown mean μ and convariance matrix $\Sigma_{\mathbf{f}}$

$$p_{field}(\mathbf{x}) = \frac{1}{|\Sigma_{\mathbf{f}}|^{1/2}(2\pi)^{d/2}} e^{-\frac{1}{2}(\mathbf{x}-\mu)^T {\Sigma_{\mathbf{f}}}^{-1}(\mathbf{x}-\mu)} \quad (5)$$

[3] available by http://science.springer.de/aa/aa-main.htm

[4] available by http://science.springer.de/aa/aa-main.htm

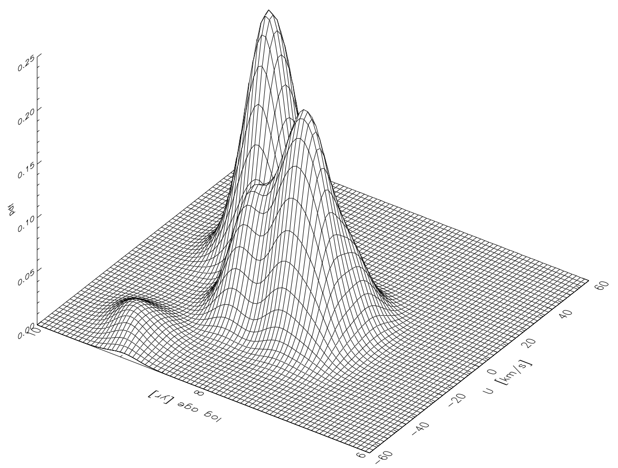

Fig. 10. The distribution function for the extracted moving group members i n the (U, log (age)) plane.

If there were no moving groups, then this distribution could replace the real distribution (Eq. 1). However, as can be seen from Fig. 6, this is not the case, some regions having more stars than expected from an ellipsoidal velocity distribution.

A priori we do not know neither the covariance matrix nor the mean values for the field stars in Eq. 5. We start an iterative process where, in the first step, $\Sigma_\mathbf{f}$ and μ are those from the total sample. Once the first moving group members have been extracted, $\Sigma_\mathbf{f}$ and μ are recomputed for the remaining field stars. The iterative procedure is carried out until no more moving group members are found.

The appropriate threshold values C1 and C2 are established by requesting a reasonable gaussian distribution for the remaining field stars. An automatic procedure is used to determine the best C1 and C2, applying a Kolmogorov-Smirnov test to the first main axis (see Sect. 3) of the three velocity components.

The results of this test are presented in Fig. 8. The final values adopted are 1.85 for C1 and 0.0075 for C2. As an example, Fig. 9 shows the histogram of the first main axis using (C1,C2) = (1.85,0.0075) and (C1,C2) = (2.1,0.011). For (C1,C2) =(1.85,0.0075), we find a probability of the distribution of the first main axis to come from the gaussian distribution of 70%, whereas for (C1,C2)=(2.1,0.011) we derive a probability of 23%. As can be seen in this figure, the second values fails to extract the members of Sirius supercluster.

In Fig. 10, we plot the pdf diagram for the extracted moving group members in the (U,log(age)) plane. We can clearly see four peaks corresponding to the Pleiades, Sirius, Hyades, and IC2391 superclusters.

Cluster Analysis (Murtagh and Heck, 1985), which is based on a minimum within-class and maximum between-class variance principle, is applied to classify the moving group members in the 3-dimensional space of (U,V,log(Age)). We realized that Cluster analysis carried out on both 3-dimensional space of (U,V,log(Age)) and 4-dimensional space of (U,V,W, log(Age)) provides the same result, indicating that the W component is not a discriminant parameter to separate moving groups. The mean velocities and ages, their standard deviations and the number of members for each of the four detected moving groups are presented in Table 3. According to the values found in the literature, our groups have been identified as Sirius, Hyades, Pleiades and IC2391.

Table 3. The means and standard deviations (between brackets) of U, V, W components (Units: km s^{-1}) and age for the four moving groups identified in the 4-dimensional space

U	V	W	age (10^8 yr)	N	Name
13.0	3.2	-7.5	6.5	212	Sirius
(8.4)	(6.5)	(6.2)	(3.1)		
-44.4	-17.8	-1.5	13.3	17	Hyades
(5.3)	(3.0)	(9.7)	(4.3)		
-10.0	-19.0	-8.1	0.7	216	Pleiades
(7.9)	(8.6)	(5.8)	(0.4)		
-15.9	-13.1	-4.5	2.8	52	IC2391
(4.1)	(6.2)	(3.0)	(0.43)		

Pleiades, Sirius and Hyades are identified from the first criterion (C1), and IC2391 is only found by the second criterion (C2) because it is very close to the centre of the background field. In Fig. 11, we show the U,V and W means and dispersions obtained using different values for C1 and C2. Although the choice of C1 and C2 slightly modifies the number of moving group members, we can see that the mean kinematic properties of the moving groups in our sample are not affected. The dispersions in the Hyades and IC 2391 change apreciabily due to the scarcity of the members; we return to this point in the appendix D [5].

5.2. *On the 3-dimensional space of U, V, W*

In order to test the influence of the hypothesis of gaussian distribution for the log (age) of field stars, and to look for the age distribution of our moving groups without any *a priori* assumption, we have applied our method to the 3-dimensional velocity space (U,V,W). The effect of the assymetrical drift has been considered by dividing our sample into three groups according to the age: group 1 contains stars younger than $2.5{\cdot}10^8$ years; group 2 is in the range $2.5{\cdot}10^8 <$ age $< 8{\cdot}10^8$ years; and group 3 is the oldest one, with ages $>8{\cdot}10^8$ years. After applying the method to each group we find the results shown in Table 4. In this case, from the Kolmogorov-Smirnov test we choose C1=1.75 and C2=0.011 as appropiate threshold values for all the three age groups.

The results of Table 3 and Table 4 are in good agreement. Due to the different C1 and C2 values used in this 3-dimensional case, a significant difference is obtained for the number of members assigned to Pleiades and IC 2391 groups. However, the method is shown to be powerful and stable enough to detect moving groups and give their mean kinematical characteristics.

[5] available by http://science.springer.de/aa/aa-main.htm

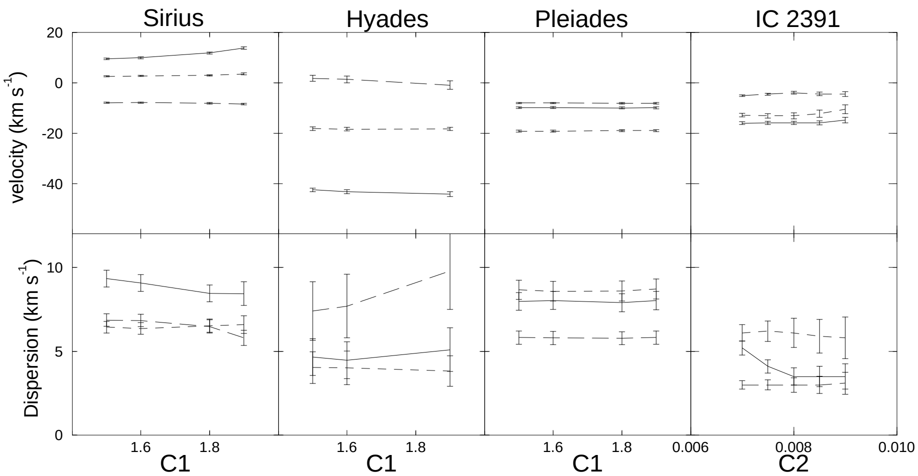

Fig. 11. Means and dispersions of the U *(solid line)*, V *(dashed)* and W *(long dashed)* for the Sirius, Hyades and Pleiades moving groups as a function of C1 and for IC 2391 as a function of C2. The error bars correspond to to statistical uncertainties calculated as $\epsilon_x = \sigma_x/\sqrt{N}$ and $\epsilon_{\sigma_x} = \sigma_x/\sqrt{2N}$

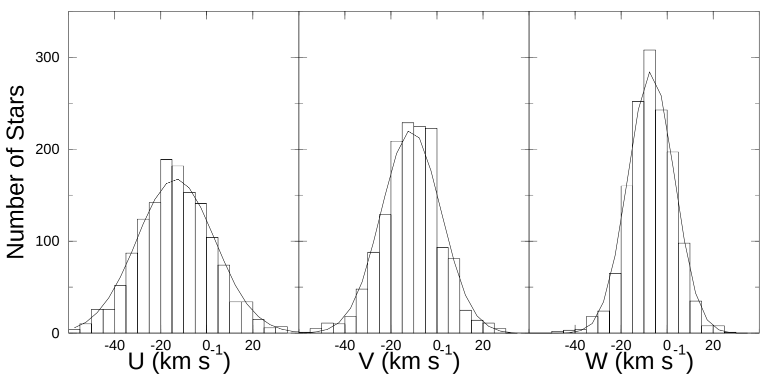

Fig. 12. The histogram of the U, V, W components for the remaining field stars

Table 4. The means and standard deviations (between brackests) of U, V, W components and Age for the four moving groups identified in the 3-dimensional space

U	V	W	Age (10^8 yr)	N	Name
10.8	2.3	-8.1	5.0	253	Sirius
(7.9)	(5.9)	(6.4)	(1.4)		
-45.5	-25.4	0.0	12.5	17	Hyades
(7.7)	(13.0)	(10.3)	(3.0)		
-5.9	-26.5	-6.1	1.1	108	Pleiades
(6.2)	(4.3)	(4.8)	(0.7)		
-20.1	-12.0	-5.2	4.6	259	IC2391
(8.5)	(5.6)	(4.7)	(1.6)		

5.3. The observational errors

Up to now, we have not considered the influence of the observational errors in our procedure. For this purpose, we have generated 20 sets of 1924 stars (the same number as our real sample) by adding an increment $(\Delta\mu_\alpha, \Delta\mu_\delta, \Delta V_r, \Delta M_v)$ to the real values of each star. Each of these increments has been randomly chosen from a normal distribution of zero mean and standard deviation equal to the individual observational error. We have applied all the procedure presented in Sect. 5.1 – four dimensional space – to each simulated sample and their mean and standard deviation are presented in Table 5. Sirius, Pleiades and IC2391 apear in all cases, whereas Hyades is only detected in four of them as expected from its poor representation in the sample. A significant difference is obtained for the mean W component of the Hyades moving group. Even including this late group, we can confirm that the observational errors do not change the mean kinematical parameters and ages we have previously obtained.

5.4. Discussion

We can compare our results of Table 3 for the 4-dimensional case to the more recent results of Eggen (1991, 1992a, b, c), using the FK5 catalogue, and to the work of Palouš and Hauck (1986) and Bubeníček et al. (1985), with the Palouš (1983) catalogue of A type stars. Eggen has discussed the four moving groups and found a mean motion of (14.9, 1.3, -11.2),(-40.0, -17.0, -2.0), (-11.6, -20.7, -10.4) and (-20.8, -15.9, -8.3) km s^{-1} for Sirius, Hyades, Pleiades and IC2391, respectively. Palouš and Hauck (1986), from their sample of 927 A stars, found a mean motion of (11.1,3.3,-8.2) km s^{-1} for Sirius, and using the same sample, Bubeníček et al. (1985) found (U,V,W) = (-41.3,-20.9,-5.8) km s^{-1} for Hyades moving group. The mean motions of the four moving groups in this paper are in good agreement with previous results. Our results indicate that the W component of the moving groups is not significantly different from that of the field, so very little information to separate the moving groups is added by this component. This seems to correspond to the decoupling of the perpendicular motion respect

Table 5. Influence of observational errors: Means and standard deviations from 20 simulated samples

U	σ_U	V	σ_V	W	σ_W	age (10^8 yr)	σ_{age}	N	Name
-13.7	17.1	-12.0	13.4	-7.0	11.0	8.6	0.4	1530	field
± 0.9	± 0.4	± 0.7	± 0.2	± 0.2	± 0.2	± 0.0	± 0.0	± 43	
12.0	8.9	3.5	6.9	-7.3	6.8	6.9	3.4	239	Sirius
± 1.2	± 0.6	± 0.8	± 0.6	± 0.8	± 0.6	± 0.2	± 0.4	± 58	
-47.7	5.9	-21.5	5.2	10.0	8.8	11.6	3.3	20	Hyades
± 1.5	± 0.5	± 3.4	± 1.0	± 8.8	± 2.6	± 2.4	± 1.0	± 9	
-11.2	10.0	-18.2	8.9	-7.1	6.1	0.8	1.4	147	Pleiades
± 1.1	± 2.1	± 1.1	± 0.6	± 0.7	± 0.5	± 0.3	± 1.1	± 25	
-16.0	5.5	-9.5	4.3	-5.7	3.1	4.0	1.3	90	IC2391
± 3.0	± 1.6	± 2.0	± 1.1	± 1.1	± 0.7	± 0.7	± 0.6	± 69	

to the plane-one. The Hyades moving group is an exception: although we have few members, our results coincide with the value found by Eggen, which is significantly different from that of the field.

In this investigation, we find a higher velocity dispersion for the moving groups than in previous works. Since our kinematic data are basically taken from the Hipparcos Input Catalogue, we believe that our propagated errors are no larger than previous works (Palouš & Hauck 1986, Eggen 1991, 1992a, b, c) so, the difference must be due to the algorithm used to extract the members. We judge the membership without any preknowledge of the moving groups and we believe that it is better not to make any assumption before understanding the formation and the physical properties of these stellar streams. When comparing the mean observational errors of our sample, $(\epsilon_U, \epsilon_V, \epsilon_W)$ = (4.45, 4.16, 3.92) km s^{-1} (see appendix A[6]), with the velocity dispersion ellipsoid obtained for each moving group $(\sigma_U, \sigma_V, \sigma_W)$ (see Table 3), we realize that the intrinsic velocity dispersion of these groups is higher than considered up to now by several authors. In this way, Casertano et al. (1993), following dynamical arguments, make it plausible that superclusters have a velocity dispersion of several km s^{-1}. Mendez et al. (1992), from a proper motion survey, also obtained a large tangential velocity dispersion for Hyades and Sirius moving groups.

We have compared our list of Sirius members with Table 1 of Palouš and Hauck (1986); among the 101 members they found, 46 stars are in our total sample, the rest being peculiar or variable stars, explicitly excluded from our compilation. We have found that 45 of this 46 are classified by us as moving group members, indicating a high degree of coincidence between the two procedures.

The age of Sirius (6.5 ± 3.1· 10^8yr) is slightly greater than that found by Palouš and Hauck (4.9 ± 1.3·10^8yr) and Soderblom and Mayor (1993) (3 · 10^8yr). For the Pleiades supercluster, Eggen (1992a) stated that the members appear to cover the age range from about 6·10^6 to about 6·10^8yr. With several "well defined" members, he found an age between 4 to 7·10^7yr; we find a mean age of 7 ± 4·10^7yr. Eggen pointed out that the Hyades moving group includes at least three age groups with ages between 3 and 8·10^8yr; this is the lower-limit of our estimation (13.3 ± 4·10^8). Finally, the age he derived for IC2391 is between 8·10^7 to 2.5·10^8yr, lower again than our estimation (2.8 ± 0.4·10^8yr). Our ages are always greater than Eggen's values; as our values come from more recent and accurate stellar evolutionary models, they should be more reliable.

The mean δm_1 computed with our Sirius stars with spectral type later than A2 is 0.015 ± 0.020 mag. Using the relation given by Smalley (1993) we find a mean metallicity of [Fe/H] = −0.08 ± 0.21 for this supercluster, very close to the value obtained by Soderblom and Mayor (1993) (-0.08 ± 0.09) and in the same sense than that given by Cayrel de Strobel and Delhaye (1983) ([Fe/H] = -0.16).

For the resulting field, we have derived an unbiased velocity ellipsoid centered at (U,V,W) = (−13.4 ± 0.4,−11.1 ± 0.3, −6.9 ± 0.2) km s^{-1} with dispersions (16.9,12.8, 9.9) km s^{-1}. In Fig. 12 we present the histograms of the three components of the velocity fitted by their corresponding gaussian distributions. As assumed, the normal distributions for the field are perfectly achived. Our mean U velocity component is larger than the classical value (Delhaye, 1965) and also larger than that given in Table 1 for the total sample. This is due to the extraction of the Sirius moving group, which has a clearly positive mean U (see Table 3). We find that the Sun is moving toward the galactic center at 13.4 km s^{-1}. Shuter and Goulet (1983) reanalyzed the velocities of groups of nearby stars using a full least-square analysis and taking into account the local velocity gradients, and found an average values of the solar motion of (14 ± 2, 13 ± 2, 5 ± 2) km s^{-1}, which is in good agreement with our present results. Recently, Jaschek and Valbousquet (1991) determine the solar motion using 5800 stars from the Bright Star catalog. They found a solar motion of 11.3 ± 0.8 km s^{-1}, and Kuijken & Tremaine (1991), using the Gliese (1969) catalogue of nearby stars, found a solar motion of 11.4 ± 1.0 km s^{-1}. Our results confirm the tendency to enlarge the value of the U_o component respect to the classical studies.

6. Conclusions

An extended data base of main sequence B, A and F stars, extracted basically from the Hipparcos Input Catalogue, has been used to investigate the presence of moving groups in the sample.

Respect to previous works, the method developed in this paper has the advantadge that it simultaneously identifies the

[6] available by http://science.springer.de/aa/aa-main.htm

moving groups without assuming any *a priori* knowledge about their existence, shape or mean kinematical parameters.

We have confirmed the existence of four moving groups near the Sun. They have been well identified with Sirius, Hyades, Pleiades, and IC2391 superclusters, discussed by other authors. We have compared our results with previous investigations, the most significant differences being the large velocity dispersions of the moving groups and the fact that 26% of the stars of our sample belongs to such stellar streams. As a result of the identificiation of moving groups, an unbiased background field has been obtained with a mean velocity of (U,V,W) $=(-13.4\pm0.4,-11.1\pm0.3,-6.9\pm0.2)$ km s^{-1} and dispersions (16.9,12.8, 9.9) km s^{-1}.

The separation of stellar streams is extremely interesting because it provides important clues to study the kinematics of young stars in the solar neigbourhood. The vertex deviation, the age-velocity relation and the heating of the disc, among others, are problems that can be better understood once the moving groups are identified (Chen et al., 1996).

On the other hand, a good knowledge of their physical characteristics such as metallicity and age may help us to understand the process of star formation, evolution and dissociation of these groups.

We plan to use the field stars of our sample to derive the age-velocity relation for stars younger than $2\cdot 10^9$ years, and to analyze the disk heating problem. Moreover, the members of the moving groups will be used to study their possible origin and evolution until their present status.

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