New moving groups members in the RasTyc sample

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We present kinematical properties of X-ray sources identified as field late-type stars with good Tycho/Hipparcos parallaxes and for which we have acquired high-resolution spectroscopic observations. These presumably young stars were selected as optical counterparts of ROSAT All-Sky Survey (RASS) sources by means of the cross-correlation of the RASS and TYCHO catalogues (called the *RasTyc* sample). During the last 20 years, many studies have shown that a fraction of X-ray active and lithium-rich stars are members of young stellar kinematic groups (SKGs). Presently, the SKGs are mainly defined by early-type stars and few studies have focused on the late-type stellar component so far. We have therefore developed two methods based on the space-velocity coordinates (*U, V, W*) to determine the membership of our candidates to already known moving groups. The reliability of our methods was tested with Monte Carlo simulations and compared with results derived using Eggen's kinematic criteria. Chromospheric activity level and lithium abundance were subsequently used to confirm membership for candidates with high probability entries. The identification of a significant number of late-type members of young SKGs would be extremely important to investigate deviations from local mean star formation history during the last billion years and to search for exoplanets just after the planetary formation stage.

I) Moving groups and *RasTyc* sample

- **Moving groups (MGs):** During the last 20 years, many studies (see, e.g., Jeffries *1995;* Montes et al. *2001*) have shown that a fraction of X-ray active and lithium-rich stars are members of young stellar kinematic groups which are kinematically coherent and composed of stars with a common origin (e.g. the evaporation of an open cluster). The main and best documented SKG are listed by Montes et al. (*2001*, Table 1). Eggen (*1994*) defined the *supercluster* as a gravitationally-unbound group of stars with the same kinematics occupying extended regions of the Galaxy and the *moving group* as the part of a supercluster that enters the solar neighborhood and can be observed all over the sky.
- **Sample:** The *RasTyc* sample is the result of the cross-correlation of the ROSAT All-Sky Survey with the Tycho catalogue (Guillout et al. *1999*) and represents the largest (≈14 000 active stars) and most comprehensive set of late-type stellar X-ray sources constructed so far. Presently, the confirmed members of the known SKG are mainly early-type stars and few studies have focused on late-type stellar component. Thus, we have started a campaign of spectroscopic observations aimed at a deep characterization of a representative sub-sample of the *RasTyc* population in the northern hemisphere. The first results from this ambitious ground-based observing program are presented by Guillout et al. (*2009*).

II) Membership methods and Monte Carlo simulations

We have developed two probabilistic methods (Klutsch et al. *in prep*) based on the space-velocity coordinates (*U, V, W*) to determine the membership's probability of our candidates for each of five well-known stellar kinematics groups :

- **3D Method:** we defined the locus of each MG in the (*U, V, W*) velocity space. Accounting for the typical spreads in *U, V,* and *W* coordinates, we have fitted each velocity distribution with one Gaussian (Fig. 1) whose properties allow us to compute the membership's probability P_{3d}.

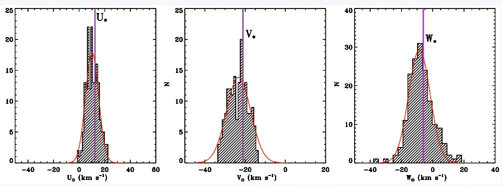
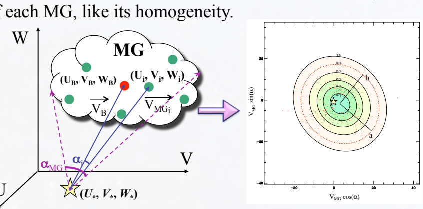


Fig.1. *U, V,* and *W* (left to right) velocities distribution of known Pleiades MG members. Gaussian fits to the velocities distribution (full red lines) and the star candidate velocity components (P_{3d} = 94.7 %; vertical purple lines) are shown as well.

- **2D Method:** We characterized the MG through its centroid in the (*U, V, W*) space and defined a new coordinate system (V_{MG}, α) as illustrated in Fig. 2 (left panel). Conceptually, a candidate has a greater chance to be a new MG member, if the distances V_B to the MG centroid and V_{MGi} to each member of the MG are small and the maximum angle α_{MG} is close to 360°. Contrariwise, if these distances are very large and α_{MG} is very small, a star can not be physically associated to the MG studied. On this basis, we can study the configuration of the vector V_B with each vector V_{MGi} forming a plane in which the above membership criteria can be given. Finally, we grouped them into the single ($V_{MG}\cos\alpha$, $V_{MG}\sin\alpha$) space (Fig. 2, right panel). We fitted this new distribution with a two-dimensional Gaussian determining the best orientation of the major and minor ellipse axis (*a* and *b*, respectively). As for the 3D Method, we computed the membership's probability P_{2d} based on the 2D Gaussians properties. With this second method, a new parameter (i.e. the angle α_{MG}) allow us to obtain a better knowledge of each MG, like its homogeneity.

Fig.2. *Left*: (V_{MG}, α) coordinate system. *Right*: MG candidate and members loci in the ($V_{MG}\cos\alpha$, $V_{MG}\sin\alpha$) coordinate systems. The probability contours and the membership threshold fixed at 10% are also shown with solid lines and a dashed line, respectively. The (a,b) space, defined by this method, is indicated as well.

Symbols : (●) MG centroid, (●) MG members and (☆) MG candidate.



- **Monte Carlo simulations:** We used them to test the reliability of our *2D Method* for each MG. According to *3D Method* membership's criteria, we created two samples (MG members and non-members) each one consisting in 2 000 sources. We list in Table 1 the fraction of sources for which the results of our methods are consistent. Our both tools are in agreement in more than 90% of cases. While the *3D Method* allows to find new MG members within the MG locus, the *2D Method* gives more quantitative confidence levels thanks to both criteria used.

Samples	MGs				
	Pleiades	IC2391	Castor	UMa	Hyades
Members	92.3 %	78.6 %	95.1 %	98.1 %	91.2 %
Non-members	96.6 %	99.6 %	93.2 %	86.4 %	90.5 %

Table 1. The fraction of sources for which our both methods are consistent.

III) New moving groups members

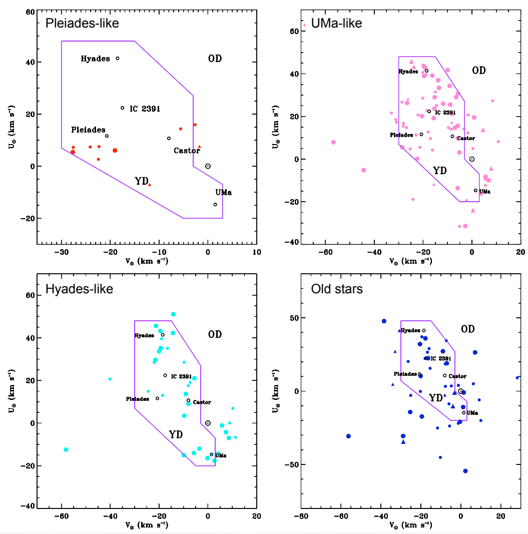
- From the optically bright sample of *RasTyc* sources (Guillout et al. *2009*), we selected stars classified as single stars or with one radial velocity measurement for compiling their all data from the literature. Finally we computed the space-velocity components of 173 single stars.
- We applied our methods to assess membership of all these stars –classified as *PMS-like*, *Pleiades-like*, *UMa-like*, *Hyades-like* and *Old* sources based on the lithium content (see Guillout et al. *2009*)– to the 5 MGs reported in Table 1. Results of *PMS-like* stars are presented by Guillout et al. (*2009*) and those for other groups in the Table 2 and on Fig. 3.
- We found that the lithium-richest stars are associated with the youngest MGs (Table 2), while the lithium-poor stars have rather kinematics consistent with those of the oldest MGs. Moreover, the stars with a detectable lithium line are mainly associated with a known MG.
- As expected, we also found that a large fraction of old and evolved stars is located outside the young-disc locus despite of their lithium content.
- Combined with Eggen criteria, 27 and 15 are highly probable members and good candidates.

Sample	Number of stars	Young disc (YD) MGs (in %)					Membership (in %)
		Pleiades	IC2391	Castor	UMa	Hyades	
PMS-like	7	72	0	14	0	0	86
Pleiades-like	10	60	0	20	0	0	80
UMa-like	75	16	11	7	9	17	60
Hyades-like	34	6	6	12	18	26	68
Old	47	2	6	0	4	11	23

Table 2. Comparison of the age class of stars and the MGs founds with our procedures. We list the number of possible new members for each age class and their distribution to the various MGs studied here.

Fig.3. *U-V* space velocities diagram of the *Pleiades-like*, *UMa-like*, *Hyades-like* and *Old RasTyc* sources. On each panel, we plotted stars with accurate distance ($\sigma_\pi/\pi \leq 0.2$) with big symbols. We used a small symbol when we computed their kinematics from a determination of their photometric distance according to their classification as a main-sequence (filled circles) star or an evolved (filled triangle) star. The locus of the young-disc (YD) and the old-disc (OD) populations are also indicated. The mean velocity components of late-type MG members (Montes et al. *2001*) are plotted (opened circles) as well. Their ages were listed by López-Santiago et al. (*2009*):

Pleiades : 10-200 Myr
IC2391: 80-250 Myr
Castor: ~200 Myr
UMa;~300-500 Myr
Hyades: ~600 Myr



IV) Conclusions and perspectives

- Together with stellar parameters (Teff, logg, [Fe/H], vsin i, Li abundance, activity), the kinematic methods we have developed allowed us to **identify new MG members** (Klutsch *2008;* Guillout et al. *2009*) and to **quantify the contamination of young MGs by old main-sequence stars** (López-Santiago et al. *2009*).
- We found a possible new young association (Guillout et al. *2010*; Klutsch et al. poster in this session) and we continue to **search for new unknown young co-moving groups**.
- The identification of late-type members of young MGs is extremely important to **investigate deviations from local mean star formation history** during the last gigayear and to **search for exoplanets just after planetary formation stage**.
- Moreover, a statistical comparison of similar **star samples** will be of valuable interest to better **understand the kinematics of young field stars** in relation with already known or new young MGs (López-Santiago et al. *2006*).

References : Eggen, O. J. 1994, "Galactic and Solar System Optical Astrometry". Cambridge Univ. Press, p. 191; Guillout, P., et al. 1999, A&A, 351, 1003; Guillout, P., et al. 2009, A&A, 504, 829; Guillout et al. 2010, A&A, accepted; Jeffries, R. D. 1995, MNRAS, 273, 559; Klutsch, A. 2008, PhD Thesis, ULP and Strasbourg Observatory; López-Santiago, J., et al. 2006, ApJ, 643, 1160; López-Santiago, J., et al. 2009, A&A, 499, 129; Montes, D., et al., 2001, MNRAS, 328, 45

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