Young stellar kinematic groups and their relation with young open clusters, star forming regions and the Gould Belt

D. Montes
Departamento de Astrofísica, Univ. Complutense de Madrid, Spain

Abstract.

Stellar kinematic groups (SKG) are kinematically coherent groups of stars that share a common origin. We have compiled (Montes et al. 1999; 2000) a sample of late-type stars of previously established members and possible new candidates to different young SKG (Local Association (20 - 150 Myr), Ursa Mayor group (300 Myr), Hyades supercluster (600 Myr), IC 2391 supercluster (35 Myr) and Castor Moving Group (200 Myr)). In order to better understand the origin of these young SKG, and to be able to identify late-type stars members of the classical and the recently identified SKG, we also need to study the kinematic properties of nearby young open clusters and star forming regions. With this aim we have taken the most recent data available in the literature (including astrometric data from Hipparcos Catalogue) of the nearby young open clusters, OB associations, T associations, and other associations of young stars as TW Hya. We use these data to calculate their Galactic space motions (U, V, W) and space coordinates (X, Y, Z) and study their possible association with the different SKG as well as with the young flattened and inclined Galactic structure known as the Gould Belt.

1. Introduction

It has long been known that in the solar vicinity there are several kinematic groups of stars that share the same space motions that well know open clusters. These stellar kinematic groups (SKG), called moving groups (MG) or superclusters (SC), are kinematically coherent groups of stars that share a common origin (the evaporation of a open cluster, the remnants of a star formation region or a juxtaposition of several little star formation bursts at different epochs in adjacent cells of the velocity field). The youngest and best documented SKG are: the Hyades supercluster (600 Myr, Eggen 1992b) the Ursa Mayor group (Sirius supercluster) (300 Myr, Eggen 1992a, 1998; Soderblom & Mayor 1993), the Local Association or Pleiades moving group (20 to 150 Myr, Eggen 1992c), the IC 2391 supercluster (35-55 Myr, Eggen 1995), and the Castor moving group (200 Myr, Barrado y Navascués 1998). Since Olin Eggen introduced the concept of moving group and the idea that stars can maintain a kinematic signature over long periods of time, their existence has been rather controversial. However, recent studies (Dehnen 1998; Chereul et al. 1999; Asiain et al. 1999; Skuljan et
Figure 1. In the left panel we plot the (U, V) diagram for a sample of late-type stars (Montes et al. 1999, 2000) identified as members (filled symbols) or possible members (open symbols) of different young stellar kinematic groups (represented by different symbols and colors). Big crosses are plotted in the central position of each group. The black dashed line represents the boundaries that determine the young disk population as defined by Eggen (1984, 1989). The color dotted-dashed rectangles represent the regions enlarged in Fig. 1, to 3. The positions of nearby young open clusters (⊙) and OB associations (⊕) are also plotted in this diagram. The right panel is an enlargement of the (U, V) diagram in the region of the Local Association.

al. 1999) using astrometric data taken from Hipparcos and different procedures to detect MG not only confirm the existence of classical young MG, but also detect finer structures in space velocity and age. Well known members to these moving groups are mainly early type stars and few studies have been centered in late-type stars. We have compiled (Montes et al. 1999, 2000) a sample of late-type stars (single and spectroscopic binaries) of previously established members and possible new candidates to these five young SKG.

In order to better understand the origin of these young MG, and to be able to identify late-type stars members of the classical and the recently identified MG and substructures, one also need to study the kinematic properties of nearby young open clusters and star forming regions. With this aim I have calculated the galactic space-velocity components (U, V, W), using the most recent data available in the literature (including astrometric data from Hipparcos Catalogue), of the nearby young open clusters (Robichon et al. 1999), OB associations (de Zeeuw et al. 1999), T associations, and other associations of young stars as TW Hya (Webb et al. 1999). The position of these different young structures in the UV and WV diagrams is compared with the position of the classical MG as well as with the position and associated velocity dispersion of the new substructures recently found by Chereul et al. (1999) and Asiain et al. (1999). Finally, the possible relation of all these young stars concentrations
with the young flattened and inclined Galactic structure known as the Gould Belt has also been analysed.

2. Young Open Clusters and OB Associations

Mean astrometric parameters of nearby young open clusters ($d < 500$ pc) have been taken from Robichon et al. (1999), from Perryman (1998) for the Hyades, Scholz et al. (1999) for IC 348 and Platais et al. (1998) for a Car. These mean parallaxes and proper motion have been computed using Hipparcos data (ESA, 1997). For other young open clusters with no Hipparcos data parameters have been taken for differences sources (Palous et al. 1977). Other clusters (as $\delta$ Lyr (Eggen 1968, 1972, 1983) and NGC1039 (Eggen 1983a)) cited in the literature as probably associated with some SKG have also been included here.

Table 1. list all the open clusters included in this study in order of increasing age. I give the name, age (Myr), distance (pc), metallicity, $[\text{Fe/H}]$, coordinates (FK5 1950.0), and the U, V, W, calculated components with their associated errors in km/s. Age, distance, and metallicity have been taken from different sources as given at the end of the table. Galactic space-velocity components (U, V, W) in a right-handed coordinated system (positive in the directions of the Galactic center, Galactic rotation, and the North Galactic Pole, respectively) and their associated errors have been calculated using the procedures given by Johnson & Soderblom (1987).

For nearby OB associations we adopt the space velocities (U, V, W) calculated by de Zeeuw et al. (1999) using mean astrometric parameters from Hipparcos (ESA, 1997).

\footnote{Table 1 available at \url{http://www.ucm.es/info/Astrof/oclusters_uvw_tab.html}}
3. Young stellar kinematic groups

The (U, V) velocity components of the five young stellar kinematic groups above mentioned are plotted in Fig. 1 (left panel). All these groups fall inside the boundaries (black dashed line in Fig. 1) that determine the young disk population as defined by Eggen (1984, 1989). The different inner structures found by Chereul et al. (1999, C99 hereafter) and Asiain et al. (1999, A99 hereafter) in these MG, as well as possible new MG identified by these authors are plotted in Fig. 1 to 3. The dashed ellipse plotted for each structure represents the associated velocity dispersion. The position of the clusters and OB associations in the UV diagram is plotted in Fig. 1 (left panel). The dotted ellipse plotted around each open cluster position represents the associated errors in U and V. Each cluster and OB associations is identified with its name in figures 1 to 3.

**Local Association**

Several clusters and associations have been suggested as members of the Local Association (LA): The southern concentrations NGC 2516, IC 2602, Upper Centaurus Lupus (UCL) and Upper Scorpion (US) (Eggen 1983a) and the northern concentrations α Per, Pleiades, NGC 1039, δ Lyr (Eggen 1983b). In Fig. 1 (right panel) we can see that the U, V velocities of all these open clusters are close to the U, V velocities of the LA, except NGC 1039 whose velocities fall even outside of the young disk boundaries. Other clusters that can also be associated to this MG are IC 4665 and a Car. The OB association UCL and Cas-Tau 1, and the structure associated to Centaurus Lupus by C99 have velocity components close to the LA, but US and Cep OB6 has U, V velocities a bit different. A99 found four substructures (B1, B2, B3 and B4) of different ages associated to the LA. As it can be seen in Fig. 1 (right panel) these structures fall well around the central position of the LA. B1 and B2 are the youngest structures and seems to be related with IC 2602, IC 4665, UCL, Cas-Tau 1 and TW Hya. B4 is associated to the Pleiades cluster, and the oldest structure B4 could be related with NGC2516. The two structures (1 and 2) found by C99 have also velocity components close to the LA.

**IC 2391**

In Fig. 2 (right panel) it can be seen that the velocity components of the IC 2391 open cluster as well as the substructures associated by C99 and A99 to the IC 2391 supercluster are above the (U, V) position given for this supercluster. Close in velocity space to IC 2391 open cluster and the substructures there are (see Fig. 2 right panel) a large concentration of open clusters: NGC 2264, NGC 2232, NGC 2547, IC 348, NGC 2532, Col 140, NGC 1901, Col 121. Other cluster as NGC 2422, NGC 2451 and Tr 10 (and Tr 10 OB association) are not in the mentioned concentration but could be related with IC 2391 supercluster.

**Castor moving group**

Fig. 3 (left panel) is centered in the (U, V) velocities of the Castor moving group. The structure associated to Centaurus Crux by C99 have a very large velocity dispersion and fall in this region together with the OB associations Lower Centaurus Crux (LCC), Cas-Tau 2, and Col 121. The velocity components of the groups c1, c3, and C1 found by A99 are more close to Cas-Tau 2 association than to the Coma Berenices open cluster (see Fig. 3 left panel).

**Ursa Mayor group**

The open cluster NGC 7091 was suggested by Eggen as possible related with
the Ursa Mayor group, but as it can bee seen in Fig. 3 (right panel) its (U, V) components are very far from the center of the group. Other cluster not related with the group is IC 4756. Four substructures (a1, a2, a3, a4) have been found by A99 in this region. a1 y a2 have U component lower than the Ursa Mayor group and are close to the OB association Cep OB2. a34 have a very low U component and is more close (see Fig. 3 right panel) to the new supercluster identified by C99. The substructures 1 and 2 of C99 have (U, V) components very close to the Ursa Mayor group.

**HYADES SUPERCLUSTER**

The Hyades and Praesepe open clusters have velocity components very very close to the (U, V) components of the Hyades supercluster (see Fig. 2 left panel). Eggen (1996) assumed the NGC 1901 cluster as a component of the Hyades supercluster, however as it can be seen in Fig. 2 (left panel) the (U, V) components of the open cluster and of the substructure associated to NGC 1901 by C99 are very different from the supercluster velocity components. At (U, V) velocities intermediate between the supercluster and NGC 1901 is where C99 found substructures Hyades 1, 2 and 3 and A99 found the substructures d1, d2 and D.

4. **The Gould Belt**

The Gould Belt (Gould 1879; Pöppel 1997) is a ring-like, expanding, flattened and inclined Galactic structure outlined by OB associations, molecular gas, star forming regions and young galactic clusters. Recently, Guillout et al. (1998a, 1998b) discovered a galactic latitude enhancement of X-ray active stars consistent with the Gould Belt. Detailed analysis of the surface density, distance and X-ray luminosity distributions led these authors to conclude that these stars are distributed in a disk disrupted near the Sun (Gould disk). Wichmann et al. (1997) have also found that the spatial distribution of the ROSAT discovered
WTTS stars near Lupus, perpendicular to the galactic plane, is centered on the Gould Belt. Many of the young stars concentrations analysed here are associated with the Gould Belt and therefore this galactic structure could also be the origin of the young moving groups (for a detailed analysis see Montes (2000, in preparation).

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