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Young Nearby Loose Associations

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Abstract. A significant population of stars with ages younger than the Pleiades exists in the solar neighborhood. They are grouped in loose young associations, sharing similar kinematical and physical properties, but, due to their vicinity to the Sun, they are dispersed in the sky, and hard to identify. Their strong stellar coronal activity, causing enhanced X-ray emission, allows them to be identified as counterparts of X-ray sources. The analysis presented here is based mainly on the SACY project, aimed to survey in a systematic way counterparts of ROSAT all-sky X-ray sources in the Southern Hemisphere for which proper motions are known. We give the definition, main properties, and lists of high-probability members of nine confirmed loose young associations that do not belong directly to the well-known Oph-Sco-Cen complex. The youth and vicinity of many members of these new associations make them ideal targets for follow-up studies, specifically geared towards the understanding of planetary system formation. Searches for very low-mass and brown dwarf companions are ongoing, and it will be promising to search for planetary companions with next generation instruments.

1. Introduction

1.1. Overview

In a seminal paper, Herbig (1978) proposed the existence of post-T Tauri stars (pTTS) and established a list of candidates. pTTS follow classical and weak line T Tauri stars (cTTS, wTTS) in an evolutionary sequence. Although they were expected to outnumber the TTS, their discovery or identification remained difficult for a long time. Their relation with another category of young stars – the isolated TTS (young low mass stars found spatially far away from any apparent dark or parental molecular cloud) – remained an open problem. Interestingly, Herbig's list of pTTS and the one of isolated TTS (Quast et al. 1987) were actually quite similar. The most intriguing example was TW Hya, a high Galactic latitude TTS (Rucinski & Krautter 1983) at a distance of at least 13° from the nearest dark clouds and located in a region characterized by the absence of any cloudlets from which it could have originated.

A systematic search for more isolated TTS was pursued with the optical spectroscopic Pico dos Dias Survey (PDS) among optical counterparts of the IRAS Point Source Catalog (Gregorio-Hetem et al. 1992; Torres et al. 1995a; Torres 1999). One of the first results of the PDS was the discovery of four additional TTS around TW Hya (de la Reza et al. 1989; Gregorio-Hetem et al. 1992). They concluded that this group was likely a very young association relatively close to the sun.

Only very few good candidates for isolated TTS were found within the PDS. But while the IR-excess selection criterion effectively finds young stellar objects embedded in their placental material or with circumstellar disks, it fails to signal older objects whose disks have already been dissipated. Therefore, most stars with ages between $\gtrsim 10-70$ Myr (i.e. wTTS and pTTS) escaped discovery by this method.

Due to the enhanced X-ray activity of young stars (Walter 1986), more efficient selection criteria for post and isolated TTS candidates were developed. The high sensitivity and full sky coverage of the ROSAT all-sky survey (Trümper 1982) revealed thousands of new X-ray sources projected in the direction of nearby star forming regions (Guillout et al. 1998). Ground-based spectroscopic follow-up studies showed that a large fraction of these X-ray sources were indeed wTTS together with older pTTS and ZAMS stars (e.g., Alcalá et al. 2000). Surprisingly, many of the newly found weak-line TTS were *not* obviously connected to any molecular cloud region, raising again many questions about their origin (Sterzik et al. 1995).

Based on the similarity of the ROSAT X-ray fluxes, radial velocities, astrometry (Hipparcos) and spectroscopic characteristics of the four stars around TW Hya, Kastner et al. (1997) confirmed that these stars formed a physical association with TW Hya, about 20 Myr old and at a distance of 40 to 60 pc from Earth, which they called the TW Hya Association.

Immediately after the existence of the TW Hya Association was confirmed, several research groups became interested in this association and other members were found (see Section 4). Two main approaches were explored, a first one aiming to study the properties of its members, whereas other groups started to look for similar nearby young associations hidden among the ROSAT X-ray sources.

In 2000, as a result of this effort to find new associations, two new adjacent and similar associations were proposed, in Tucana (Zuckerman & Webb 2000) and in Horologium (Torres et al. 2000). To examine the physical relation between them and to search for other associations, we started the SACY (Search for Associations Containing Young stars) survey (Torres et al. 2006). The SACY sample contains stars:
(i) later than G0, in order to be able to use the Li λ6707 line as a youth indicator (Martín 1997);
(ii) belonging to the TYCHO-2 or Hipparcos catalogs in order to have access to proper motions;
(iii) that are candidate optical counterparts of sources from the ROSAT All-Sky Bright Source Catalogue.

Torres et al. (2006) presented a catalog of 1626 spectroscopically observed stars in the Southern Hemisphere. In Figure 3 we show the celestial distribution of the observed SACY sample, with additional stars observed from 2006 to 2008. The SACY survey is now complete in the Southern Hemisphere (but for four stars) and the updated catalog has 2093 stars. The survey enables us to define properties and membership probabilities for stars in these putative associations. Preliminary results appear in Torres et al. (2003a,b). In Torres et al. (2006), the prototypical methodology and analysis of the β Pic Association is presented and in forthcoming papers (in preparation) a more detailed analysis of other associations found will be given. The Lithium abundances of the nine associations presented in this chapter are studied in da Silva et al. (2008) where they present the lists of the association members.

A similar survey is being pursued in the Northern Hemisphere and the first results are appearing now (Guillout et al. 2008). Only a very low frequency of stars younger than the Pleiades is identified, more than one order of magnitude less than in the SACY survey. This strong hemispheric anisotropy could be explained, at least partially, by taking into account the different survey biases and completeness limits. Anyway, with only five young stars at this moment, the Northern survey does not help to find young associations.

1.2. Method of Analysis

An association is a group of stars appearing *concentrated* together in a small volume in space sharing some common properties such as age, chemical composition, distance and kinematics[1]. However, if such a group is close enough to the Sun, its members will appear to cover a large extent in the sky (as an example, Orion at 50 pc would cover almost the whole sky). Thus, to find a group, projected spatial concentrations (i.e., in terms of right ascension and declination only) and proper motions may not be enough. A better criterion is to look for objects sharing similar heliocentric space motions (UVW) all around the sky (U positive towards the Galactic center, V positive in the direction of Galactic rotation).

Torres et al. (2006) describe the convergence method developed to search for members of an association and a corresponding membership probability model in detail. Both convergence method and probability model examine the stars in the hexa-dimensional space, UVWXYZ, as defined by the space motions relative to the Sun and the physical space coordinates centered on the Sun (XYZ, in the same directions as UVW). We represent with m_v, M_v and $\mathrm{M}_{v,iso}$ the apparent visual magnitude, the resultant absolute magnitude with the distance obtained from the convergence method, and the absolute magnitude given by the adopted isochrone for the $(V-I)_C$ stellar color; and μ_α, μ_δ and V_r are the proper motions and the radial velocity. Briefly explained, if there is no reliable trigonometric distance available[2], the convergence method finds the distance (d) for each star in the sample that minimizes the F value of Equation 1. The first term is a photometric distance modulus and the second is a kinematical one. The method needs, as input, an assumed age and initial velocity values (U_0, V_0, W_0) for the proposed association, and a cutoff value for F above which stars should be considered spurious. This cutoff value varies for each association but usually we begin with 3.5 (this approximately means 0.7 magnitudes for the distance modulus and 3 km s^{-1} for the velocity modulus). The method is iterative, and for each iteration a list of stars with new (U_0, V_0, W_0) is obtained. The process ends when the list of stars and the velocities (U_0, V_0, W_0) do not change significantly.

$$
\begin{aligned}
&F(m_v, \mu_\alpha, \mu_\delta, V_r; d) = \\
&\quad [p \times (M_v - M_{v,iso})^2 + (U-U_0)^2 + (V-V_0)^2 + (W-W_0)^2]^{1/2}
\end{aligned}
\tag{1}
$$

where p is a constant weighting the importance of the evolutionary distance with respect to the kinematic distance. Actually we use $p > 0$ only for the Oct Association, since it has no stars with trigonometric parallax. This means that in general our distances are only kinematical.

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[1] In this sense we prefer to use the term association and not moving group.

[2] We consider the trigonometric parallaxes as unreliable if they have errors larger than 2 mas and we do not use them.

The list of candidates serves as a training set for the probability model (k–NN model, Sterzik et al. 1995). In this model we define around each star of the entire sample 6-dimensional spheres that contain a certain number k of stars. A membership probability is then defined by the proportion of stars in these spheres that belong to the training set. The probabilities depend on the compactness of the association and the field density. Thus, for each association we can define a cutoff probability where we consider the stars as probable members. Using this list of (high) probability members, we return to the convergence method until both lists match. Finally, a possible kinematical member becomes an actual good candidate if its Li content is compatible with the Li depletion for its age (Neuhäuser 1997).

As all the nearby loose associations proposed at this moment can be defined through their properties using SACY stars, membership probabilities for stars suggested elsewhere can be calculated whenever their basic kinematic data are available.

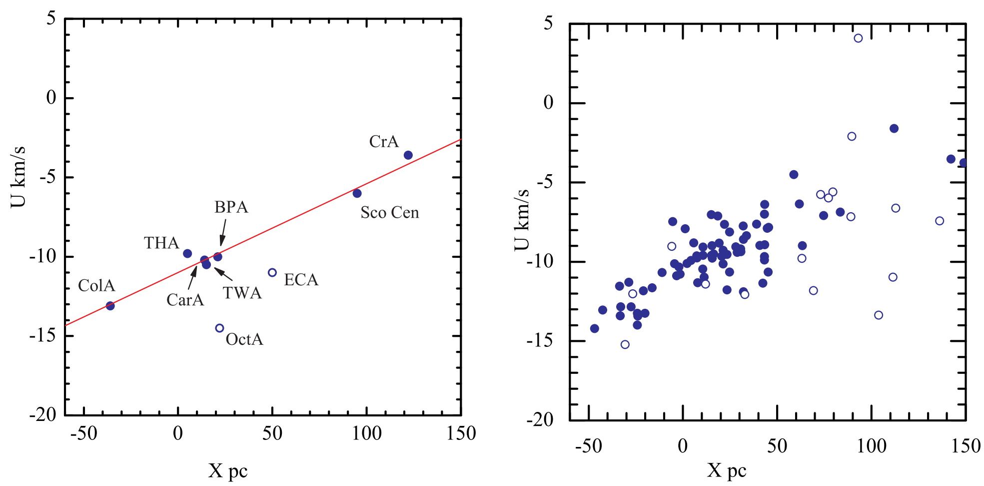

Figure 1. *Left:* The expansion in X direction for the young nearby associations, including the Sco-Cen and the R CrA (CrA) associations using the SACY data. We could not find expansion for the ϵ Cha and the Carina associations, as they are very compact, and any expansion of the Oct Association should be confirmed – see Section 6. The other abbreviations in the figure mean the associations: Columba, Tucana-Horologium, TW Hya, β Pic, ϵ Cha and Octans. *Right:* The expansion of all young stars in the SACY sample with reliable parallaxes. Open circles are stars which are not members of any association.

When analyzing the entire SACY sample, we discovered an unexpected kinematical phenomenon that seems to be a general property of the young stars in the solar neighborhood and affects the application of the convergence method – a positive correlation ($r = 0.99$) between U and X for stars younger than $\sim$30 Myr. The correlation is seen in Figure 1 where, in the left panel, we plot the mean values of U and X derived from the SACY sample for these associations. This correlation can be interpreted as a physical expansion in the X direction.

This is not an artifact from the convergence method. The right panel of Figure 1 shows the observed U and X values for all young SACY stars that have good quality Hipparcos parallaxes. While a strong correlation ($r = 0.98$) of U and X persists for those stars that belong to young associations (filled circles), the correlation is only weak (r = 0.46) for stars that do not belong to any association. Maybe one reason for the difference is the presence of not identified single lined spectroscopic binaries. The expansion is not only seen in the sample of nearby young associations as a whole, but also within each of these associations, with a similar spread of U and X values (Torres et al. 2006). Some young associations have only a small extension in the X axis, and do not allow to determine their expansion (ϵ Cha and Car associations). The Oct Association does not seem to follow the behavior shown in Figure 1, perhaps due to its higher Galactic latitude (see Table 2). For associations older than $\sim$30 Myr this expansion is not present any more (AB Dor and Argus associations; see Table 1).

A similar phenomenon has been reported for a few individual associations, see for example Mamajek (2005) and Bobylev & Bajkova (2007), but the global expansion must be considered first. Unfortunately we have no explanation for the presence of this expansion. It might reflect a more global motion like the Galactic arm epicycle movement which is still conserved from a recent local star formation event, and which has not yet been lost by higher dispersion acquired through Galactic dynamics on a longer timescale.

Regardless of the cause of this expansion, it must be taken into account when searching for kinematical young associations. It can be represented by the relation of Equation 2 that is incorporated in the convergence method in the appropriate cases:

$$U = 0.05(X) - U_0 \tag{2}$$

Reliable isochrones are essential as input to obtain the photometric distance modulus. However, none of the observed sequences can be represented by the published theoretical isochrones for these associations. Thus, to test the star membership, adhoc observational evolutionary sequences were used in the convergence method, represented by third degree polynomials:

For 5 Myr:

$$M_v = 0.60 + 4.98(V-I)_C - 1.16(V-I)_C^2 + 0.193(V-I)_C^3 \tag{3}$$

For 8 Myr:

$$M_v = 1.20 + 4.98(V-I)_C - 1.16(V-I)_C^2 + 0.193(V-I)_C^3 \tag{4}$$

For 10 Myr:

$$M_v = 1.50 + 4.98(V-I)_C - 1.16(V-I)_C^2 + 0.193(V-I)_C^3 \tag{5}$$

For 30 Myr:

$$M_v = 1.18 + 6.28(V-I)_C - 1.68(V-I)_C^2 + 0.248(V-I)_C^3 \tag{6}$$

For 70 Myr:

$$M_v = 0.64 + 7.14(V-I)_C - 2.05(V-I)_C^2 + 0.314(V-I)_C^3 \tag{7}$$

valid in the color interval $-0.1 < (V-I)_C < 3.1$

These heuristic *absolute* ages obtained partially in comparison with pre-main sequence models (Siess et al. 2000) must obviously be taken with caution. Nevertheless, the *relative* ages are real: for example, the TW Hya Association is older than the ϵ Cha Association and younger than the β Pic Association.

1.3. General Results

Almost half of the young stars in the SACY sample belong to the large Oph-Sco-Cen Association (see the chapters by Wilking et al. and Preibisch & Mamajek). In this chapter we discuss nine nearby young loose associations, which are kinematically well defined, but do not belong directly to the Oph-Sco-Cen Complex. Their main characteristics are summarized in Tables 1 and 2. Their distribution in the sky can be seen in polar projection in Figures 3 to 7.

Table 1. Heliocentric space motions and expansion of the nearby associations

Association	U [km s^{-1}]	V [km s^{-1}]	W [km s^{-1}]	Expansion	N
β Pic	-10.1±2.1	-15.9±0.8	-9.2±1.0	yes	48
Tuc-Hor	-9.9±1.5	-20.9±0.8	-1.4±0.9	yes	44
Col	-13.2±1.3	-21.8±0.8	-5.9±1.2	yes	41
Car	-10.2±0.4	-23.0±0.8	-4.4±1.5	no?	23
TW Hya	-10.5±0.9	-18.0±1.5	-4.9±0.9	yes	22
ϵ Cha	-11.0±1.2	-19.9±1.2	-10.4±1.6	no?	24
Oct	-14.5±0.9	-3.6±1.6	-11.2±1.4	no?	15
Argus	-22.0±0.3	-14.4±1.3	-5.0±1.3	no	64
AB Dor	-6.8±1.3	-27.2±1.2	-13.3±1.6	no	89

Table 2. Space distribution, mean distances and ages of the nearby associations

Assoc.	X [pc]	X Range [pc]	Y [pc]	Y Range [pc]	Z [pc]	Z Range [pc]	D [pc]	Age [Myr]
β Pic	20	-32/76	-5	-33/21	-15	-29/-1	31±21	10
Tuc-Hor	3	-61/43	-24	-47/-4	-35	-44/-30	48±7	30
Col	-42	-106/9	-56	-168/1	-47	-99/6	82±30	30
Car	14	-2/33	-94	-154/-39	-17	-33/5	85±35	30
TW Hya	15	2/34	-44	-61/-26	21	10/27	48±13	8
ϵ Cha	50	34/60	-92	-105/-78	-28	-44/-12	108±9	6
Oct	22	-79/142	-106	-138/-60	-68	-85/-38	141±34	20?
Argus	5	-55/64	-115	-154/-6	-18	-67/8	106±51	40
AB Dor	-6	-94/73	-14	-131/58	-20	-66/23	34±26	70

There are interpretations connecting the local young associations with some more global stellar populations, like the Oph-Sco-Cen Complex. A particularly interesting paper is the one by Fernández et al. (2008), in which they propose that both the Sco-Cen Complex and the young local associations originated by the impact of the spiral shock wave against a giant molecular cloud. To clarify the questions opened by these kinds of models, it is fundamental to have a precise definition of each association and a very good way to define their star memberships and, also, their age.

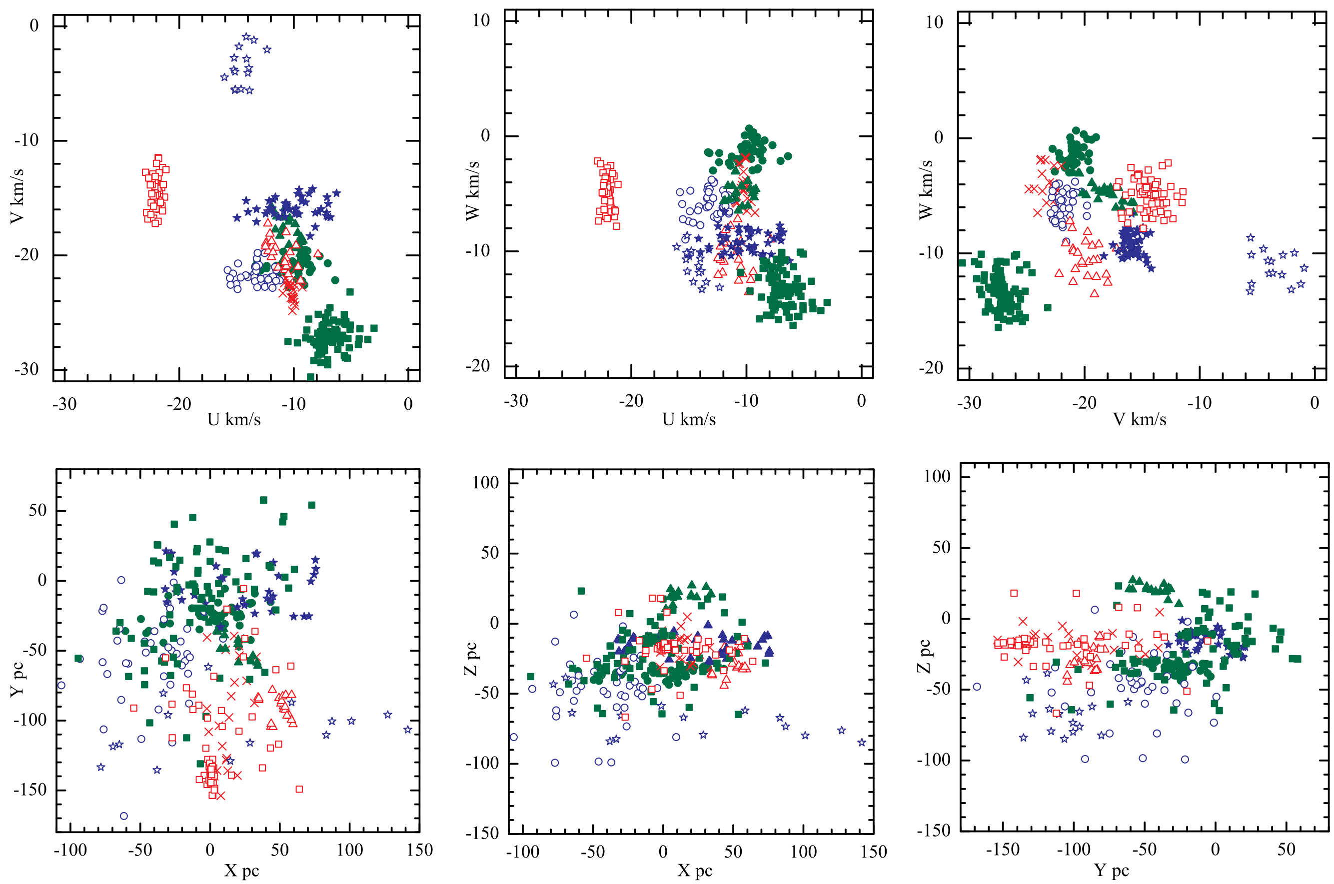

Figure 2. Combinations of the sub-spaces of the UVWXYZ–space for the SACY Associations showing the clusters in both kinematical and spatial coordinates. Associations symbols: filled stars - β Pic; filled circles - Tuc-Hor; open circles - Columba; crosses - Carina; filled triangles - TW Hya; open triangles - ϵ Cha; open stars - Octans; open squares - Argus; filled squares - AB Dor.

A distinct and independent way to obtain the age and the origin of nearby young stars is proposed by Makarov (2007). He traces back in time the Galactic orbits and evaluates near approaches in order to infer close conjunctions and clustering in the past of the stars. He concludes that the majority of nearby young stars were formed during close passages or encounters of their natal clouds with other cloud complexes today located at somewhat larger distances. The method requires excellent kinematical data and depends on the true membership of the proposed star for each association. The ages of the Tuc-Hor and TW Hya associations agree reasonably well for both approaches.

These young associations have remarkably small velocity dispersions ($\approx$1 km per sec, see Table 1). Their sizes are larger than implied from their dispersion velocities and their ages, but they are fully consistent with low-mass star forming regions and OB associations. Most of these associations have a non-spherical distribution, and show distortions that seem age-dependent: the younger ones are almost spherical (ϵ Cha and TW Hya associations), the ones with intermediate age are extended in X direction (β Pic, Oct, Tuc-Hor associations) while the older ones in Y direction (Car, Col, Argus and AB Dor associations). If we approximate them with spheres, they will be within a radius of 25 pc for the ϵ Cha and the TW Hya associations, 40 pc for the Tuc-Hor Association, 60 pc for the β Pic, the Car and the Col associations, and 100 pc for the Oct, the Argus, and the AB Dor associations.

The important review on nearby young stars and their properties by Zuckerman & Song (2004b) presents five associations known at that time (β Pic, Tuc-Hor, TW Hya, η Cha and AB Dor associations) and introduces a new one, ”Cha-Near” [3]. The focus of the present review is the re-definition of their nearby associations and the definition of new ones with the method described above and the significantly increased sample. We emphasize that the strength of our method is the availability of high quality radial velocities and proper motions together with spectral information, which is essential to find the associations presented here. For that the SACY sample is of great importance to better define these associations. Nevertheless it is of almost no help for the ϵ Cha association, which is at the limit of the SACY sample possibilities, with most of the candidates coming from the literature. Therefore, in the next sections, we will present the high probability members of these nine associations and their main characteristics, and, when pertinent, we compare our new definitions with those of Zuckerman & Song (2004b).

As will be more clearly explained in the next sections, the definition of the associations, especially their age, is strongly dependent on their low mass star population. The depth limit of the SACY sample can give low mass candidates only for the associations nearer than $\sim$50 pc. For the more distant associations for which we found no other way to obtain low-mass candidates, their definitions are less reliable.

From Figures 3 to 7 we can see that the Columba, β Pic and AB Dor associations have members in the Northern Hemisphere and surveys in this part of the sky can reveal new members for these associations (and perhaps for the Tuc-Hor Association too). Also other authors are trying to obtain associations or new members, mainly by the convergence point method (see, for example, de Bruijne 1999). Our experience shows that this method has low reliability. Song et al. (2002b) arrive at a similar conclusion in a fruitless search for new TW Hya Association members in a list of candidates proposed by Makarov & Fabricius (2001) using the convergence point method. Another example

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[3] It is very similar to the ϵ Cha Association (that includes the η Cha cluster) defined here, see Section 5.

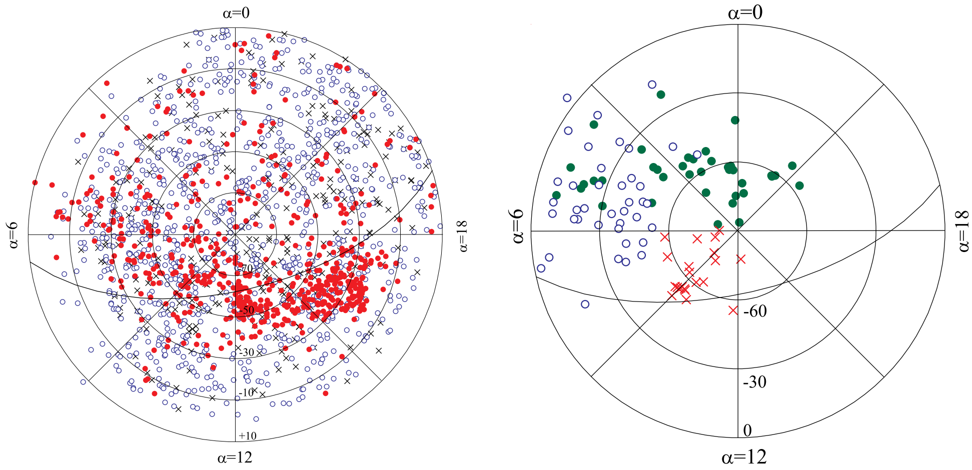

Figure 3. *Left:* Celestial polar projection of the actual SACY observed sample. This projection reaches out to +10°. Young stars are in filled circles. Note the concentration at the Sco-Cen complex (from α 12 to 18). Crosses are giant stars observed in the survey. *Right:* Celestial polar projection of the associations in the GAYA complex (see Section 3): the Tuc-Hor (filled circles), the Col (open circles) and the Car (crosses) associations. The transverse curve represents the Galactic plane.

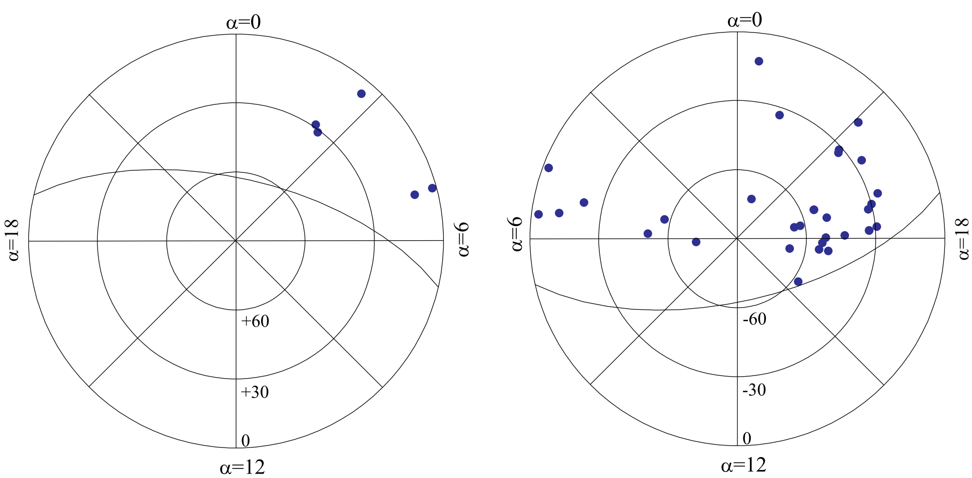

Figure 4. Celestial polar projections of the β Pic Association. *Left:* Northern Hemisphere. *Right:* Southern Hemisphere. The transverse curve represents the Galactic plane.

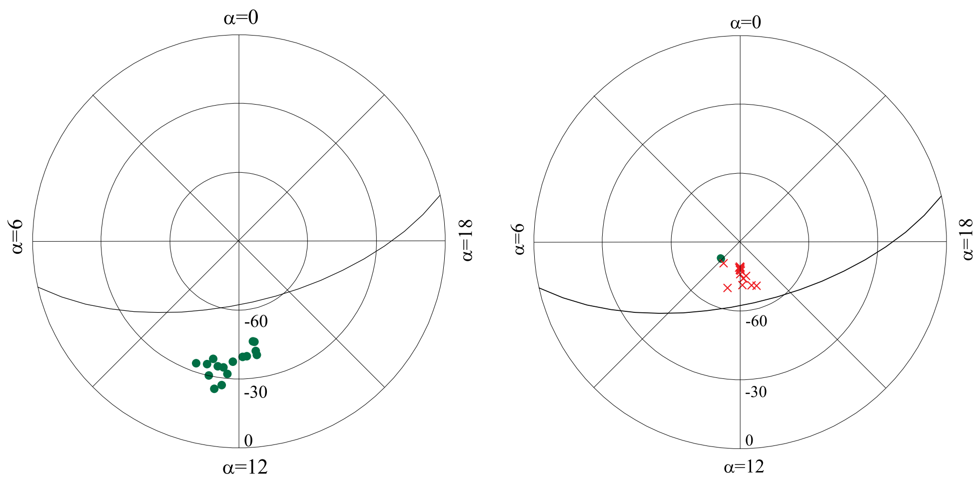

Figure 5. *Left:* Celestial polar projection of the TW Hya association. *Right:* Celestial polar projection of the ϵ Cha Association – the crosses represent the field ϵ Cha Association members and the filled circles the η Cha cluster members. The transverse curve represents the Galactic plane.

is the moving group in Carina-Vela proposed by Makarov & Urban (2000), as it is discussed in Sections 3.3 and 7 that seems to be, at least partially, a mixture of Car and Argus associations.

In some cases, visual binary components (or cluster members) have distinct proper motions or radial velocities. This may result in distinct convergence values, membership probabilities and, sometimes, distances. In the worst cases, only one component is a high probability member, and only this one is presented. Evidently this is an indication that the kinematical data of the system needs to be improved.

Close visual binaries or spectroscopic binaries may deteriorate the quality of the kinematical data. An instructive example is HD 202947 (BS Ind), proposed by Zuckerman & Song (2004b) as a member of the Tuc-Hor Association. It has been observed 11 times in SACY and found to be a double line spectroscopic binary. The Hipparcos catalogue detected an eclipsing binary light curve with a period of 0.435 days. Guenther et al. (2005) studied the radial velocities of BS Ind and found a period of 3.3 years, and the true systemic velocity could finally be derived. (There are also broad peaks in the cross correlation function both from SACY and Guenther et al. (2005) that can be assigned to the eclipsing binary.) Due to its strong Li line BS Ind is considered a young object, but for its space motions (U=+0.1, V=–25.3, W=–8.6) it can not belong to the Tuc-Hor Association or to any of the nearby associations presented here.

The young loose associations, being near to the Sun and having an age distribution from 5 Myr to about 100 Myr, enable studies of stellar physics that depend on the initial phases of the stellar evolution, for example multiplicity, abundances, rotation, stellar activity, etc. Examples of papers on rotation and activity using these associations are de la Reza & Pinzón (2004) and Scholz et al. (2007). A preliminary study (Kastner et al. 2003) of the X-ray emission properties of members of the TW Hya, β Pic and

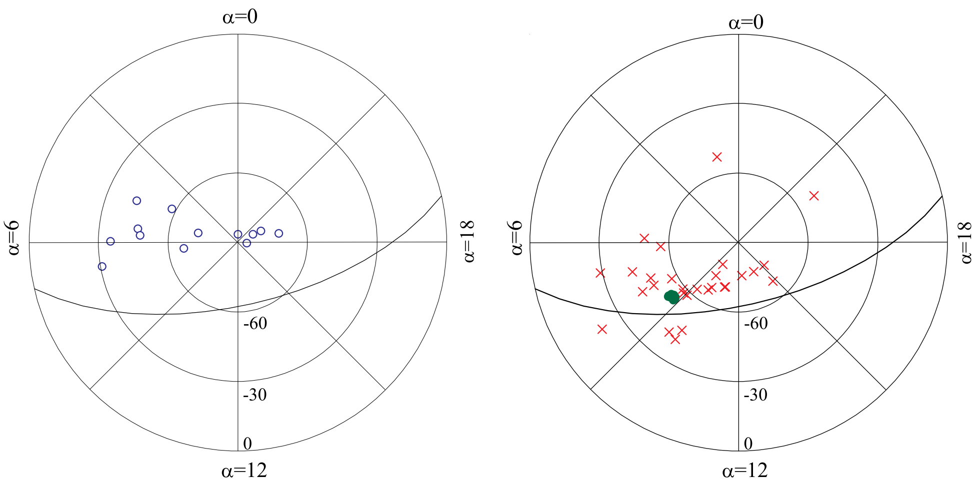

Figure 6. *Left:* Celestial polar projection of the Octans Association. *Right:* Celestial polar projection of the Argus Association – the crosses represent the field Argus Association members and the filled circles the IC 2391 members. The transverse curve represents the Galactic plane.

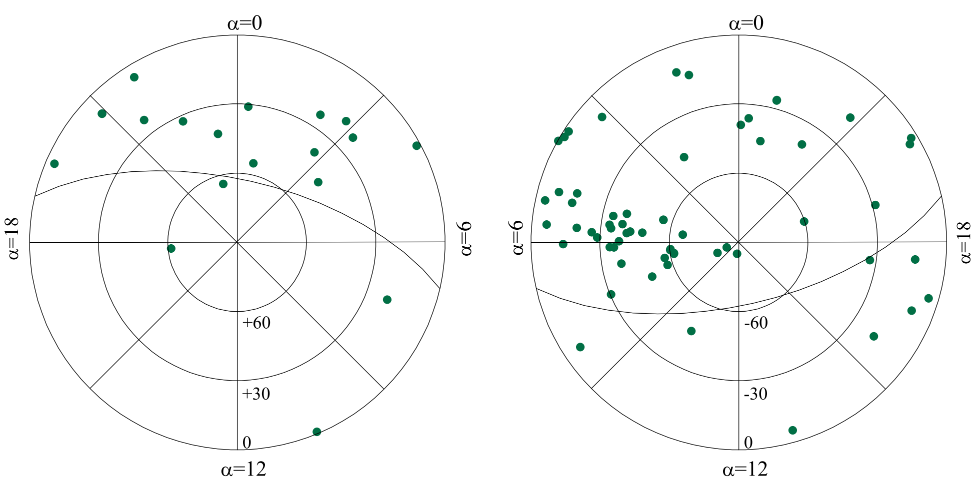

Figure 7. Celestial polar projections of the AB Dor Association. *Left:* Northern Hemisphere. *Right:* Southern Hemisphere.

Tuc-Hor associations shows trends in the hardness ratio distributions when compared to TTS, the Hyades or older stars.

At a glance, looking at the figures of the Lithium distribution in the next sections, we can see that the Lithium depletion appears to be more scattered in the older associations. The present collection of several associations with ages from 6 up to 70 Myr (Table 2) furnishes an excellent opportunity to investigate the Lithium depletion during this time interval in the PMS evolution (da Silva et al. 2008). The Lithium depletion in associations can be compared with that in open clusters (see Jeffries (2006) for a review on this subject). The effect of rotation on the Lithium depletion in the PMS phase is also important. In fact, stars that are fast rotators (vsin(i) $\gtrsim$ 20 km s^{-1}) have higher Li line equivalent widths (upper points of the Lithium distribution in the figures of the next sections). This is in agreement with what is found for cluster stars, at least for K type stars, in the sense that fast rotators appear to have high Lithium abundances (Jeffries 2006).

Most of the stars of the lists presented in the next sections stem from the SACY sample, that is, X-ray selected low mass stars. Any study using our sample must be aware of this bias. The data presented in Tables 1 and 2 define the main characteristics and properties of these associations and can be used as starting points to find additional members. For example, GAIA will be an excellent tool to construct unbiased samples.

Stars in the young nearby associations are ideal targets for studies of planetary formation and very low mass sub-stellar objects. As a matter of fact, many members of the associations presented here have already been studied in the context of the characterization of their protoplanetary disks and the search for sub-stellar companions. These works are reviewed in the last section.

2. The β Pic Association

The β Pic Association was first proposed by Zuckerman et al. (2001a) and new members were suggested by Song et al. (2003) and by Moór et al. (2006). Zuckerman et al. (2001a) and Kaisler et al. (2004) noted that the so-called Capricornus Association formerly proposed by van den Ancker (2000) is part of the β Pic Association. A list of 33 proposed members is given in Zuckerman & Song (2004b). Only one of the proposed members, the brown dwarf HD 181296B (Lowrance et al. 2000), has no kinematical data published and its membership can not be determined by the methods presented here.

The β Pic Association is well defined in the SACY sample (Torres et al. 2006). Using the SACY sample and all other members proposed, the convergence solution gives 48 high probability members. There are 30 stars from the Zuckerman & Song (2004b) list and 18 new proposed members. They are listed in Table 3 and their spatial and velocity distributions are shown in Figure 8. Only two stars of the Zuckerman & Song (2004b) list, namely HD 203 and HIP 79881, are rejected by the convergence method and their membership probabilities are 0.75 and 0.85, respectively. The rejection of HIP 79881 is in-line with Song et al. (2003) and Ortega et al. (2004) who also considered this object as an outlier. HD 203 is rejected using the radial velocity obtained in four observations made by us, 8.8$\pm$2.9 km s^{-1}. Nevertheless, its radial velocity is less reliable as it is a fast rotator. Using the velocity in Barbier-Brossat & Figon (2000) (6.5$\pm$3.5 km s^{-1}) it becomes a high probability member. (This is another example of the need for good kinematical data to properly characterize memberships,

Table 3. The high probability members proposed for the β Pic Association

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
HD 203	00 06 50.1	-23 06 27	6.19	F3V	39H	75	Z
HIP 10679	02 17 24.7	+28 44 31	7.75	G2V	39	100	Z
HD 14062	02 17 25.2	+28 44 43	6.99	F5V	40	95	Z
HD 15115	02 26 16.2	+06 17 33	6.79	F4IV	45H	60	M
BD+30 397B	02 27 28.1	+30 58 41	12.44	M2Ve	43	90	Z
AG Tri	02 27 29.3	+30 58 25	10.12	K6Ve	43	100	Z
BD+05 378	02 41 25.9	+05 59 18	10.37	K6Ve	39	95	Z,S
HD 29391	04 37 36.1	-02 28 24	5.22	F0V	30H	100	Z
GJ 3305	04 37 37.5	-02 28 28	10.59	M1Ve	30H	100	Z
V1005 Ori	04 59 34.8	+01 47 01	10.05	M0Ve	24	100	S
CD-57 1054	05 00 47.1	-57 15 25	10.00	M0Ve	26H	100	Z,S
HIP 23418	05 01 58.8	+09 59 00	11.95*	M3Ve	34	100	Z
BD-21 1074BC	05 06 49.5	-21 35 04	11.61*	M3Ve	18	100	S,B
BD-21 1074A	05 06 49.9	-21 35 09	10.29	M1Ve	18	100	S,B
AF Lep	05 27 04.7	-11 54 03	6.56*	F7V	27H	100	Z
V1311 Ori	05 32 04.5	-03 05 29	11.52	M2Ve	36	95	S,B
β Pic	05 47 17.1	-51 04 00	3.77	A3V	19H	100	Z
AO Men	06 18 28.2	-72 02 41	9.80	K4Ve	39H	95	Z,S
HD 139084B	15 38 56.8	-57 42 19	14.80	M5Ve	40H	95	Z,S
V343 Nor	15 38 57.6	-57 42 26	7.97	K0V	40H	90	Z,S
V824 Ara	17 17 25.5	-66 57 04	7.23*	G7IV	31H	100	Z,S
HD 155555C	17 17 31.3	-66 57 06	12.82	M3Ve	31H	100	Z,S
GSC8350-1924	17 29 20.7	-50 14 53	13.47*	M3Ve	76	95	B
CD-54 7336	17 29 55.1	-54 15 49	9.55	K1V	66	90	S
HD 161460	17 48 33.8	-53 06 43	9.61*	K0IV	74	90	S
HD 164249	18 03 03.4	-51 38 56	7.01	F6V	47H	100	Z
HD 164249B	18 03 04.1	-51 38 56	12.5	M2Ve	47H	100	T
HD 165189	18 06 49.9	-43 25 31	5.67*	A5V	44H	100	Z
V4046 Sgr	18 14 10.5	-32 47 33	10.94*	K6Ve	73	95	T
GSC7396-0759	18 14 22.1	-32 46 10	12.78	M1Ve	73	90	T
HD 168210	18 19 52.2	-29 16 33	8.89	G5V	75H	90	S
HD 172555	18 45 26.9	-64 52 15	4.78	A6IV	29H	100	Z
CD-64 1208	18 45 36.9	-64 51 48	9.54	K5Ve	29H	100	Z
TYC9073-0762	18 46 52.6	-62 10 36	12.08	M1Ve	54	100	S
CD-31 16041	18 50 44.5	-31 47 47	11.20	K7Ve	51	95	S
PZ Tel	18 53 05.9	-50 10 49	8.29	G9IV	50H	100	Z,S
TYC6872-1011	18 58 04.2	-29 53 05	11.78	M0Ve	79	95	S
CD-26 13904	19 11 44.6	-26 04 09	10.39*	K4V(e)	80	95	S
η Tel	19 22 51.2	-54 25 25	5.02	A0V	48H	100	Z
HD 181327	19 22 58.9	-54 32 17	7.03	F6V	51H	100	Z
HD 191089	20 09 05.2	-26 13 27	7.18	F5V	53H	100	M
AT MicB	20 41 51.1	-32 26 10	11.09*	M4Ve	9.5	100	Z,S
AT MicA	20 41 51.2	-32 26 07	10.99*	M4Ve	9.5	100	Z,S

(Continued)

Table 3. (Continued)

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
AU Mic	20 45 09.5	-31 20 27	8.73	M1Ve	10H	100	Z,S
HD 199143	20 55 47.7	-17 06 51	7.35*	F7V	48H	75	Z
AZ Cap	20 56 02.7	-17 10 54	10.62*	K6Ve	47	95	Z,S
CP-72 2713	22 42 49.0	-71 42 21	10.60	K7Ve	36	100	S
WW PsA	22 44 58.0	-33 15 02	12.07	M4Ve	20	100	Z,S
TX PsA	22 45 00.0	-33 15 26	13.36	M5Ve	20	100	Z,S
BD-13 6424	23 32 30.9	-12 15 52	10.54	M0Ve	28	100	S

(*) the photometric values are corrected for duplicity.
The distances are from Hipparcos (H in the table) or kinematical ones, calculated with the convergence method.
italics = possible members (see text).
Z=Zuckerman & Song (2004b); S=in the SACY survey; M=Moór et al. (2006); T=Torres et al. (2006), not in the SACY sample; B=proposed in this Handbook.

although good quality radial velocities are hard to obtain for hot fast rotators.) Hence we consider it as possible member and it is included in the Table 3, in italics, but not in the figures or in the statistics.

The solution in Torres et al. (2006) has 41 high probability members, but subsequently a few updates have changed somewhat the solution of the original paper, mainly by the inclusion of four new proposed members, by revising the status of some stars, and by the addition of the stars from Moór et al. (2006). With new radial velocity observations, HD 165189 and HD 199143 have been revised to be high probability members. Moór et al. (2006) have proposed two members with debris disks, HD 15115 and HD 191089. Kalas et al. (2007) detected the scattered light of an extremely asymmetric dusty debris disk around HD 15115 that would make it a very interesting candidate, but from the convergence method the star is not a good member and its probability is low (p=0.7). The bona fide member BD+05 378 is close to HD 15115 at an angular distance of only 3.9° and they share similar kinematics. Thus, an adjustment of the kinematical data of HD 15115 may promote it to a bona fide member. Actually Kalas et al. (2007) proposed that the extreme asymmetries of its disk are due to dynamical perturbations from BD+05 378 (itself a single line spectroscopic binary). As for HD 203, HD 15155 is considered as a possible member and it is included in Table 3, in italics, but not in the figures or in the statistics.

The obtained age for the β Pic Association is about 10 Myr but, as commented before, the ages obtained with the *ad-hoc* isochrones must be taken with caution. Zuckerman et al. (2001a) suggested 12^{+8}_{-4} Myr, and Feigelson et al. (2006) estimate the age of the member GJ 3305 to be 13^{+4}_{-3} Myr. This is consistent with 11 Myr obtained by dynamical back-tracing models (Ortega et al. 2002, 2004; Song et al. 2003). These authors agree with the suggestion of Mamajek & Feigelson (2001) which places the birthplace of the β Pic Association into the Sco-Cen complex. The Li distribution (Figure 9) agrees well with these ages. The two points with high Li equivalent width around $(V-I)_C$ = 3.1 in (Figure 9) correspond to TX PsA and HD 139084B. TX PsA forms a binary with the slightly brighter and hotter WW PsA. However, in contrast to the strong

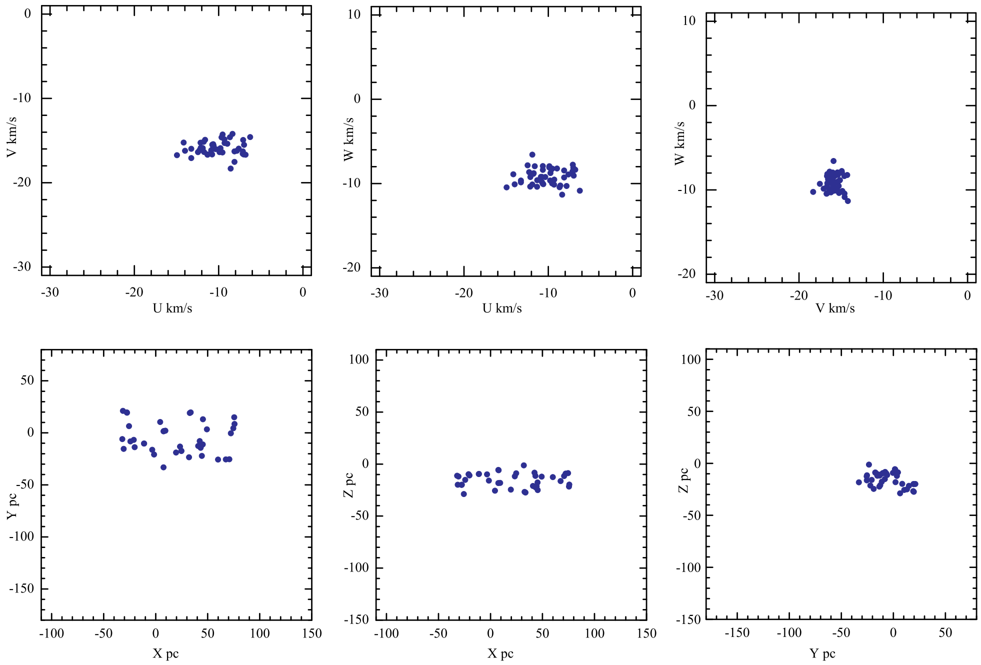

Figure 8. Combinations of the sub-spaces of the UVWXYZ–space for the β Pic Association showing a well defined clustering in both kinematical and spatial coordinates.

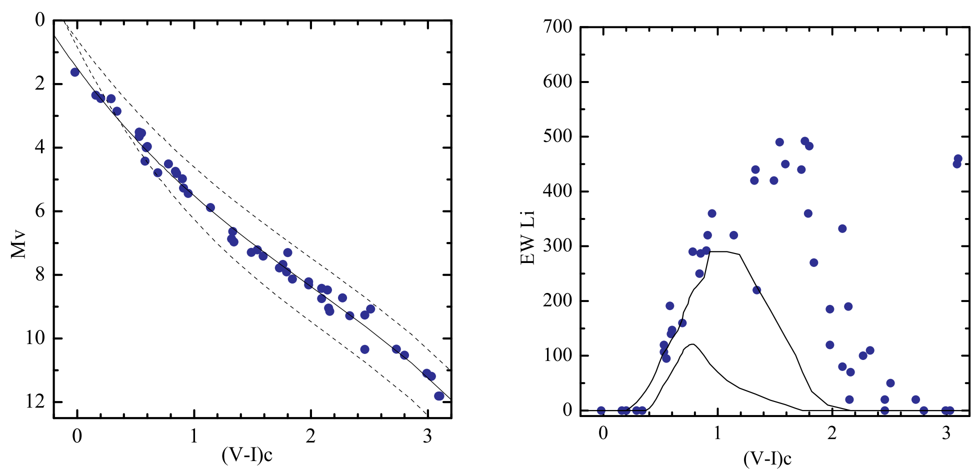

Figure 9. *Left:* The HR diagram of the members proposed for the β Pic Association; the over-plotted isochrones are the *ad-hoc* ones given in the text for 5, 10 and 70 Myr. *Right:* The distribution of the Li equivalent width as a function of $(V-I)_C$; the curves are the upper and lower limits for the age of the Pleiades (Neuhäuser 1997).

Li found in TX PsA, WW PsA has the Li fully depleted. Song et al. (2002a) interpreted the pair in the context of Li depletion boundary, and concluded that it can give a strong observational constraint to age determinations using the boundary of Li depletion. If instead the kinematical distance is the correct one (it is at $2\,\sigma$ of the Hipparcos parallax error), the stars could be 0.33 mag fainter, and this should be considered in the discussion of the Li-age relations. HD 139084B may help in this context.

AT Mic and AU Mic were already noted as young stars by Eggen (1968) and their connection with the debris disk A type star β Pic was first proposed by Barrado y Navascués et al. (1999). The weak Li line of AU Mic was first detected by de la Reza et al. (1981) during an attempt to find other active red dwarfs with Li to explain the odd Li-rich V1005 Ori (Gl 182) (Bopp 1974). de la Reza et al. (1981) tried to interpret the Li line of Gl 182 in terms of the Li production by spallation reactions. They discarded this possibility and proposed that V1005 Ori may be a member of a very young kinematical group suggested by Kunkel (1975), that includes also AU Mic and AT Mic. These three stars are now proposed to belong to the β Pic Association.

One of the new members proposed, GSC 8350-1924, is a serendipitous discovery of the SACY. The TYCHO star is farther away from the ROSAT source and we inadvertently observed the nearest star, GSC 8350-1924. The photometric observations show that the TYCHO star actually is a hot star, the color in the catalogue being erroneous. The proper motions used for GSC 8350-1924 are taken from UCAC2. Huélamo et al. (2008a) detected a companion at $0.767''$ with similar magnitude.

Another interesting star proposed now is V1311 Ori, a wTTS known long ago (HBC 97; (Herbig & Bell 1988)) but poorly studied. It has spot photometric variations with a period of 4.5 d, similar to AU Mic, determined by Gahm et al. (1995).

The β Pic Association has six known spectroscopic binaries (double line spectroscopic binary stars: HIP 23418, AF Lep, V824 Ara, HD 161460, V4046 Sgr; single line spectroscopic binary star: BD+05 378). One of these double line spectroscopic binary stars, V4046 Sgr, a non-SACY star proposed by Torres et al. (2003a,b) to be another possible member, was confirmed as high probability member in the final analysis (Torres et al. 2006). V4046 Sgr is an interesting double line spectroscopic binary isolated cTTS with a circumbinary disk (Quast et al. 2000; Stempels & Gahm 2004). It has a possible faint optical companion, GSC 7396-0759 (see Table 3). This star has now been observed twice, and a spectral feature reported before (Torres et al. 2006) is not present in the new spectrum. The two radial velocities are very similar, so, even in the case of being a spectroscopic binary, the systemic velocity should be near the mean radial velocity. We used the proper motions of V4046 Sgr but a good proper motion determination is important to confirm the membership.

In addition to these six spectroscopic binaries, the β Pic Association has 13 wide visual binaries, easily recognized in Table 3 since they have two entries, and ten close visual binaries: HIP 23418 (sep.=$1.0''$), BD-21 1074 BC (sep.=$1.2''$), GSC 8350-1924 (sep.=$0.8''$), HD 161460 (sep.=$0.1''$), HD 165189 (sep.=$1.7''$), CD-64 1208 (sep.=$0.2''$), CD-26 13904 (sep.=$1.1''$), η Tel (sep.=$4.2''$), HD 199143 (sep.=$1.1''$) and AZ Cap (sep.=$2.2''$). The very close optical companion of HD 161460, detected by Huélamo et al. (2008a), is also probably the spectroscopic one.

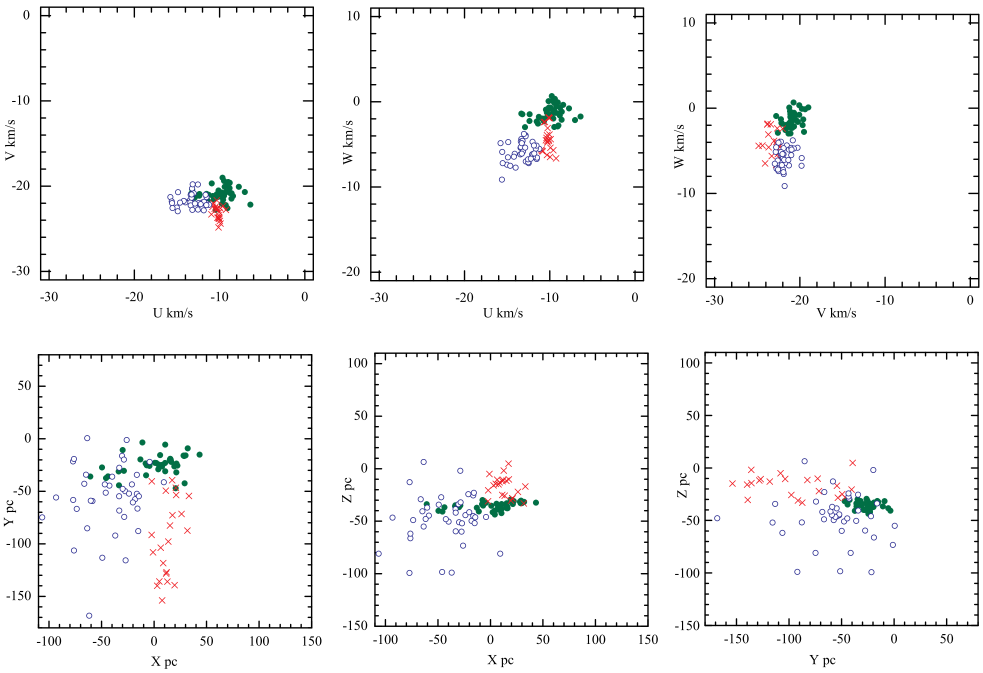

Figure 10. Combinations of the sub-spaces of the UVWXYZ–space for the GAYA complex – Tuc-Hor Association (filled circles), Col Association (open circles) and Car Association (crosses) – showing their clustering in both kinematical and spatial coordinates.

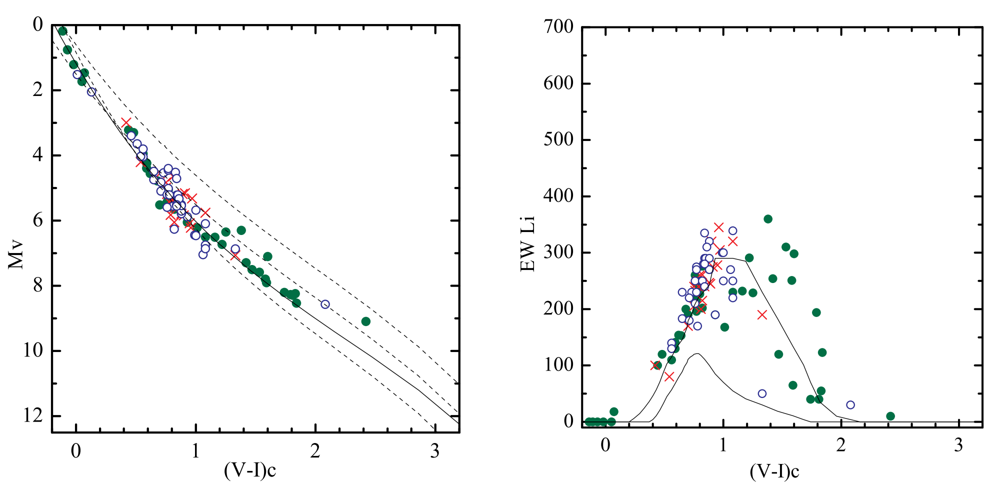

Figure 11. *Left:* The HR diagram for the associations of the GAYA complex (symbols are as in Figure 10 and the *ad-hoc* isochrones are for 5, 10, 30 and 70 Myr). *Right:* The distribution of Li equivalent width as a function of $(V-I)_C$; the curves are the upper and lower limits for the age of the Pleiades (Neuhäuser 1997).

3. The GAYA Complex

We recall that it was the independent and almost simultaneous discovery of the Tucana Association (Zuckerman & Webb 2000) and the Horologium Association (Torres et al. 2000) that motivated the SACY project. One of its first results was to postulate a large population of young stars in the southern sky with kinematical and physical properties similar to both associations, initially called GAYA (from Great Austral Young Association) (Torres et al. 2001). Now it becomes clear that it can be subdivided into, at least, three distinct, but similar associations: the Tucana-Horologium Association, almost the same as the one originally defined by Zuckerman et al. (2001b), the Columba Association and the Carina Association, the last two coming from a division of the early GAYA2 (Torres et al. 2003a,b, 2006).

In Tables 1 and 2 it can be noted that the three associations can be distinguished in at least one of the velocity components and that they form a sequence in physical space. This can be visualized in Figure 10. Anyway these three associations are not very distinct from one another. The Tuc-Hor Association is clearly more compact and closer to what we expect for an association. The other two are more difficult to define and this is reflected in the probability values. There are many stars not included in any of these two associations; nevertheless they have similar kinematical properties. This situation seems similar to the large Sco-Cen Association but GAYA is older and, therefore, more scattered. The Col and Car associations may be like reefs in a sea of similar young stars. Attempts to obtain solutions merging Col and Car associations (GAYA2) gave worse results.

Zuckerman & Song (2004b) proposed 50 stars to be members of the Tuc-Hor Association[4], but only 25 of them are in the SACY sample. The non-SACY members were also included to be tested in the convergence method. From these 50 stars, 31 were found to be high probability members of the new definition of the Tuc-Hor Association; three of the Col Association; and three of the Car Association. Some of the 13 stars rejected could still be classified as possible members of one of these associations of the GAYA complex. In fact, the quality of the proper motions and radial velocities is crucial to establish a membership, but errors in their kinematical data or a natural spread of the stars born in these associations may reduce their membership probabilities. This can be said about any association, but it is particularly true here. Actually four of these rejected stars are fast rotators and their radial velocities are unreliable, but their space motions are not very far from those of the Tuc-Hor Association and, although their convergence values are bad, they have high values in the probability model. Therefore these high rotators, HD 12894 (p=0.9), HD 20385 (p=0.9), HD 208233 (p=0.8) and η Tuc (p=0.8), can be considered possible members. A possible member for the Col Association is V1358 Ori, that is good in the convergence method but with very low probability. Another active star proposed, AT Col, has low probability for any of the three associations and has space motions very similar to the Car Association values, but it lies in XYZ–space in the Col Association. GSC 8056-0482 has badly determined proper motions and a Lithium equivalent width of 380 mÅ, too high for the Tuc-Hor age (Torres et al. 2000; Zuckerman et al. 2004c). CD-34 2406 has the duplicity confirmed by TYCHO and its corrected magnitude is too faint to belong to the GAYA complex.

[4]Actually there are 49 entries in their table, but we discriminate both companions of the wide binary DS Tuc.

HIP 3556, CD-64 120, HD 53842, HD 200798 and BS Ind (see Section 1.3) have space motions far from those of the GAYA associations.

3.1. The Tuc-Hor Association

The 44 high probability members of the Tuc-Hor Association are presented in Table 4. From this list, 31 stem from the previous list of Zuckerman & Song (2004b), 17 of them being also in the SACY sample. We proposed 13 new members. As can be seen in Figure 10, the Tuc-Hor Association is more compact than the Col or the Car associations. Figure 11 suggests that it may be younger than the other two. Actually, it is the best defined association of the GAYA complex and it seems to have a nucleus, containing at least seven stars, around β Tuc (α = 00:32 δ = –63° – see Fig 3 and Table 4)

BD-09 1108 is located in front of the Orion Complex but, as it is not correlated with Orion CO lines, Alcalá et al. (2000) suggested a possible connection with the Gould Belt. Using TYCHO-2 proper motions we propose it as the farthest Tuc-Hor member (78 pc).

There are nine visual double or multiple systems in the Tuc-Hor Association, four of them wide: *i)* the β Tuc multiple system, with at least five components, three in Table 4 – HD 2884 (double, sep.=2.4″), HD 2885 (double, sep.=0.4″) and HD 3003; *ii)* the pair HD 13246 / CD-60 416; *iii)* the pair CD-53 544 / AF Hor; *iv)* the pair DS Tuc / HD 222559B. The five other systems, having separations less than 1″, are: HIP 1910 (sep.=0.6″); DK Cet (sep.=0.2″); HD 207964 (sep.=0.4″); TYC 9344-0293 (sep.=0.2″) and HD 22705 – Makarov (2007) determined its orbit, based on Hipparcos data, and found a period of 201 days and a semi-major axis of only 5 mas. HD 22705 is also a possible low amplitude single line spectroscopic binary (Nordström et al. 2004), probably the same as the astrometric one. Another low amplitude single line spectroscopic binary is α Pav, detected as early as 1907, by Curtis (1907). The only double line spectroscopic binary in the Tuc-Hor Association, detected in the SACY, is BD-20 951. Observed only once, its systemic velocity is less reliable.

The very massive star α Pav is leaving the main sequence, and our polynomial *ad-hoc* isochrones are no more appropriate (its color is anyway out of the limits of Equation 6).

3.2. The Columba Association

We found 41 members for the Col Association which are presented in Table 5; only seven are not in the SACY data sample. Three stars (one in the SACY sample) were proposed by Zuckerman & Song (2004b) to be members of the Tuc-Hor Association, but they fit better in the Col Association. There are also five stars proposed by Moór et al. (2006), all having debris disks. The authors proposed another one, HD 37484, for the Tuc-Hor Association. In fact HD 37484 has a very good solution in the convergence method for the Col Association, but not for the Tuc-Hor Association. Nevertheless it has a low probability (p=0.45) and should be considered only as a possible member.

We accepted some low probability members (0.6<p<0.8) for the Col and Car associations since the convergence method gives reliable solutions for them. Actually the values given by the probability model must be interpreted in a relative sense. For a certain cutoff value of the probability it discriminates bona fide members from the field stars. This value depends on the density of the bona fide members of the association in the UVWXYZ–space relative to the density of the possible members in the field. Now,

Table 4. The high probability members proposed for the Tuc-Hor Association

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
HD 105	00 05 52.5	-41 45 11	7.53	G0V	40H	100	Z,S
HD 987	00 13 53.0	-74 41 18	8.78	G8V	44H	100	Z,S
HD 1466	00 18 26.1	-63 28 39	7.45	F8V	41H	100	Z
HIP 1910	00 24 09.0	-62 11 04	11.49*	M0Ve	44	100	Z
CT Tuc	00 25 14.7	-61 30 48	11.47	M0Ve	43	100	Z
HD 2884	00 31 32.7	-62 57 30	4.36	B9V	43H	90	Z
HD 2885	00 31 33.5	-62 57 56	4.77*	A2V	46	100	Z
HD 3003	00 32 43.9	-63 01 53	5.07	A0V	47H	100	Z
HD 3221	00 34 51.2	-61 54 58	9.61	K4Ve	46H	100	Z,S
CD-78 24	00 42 20.3	-77 47 40	10.21	K3Ve	50	100	S
HD 8558	01 23 21.3	-57 28 51	8.51	G7V	49H	100	Z,S
CC Phe	01 28 08.7	-52 38 19	9.07	K1V	37H	100	Z,S
DK Cet	01 57 49.0	-21 54 05	8.66*	G4V	42H	100	Z,S
HD 13183	02 07 18.1	-53 11 57	8.63	G7V	50H	100	Z,S
HD 13246	02 07 26.1	-59 40 46	7.50	F7V	45H	100	Z,S
CD-60 416	02 07 32.2	-59 40 21	10.68	K5Ve	48	100	Z,S
ϕ Eri	02 16 30.6	-51 30 44	3.56	B8V	47H	100	Z
ϵ Hyi	02 39 35.4	-68 16 01	4.12	B9IV	47H	85	Z
CD-53 544	02 41 46.8	-52 59 52	10.22	K6Ve	42	100	Z,S
AF Hor	02 41 47.3	-52 59 31	12.21	M2Ve	42	100	Z,S
CD-58 553	02 42 33.0	-57 39 37	10.98	K5Ve	50	100	Z,S
CD-35 1167	03 19 08.7	-35 07 00	11.12	K7Ve	44	100	S
CD-46 1064	03 30 49.1	-45 55 57	9.55	K3Ve	44	100	S
CD-44 1173	03 31 55.7	-43 59 14	10.90	K6Ve	42	100	S
HD 22213	03 34 16.4	-12 04 07	8.85	G7V	48	95	S
HD 22705	03 36 53.4	-49 57 29	7.65*	G2V	42H	100	Z
BD-12 943	04 36 47.1	-12 09 21	9.86	K0V	69	100	S
HD 29615	04 38 43.9	-27 02 02	8.47	G3V	55H	100	Z,S
HD 30051	04 43 17.2	-23 37 42	7.12	F2IV	58H	100	Z
TYC8083-0455	04 48 00.7	-50 41 26	11.53	K7Ve	46	90	S
HD 32195	04 48 05.2	-80 46 45	8.14	F7V	60H	80	Z
BD-20 951	04 52 49.5	-19 55 02	10.33*	K1V(e)	72	90	S
BD-19 1062	04 59 32.0	-19 17 42	10.65	K3V(e)	68	90	S
BD-09 1108	05 15 36.5	-09 30 51	9.79	G5V	78	85	S
CD-30 2310	05 18 29.1	-30 01 32	11.66	K4Ve	65	90	S
α Pav	20 25 38.9	-56 44 06	1.91	B2IV	56H	100	Z
HD 202917	21 20 50.0	-53 02 03	8.69	G7V	46H	100	Z,S
HIP 107345	21 44 30.1	-60 58 39	11.61	M0Ve	47	100	Z,S
HD 207575	21 52 09.7	-62 03 09	7.22	F6V	45H	100	Z
HD 207964	21 55 11.4	-61 53 12	6.56*	F0IV	47H	100	Z

(Continued)

Table 4. (Continued)

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
TYC9344-0293	23 26 10.7	-73 23 50	11.83*	M0Ve	46	100	S
CD-86 147	23 27 49.4	-86 13 19	9.29	G8IV	60	85	S
HD 222259B	23 39 39.1	-69 11 40	9.84	K3Ve	46H	100	Z,S
DS Tuc	23 39 39.5	-69 11 45	8.49	G6V	46H	100	Z,S

(*) the photometric values are corrected for duplicity.
The distances are from Hipparcos (H in the table) or kinematical ones, calculated with the convergence method.
Z=Zuckerman & Song (2004b); S=in the SACY survey.

the Col and Car associations, as we noted before, are loose associations immersed in a field of young stars with similar kinematical and physical properties, and therefore their cutoff values may be lower. Compared to other well defined associations, we have chosen for both associations lower cutoff probabilities (p=0.6), but yielding consistent membership lists. It is another sign of the sea of young stars in this region, possibly belonging also to the GAYA complex, but more kinematically dispersed. But Col and Car Associations are also large and distant, near the SACY limit (see Table 2; the other three distant associations are compact or are at special locations in the hexa-dimensional space). Therefore we lose almost completely their low mass population. A deeper survey would give a better insight into these associations. Another approach could be to define a ”GAYA” association, with less restrictive kinematical parameters, but losing the details.

The age obtained for the Col Association is the same as that for the Tuc-Hor and Car associations, but it depends largely on the badly determined low equivalent width of the Li line of GSC 8077-1788, a M0Ve wide companion of HD 31242 (sep.=18.3″). Stars near K0 indicate an older age (see Figure 11), thus the age proposed for the Col Association in Table 2 should be better investigated. Compared to all other associations exhibiting an expansion in the X direction (Figure 1), the Col Association is the farthest towards the Galactic anti-center. There seems to be a correlation of age with X, in the sense that associations farther towards the Galactic center tend to be younger. An older age for the Col Association would follow such a trend.

CD-52 381, proposed by Torres et al. (2000) to belong to the Hor Association, is a more probable member of the Col Association. Chauvin et al. (2003) found a possible substellar companion, confirmed by Neuhäuser & Guenther (2004) and Chauvin et al. (2005b) as a brown dwarf (M$\sim 25\ M_J$).

BD-08 1115 (PDS 111) is a wTTS in the direction of the Orion Cloud (Torres et al. 1995a), but the convergence method gives a much shorter distance and we propose that it belongs to the Col Association. If the source IRAS 05222-0844 is really associated with this star and if the membership is correct, it would have an exceptional amount of circumstellar material for such an old star.

BD-08 1195, very similar to PDS 111, is also in the direction of the Orion Cloud (Alcalá et al. 2000), and as PDS 111 we propose it to belong to the Col Association.

HD 36329 is a double line spectroscopic binary star, discovered in the SACY, with similar components. HD 62237, observed once, is another possible SB2. Zickgraf et

Table 5. The high probability members proposed for the Columba Association

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
CD-52 381	01 52 14.6	-52 19 33	10.89*	K2V(e)	92	80	S
BD-16 351	02 01 35.6	-16 10 01	10.33	K1V(e)	78	95	S
CD-44 753	02 30 32.4	-43 42 23	10.42	K5V(e)	52	70	S
BD-11 648	03 21 49.7	-10 52 18	11.32	K0Ve	127	75	S
V1221 Tau	03 28 15.0	+04 09 48	9.70*	K0	84	60	S,zi
HD 21955	03 31 20.8	-30 30 59	9.93*	G7IVe	122	70	S
HD 21997	03 31 53.6	-25 36 51	6.38	A3V	73H	80	M
BD-04 700	03 57 37.2	-04 16 16	10.61	G8V(e)	103	85	S
BD-15 705	04 02 16.5	-15 21 30	10.17	K3(e)	49	75	z,S
HD 26980	04 14 22.6	-38 19 02	9.08	G3V	83H	90	S
HD 27679	04 21 10.3	-24 32 21	9.43	G2V	75	95	S
CD-43 1395	04 21 48.7	-43 17 33	10.18	G7V	143	100	S
CD-36 1785	04 34 50.8	-35 47 21	10.84	K1Ve	77	85	S
HD 30447	04 46 49.5	-26 18 09	7.85	F3V	78H	60	M
GSC8077-1788	04 51 53.0	-46 47 31	13.03	M0Ve	80	85	S
HD 31242	04 51 53.6	-46 47 13	9.85	G5V	72	85	S
HD 272836	04 53 05.2	-48 44 39	10.78	K2V(e)	76	80	S
TYC5900-1180	04 58 35.8	-15 37 31	11.15	G9V	152	90	S
BD-08 995	04 58 48.6	-08 43 40	10.32	K0V	83	85	S
HD 32372	05 00 51.9	-41 01 07	9.50	G5V	72H	95	S
AS Col	05 20 38.0	-39 45 18	7.34	F6V	46H	70	z
BD-08 1115	05 24 37.3	-08 42 02	9.88	G7V(e)	118	80	S
HD 35841	05 26 36.6	-22 29 24	8.91	F3V	96	65	M
HD 274561	05 28 55.1	-45 34 58	11.45	K1V(e)	78	75	S
HD 36329	05 29 24.1	-34 30 56	9.22*	G3V	75H	95	S
AG Lep	05 30 19.0	-19 16 32	9.62	G6V	111	95	S
BD-08 1195	05 38 35.0	-08 56 40	9.84	G7V	83	80	S
HD 38207	05 43 21.0	-20 11 21	8.46	F2V	93	80	M
HD 38206	05 43 21.7	-18 33 27	5.73	A0V	69H	95	M
CD-38 2198	05 45 16.3	-38 36 49	10.95	G9V	90	85	s
CD-29 2531	05 50 21.4	-29 15 21	11.31	K0V(e)	149	95	S
CD-52 1363	05 51 01.1	-52 38 13	10.61	G9IV	106	85	S
HD 40216	05 55 43.1	-38 06 16	7.46	F7V	54H	80	z
CD-40 2458	06 26 06.9	-41 02 54	10.00	K0V	91	70	S
CD-48 2324	06 28 06.1	-48 26 53	11.08	G9V	135	60	S
TYC4810-0181	06 31 55.2	-07 04 59	11.80	K3Ve	96	70	S
HD 48370	06 43 01.0	-02 53 19	7.92	G8V	35	70	S
CD-36 3202	06 52 46.8	-36 36 17	11.22	K2V(e)	135	100	S
HD 51797	06 56 23.5	-46 46 55	9.84	K0V(e)	75	80	S

(Continued)

Table 5. (Continued)

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
CD-39 3026	07 01 51.8	-39 22 04	11.05	G9V(e)	189	75	S
HD 62237	07 42 26.6	-16 17 00	9.88*	G5V	104	85	S

(*) the photometric values are corrected for duplicity. The distances are from Hipparcos (H in the table) or kinematical ones, calculated with the convergence method.
S=in the SACY survey; s=observed in the SACY, but outside of the sample definition; z=Zuckerman & Song (2004b); M=Moór et al. (2006); zi=Zickgraf et al. (2005). (Here and in the next tables, small letters in the last column mean a star not proposed by the authors to belong to this association).

al. (2005) detected V1221 Tau as a double line spectroscopic binary, probably the same as the visual pair (sep=0.9″) whose brighter component is a fast rotator (Cutispoto et al. 1999). AS Col may also be a spectroscopic binary, since there is some spread in the published velocities, but it is a fast rotator and a short period photometric variable (Cutispoto et al. 1999).

There are four visual binaries in the Col Association: besides HD 31242, CD-52 381 and V1221 Tau mentioned above, HD 21955 is a close visual binary (sep.=0.9″). V1221 Tau has a possible F8 distant companion (sep=73″) measured by Hipparcos - our kinematical distance is shorter but within the parallax errors.

3.3. The Carina Association

The convergence method yields 23 high probability members for the Car Association,[5] presented in Table 6. As explained for the Col Association, we chose a low cutoff probability. Only one member was not observed in the SACY: HD 107722 – it is in front of the Cha region (Whittet et al. 1997). The authors proposed a distance of 74 pc and negligible reddening. The data used here were taken from Guenther et al. (2007). There are also three stars that Zuckerman & Song (2004b) proposed as members of the Tuc-Hor Association, all in the SACY sample.

Makarov & Urban (2000) found a sparse young moving group located in Carina and Vela and from their list of 58 candidate members, eight are probable members of the Car Association. Nevertheless, their moving group is more similar to the Argus Association and it will be discussed in Section 7. The age of the Car Association is similar to the one of the Tuc-Hor Association.

AB Pic was proposed by Song et al. (2003) as a member of the Tuc-Hor Association and we now change it to the Car Association. It has a low mass companion detected by Chauvin et al. (2005c), at the brown dwarf/planet boundary, and it may be one of the few planets detected by direct imaging (see Section 9).

There are two double line spectroscopic binary stars in the Carina Association: CD-53 2515, discovered in SACY and observed on 17 nights with an orbital period of

[5]The Car Association must not be confused with the Carina-Near moving group proposed by Zuckerman et al. (2006), supposed to be much older (∼200 Myr) and therefore beyond the scope of this review.

Table 6. The high probability members proposed for the Carina Association

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
HD 42270	05 53 29.3	-81 56 53	9.14	K0V	59	70	S
AB Pic	06 19 12.9	-58 03 16	9.13	K1V(e)	45H	60	z,S
HD 49855	06 43 46.2	-71 58 35	8.94	G6V	56H	90	z,S
HD 55279	07 00 30.5	-79 41 46	10.11	K2V	64H	70	z,S
CD-57 1709	07 21 23.7	-57 20 37	10.72	K0V	100	70	S
CD-63 408	08 24 05.7	-63 34 03	9.87	G5V	104	100	S,m
CD-61 2010	08 42 00.4	-62 18 26	10.95	K0V	147	100	S,m
CD-53 1875	08 45 52.7	-53 27 28	10.29	G2V	145	90	S,m
CD-75 392	08 50 05.4	-75 54 38	10.59	G9V	101	80	S
CD-53 2515	08 51 56.3	-53 55 57	11.06*	G9V	141	100	S
TYC8582-3040	08 57 45.7	-54 08 37	11.71	K2IV(e)	159	100	S,m
CD-49 4008	08 57 52.2	-49 41 51	10.51	G9V	111	100	S,m
CD-54 2499	08 59 28.8	-54 46 49	10.08	G5IV	106	100	S,m
CP-55 1885	09 00 03.3	-55 38 24	10.83	G5V	122	100	S
CD-55 2543	09 09 29.3	-55 38 27	10.20	G8V	133	100	S
CD-54 2644	09 13 16.9	-55 29 03	11.36	G5V	132	100	S
V479 Car	09 23 35.0	-61 11 36	10.86	K1V(e)	85H	90	S,m
HD 83096	09 31 24.9	-73 44 49	7.49*	F2V	79H	90	s
HIP 46720B	09 31 25.2	-73 44 51	10.02*	G9V	79H	80	S
CP-52 2481	09 32 26.1	-52 37 40	10.86	G8V	139	100	S
CP-62 1293	09 43 08.8	-63 13 04	10.44	G6V	77	100	S,m
CD-54 4320	11 45 51.8	-55 20 46	10.24	K5Ve	44	80	S
HD 107722	12 23 29.0	-77 40 51	8.30	F6	67	60	g

(*) the photometric values are corrected for duplicity.
The distances are from Hipparcos (H in the table) or kinematical ones, calculated with the convergence method.
S=in the SACY survey; s=observed in the SACY, but outside of the sample definition; m=Makarov & Urban (2000) proposed this star as belonging to the Carina-Vela moving group, z=Zuckerman & Song (2004b); g=Guenther et al. (2007).

24.06 days, and the faint visual companion of HD 83096 (sep.=1.9″), the only visual binary of this association, observed only once spectroscopically.

4. The TW Hya Association

Although the TW Hya Association was the first of the nearby associations discovered, it is one of the hardest to establish memberships for by the convergence method, due to the lack of good kinematical data. The reasons for this lack are two-fold. First, as many of the members proposed are faint they have no accurate proper motions, like those of the Hipparcos mission. And second, there is a large number of binary stars in the TW Hya Association. Close visual binaries make the determination of proper motions using photographic plates less reliable. If the orbit has a relatively short period it is necessary to use the systemic motion, which is also not easy to obtain. Moreover, there are suspected long period single line spectroscopic binaries, systems for which it is hard to obtain systemic velocities.

One example is TWA 3 (Hen 3-600), a visual binary separated by 1.5″: its barycenter may not coincide with the photocenter on a plate. There could be orbital motion not taken into account in the published proper motions. The separation of 1.5″ does not allow to obtain separate spectra with FEROS or similar fiber spectrographs. For slit spectrographs the effort to obtain separate spectra may arise in bad slit centering, resulting in velocity shifts. We may therefore expect that the radial velocity of TWA 3 is unreliable. Moreover (or as a consequence...), one of the stars of the pair is suspected to be a long period single line spectroscopic binary, maybe even both! Actually Jayawardhana et al. (2006) claim that TWA 3A is a double line spectroscopic binary star, but as they give no details, we can not correct the photometry for duplicity and TWA 3 also requires more precise proper motion determinations (the USNO proper motions used here are of lower quality). In our solution both stars are over-luminous, which may be another indication of these possible missing companions.

Lists of potential members of the TW Hya Association appear in Reid (2003), Torres et al. (2003c), Zuckerman & Song (2004b), Mamajek (2005) and Barrado y Navascués (2006). Stars in the TW Hya Association have traditionally been designated with association names. There are 28 stars with TWA designations, eight of them being visual binaries with separation greater than 1″ that allow us to study each component separately. From these 36 stars, 11 are in the SACY sample and we obtained spectra for 17 stars. We tried to introduce all proposed stars to be tested by the convergence method. For the sake of getting the most homogeneous data we used SACY data whenever possible. The other data were taken from Mamajek (2005), who got proper motions for some stars and compiled radial velocities for all stars. There are four stars that lack kinematical data and could not be used in this way: TWA 15B, TWA 22, TWA 23 and TWA 28 (SSPM J1102-3431: a young brown dwarf, Scholz et al. 2005).

Applying the convergence method to the 32 remaining stars we found 22 to be high probability members (seven in the SACY sample). They are listed in Table 7. From the ten stars rejected, six are also rejected by Mamajek (2005): TWA 12 (p=0.6, and farther in Y direction); TWA 17 (p=0, distant and with bad resultant spatial velocity); TWA 18, TWA 19A and B, TWA 24 (all with p=0 and belonging to the Sco-Cen Association). This possible membership of the Sco-Cen Association for some of the TW Hya Association candidate stars was proposed earlier by Mamajek & Feigelson (2001). The other four rejected stars are: TWA 15 (p=0, the proper motions are unreliable but, anyway, the photometric data impose an unacceptably large distance); TWA 21 (p=0.6, is farther in Z direction); TWA 6 (p=0.7, it is in the SACY sample); TWA 14 (p=0.3, is somewhat farther in Y direction). These last two stars show spreads in their published radial velocities and could be single line spectroscopic binaries. With the determination of the systemic velocities they could eventually become bona fide members of the TW Hya Association. TWA 6 and TWA 14 should be considered as possible TW Hya Association members.

TW Hya itself (TWA 1) is a cTTS (Rucinski & Krautter 1983), it is very well studied and possesses an optical circumstellar disk (Krist et al. 2000). There is an extensive bibliography both about TW Hya and its disk. It is also one of the oldest cTTS known. As already mentioned in Section 1.1, in the PDS program we had searched for other young stars around it using IRAS source or emission line stars in the Stock &

Table 7. The high probability members proposed for the TW Hya Association

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
TWA 7	10 42 30.1	-33 40 16	11.65	M2Ve	28	100	W,S
TWA 1	11 01 51.9	-34 42 17	11.07	K6Ve	53	100	G,S
TWA 2	11 09 13.8	-30 01 40	11.43*	M2Ve	41	90	G,S
TWA 3B	11 10 27.8	-37 31 53	13.07*	M4Ve	37	90	G
TWA 3A	11 10 27.9	-37 31 52	12.57*	M4Ve	37	90	G
TWA 13A	11 21 17.2	-34 46 46	11.46*	M1Ve	55	100	St
TWA 13B	11 21 17.4	-34 46 50	11.96*	M1Ve	55	100	St
TWA 4	11 22 05.3	-24 46 40	9.42*	K5V	44	100	G,S
TWA 5A	11 31 55.3	-34 36 27	12.12*	M2Ve	45	90	G,S
TWA 5B	11 31 55.4	-34 36 29	20.40	M8Ve	45	90	W
TWA 8A	11 32 41.2	-26 51 56	12.23	M3Ve	39	100	W
TWA 8B	11 32 41.2	-26 52 09	15.3	M5Ve	40	100	W
TWA 26	11 39 51.1	-31 59 21	20.5	M8Ve	41	100	Gi
TWA 9B	11 48 23.7	-37 28 48	14.00	M1Ve	68	90	W,S
TWA 9A	11 48 24.2	-37 28 49	11.26	K5Ve	68	100	W,S
TWA 27	12 07 33.4	-39 32 54	20.2	M8Ve	53	100	Gi
TWA 25	12 15 30.7	-29 48 43	11.44	M1Ve	51	100	So,S
TWA 20	12 31 38.1	-45 58 59	13.3	M3Ve	73	100	R
TWA 16	12 34 56.4	-45 38 07	12.8*	M1Ve	70	100	Zb
TWA 10	12 35 04.2	-41 36 39	12.96	M2Ve	52	100	W
TWA 11B	12 36 00.6	-39 52 16	12.80	M2Ve	67H	90	Zb,S
TWA 11A	12 36 01.1	-39 52 10	5.78	A0V	67H	100	Zb

(*) the photometric values are corrected for duplicity.
The distances are from Hipparcos (H in the table) or kinematical ones, calculated with the convergence method.
S=in the SACY survey; G=Gregorio-Hetem et al. (1992); Gi=Gizis (2002); R=Reid (2003); So=Song et al. (2003); St=Sterzik et al. (1999); W=Webb et al. (1999); Zb=Zuckerman et al. (2001c).

Wroblewski (1972) catalog, resulting in the discovery of four stars (de la Reza et al. 1989; Gregorio-Hetem et al. 1992), later confirmed by Kastner et al. (1997). They were designated with the names TWA 2 to TWA 5.

TWA 2 (CD-29 8887) was serendipitously discovered (de la Reza et al. 1989) at the beginning of the PDS survey (the nearby IRAS source is a galaxy) and no disk has been detected for this star. It is a visual binary (sep.=0.6″).

TWA 3 (Hen 3-600, see above) was the first star observed in the PDS survey. Although the binary system has roughly equal mass components, only the primary (possibly a double line spectroscopic binary) has a disk (Jayawardhana et al. 1999).

TWA 4 (HD 98800; TV Crt) was first proposed to be a young star by Gregorio-Hetem et al. (1992). It is a visual binary star (sep.=0.8″), and Torres et al. (1995b) established that both visual components are themselves spectroscopic binaries, the primary being a single line spectroscopic binary (period=262 d) and the secondary a double line spectroscopic binary (period=315 d). A preliminary orbit of the visual system

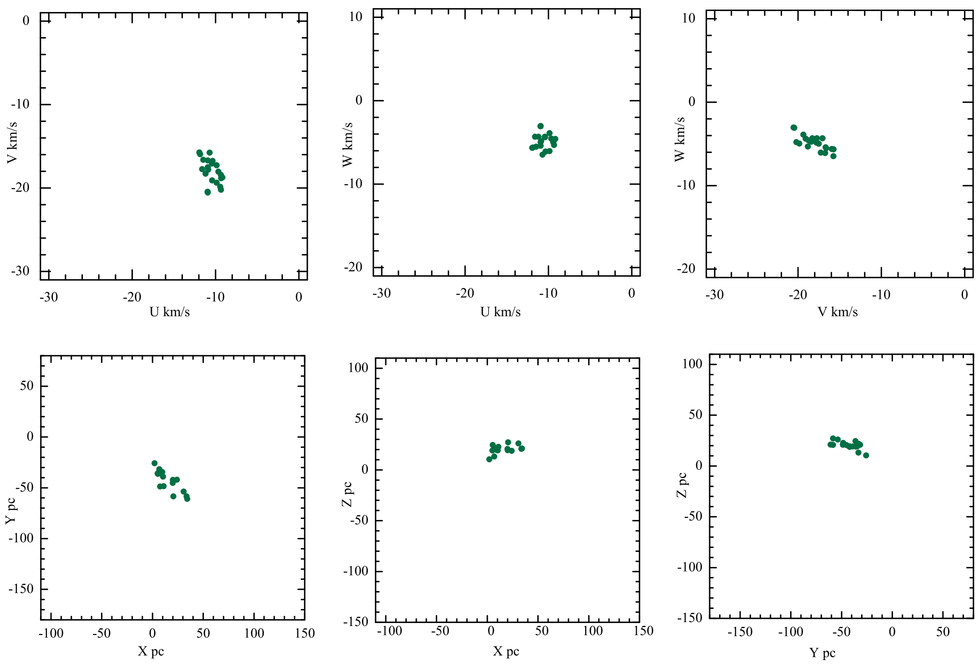

Figure 12. Combinations of the sub-spaces of the UVWXYZ–space for the TW Hya Association showing a well defined clustering in both kinematical and spatial coordinates.

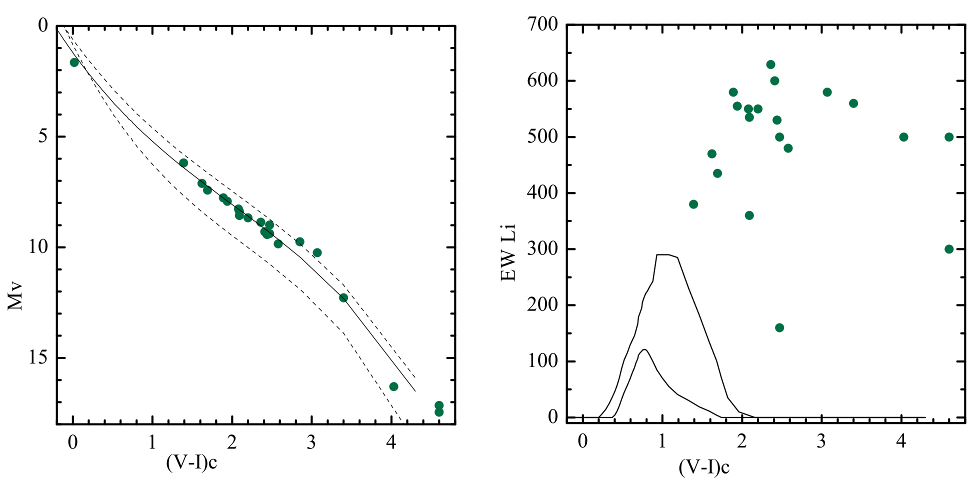

Figure 13. *Left:* The HR diagram of the members proposed for the TW Hya Association; the over-plotted isochrones are the ones for 5, 8, and 70 Myr. *Right:* The distribution of Li equivalent width as a function of $(V-I)_C$; the curves are the upper and lower limits for the age of the Pleiades (Neuhäuser 1997).

is presented by Tokovinin (1999). The subsystem TWA 4B has a visual and physical orbit determined by Boden et al. (2005) using interferometry with the Keck telescope and images from the Hubble Space telescope. TWA 4B is surrounded by a disk (Koerner et al. 2000).

TWA 5 (CD-33 7795) harbors the brown dwarf companion TWA 5B (sep.=2″), (Lowrance et al. 1999; Webb et al. 1999). TWA 5A is also resolved as a close visual binary with nearly equal components by Macintosh et al. (2000), and an orbit solution with a 5.9 yr period is presented by Konopacky et al. (2007). The situation is even more complicated as some authors detected radial velocity variations in TWA 5A, indicating another object in the system (see Torres et al. 2003c). The lines sometimes suggest a double line spectroscopic binary (see Reid 2003) and could be from the close visual components. The apparent high rotation may come from the blended lines of both components. Nevertheless, the mean lines of the 10 SACY spectra are consistent with a sinusoidal variation with a period very close to 1 day.

TWA 7 (GSC 7190-2111) was proposed as a TW Hya Association member by Webb et al. (1999) (together with TWA 6 to TWA 10). A suspected disk (Zuckerman 2001d; Low et al. 2005) was confirmed by Matthews et al. (2007).

TWA 8 (GSC 6659-1080) was discovered as an active star by Fleming (1998), and was proposed as a TW Hya Association member by Webb et al. (1999). They also detected a faint companion at a distance of 13″ (TWA 8B).

TWA 9 (HIP 57589), another one of the members proposed by Webb et al. (1999), was independently discovered by Jensen et al. (1998) and it is also a visual binary (sep.=5.8″).

TWA 10 (GSC 7766-0743), proposed as a TW Hya Association member by Webb et al. (1999), has Hα variations, probably from a chromospheric flare event, not due to accretions (Jayawardhana et al. 2006).

TWA 11 (HR 4796) is the only early-type star (spectral type A0) in the TW Hya Association – all other members are later than K5! The presence of a disk around it was proposed by Jura et al. (1993) and later confirmed through infrared imaging by Koerner et al. (1998) and Jayawardhana et al. (1998). Webb et al. (1999) proposed that this star belongs to the TW Hya Association. Zuckerman et al. (2001c) searched for young stars near TWA 11 and found six more TTS. They proposed all these stars to belong to the TW Hya Association (TWA 14-19). In our analysis, only TWA 16 is a bona fide member. Jura et al. (1993) showed that TWA 11A/B (sep.=7.8″) form a physical system with the A0 primary (they rejected the “C” star) and they suggested that TWA 11B may be a young star, later confirmed by Stauffer et al. (1995).

TWA 13 (CD-34 7390) is a visual binary (sep.=5.1″). Both components have TTS signatures and are proposed as TW Hya Association members by Sterzik et al. (1999).

TWA 16 is a member proposed by Zuckerman et al. (2001c). They argue it is a close visual binary (sep.=0.7″), but this needs confirmation.

TWA 20 (GSC 8231-2642) is rejected by Song et al. (2003) due to its weak Li (EW=160 mÅ). Indeed, this value is somewhat discrepant, as can be seen in Figure 13. However, it may depend critically on its photometry (which may be highly uncertain), and Li may easily be depleted in this star. Mamajek (2005) also agrees with its membership. However, TWA 20 is also claimed to be a spectroscopic binary (Jayawardhana et al. 2006), so its radial velocity might be uncertain.

TWA 21-25 were proposed by Song et al. (2003). We rejected TWA 21 and TWA 24 and there are no complete kinematical data to test TWA 22 and TWA 23. TWA 25 (GSC 7760-0283) is a bona fide member.

TWA 26 and TWA 27 are brown dwarfs proposed as TW Hya Association members by Gizis (2002).

TWA 27 is a visual binary with a companion of Jupiter mass (Chauvin et al. 2004, 2005a). The system was analyzed by Mohanty et al. (2007) who found that the planetary mass object would be underluminous. They suggested an edge-on disk around it to explain this discrepancy (but see Marley et al. 2007). Its age and distance match very well with those proposed here. It has also an accretion disk (Riaz et al. 2006; Riaz & Gizis 2007). New trigonometric distances have been recently determined by three groups: Gizis et al. (2007) found 54$\pm$3 pc; Biller & Close (2007), 59$\pm$7 pc; Ducourant et al. (2008), 52.4$\pm$1.1. These determinations agree very well with our kinematical distance (53 pc; see Table 7).

For a discussion of rotation in the TW Hya Association see Lawson & Crause (2005). Using the period distribution they arrived at a similar conclusion about the TW Hya Association memberships presented here. One of the more enigmatic properties of the TW Hya Association is the absence of F, G and early-type K stars. As they would be very bright, this deficit can not be explained by observational bias.

5. The ϵ Cha Association

A kinematic group of young stars in the Cha region was proposed earlier by Frink et al. (1998). The group was discussed by Terranegra et al. (1999), who defined 12 members (four in the SACY sample) and reviewed by Mamajek et al. (2000), when studying the η Cha cluster, calling it the ϵ Cha group. Using the first papers, they suggested nine members, only one in the SACY sample. Feigelson et al. (2003) selected X-ray sources, using the Chandra X-ray Observatory, near one of the proposed stars, DX Cha, and found some interesting faint young stars that could be related to the star ϵ Cha. However, no kinematical data are available for the application of the convergence method. Using IR data, Luhman (2004) proposed three more candidates that also lack kinematical data. Zuckerman & Song (2004b), reviewing the literature, suggest the existence of a similar association in this region, with 17 members, which they call the ”Cha-Near” region. It is considerably larger in space dimension than the proposed ϵ Cha group. Among their list, there are only four stars in the SACY sample and six proposed members have no complete kinematical data. Their list excludes the region close to the star ϵ Cha, but four of the ”Cha-Near” members are in the group proposed by Mamajek et al. (2000). Thus the situation is unclear – *are these three proposed groups the same?*

Mamajek et al. (2000) used the available kinematical data of the members of the η Cha cluster, obtaining a heliocentric velocity of (–11.8, –19.1, –10.5) km s^{-1} and a distance of 97.3$\pm$3.0 pc, close to the velocities and distances we had found for the ϵ Cha Association in previous analysis (Torres et al. 2003a,b). This poses another question: *what connection exists between the ϵ Cha group and the η Cha cluster?*

Unfortunately, to explore these questions, we have few stars in the SACY sample in any of these proposed groups, and only a fraction of their proposed members have kinematical data. Thus we included samples of young stars from other surveys in this region – Covino et al. (1997), Melo (2003), James et al. (2006), Guenther et al. (2007) and some PDS data. We also added six stars of the η Cha cluster that have kinematical

Table 8. The high probability members proposed for the ϵ Cha Association

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
The η Cha cluster kinematical members							
EG Cha	08 36 56.2	-78 56 46	11.36*	K4Ve	99	100	S,m
η Cha	08 41 19.5	-78 57 48	5.46	B8V	97H	90	m
RS Cha	08 43 12.2	-79 04 12	6.80*	A7+A8	98H	100	m
EQ Cha	08 47 56.9	-78 54 54	13.92*	M3e	122	100	m,c
Field members							
HD 82879	09 28 21.1	-78 15 35	8.99	F6V	120	80	c
CP-68 1388	10 57 49.3	-69 14 00	10.39	K1V(e)	112	70	S
DZ Cha	11 49 31.9	-78 51 01	12.9V	M0Ve	110	100	L,g,c
T Cha	11 57 13.5	-79 21 32	12.0V	K0Ve	109	100	M,T,Z
GSC9415-2676	11 58 26.9	-77 54 45	14.29	M3e	123	100	L,T
EE Cha	11 58 35.4	-77 49 31	6.73	A7V	105H	100	M,Z
ϵ Cha	11 59 37.6	-78 13 19	5.34*	B9V	111H	100	M
HIP 58490	11 59 42.3	-76 01 26	11.31	K4Ve	93H	90	S,M,T,Z
DX Cha	12 00 05.1	-78 11 35	6.73*	A8Ve	116H	100	M,T
HD 104237D	12 00 08.3	-78 11 40	14.28	M3Ve	116	100	F
HD 104237E	12 00 09.3	-78 11 42	12.08	K4Ve	116	100	F
HD 104467	12 01 39.1	-78 59 17	8.56	G3V(e)	104	100	S,T,Z
GSC9420-0948	12 02 03.8	-78 53 01	12.48	M0e	120	100	c
GSC9416-1029	12 04 36.2	-77 31 35	13.81*	M2e	123	100	Z,T
HD 105923	12 11 38.1	-71 10 36	9.16	G8V	115	80	S
GSC9239-1495	12 19 43.5	-74 03 57	13.08	M0e	105	100	Z,T
GSC9239-1572	12 20 21.9	-74 07 39	12.85*	K7e	110	100	Z,T
CD-74 712	12 39 21.2	-75 02 39	10.30	K3e	103	90	S,T,Z
CD-69 1055	12 58 25.6	-70 28 49	9.95	K0Ve	101	80	S
MP Mus	13 22 07.6	-69 38 12	10.35	K1Ve	103	80	S,g

(*) the photometric values are corrected for duplicity.
The distances are from Hipparcos (H in the table) or kinematical ones, calculated with the convergence method.
S=in the SACY survey; F=Feigelson et al. (2003); L=Luhman et al. (2008); M=Mamajek et al. (2000); T=Terranegra et al. (1999); Z=Zuckerman & Song (2004b), member of the "Cha-Near"; c=Covino et al. (1997), wTTS in Cha region; g=Gregorio-Hetem et al. (1992), (PDS); m=Mamajek et al. (1999), member of the η Cha Cluster.

data: EG Cha is in SACY; for EM Cha we took the data from Covino et al. (1997); for EO Cha and EQ Cha from Guenther et al. (2007); for η Cha from SIMBAD and for RS Cha from Alecian et al. (2005).

The application of the convergence method yields 24 *kinematical* members proposed for the ϵ Cha Association (Table 8 and Figures 14 and 15), near the 5 Myr isochrone, and at a mean distance of 108 pc, eight of them in the SACY sample. Due to the low extension in X direction (Figure 14) we used no expansion. This solution is distinct from the preliminary one by Torres et al. (2003a,b), being farther away and larger.

It has eight new members proposed, four of them belonging to the SACY sample, besides those of previous suggested associations. As this ”new” association includes ϵ Cha itself, its brightest member, we keep with the old designation of the association. This association is nearer and older than the more compact background ChaI star forming region (see the chapter by Luhman in this book).

The present solution includes nine of the 12 stars of the kinematical group proposed by Terranegra et al. (1999) (only two not in the ”Cha-near”). Two stars of their list have no published radial velocity and only one star is rejected (GSC 9415-1685). It also includes five stars of the ϵ Cha group (Mamajek et al. 2000) (three of them are also in the ”Cha-Near” list), and two faint companions of HD 104237 (DX Cha), proposed by Feigelson et al. (2003). It is larger than ”Cha-Near”, including eight of its members proposed. Three of the ”Cha-Near” stars with kinematical data were rejected: HD 99827 is a member proposed for the AB Dor Association (see Section 8); again, GSC 9415-1685, using proper motions from UCAC2 and radial velocity from Guenther et al. (2007), is very far from the convergence solution; and the wTTS DW Cha. This last star has a close visual companion (sep.=0.07$''$) detected by Köhler (2001) and a wide one, GSC 9415-2676, at 16.1$''$. The solution of the convergence method for GSC 9415-2676, using the UCAC2 proper motions and the radial velocity from Covino et al. (1997), defines it as a high probability member, with a larger distance than the Hipparcos parallax for DW Cha (but still at 2.6σ). Perhaps the close visual companion, not detected by Hipparcos, perturbs the parallax and proper motions (and even the radial velocities) of DW Cha. If we use the UCAC2 proper motions and no trigonometric parallax, the star would be an ϵ Cha Association member and form a physical pair with GSC 9415-2676. Even using the Hipparcos data it has a 70% membership probability, but with very bad kinematics. Then, DW Cha must be considered a possible member of the ϵ Cha Association and its astrometric data deserve re-examination. After this analysis was finished, Luhman et al. (2008) published a new list of members, two of them are in Table 8 and one is GSC 9415-2676. Except for DW Cha, the other members proposed have no good-quality kinematical data to be tested by the convergence method.

Finally, from the six members of the η Cha cluster having kinematical data, four are high probability members of this solution for the ϵ Cha Association. The two not included in the solution are EM Cha, a double line spectroscopic binary (Lyo et al. 2003) without systemic velocity, and EO Cha, with large discrepancy between the proper motions from UCAC2 and from Ducourant et al. (2005). This kinematical study indicates that the η Cha cluster may belong to the ϵ Cha Association. Since this conclusion is based on only four of the 18 members proposed for the η Cha cluster, this must be investigated further, with more extensive kinematical data.

When we try to obtain a photometric parallax for the other members of the cluster, using the 5 Myr isochrone, we find a mean distance of 120 pc. In fact both these 14 η Cha cluster members, using the 108 pc mean distance, and the 24 members proposed for the ϵ Cha Association are slightly displaced below the 5 Myr isochrone (see Figure 15). A compromise could be to consider the ϵ Cha Association having an age around 6-7 Myr. In fact, Jilinski et al. (2005), using their dynamical approach, argue that the ϵ Cha Association and the η Cha open cluster were formed together 6.7 Myr ago. It is interesting to note that the ages obtained with the convergence method for the ϵ Cha, the TW Hya and the β Pic associations (all of them possibly formed in the Sco-Cen Association), that is, $\sim$6 Myr, 8 Myr and 10 Myr (Table 2), all agree with

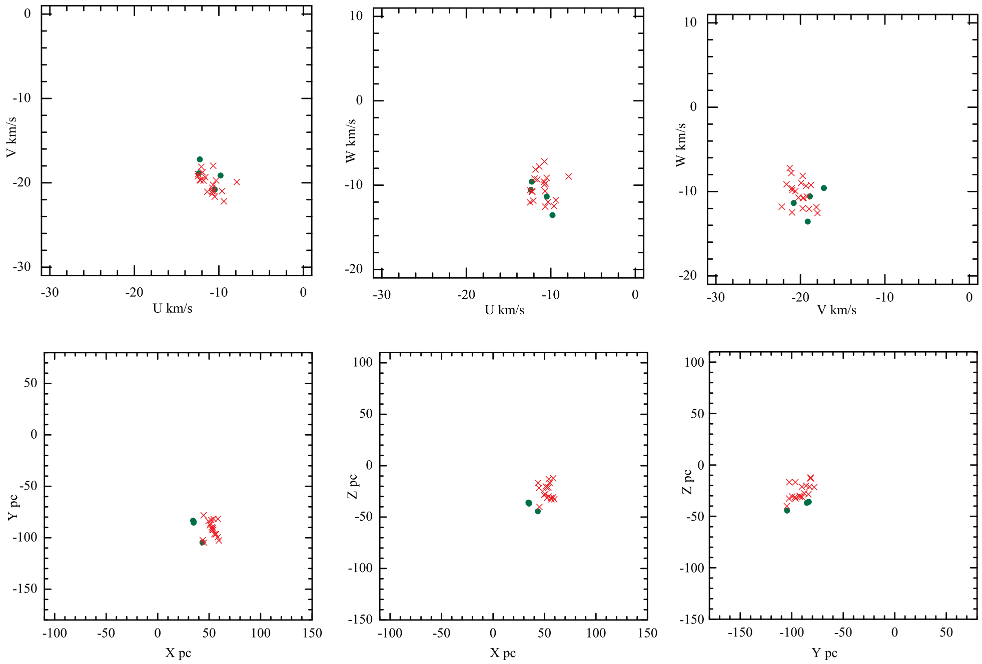

Figure 14. Combinations of the sub-spaces of the UVWXYZ–space for the ϵ Cha Association showing a well defined clustering in both kinematical and spatial coordinates. Crosses represent the ϵ Cha Association field members and filled circles, the η Cha members.

dynamical ages obtained for the same associations: ϵ Cha Association, with 6.7 Myr (Jilinski et al. 2005); TW Hya Association with 8.3 Myr (de la Reza et al. 2006) and β Pic Association, with 11.2 Myr (Ortega et al. 2002, 2004). Clearly distinct ages for these three groups appear to be present.

The new definition of the ϵ Cha Association, given in Table 8, with its young age, explains better the evolutionary status of MP Mus (PDS 66), commonly classified as an “old” cTTS. Its old age arises mainly from the suggestion that it is a member of the LCC (Mamajek et al. 2002), that would have an age of about 15 Myr (but see the discussion of Preibisch & Mamajek in their chapter in this book). Our convergence method gives a higher likelihood for MP Mus to be an ϵ Cha Association member than a LCC one. Silverstone et al. (2006) find an optically thick disk, and Argiroffi et al. (2007) study its X-ray emission, but the conclusion of these papers may change with the new proposed age.

Actually MP Mus would not be an exception in the ϵ Cha Association. Two other members of the η Cha cluster are also cTTS: ET Cha (Lawson et al. 2002) and RECX 16 (Song et al. 2004). T Cha, a very interesting TTS, was classified by Alcalá et al. (1993) as a wTTS, for the strength of the Hα emission. In the PDS we found its Hα highly variable, ranging from absorption to 25 Å emission. Thus, in its active phase it would also be classified as a cTTS. Its photometric variations are discussed in Batalha et al. (1998). It could be associated with the cloud FS 195 (Covino et al. (1997)) and, in that

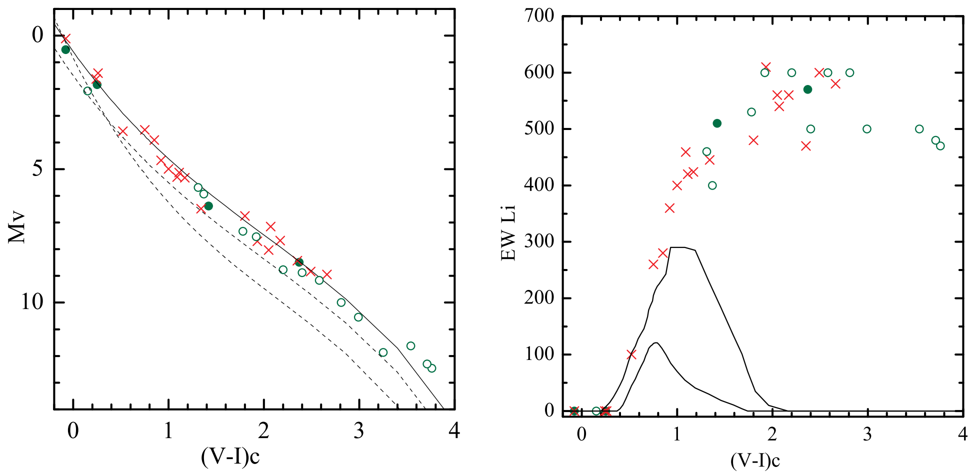

Figure 15. *Left:* The HR diagram of the members proposed for the ϵ Cha Association; the over-plotted isochrones are the ones for 5, 8, and 70 Myr. Crosses represent the ϵ Cha Association field members, filled circles the η Cha members kinematically proposed as belonging to the ϵ Cha Association, and open circles the η Cha members without complete kinematical data (their distance was supposed to be 108 pc). *Right:* The distribution of Li equivalent width as a function of $(V-I)_C$; the curves are the upper and lower limits for the age of the Pleiades (Neuhäuser 1997).

case, it would be the only star in young associations near a cloud. T Cha definitely deserves a fresh look. If we accept T Cha as a cTTS, then the ϵ Cha Association has four cTTS. This is one more indication that the ϵ Cha Association is younger than the TW Hya and the β Pic associations, which have only one cTTS each (TW Hya and V4046 Sgr).

In Table 8 there are three double line spectroscopic binary stars: the eclipsing binary RS Cha, DX Cha and GSC 9416-1029. RS Cha has also signatures of δ Scuti type pulsations (Alecian et al. 2005). The authors revisited the solution for the system and found that the orbital period is not constant. Alecian et al. (2007) give an age of 9.5 Myr for the system, older than our kinematical one. The HAEBE star DX Cha (HD 104237A) has also signatures of δ Scuti type pulsations (Kurtz & Müller 1999). Böhm et al. (2004) studied the spectroscopic orbit and the δ Scuti pulsations. This very interesting system, with at least two more TTS components (presented in Table 8 as HD 104237D and E), has been studied in detail by Grady et al. (2004) using many different techniques. GSC 9416-1029 has recently been detected as a double line spectroscopic binary star by Doppmann et al. (2007) with a period of 5.35 days and an age of 5 Myr. EQ Cha, η Cha, T Cha and HD 104467 are suspected to be spectroscopic binaries. EG Cha, EQ Cha, ϵ Cha, DX Cha and GSC 9239-1572 have close visual companions. Besides RS Cha and DX Cha, another δ Scuti star in the ϵ Cha Association is EE Cha (Kurtz & Müller 1999).

The possible connection between the ϵ Cha Association and the nearby η Cha open cluster must be investigated further. It is very important to obtain radial velocities for the stars having only proper motions and to search for candidates in the region between

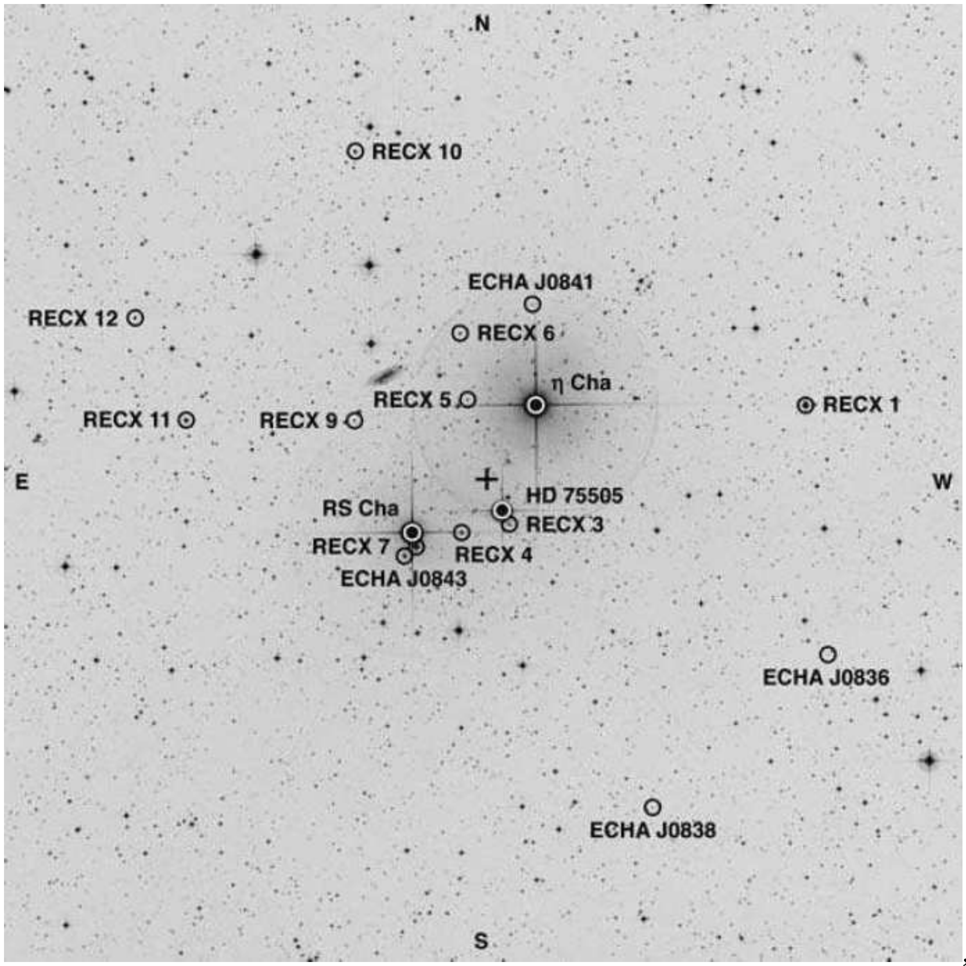

Figure 16. 45 x 45 arcmin POSS-II red-band image of the η Cha cluster region, centred (plus) at α_{2000} = 8h42m & δ_{2000} = –79°01′. (RECX 16 is outside of the field.) From Lyo et al. (2004).

the η Cha cluster and the main concentration of the ϵ Cha association. For example, knowing now the spatial motion of this association, the candidates can be found in deeper proper motion surveys.

5.1. The η Cha Open Cluster

On the basis of a spatial clustering of X-ray sources, Mamajek et al. (1999) found an open, young, and poor cluster in the vicinity of η Cha. They proposed 13 members, 12 of them being X-ray sources. Their main properties are investigated in Mamajek et al. (2000), where the authors first show a possible connection with the ϵ Cha Association. Lawson et al. (2001) present a photometric study of ten low-mass candidate members and find that all are variables, with periods ascribed to rotational modulation by starspots. They estimate an age of 4-9 Myr. Lawson et al. (2002), Song et al. (2004), and Lyo et al. (2004) propose five more members and the cluster now consists of 18 pri-

Table 9. Members of the η Cha cluster, not included in Table 8.

Name	other	α_{2000}	δ_{2000}	V	Sp.T.	Ref.
RECX 18		08 36 10.6	-79 08 18	17.66	M5e	So
RECX 17		08 38 51.5	-79 16 14	16.82	M5e	So
RECX 14	ES Cha	08 41 30.6	-78 53 07	17.07	M5e	L
RECX 3	EH Cha	08 41 37.2	-79 03 31	14.37	M3e	M
RECX 13	HD 75505	08 41 44.7	-79 02 53	7.27	A1V	M
RECX 4	EI Cha	08 42 23.7	-79 04 04	12.73	M1e	M
RECX 5	EK Cha	08 42 27.3	-78 57 48	15.20	M4e	M
RECX 6	EL Cha	08 42 39.0	-78 54 44	14.08	M3e	M
RECX 7	EM Cha	08 43 07.7	-79 04 52	10.89*	K6e	M
RECX 15	ET Cha	08 43 18.4	-79 05 21	13.97	M3e	L
RECX 16		08 44 09.1	-78 33 46	17.5	M5e	So
RECX 9	EN Cha	08 44 16.6	-78 59 09	15.75*	M4e	M
RECX 10	EO Cha	08 44 32.2	-78 46 32	12.53	M0e	M
RECX 11	EP Cha	08 47 01.8	-78 59 35	11.13	K6e	M

(*) the photometric values are corrected for duplicity.
L=Lawson et al. (2002); M=Mamajek et al. (1999); So=Song et al. (2004).
RECX 13 is not a X-ray source but this designation is in SIMBAD.

mary stars (see Figure 16), four of which, with good kinematical data, we found as high probability members of the ϵ Cha Association. The 14 members of the η Cha cluster, not included in Table 8, are presented, for completeness, in Table 9, with the Luhman & Steeghs (2004) identification numbers. Deeper searches to find fainter members did not produce results so far (Luhman 2004; Lyo et al. 2006).

Besides the binaries mentioned for the ϵ Cha Association, EN Cha is a close visual double having similar components (sep.=0.2″) (Brandeker et al. 2006) and EM Cha is a double line spectroscopic binary star with a period of 2.6 d, equal to its photometric period (Lyo et al. 2003).

6. The Octans Association

The Oct Association was already postulated in SACY (Torres et al. 2003a,b). In their first solution they found only six members, none in the Hipparcos. Of course, this fact limits the accuracy of the distances and ages obtained by the convergence method. We applied the convergence method assuming an age of 10 Myr based on the lithium distribution, using a high p value in Equation 1, and no expansion (the more conservative option). Under these assumptions, the solution has 15 members which are shown in Table 10. It includes all six members previously proposed (the last six entries in Table 10) which gave the association its name.

The mean distance, 141 pc, is near the observational limit of SACY and thus explains the absence of redder stars. The members proposed include two middle F stars: CD-30 3394, observed as its visual companion is a SACY star and HD 155177, observed in another similar program. CD-72 248 and CD-66 395 are very fast rotators (vsin(i) $\sim$200 km s^{-1}). They were observed only once, therefore their radial veloci-

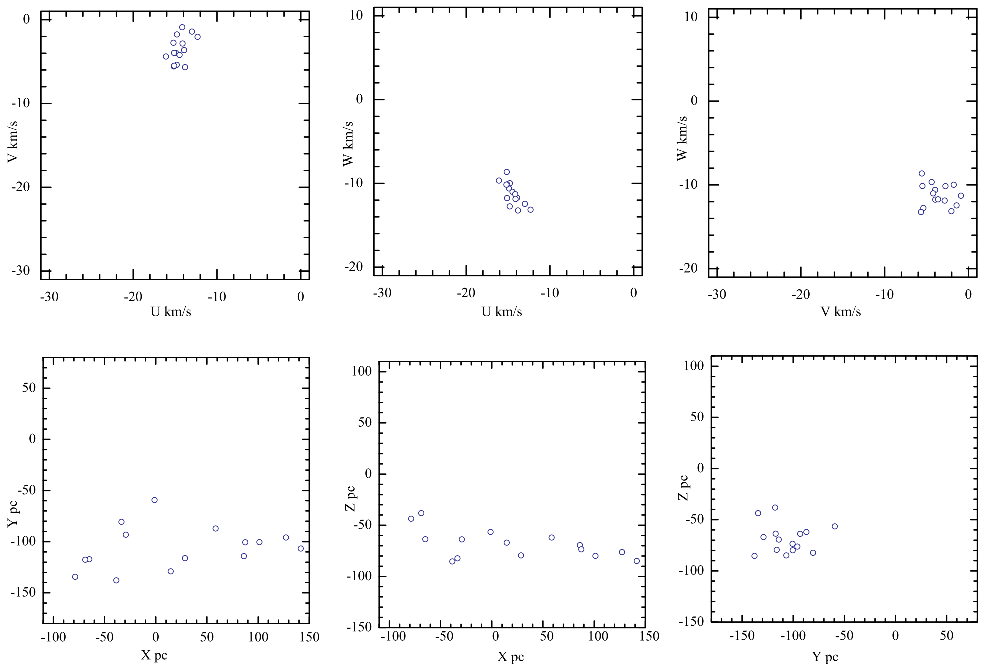

Figure 17. Combinations of the sub-spaces of the UVWXYZ–space for the Octans Association showing a well defined clustering in both kinematical and spatial coordinates.

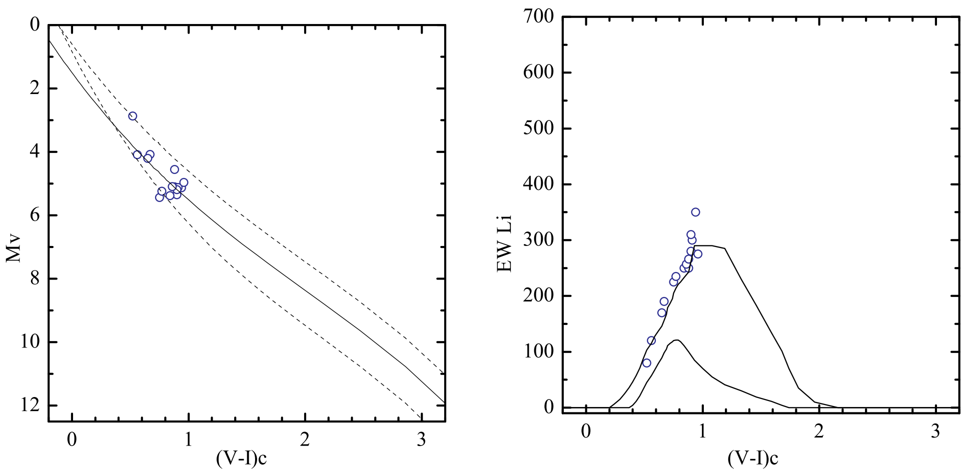

Figure 18. *Left:* The HR diagram of the members proposed for the Oct Association; the over-plotted isochrones are the ones for 5, 10, and 70 Myr. *Right:* The distribution of Li equivalent width as a function of $(V-I)_C$; the curves are the upper and lower limits for the age of the Pleiades (Neuhäuser 1997).

Table 10. The high probability members proposed for the Octans Association

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
CD-58 860	04 11 55.6	-58 01 47	10.01	G6V	82	90	S
CD-43 1451	04 30 27.3	-42 48 47	10.75	G9V(e)	120	80	S
CD-72 248	05 06 50.6	-72 21 12	10.91	K0IV	143	100	S
HD 274576	05 28 51.4	-46 28 18	10.57	G6V	116	100	S
CD-47 1999	05 43 32.1	-47 41 11	10.19	G0V	167	100	S
TYC7066-1037	05 58 11.8	-35 00 49	11.24	G9V	149	100	S
CD-66 395	06 25 12.4	-66 29 10	10.92	K0IV	147	100	S
CD-30 3394A	06 40 04.9	-30 33 03	9.84	F6V	141	70	s
CD-30 3394B	06 40 05.7	-30 33 09	10.24	F9V	161	80	S
HD 155177	17 42 09.0	-86 08 05	8.88	F5V	159	100	s
TYC9300-0529	18 49 45.1	-71 56 58	11.59	K0V	196	100	S
TYC9300-0891	18 49 48.7	-71 57 10	11.43*	K0V(e)	175	100	S
CP-79 1037	19 47 03.9	-78 57 43	11.16	G8V	164	100	S
CP-82 784	19 53 56.7	-82 40 42	10.87	K1V	152	100	S
CD-87 121	23 58 17.7	-86 26 24	9.98	G8V	122	100	S

(*) the photometric values are corrected for duplicity.
The distances are calculated with the convergence method.
S=in the SACY survey; s=observed in the SACY, but outside of the sample definition.

ties have large errors. In fact, all members proposed, except for the close visual binary TYC 9300-0891, have vsin(i) $\geq 20\,\mathrm{km\,s^{-1}}$, another indication that the association must be young. The companion of TYC 9300-0891 is at 0.9″, according to TYCHO-2, and they are 20″ from TYC 9300-0529. Another wide visual binary in this association is the pair CD-30 3394, at a separation of 12.4″. There is also a faint star 10.9″ from CD-87 121, a possible companion.

Based on these 15 stars, the Oct Association is compact in Y and Z directions, but in X direction it appears much larger than expected for the age assumed in the convergence method. As a compromise we propose in Table 2 an age of about 20 Myr. Its V velocity is peculiar in relation to all other nearby young associations and it has the lowest Z. These peculiarities and its position in the sky are the main reasons to believe that this association is real despite the small number of members and their distribution in X direction. Anyway, that is why we prefer not to use a solution with expansion, although using it we obtain a similar solution, but even more extended in X direction. A good solution and better age determination must await fainter members and some trigonometric distances.

7. The Argus Association

The Argus Association was easily discovered in the SACY survey due to its special U velocity (Torres et al. 2003b). Makarov & Urban (2000), analyzing a global proper motion convergence map, found a sparse young moving group located in Carina and Vela, having considerable geometrical depth. From their list of 58 candidate members,

Table 11. The high probability members of the Argus Association
(a) IC 2391 members

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	% %	Ref.
PMM 7422	08 28 45.6	-52 05 27	10.49	G6	120	100	p,m
PMM 7956	08 29 51.9	-51 40 40	11.62	Ke	141	100	p
PMM 1560	08 29 52.4	-53 22 00	10.66	G3	135	95	p
PMM 6974	08 34 18.1	-52 15 58	12.26		147	100	p
PMM 4280	08 34 20.5	-52 50 05	10.34	G5	145	95	p
PMM 6978	08 35 01.2	-52 14 01	12.07		128	100	p
PMM 2456	08 35 43.7	-53 21 20	12.20	K3e	135	100	p
PMM 351	08 36 24.2	-54 01 06	10.18	G0	128	100	p
PMM 3359	08 36 55.0	-53 08 34	11.51		137	100	p
PMM 5376	08 37 02.3	-52 46 59	14.30	Me	132	100	p
PMM 4324	08 37 47.0	-52 52 12	9.66	F5V	137	100	p
PMM 665	08 37 51.6	-53 45 46	11.35	G8	139	100	p
PMM 4336	08 37 55.6	-52 57 11	11.58	G9	139	100	p
PMM 4362	08 38 22.9	-52 56 48	10.97		147	100	p
PMM 4413	08 38 55.7	-52 57 52	11.06*	G2	141	100	p
PMM 686	08 39 22.6	-53 55 06	12.63	Ke	137	100	p
PMM 4467	08 39 53.0	-52 57 57	11.86V	K0(e)	137	100	p
PMM 1083	08 40 06.2	-53 38 07	10.45V	G0	139	100	p,m
PMM 8415	08 40 16.3	-52 56 29	11.84	G9(e)	141	100	p
PMM 1759	08 40 18.3	-53 30 29	13.54	K3e	135	100	p
PMM 1142	08 40 49.1	-53 37 45	11.08	G6	147	100	p
PMM 1174	08 41 22.7	-53 38 09	9.54	F3V	139	100	p
PMM 1820	08 41 25.9	-53 22 41	12.56V	K3e	154	90	p
PMM 4636	08 41 57.8	-52 52 14	13.57	K7e	135	100	p
PMM 3695	08 42 18.6	-53 01 57	13.96	M2e	137	100	p
PMM 756	08 43 00.4	-53 54 08	11.16	G9	149	100	p
PMM 5811	08 43 17.9	-52 36 11	9.16	F2V	145	100	p
PMM 2888	08 43 52.3	-53 14 00	9.76	F5	135	100	p
PMM 2012	08 43 59.0	-53 33 44	11.67	K0(e)	135	100	p
PMM 4809	08 44 05.2	-52 53 17	10.85V	G3(e)	154	100	p
PMM 1373	08 44 10.2	-53 43 34	12.25		141	100	p
PMM 5884	08 44 26.2	-52 42 32	11.46V	G9(e)	139	100	p
PMM 4902	08 45 26.9	-52 52 02	12.76V	K3e	133	100	p
PMM 6811	08 45 39.1	-52 26 00	9.91V	F8Ve	135	100	p,m
PMM 2182	08 45 48.0	-53 25 51	10.22	G2(e)	152	100	p

(*) the photometric values are corrected for duplicity.
Names as in Platais et al. (2007). The distances are calculated with the convergence method.
p=Platais et al. (2007); m=Makarov & Urban (2000), member of the Car-Vela moving group.

Table 12. The high probability members of the Argus Association
(b) Field members

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	% %	Ref.
BW Phe	00 56 55.5	-51 52 32	9.62*	K3Ve	56	90	S
CD-49 1902	05 49 44.8	-49 18 26	11.37	G7V	133	90	S
CD-56 1438	06 11 53.0	-56 19 05	11.11	K0V	101	95	S
CD-28 3434	06 49 45.4	-28 59 17	10.38	G7V	109	90	S
CD-42 2906	07 01 53.4	-42 27 56	10.61	K1V	96	100	S
CD-48 2972	07 28 22.0	-49 08 38	9.84	G8V	85	100	S
CD-48 3199	07 47 26.0	-49 02 51	10.61	G7V	95	100	S,m
CD-43 3604	07 48 49.6	-43 27 06	10.88	K4Ve	79	100	S
TYC8561-0970	07 53 55.5	-57 10 07	11.50	K0V	133	100	S,m
HD 67945	08 09 38.6	-20 13 50	8.08	F0V	64	95	s
CD-58 2194	08 39 11.6	-58 34 28	10.11	G5V	106	100	S,m
CD-57 2315	08 50 08.1	-57 45 59	10.21	K3Ve	94	100	S,m
TYC8594-0058	09 02 03.9	-58 08 50	11.30	G8V	141	100	S,m
CD-62 1197	09 13 30.3	-62 59 09	10.46	K0V(e)	111	100	S,m
TYC7695-0335	09 28 54.1	-41 01 19	11.70	K3V	143	100	S
HD 84075	09 36 17.8	-78 20 42	8.59	G1	63H	100	g
TYC9217-0641	09 42 47.4	-72 39 50	12.40	K1V	132	100	S
CD-39 5883	09 47 19.9	-40 03 10	10.89	K0V	100	95	S
HD 85151A	09 48 43.3	-44 54 08	9.61	G7V	69	95	S
HD 85151B	09 48 43.5	-44 54 09	10.21	G9V	69	100	S
CD-65 817	09 49 09.0	-65 40 21	10.33*	G5V	141	100	S,m
HD 309851	09 55 58.3	-67 21 22	9.90	G1V	103	100	S,m
HD 310316	10 49 56.1	-69 51 22	10.82*	G8V	128	100	S
CP-69 1432	10 53 51.5	-70 02 16	10.66	G2V	164	100	S
CD-74 673	12 20 34.4	-75 39 29	10.72	K3Ve	50	90	S,g
CD-75 652	13 49 12.9	-75 49 48	9.67	G1V	81	95	s,g
HD 129496	14 46 21.4	-67 46 16	8.78	F7V	85	95	s
NY Aps	15 12 23.4	-75 15 15	9.42	G9V	50H	90	S
CD-52 9381	20 07 23.8	-51 47 27	10.59	K6Ve	29	95	S

(*) the photometric values are corrected for duplicity.
The distances are from Hipparcos (H in the table) or kinematical ones, calculated with the convergence method.
S=in the SACY survey Torres et al. (2006); s=not in the SACY sample definition, but observed in this program; g=Guenther et al. (2007), wTTS in Cha region; m=Makarov & Urban (2000), member of the Car-Vela moving group.

30 are in SACY, but eight of them are proposed as members of the Car Association (Table 6). Only 11 stars of their list are considered as members of the new Argus Association (Tables 11 and 12). This challenges their proposed moving group. Our new definition of the Argus Association is distinct and much larger than the moving group mentioned.

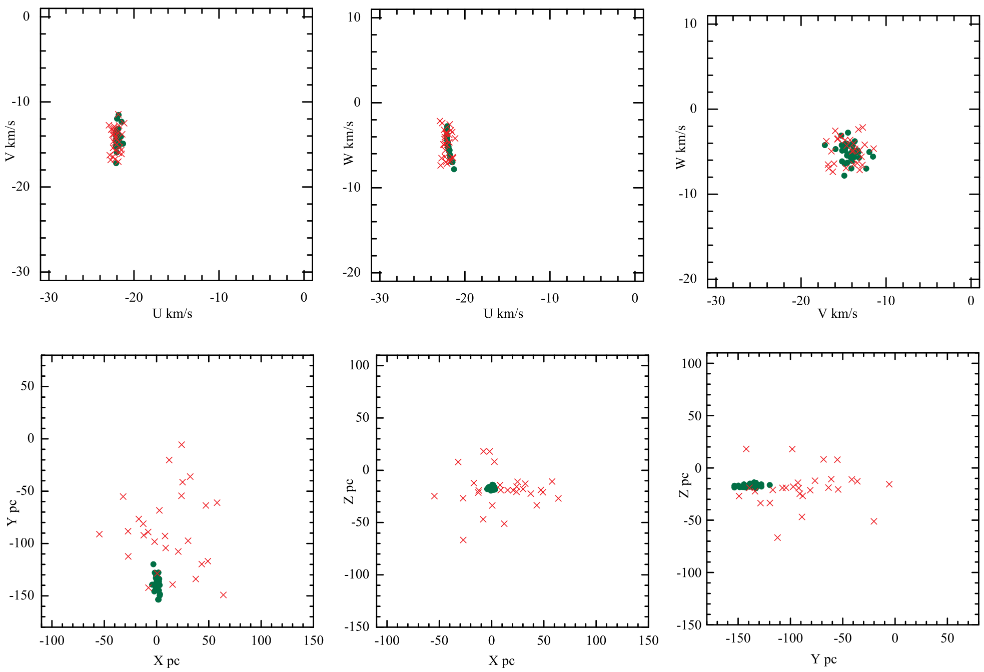

Figure 19. Combinations of the sub-spaces of the UVWXYZ–space for the Argus Association showing a well defined clustering in both kinematical and spatial coordinates. Crosses represent the field members and filled circles, the IC 2391 members.

Makarov & Urban (2000) also proposed the open cluster IC 2391 as part of this moving group. IC 2391 is reviewed by Pettersson in the chapter on Puppis and Vela in this book. In order to test the possibility that IC 2391 may be connected with the Argus Association, we used proper motions and radial velocities of the possible cluster members measured by Platais et al. (2007). There are 41 stars with all kinematical data, excluding the spectroscopic binaries (20) except PMM 4413, for which they published an orbital solution. To convert their relative proper motions to the TYCHO-2 system we used 17 stars in common. The convergence method actually shows quite a good match between IC 2391 and the Argus Association from Torres et al. (2003b).

In Table 12 we present an updated solution with the 29 field members, and in Table 11 the 35 IC 2391 members that have similar kinematical and physical data. Actually, in Figure 20 it is hard to note any physical distinction between both kinds of members. Two of the IC 2391 members proposed (PMM 1820 and PMM 5376) are not considered bona fide ones by Platais et al. (2007), and only one of their bona fide members (PMM 5829) is among the six IC 2391 stars we rejected. The mean distance of IC 2391 obtained by this convergence method is 139$\pm$7 pc.

In Figure 19 the concentration of IC 2391 can be noted at X $\sim$0 and Y $\sim$–140. The obtained distribution in Y axis (a ”finger-of-god” effect) is an artifact of the convergence method. As IC 2391 is along the Y–direction on the sky, the only possible spread coming from the kinematical errors is in the distance (i.e., along the Y–axis). Were IC 2391 located in a different place on the sky, the spread would also be in the other

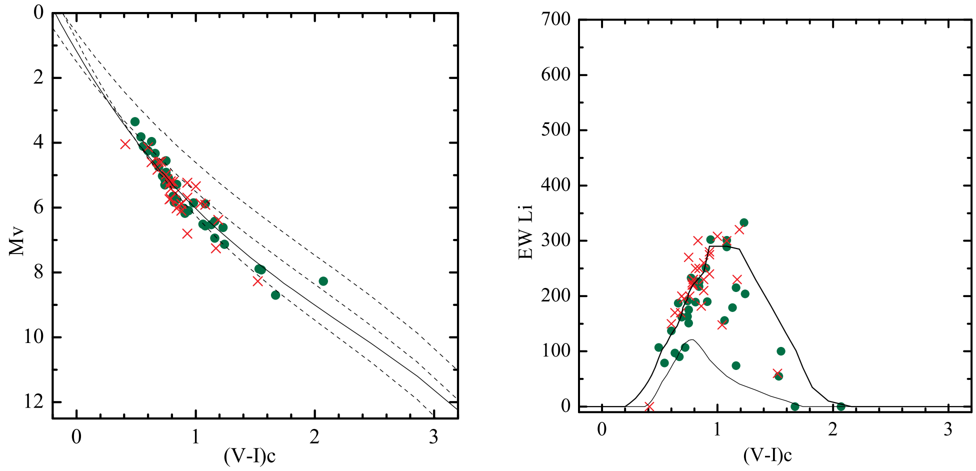

Figure 20. *Left:* The HR diagram of the members proposed for the Argus Association; the over-plotted isochrones are the ones for 5, 10, 30 and 70 Myr. (Symbols are as in Figure 19). *Right:* The distribution of Li equivalent width as a function of $(V-I)_C$; the curves are the upper and lower limits for the age of the Pleiades (Neuhäuser 1997).

space axes and the distribution in space would be more spherical. As the distance of IC 2391 is somewhat extreme for the Argus Association, we can suppose that the association must be larger and that we have detected only its nearby members. To avoid confusion with the IC 2391 Supercluster proposed by Eggen (1991), we remained with our designation of ”Argus Association”. In any case, if the Supercluster is real, it eludes detection in the SACY and we can not check it as its members proposed are mainly early-type stars that are not in the SACY database.

Very few of the 29 SACY field members have been observed elsewhere. BW Phe was proposed by Zuckerman et al. (2001b) as a possible member of the Tucana Association. CD-39 5883 has been proposed by Reid (2003) to be a possible member of the TW Hya Association. Three stars are in front of the Cha complex, and were observed by Covino et al. (1997) and Guenther et al. (2007): HD 84075, CD-74 673 and CD-75 652.

Guenther et al. (2007) found CD-74 673 as a long period (613.9d) single line spectroscopic binary star, and until now it is the only spectroscopic binary among the field stars of the Argus Association.

There are four known visual binaries in this association: BW Phe (sep.= 0.2″), HD 85151 (sep.=2.3″), CD-65 817 (sep.=2.0″), and HD 310316 (sep.=0.6″). The star CD-48 2972 has a possible bright companion at 81.7″, HD 59659, a F7V star with V = 8.80. Both their proper motions are similar, and Hipparcos gives a distance of 90 pc for HD 59659.

Table 13. The high probability members proposed for the AB Dor Association

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
PW And	00 18 20.9	+30 57 22	9.14	K2V(e)	27	100	Z
HD 4277	00 45 50.9	+54 58 40	7.80*	F8V	49H	95	Z
HD 6569	01 06 26.2	-14 17 47	9.50	K1V	50H	100	Z,S
BD-12 243	01 20 32.2	-11 28 03	8.43	G9V	35H	100	Z,S
CD-46 644	02 10 55.4	-46 03 59	11.24	K3IVe	70	90	S
HD 13482	02 12 15.4	+23 57 30	7.94	K1V	32H	100	Z
HIP 12635	02 42 21.0	+38 37 21	10.28	K2V	49	100	Z
HD 16760	02 42 21.3	+38 37 07	8.77	G2V	48	100	Z
HD 17332B	02 47 27.2	+19 22 21	8.11*	G6V	33H	100	Z
HD 17332A	02 47 27.4	+19 22 19	7.32*	G1V	33H	100	Z
IS Eri	03 09 42.3	-09 34 47	8.48	G0V	40H	100	L
HIP 14807	03 11 12.3	+22 25 23	10.47	K6	45	100	Z
HIP 14809	03 11 13.8	+22 24 57	8.51	G5V	50H	100	Z
V577 Per	03 33 13.5	+46 15 27	8.26	G5V	34H	100	Z
HD 21845B	03 33 14.0	+46 15 19	11.20	M0Ve	34H	100	Z
HIP 17695	03 47 23.3	-01 58 20	11.51	M3Ve	16	100	Z,S,z
HD 24681	03 55 20.4	-01 43 45	9.05	G8V	53	100	S,z
HD 25457	04 02 36.7	-00 16 08	5.38	F6V	19H	100	Z
HD 25953	04 06 41.5	+01 41 02	7.83	F5	55H	100	Z
TYC5899-0026	04 52 24.4	-16 49 22	11.61	M3Ve	16	100	S
CD-56 1032B	04 53 30.5	-55 51 32	12.10	M3Ve	11	100	S
CD-56 1032A	04 53 31.2	-55 51 37	11.16	M3Ve	11	100	S
HD 31652	04 57 22.3	-09 08 00	9.98	G8V	88	95	S
CD-40 1701	05 02 30.4	-39 59 13	10.57	K4V	42	100	S
HD 32981	05 06 27.7	-15 49 30	9.13	F9V	81	100	S
HD 293857	05 11 09.7	-04 10 54	9.26	G8V	78	100	S
HD 33999	05 12 35.8	-34 28 48	9.37	F8V	106	100	s
HD 35650	05 24 30.2	-38 58 11	9.08	K6V	18H	100	Z,S
AB DorB	05 28 44.4	-65 26 47	13.2*	M4Ve	15H	100	Z,S
AB Dor	05 28 44.8	-65 26 56	6.88	K0Ve	15H	100	Z,S
UX Col	05 28 56.5	-33 28 16	10.46	K3Ve	57	100	S
CD-34 2331	05 35 04.1	-34 17 52	11.84	K3Ve	78	100	S
HIP 26369	05 36 55.1	-47 57 48	9.81	K6Ve	24H	100	Z,S
UY Pic	05 36 56.9	-47 57 53	7.84	K0V	24H	100	Z,S
WX Col	05 37 12.9	-42 42 56	9.55*	G7V	75H	100	S
HIP 26401B	05 37 13.2	-42 42 57	10.65*	K1V	75H	100	S
Par 2752	05 38 56.6	-06 24 41	10.91	G8V	116	100	S
CP-19 878	05 39 23.2	-19 33 29	10.71	K1V	71	100	S
TYC7605-1429	05 41 14.4	-41 17 59	12.29	K4IVe	128	100	S
CD-26 2425	05 44 13.4	-26 06 15	10.88	K2Ve	70	100	S
TZ Col	05 52 16.0	-28 39 25	9.04	G3V	88H	90	S
TY Col	05 57 50.8	-38 04 03	9.56	G6V(e)	68	100	S

(Continued)

Table 13. (Continued)

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
BD-13 1328	06 02 21.9	-13 55 33	10.58	K4V(e)	39	95	S
CD-34 2676	06 08 33.9	-34 02 55	10.17	G9Ve	72	100	S
CD-35 2722	06 09 19.2	-35 49 31	10.98	M1Ve	24	100	S
HD 45270	06 22 30.9	-60 13 07	6.53	G1V	23H	100	Z,S
GSC8894-0426	06 25 56.1	-60 03 27	12.7	M3Ve	23H	100	Z
AK Pic	06 38 00.4	-61 32 00	6.27*	G2V	22H	100	Z,S
CD-61 1439	06 39 50.0	-61 28 42	9.71	K7V(e)	22H	100	Z,S
TYC7627-2190	06 41 18.5	-38 20 36	11.08	K2Ve	78	100	S
GSC8544-1037	06 47 53.4	-57 13 32	11.8	K4V	143	95	s
CD-57 1654	07 10 50.6	-57 36 46	10.44	G2V	103	100	S
BD+20 1790	07 23 43.6	+20 24 59	9.93	K5Ve	26	100	L,S
HD 59169	07 26 17.7	-49 40 51	10.22	G7V	118H	90	S
V372 Pup	07 28 51.5	-30 14 47	10.13*	M1Ve	13	95	Z,S
CD-84 80	07 30 59.5	-84 19 28	9.96	G9V	71	100	S
HD 64982	07 45 35.5	-79 40 09	8.96*	G0V	83H	95	S
BD-07 2388	08 13 51.0	-07 38 25	9.38	K1V(e)	93	100	S
CD-45 5772	10 07 25.2	-46 21 50	10.89	K4V	70	95	S
BD+01 2447	10 28 55.6	+00 50 28	9.65	M2V	6.6	100	L,z
HD 99827	11 25 17.7	-84 57 16	7.70*	F5	83H	95	c
PX Vir	13 03 49.7	-05 09 43	7.69	K1V	22H	100	Z,S
HD 139751	15 40 28.4	-18 41 46	10.44*	K5Ve	37	100	Z,S
HIP 81084	16 33 41.6	-09 33 12	11.30	M0e	30	100	Z,S
HD 152555	16 54 08.1	-04 20 25	7.82	G0	48H	100	Z
HD 317617	17 28 55.6	-32 43 57	10.45	K3V	56	85	S
HD 159911	17 37 46.5	-13 14 47	10.10	K4Ve	45	100	S
HD 160934	17 38 39.6	+61 14 16	10.45*	K7Ve	33	100	Z
HD 176367	19 01 06.0	-28 42 50	8.48	G1V	63H	95	s
HD 178085	19 10 57.9	-60 16 20	8.34	G1V	57H	100	S
TYC0486-4943	19 33 03.8	+03 45 40	11.29	K3V	71	100	S
HD 189285	19 59 24.1	-04 32 06	9.43	G7V	95	90	S
BD-03 4778	20 04 49.4	-02 39 20	10.02	K1V	70	100	S
HD 199058	20 54 21.1	+09 02 24	8.61	G5V	75	100	S
TYC1090-0543	20 54 28.0	+09 06 07	11.29	K4Ve	75	100	S
HD 201919	21 13 05.3	-17 29 13	10.64	K6Ve	39	100	S
LO Peg	21 31 01.7	+23 20 07	9.19	K5Ve	25H	100	Z
HD 207278	21 48 48.5	-39 29 10	9.66	G7V	84H	100	S
HIP 107948	21 52 10.4	+05 37 36	12.11	M2Ve	30	100	S,z
HIP 110526A	22 23 29.1	+32 27 34	11.45*	M3e	15	100	Z
HIP 110526B	22 23 29.1	+32 27 32	11.55*	M3e	15	100	Z
HD 217343	23 00 19.3	-26 09 14	7.49	G5V	32H	100	Z,S
HD 217379	23 00 28.0	-26 18 43	10.45*	K7V	33	100	Z,S
HIP 114066	23 06 04.8	+63 55 34	10.87	M1e	25H	100	Z

(Continued)

Table 13. (Continued)

Name	α_{2000}	δ_{2000}	V	Sp.T.	D [pc]	P. %	Ref.
HD 218860A	23 11 52.1	-45 08 11	8.75	G8V	51H	100	Z,S
HD 218860B	23 11 53.6	-45 08 00	13.8	M3Ve	51H	100	S
HIP 115162	23 19 39.5	+42 15 10	8.94	G4	49H	100	Z
HD 222575	23 41 54.3	-35 58 40	9.39	G8V	62H	100	S
HD 224228	23 56 10.7	-39 03 08	8.22	K2V	22H	100	Z,S

(*) the photometric values are corrected for duplicity.
The distances are from Hipparcos (H in the table) or kinematical ones, calculated with the convergence method.
S=in the SACY survey; s=observed in the SACY, but outside of the sample definition; L=López-Santiago et al. (2006); Z=Zuckerman et al. (2004c); c=Covino et al. (1997), z=Zickgraf et al. (2005).

8. The AB Dor Association

The AB Dor Association is a relatively old association ($\sim$70 Myr), independently postulated by Zuckerman et al. (2004c), and in the SACY project (Torres et al. 2003a,b) with the designation of AnA. From the 37 members proposed by Zuckerman et al. (2004c), 18 are in the SACY sample. López-Santiago et al. (2006) proposed 11 other possible members[6], five of them within SACY. The convergence method was applied including the non-SACY members that were proposed. In Table 13 we present the 89 high probability members. The solution has a velocity dispersion a little higher than the other associations but this may be expected since it is the oldest one (see Tables 1 and 2). All members proposed by Zuckerman et al. (2004c) are also in this solution. In Table 13 there are actually 40 stars from their list since we included separately the components of three visual binaries, not discriminated by them. From the 11 members proposed by López-Santiago et al. (2006) we classified only three as high probability members (one in the SACY). We added 46 new members, 42 from the SACY sample.

Luhman et al. (2005) have argued that the AB Dor Association is a remnant of the large-scale star formation event that has also formed the Pleiades, and being somewhat older (75-150 Myr). As their arguments are based on the Zuckerman et al. (2004c) list of members it will be important to revisit the question of the origin of the AB Dor Association on the basis of the more extensive list presented here. Nonetheless, our newly derived space motions are even more similar to those of the Pleiades cluster. This common origin of the AB Dor Association and the Pleiades has been recently reinforced by Ortega et al. (2007), using Galactic dynamics calculations. This common origin would have occurred 119$\pm$20 Myr ago at a height of about 250 pc below the Galactic plane.

AB Dor itself is a well-studied active star, forming a system of four stars (Close et al. 2005). We have taken the proper motions and the parallax from the recent re-analysis of the system by Guirado et al. (2006), using Hipparcos and VLBI data. Janson et al.

[6]Although the authors say they added 13 stars, actually two of them are in the list of Zuckerman et al. (2004c)

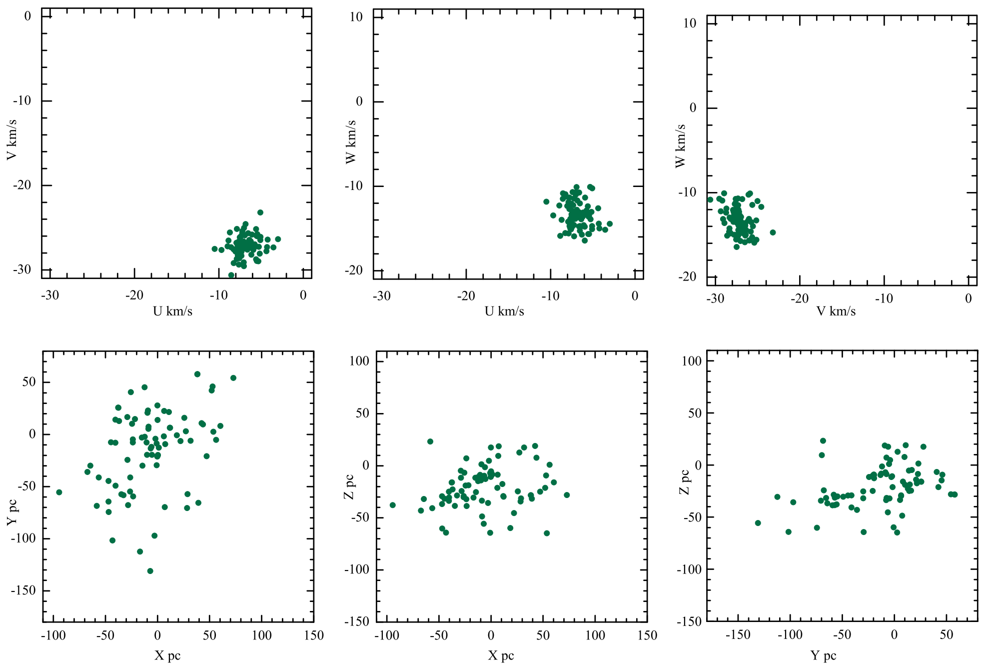

Figure 21. Combinations of the sub-spaces of the UVWXYZ–space for the AB Dor Association showing a well defined clustering in both kinematical and spatial coordinates.

(2007) obtain an age of about 50 to 100 Myr for the system. Close et al. (2007) infer an age of about 75 Myr by analyzing new photometric and spectroscopic measurements of AB DorC.

Not only the star AB Dor, but also many other stars in this association have been proposed as RS CVn or BY Dra variables. This can be noted by the names in Table 13. As, in general, they are fast rotators, the spread of the radial velocity values may indicate a spectroscopic binary nature, but few were confirmed. As they are young fast rotators, they have strong X-ray emission and spots, having therefore been confused with the true RS CVn variables. In fact, all are spotted variable stars and they are important for rotation and corona studies. In the AB Dor Association there are 15 of this kind of variables: PW And, IS Eri, V577 Per, AB Dor, UX Col, UY Pic, WX Col, TZ Col, TY Col, AK Pic, BD+20 1790, V372 Pup, PX Vir, HD 160934, LO Peg.

HD 33999 is a close visual binary (sep.=0.6″), not resolved by our spectrograph. The spectrum exhibits three features in the cross-correlation function. We interpret the stronger feature as coming from the hotter component, and the other two lines as coming from the fainter star, forming a double line spectroscopic binary.

UX Col had its photometric variations observed by Cutispoto et al. (2003) who determined a period of 2.29 days. Torres et al. (2006) obtained a vsin(i) = 41.5 km s^{-1}, similar to the one found by Tagliaferri et al. (1994). This would imply a minimum radius of 1.9 $R_\odot$ which is substantial for a K3V star at the age of the AB Dor Association.

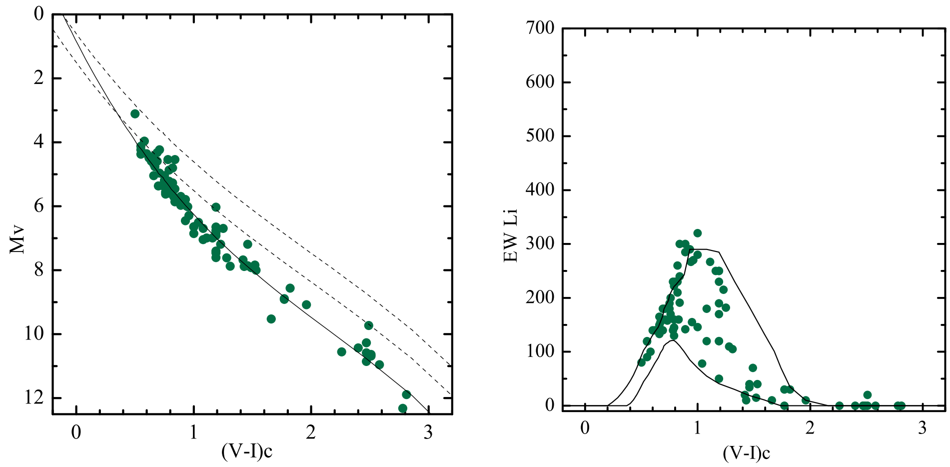

Figure 22. *Left:* The HR diagram of the members proposed for the AB Dor Association; the over-plotted isochrones are the ones for 5, 10, and 70 Myr. *Right:* The distribution of Li equivalent width as a function of $(V-I)_C$; the curves are the upper and lower limits for the age of the Pleiades (Neuhäuser 1997).

This could be resolved if one assumes that the true rotational period is actually a shorter alias period.

TY Col was observed by Cutispoto et al. (2001) who found a period of 3.82 days. Torres et al. (2006) obtained a vsin(i) = 55.0 km s^{-1}, similar to the one found by Tagliaferri et al. (1994). As for UX Col, this would imply a minimum radius of 4.1 $R_\odot$, incompatible with the age of 70 Myr . Again, the solution could be a short rotational period. Our spectral classification is similar to that of Cutispoto (1998) who discusses these difficulties.

GSC 8894-0426 was proposed by Zuckerman & Song (2004b) as a member of the AB Dor Association, but it has no astrometric data. It is separated by 27.2′ from HD 45270 (itself a wide binary, the companion being an active late-K star (Cutispoto et al. 2002)). If they are at the same distance, this would imply a separation of 0.2 pc. Using the HD 45270 Hipparcos astrometric data, GSC 8894-0426 becomes a bona fide member.

AK Pic (HD 48189) has a companion at 0.8″. This separation has changed in time, but it has no orbit determined yet. Proper motions of Hipparcos and TYCHO-2 disagree in RA and Hipparcos gives distinct RA proper motions for the components, thus we used the TYCHO-2 values. The radial velocities measured by different authors show a spread greater than the errors indicating a single line spectroscopic binary star. We used a compromise among the published values (30 km s^{-1}).

HD 99877 lies in front of the Cha region and the difference between the radial velocity measured by Covino et al. (1997) and by Nordström et al. (2004) is larger than the observational errors, indicating a possible spectroscopic binary.

PX Vir may also be a single line spectroscopic binary, given the spread of the radial velocity in the literature. In fact Hipparcos found an astrometric orbit, with P=231 d, and a semi-major axis of 11 mas, thus explaining this spread in radial velocities. We used a compromise value of 0 km s^{-1}. It is also a spotted variable star with P=6.5 days (Gaidos et al. 2000; Strassmeier et al. 2000).

HD 160934 is another single line spectroscopic binary with very long period (Gálvez et al. 2006). It was optically resolved at 0.2″ by Hormuth et al. (2007) who suggest a period of ∼8.5 years from both spectroscopic and visual data. This system has also a dM4e companion at 19.1″.

HD 217379 is a visual binary (sep.=1.8″), not separated in our spectrum. The spectrum shows a triple line system, formed by one K5V and two K7V stars. The brighter visual component seems to be the double line spectroscopic K7V binary. We used the velocity of the K5V component as the systemic velocity, supposing that the velocity of the visual spectroscopic single secondary is near the systemic one.

HD 218860 had its red companion recognized for the first time in the SACY. The stars have similar radial velocities, and for the red star we used the proper motions of the primary.

The AB Dor Association has 25 known visual binaries (two are triples and one is quadruple), presented in Table 14. There are also in the AB Dor Association two triple line spectroscopic multiples (HD 33999 and HD 217379), three single line spectroscopic binaries (AK Pic, PX Vir and HD 160934) and three stars are possible spectroscopic binaries (CD-26 2425, TZ Col and HD 99827).

Table 14. The visual binaries in AB Dor Association

Name	sep. ″	Name	sep. ″	Name	sep. ″
HD 4277	3.8	AB Dor AC	0.2	HD 99827	3.5
CD-46 644	21.7	AB Dor BaBb	0.06	PX Vir	0.01
HD 13482	1.8	UY Pic	10.3	HD 139751	0.9
HD 16760	14.6	WX Col	3.9	HD 160934 AB	0.2
HD 17332	3.6	HD 45270	16.2	HD 160934 AC	19.1
HIP 14809	33.2	AK Pic	0.8	HD 176367	11.2
V577 Per	9.5	HD 59169	1.2	HIP 110526	1.8
CD-56 1032	7.8	V372 Pup AB	0.2	HD 217379	1.8
HD 33999	0.7	V372 Pup AC	6.6	HD 218860	19.6
AB Dor AB	9.0	HD 64982	5.7		

9. Disks and Sub-stellar Objects

The discovery of 51 Peg b by Mayor & Queloz (1995) is without doubt among the scientific highlights of the last century. It triggered an incredible number of observational and theoretical studies aiming to find new worlds and understand their physics. In relation to the question of planetary system formation, it appeared already that, in the light of the discovery of 51 Peg b, the relevant timescales (disk evolution, planet formation, and migration) are all roughly of the same order of magnitude, i.e., ~ 10 Myr (e.g. Pollack et al. 1996; Ida & Lin 2004; Alibert et al. 2005; Haisch et al. 2001b). These timescales predicted by the models depend on the physical properties of the circumstellar disks, such as density profile, composition, grain size, etc. (e.g. Hubickyj et al. 2004), which in turn are themselves not well known. Clearly, a better understanding of disk properties and how they evolve in time is of paramount importance to planetary formation theories.

The link of the young, nearby associations to planetary system research is evident. Most of these associations are within an age range where disks are quickly evolving from a rather massive, accreting, gas-rich disk as found around TTS towards more quiescent, cold, debris disk where grain coagulation and re-processing, vertical settling, and planetesimal formation are thought to have occurred and large gaps may have opened as a result of the formation of planets. The literature about this topic is vast, and the *Spitzer Space Observatory* launched in 2003 continues to contribute in this field, e.g. via the key program "from disks to planets" (for a review see, e.g., Werner et al. 2006). In the following we focus on recent results that concern the young nearby associations discussed here. For a broader view on disk evolution we refer to recent reviews of Hillenbrand (2005) and Hartmann (2005).

A number of near (JHK) to mid-infrared (LMN) studies have been carried out during the last years in order to probe disk frequencies and dispersal times for stars with different ages. Based on the extrapolation of their relation between frequency of stars showing JHKL–excess and age, Haisch et al. (2001a) conclude that no excess is expected beyond 6 Myr. In other words, the inner region ($<$1 AU) of primordial hot and gas-rich circumstellar disks are thought to have dissipated after $\sim$6 Myr.

Jayawardhana et al. (1999) (for a summary, see also Jayawardhana 2001) conducted a mid-IR survey of the TW Hya Association members. They find that most of the TW Hya Association stars have little or no disk emission at 10 μm. Among those showing some 10 μm emission, gaps in disks appear to be established, suggesting that critical disk evolution has taken place already at the age of the TW Hya Association (see below). Mamajek et al. (2004) present an N-band survey of 14 young stars in the $\sim$30 Myr old Tuc-Hor Association to search for evidence of warm, circumstellar dust disks. They find that none of the stars have a statistically significant N-band excess compared to the predicted stellar photospheric flux, corroborating the notion that at this age, warm thick disks have already dissipated. In contrast to the TW Hya Association or the Tuc-Hor Association where few or no disks were detected, the η Cha cluster[7] seems to be an interesting exception to the disk frequency-age relation found by Haisch et al. (2001a). Lyo et al. (2003) found that 60% of the observed stars have near infrared excess. According to Lawson & Feigelson (2001), the age of the η Cha cluster is about 9 Myr. The direct implication is that stars in the η Cha cluster have retained their primordial disks longer than the observed trend. Clearly, the age of the η Cha cluster plays a key role in the discussion. Haisch et al. (2005) have recently revisited the issue. Their disk frequency is much smaller than that reported by Lyo et al. (2003), 28%$\pm$13 versus 60%$\pm$13%. This revised disk frequency along with the age estimate of Luhman & Steeghs (2004) which gives 6 Myr (similar to what we found in Section 5) instead of 9 Myr puts the η Cha cluster back into the linear relation of Haisch et al. (2001a). Haisch et al. (2005), on the other hand, do not exclude that the η Cha cluster is indeed 9 Myr old. In this case, after a rapid decline during which the dust in the inner disk is dissipated or accumulates into larger bodies, the disk fraction in clusters would

[7]Although throughout this section we refer to η Cha cluster, our analysis presented in Section 5 suggests that η Cha cluster belongs to what we call the ϵ Cha Association.

decrease more slowly, with a small number of stars ($\sim$10%) retaining their disks for times comparable to the cluster age. Megeath et al. (2005) presented *Spitzer* observations which show that one member of the η Cha cluster has an excess similar to a cTTS (ET Cha), whereas five other members show only weak IR-excesses. Interestingly, Hα spectroscopic data suggest that among these six stars, five are accreting, although at a much smaller rate than in the T Tauri regime. The authors suggest that, like in the TW Hya Association, we are witnessing a fast transition from a cTTS like disk to a debris disk.

One of the fundamental motivations to determine disk lifetimes is to assess the amount of molecular gas available and the time-span available in which giant planets could be formed. Although a direct measurement of gas densities and masses is difficult to obtain (Richter et al. 2002), it can be inferred from accretion signatures. Using mainly the equivalent width of Hα as an accretion diagnostic, Jayawardhana et al. (2006) estimate the frequency of accretors in the η Cha cluster, the TW Hya, the β Pic, and the Tuc-Hor associations. They find that three out of 11 ($\sim$ 27%) late-type stars in the η Cha cluster are accreting, whereas only two of the 32 targets ($\sim$ 6%) in the TW Hya Association show evidence for accretion. None of the β Pic and the Tuc-Hor Association members show these signatures. Jayawardhana et al. (2006) infer an inner disk lifetime of about 10 Myr. Moreover, the notion of long-lived primordial disks seems weakened since no accreting star was present in either the β Pic Association (12 Myr) or the Tuc-Hor Association (30 Myr). These results have been recently corroborated by Rebull et al. (2008, see also reference therein) who found an inside-out infrared excess reduction with time, wherein the shorter-wavelength excesses disappear before longer-wavelength excesses. Such a decrease is consistent with the overall decrease of disk frequency with stellar age. Moreover, optically thick disks, seen in the younger TW Hya Association and the η Cha cluster, are entirely absent in the β Pic Association.

Most stars in the nearby young associations studied here show clear signs that their primordial disks have already evolved into debris disks. A debris disk consists of a mixture of smaller and larger grains, and larger bodies like planetesimals required for the planetary formation processes. In these disks, dust grains are continuously regenerated by collisions and/or evaporation of planetesimals. This dust absorbs stellar radiation at visual wavelengths and re-radiates the energy at infrared to submillimeter wavelengths. It is the large emitting surface area of these numerous grains that makes debris disks around stars observable in the infrared and submillimeter, while the mass-dominant planetesimals remain undetected.

Due to the limitation imposed by Earth's atmosphere, space-based facilities like HST, IRAS, ISO and *Spitzer* are primary sources of information for the study of debris disks (Figure 23). A number of studies have correlated the far infra-red fluxes obtained by these facilities with catalogs of nearby stars (e.g., Chen et al. 2005; Moór et al. 2006; Rhee et al. 2007a). The main goal is to make a census of the debris disks around nearby stars of different spectral types and to understand how these disks evolve in time. These studies suffer from the difficulty of determining stellar ages for field stars. Moór et al. (2006) suggest to take advantage of the fact that several nearby stars are members of young nearby associations to improve age estimates for the debris disks. They found that the most prominent debris disks are found around members of the loose associations. Using the age estimates for the associations, they also found a moderate agreement between the theoretical predictions of the evolution of the fractional lumi-

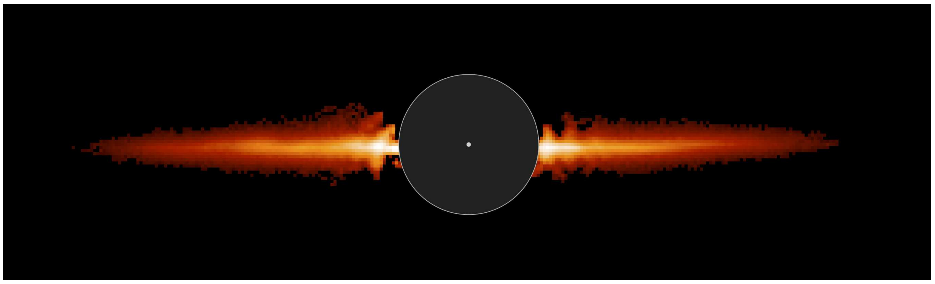

Figure 23. The debris disk around AU Mic is seen in this image obtained with the HST. Courtesy STScI.

nosity as function of the age. In the same line, Rhee et al. (2007b) estimate that 13% of the stars with spectral type earlier than G0 belonging to one of the nearby young associations show evidence of possessing a warm ($\gtrsim$ 150K) mid-IR excess related to debris-disks or a mix of debris-disk and primordial-disk material.

Since the debris disks are generated by collisions of planetesimals, usually the presence of (undetected) planets is inferred from the presence of a debris disk itself. The existence of planets in the debris disk of Vega-like stars has been suggested based on the non-axissymmetric structures observed in many of these disks. Such structures are thought to be caused by the gravitational perturbation of massive bodies (Jupiter and brown dwarf masses) orbiting around the host star (e.g. Macintosh et al. 2003; Zuckerman & Song 2004a; Okamoto et al. 2004, and references therein).

So far, attempts to find the perturbing body around stars with debris disks via adaptive optics systems have failed (Macintosh et al. 2003; Zuckerman & Song 2004a). Concerning the nearby young associations, debris disks have been detected in a few members of the β Pic Association, the TW Hya Association and other nearby stars (Zuckerman et al. 2001a; Zuckerman & Song 2004a; Zuckerman & Song 2004b). In the TW Hya Association, the 10 μm study carried out by Jayawardhana et al. (1999) showed that most of the TW Hya Association stars have little or no disk emission at 10 μm. Low et al. (2005) using *Spitzer* showed that even at 24 μm most of the stars show no excess. This implies the absence of dust warmer than 100 K. For four other objects (TW Hya, TWA 3, TWA 4, and TWA 11A) the excess at 24 μm is, however, a factor of $\sim$100 above the photosphere in a clear bimodal distribution (Figure 1 of Low et al.). A similar behavior is also seen at 70 μm, although less marked than at 24 μm. Remarkably, mid-infrared images of the disk around β Pic itself reveal brightness asymmetries that can be interpreted as resulting from a cataclysmic break-up of planetesimals (Telesco et al. 2005).

Again, as for the η Cha cluster, it seems that disks evolve fast during this age, and thus a mix of disk characteristics is seen. The most interesting case is perhaps TW Hya itself which looks like a cTTS (e.g. Rucinski & Krautter 1983; de la Reza et al. 1989; Gregorio-Hetem et al. 1992) but whose disk shows signs of evolution (Krist et al. 2000; Weinberger et al. 2002, 2004; Wilner et al. 2005; Low et al. 2005). Wilner et al. (2005) in particular, based on VLA observations at $\lambda = 3.5$ cm, suggest that the emission observed at this wavelength can only be explained if planetesimals of centimeter size have already been formed in the disk of TW Hya.

Direct imaging and spectroscopy of Jupiter mass and brown dwarf objects also benefit from the young age and proximity of the associations discussed here since atmospheres of very low mass objects look brighter at near-IR wavelength (e.g. Burrows et al. 1997) and therefore can be imaged by current adaptive optics systems. For instance, an object of 5 M_J can be detected around a K0V star at separations larger than 0.7″ (Masciadri et al. 2005). Not surprisingly, Chauvin et al. (2004, 2005a) imaged the first extra-solar planet around a brown-dwarf member of the TW Hya Association. A second case (bearing IAU definition of what is a planet) of a sub-stellar object of 13 M_J was reported by Chauvin et al. (2005c) at ~ 260 AU from AB Pic, a member proposed of the Car Association.

It is interesting to note that Masciadri et al. (2005), using adaptive optics techniques, searched for other giant planets around members of the Tuc-Hor, the β Pic and the TW Hya associations and young field stars. They report a null result. Kasper et al. (2007) used L-band adaptive optics-assisted imaging to look for planets around 22 members of Tuc-Hor and β Pic associations. Their observations were sensitive to companions with masses down to 1 to 2 M_J at separations larger than 5 to 30 AU. In spite of the unprecedented sensitivity, no sub-stellar companions were found.

It is an open question whether the low number of sub-stellar detections beyond 5 AU reported by the direct imaging surveys is real or due to an overestimated sensitivity related to uncertainties in the predicted luminosities at early ages (Marley et al. 2007). In spite of this, it is expected that the next generation adaptive optics systems (i.e., the planet finders) will be able to probe fainter objects closer to the central star ($\Delta M \sim 17.5$ at 0.5″). Thus the members of the nearby young associations described here are still prime candidates to these future adaptive optics surveys.

Radial velocity surveys usually do not target young stars (<10 Myr or so). This is due to the fact that accretion, high rotation and chromospheric activity affect a great deal the quality of the radial velocity, thus hampering any attempt to reach the few m/s precision needed to find Jovian planets. In spite of these difficulties, a few groups have been trying to conduct radial velocity surveys around young stars. Setiawan et al. (2008) announced the discovery of a massive (10 M_J) hot-Jupiter around TW Hydrae. However, the results of Huélamo et al. (2008b) cast doubts about the existence of TW Hya's hot-Jupiter. Both results, in spite of being contradictory, are exciting and will certainly trigger a number of studies in the optical and in the near-infrared. The discovery of a population of hot-Jupiters already at a few Myr would lead to strong constraints on their formation and evolutionary time-scales.

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