NEW RESULTS FOR THREE NEARBY OB ASSOCIATIONS

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ABSTRACT

We have developed a new procedure to identify moving groups, and have applied it to carry out a census of the nearby OB associations based on Hipparcos parallaxes and proper motions (see de Bruijne et al. 1997, de Zeeuw et al. 1997). Here we present three illustrative cases. For α Persei our method allows us to refine the bright end of the membership list, while for Collinder 121 the Hipparcos data change the whole appearance of the association. Finally, we report the discovery of a new association in the field of Cepheus OB2.

Key words: OB associations; moving groups.

1. INTRODUCTION

OB associations are dynamically unbound groups of young massive stars, located near star forming regions. They form a perfect laboratory to study the processes involved in high mass star formation in giant molecular clouds (Blaauw 1964, 1991). Detailed knowledge on the stellar content, i.e. the membership, provides information on the initial mass function, the local star formation rate and efficiency, differential age effects between subgroups within associations, the binary population, and the interaction between stars and the interstellar medium.

Membership of associations based on pre-Hipparcos proper motions is known only for stars with spectral types earlier than B5 (e.g. Blaauw 1946, Bertiau 1958). Photometric studies extend membership to later spectral types (e.g. Warren & Hesser 1978, de Geus 1989, Brown et al. 1994). However, relying on the photometric distance as the only membership criterion is dangerous: field stars are easily selected as members due to the large physical size and loose structure of an association.

To obtain reliable membership lists we have developed a new selection procedure (de Bruijne et al. 1997) which uses Hipparcos data to detect moving groups and determine membership. This work is part of a larger investigation of the nearby OB associations and related star forming regions (see de Zeeuw et al. 1994). Here we present three examples of the results of the new member selection. An overview of the project, and results for other associations, can be found in de Zeeuw et al. (1997).

2. α PERSEI

Immediately after publication of the Preliminary General Catalogue in 1910, Eddington, Boss, and Kapteyn independently reported the presence of a moving group of B stars in the Perseus region. These stars have large proper motions and stand clear from the field star population, allowing for reliable membership selection. Rasmuson (1921) extended the membership list with 45 stars of all spectral types. Heckmann et al. (1956) and Heckmann & Lübeck (1958) re-investigated the positions and proper motions in the region of α Persei and found 163 members brighter than $V = 12.2$ down to spectral type G5. Much fainter members, $V < 19$, were identified by Stauffer et al. (1985, 1989) and Prosser (1992). These studies resulted in about 300 known members. The α Persei moving group is sometimes referred to as Per OB3, and may be related to the nearby old Cas–Tau association (Blaauw 1956), which has similar kinematics.

Our Hipparcos sample for α Persei consists of 425 stars of spectral type earlier than G5 in the field $140° < \ell < 155°$ and $-11° < b < -3°$. Figure 1 shows the vector point diagram, for the different spectral types. The moving group is recognized easily in the B and A stars due to the small velocity dispersion in the population of early-type field stars. The separation between group and field becomes less clear for the F and G stars because of the increased velocity dispersion in the field population.

We first apply our selection procedure to the B and A stars. Of the 254 stars 70 are found to be members. We then use the space motion of the group defined by these B and A stars to search for comoving F and G stars. Of the 171 F and G stars, 17 are found to be comoving with the B and A members. In total we find 87 members; 32 B, 38 A, 15 F, 1 G, and 1 K type. The positions and proper motions are shown in Figure 2. The apparent lack of late type members compared to e.g. Stauffer et al. (1985, 1989) and Prosser (1992) is caused by the completeness limits of the Hipparcos Catalogue. Of the 163 bright mem-
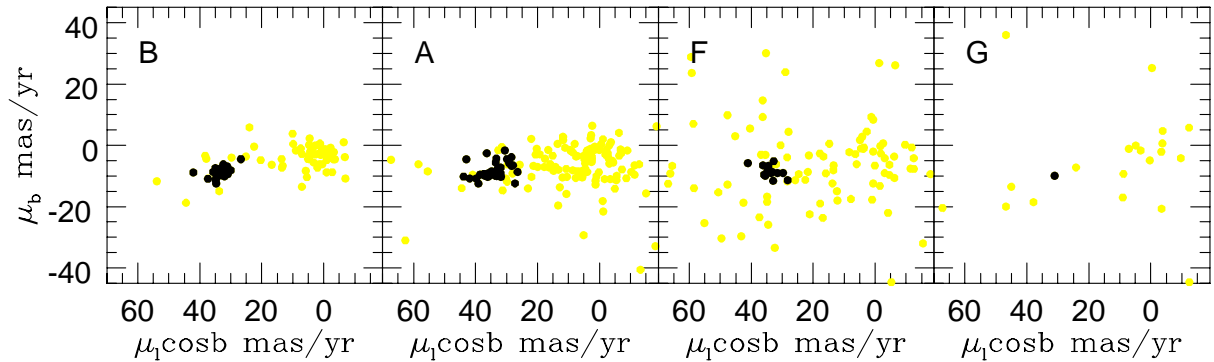
Figure 1. Vector point diagrams for the B, A, F, and G stars in the α Persei field; black dots indicate members and gray dots are field stars. The separation between cluster and field is evident for the B and A stars, becomes less clear for F stars, and has disappeared for G stars.

bers listed by Heckmann et al. (1956) only 53 are contained in the Hipparcos Catalogue. Of these, 15 are rejected by our selection procedure.

Following the procedure described in de Zeeuw et al. (1997) we obtain a mean distance of 176 ± 5 pc for the α Persei cluster, where the error corresponds to the error in the mean parallax. This agrees with previous distance estimates which range from 160 to 180 pc (e.g. Roman & Morgan 1950, Mitchell 1960). The parallax distribution (Figure 3) shows that the cluster has a depth less than ~ 60 pc, but with an average error of 1 mas in parallax we are unable to resolve the depth of the cluster.
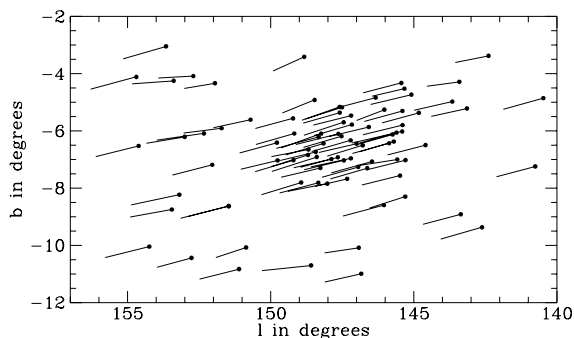

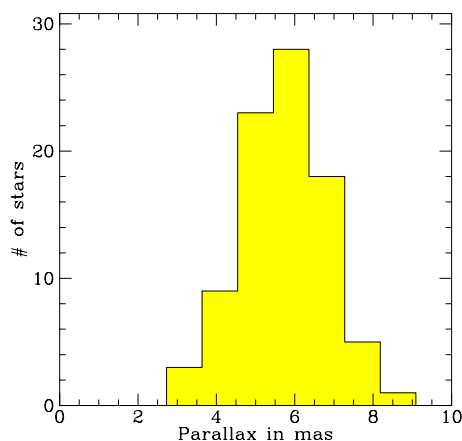Figure 2. Positions (dots) and proper motions (lines) of the α Persei members.

3. COLLINDER 121

Collinder 121 was first recognized as a physical group of stars by Collinder (1931). He found an open cluster of 20 stars at a distance of 590 pc within an area of 1 square degree. Of these, 8 are contained in the HD catalogue. Feinstein (1967) found 11 stars belonging to the cluster in the central region defined by Collinder, and he extended the membership list with 16 bright and 12 faint stars in a 10° circle around the cluster center. Feinstein put the cluster at 630 pc. Eggen (1981) suggested a division into two groups for the stars in this region: an open cluster-like group of 13 stars at 1.17 kpc and another group of 18 stars at 740 pc resembling an OB association. Figure 4 shows the stars listed by Feinstein as classical members of Collinder 121. Evidence for a moving group can be seen in the Hipparcos proper motions, although some of the stars are clearly non-members based on the magnitude and direction of the proper motion.

Our Hipparcos sample for Collinder 121 consists of all O and B stars in the field $222° < \ell < 246°$ and $-16° < b < -3°$. After applying our selection procedure we are left with 105 of the 449 stars. The earliest spectral type among the members is B2 (Figure 5). Most of the members are evolved early-type stars suggesting an old association. Collinder 121 has dramatically changed its appearance compared to the previous membership lists (see Figure 4). While 5 of the 8 HD stars listed as members by Collinder are contained in the Hipparcos Catalogue, only 2 are selected as member. From the 39 stars listed by Feinstein, 35 are in the Hipparcos Catalogue and 10 are classified as members by our selection procedure. For Eggen's distant group in the Collinder 121 region we select 4 from the 7 stars contained in the Hipparcos Catalogue, and another 3 from the 6 stars
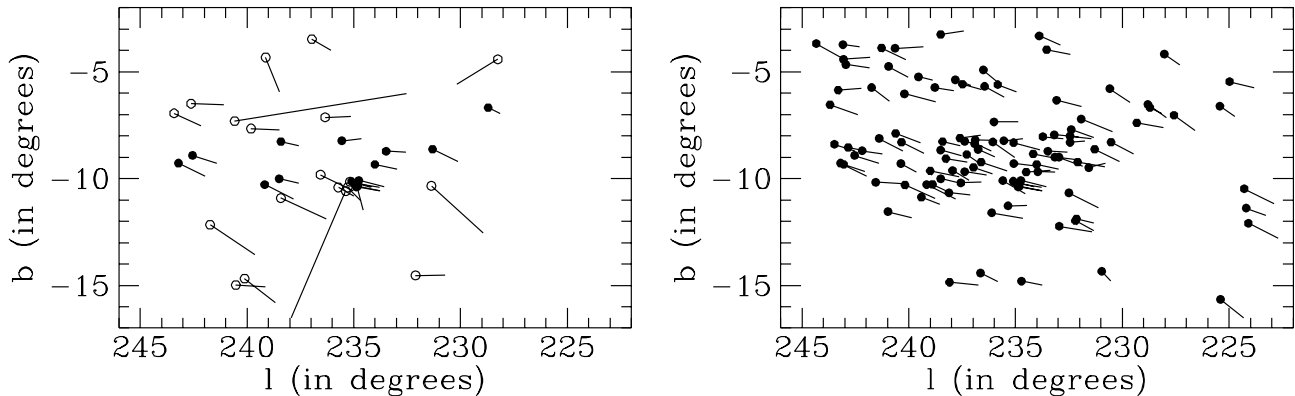

Figure 3. Parallax distribution of the α Persei members. The mean parallax is 5.7 ± 0.1 mas.

Figure 4. *Left: Hipparcos positions and proper motions of the classical 'members' of Collinder 121. Filled dots are stars confirmed as member, while open dots are rejected by our selection procedure. Right: same plot for the stars we select as members of Collinder 121. Note the dramatic changes from pre-Hipparcos to post-Hipparcos.*

in the closer group. There is no clear difference in the parallaxes for these two groups, suggesting that the division made by Eggen is unphysical.

We derive a distance of 546 ± 30 pc for Collinder 121. This is closer than all previous distance determinations. The well-studied Wolf-Rayet star WR6 (EZ CMa) is a member. Its parallax of 1.74 ± 0.76 mas places the star in the middle of the cluster. This is in disagreement with the lower limit on the distance of 1.8 kpc derived by Howarth & Schmutz (1995), and indicates that the absolute luminosity of this WR star is an order of magnitude lower than thought previously.
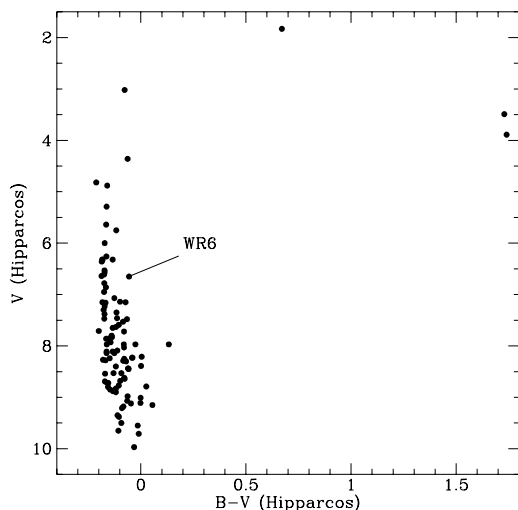

Figure 5. *Colour-magnitude diagram, uncorrected for reddening, for the Collinder 121 members. The earliest spectral type is B2. The unusual position of WR6 is caused by systematic effects in the Hp to V and $B_T - V_T$ to $B - V$ transformation. Feinstein (1967) obtained $V = 6.91$, $B - V = -0.28$.*

4. A NEW GROUP

We have discovered a previously unknown group of comoving early-type stars in the Cepheus OB2 field. The Hipparcos sample consists of 388 stars (all B stars, plus all A stars fainter than $V = 8$) in the field $96° < \ell < 108°$ and $-1° < b < 12°$. The new group contains 15 stars with spectral types later than B6, and is located at the edge of the Cepheus OB2 field. Their positions and proper motions clearly reveal a moving group (see Figure 6). Figure 7 shows the Hipparcos colour-magnitude diagram. The main sequence is evident, which suggests the stars are at a similar distance. The lack of early spectral types suggests an old association, similar to Collinder 121. However, we may well have missed the most massive members of the group due to the field limits (Figure 6). A more detailed description of this group will be possible when the whole Hipparcos Catalogue becomes available, and we can search the adjacent area. We have initiated a radial velocity study to refine the membership list further.

The IRAS 60 micron map for the Cepheus region shows a varying intensity across the field of this new group. The scatter around the main sequence may thus be caused by variable extinction. Strömgren photometry is available for one of the two stars above the main sequence, and indicates a reddening larger than 0.5 magnitudes in V. It will be interesting to obtain homogeneous multi-colour photometry for all members of this group.

We derive a distance of 240 ± 10 pc for the new group. This places it inside the Gould Belt, the well-known ring-like distribution of early-type stars which is tilted by $\sim 20°$ with respect to the Galactic plane. Some of the nearby OB associations, including Sco OB2, Ori OB1 and Per OB2, are part of this structure (e.g. Lindblad et al. 1997, Torra et al. 1997, and references therein). The α Persei cluster and the Cas–Tau association are located in the middle of the Gould Belt, and may be related to its origin.
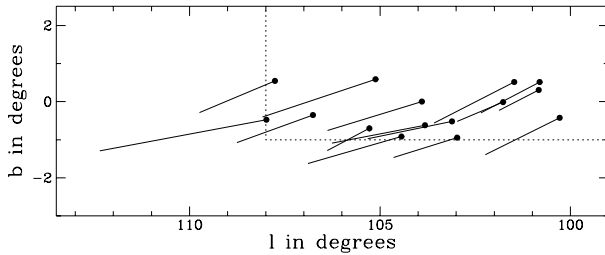
Figure 6. Positions and proper motions for members of a new group of comoving stars in the Cepheus OB2 field. The dotted lines are the field limits of our present sample.

5. CONCLUDING REMARKS

We have presented results on the member selection and distance analysis of two known OB associations, α Persei and Collinder 121, and one newly discovered group in the field of Cepheus OB2. They are part of a larger census of the nearby OB associations discussed by de Zeeuw et al. 1997. The three examples given here illustrate the major step forward in our understanding of OB associations provided by Hipparcos. We refined the membership list for α Persei, based on 87 bright members identified in our Hipparcos sample. The accuracy of the membership list was already good due to the large tangential velocity of α Persei, 30 km s^{-1} with respect to the Sun. The new distance of 176±5 pc agrees well with previous estimates. The appearance of Collinder 121 changed from a compact open cluster (1 square degree, 20 members at 590 pc) to an old OB association at 546±30 pc with 105 members distributed over ∼ 45 square degrees. Finally, we discovered a new group of 15 comoving early-type stars in the Cepheus OB2 region at 240 ± 10 pc. Further investigation is needed because the group is located at the edge of the field and we expect to find more members when the whole Hipparcos Catalogue becomes available.

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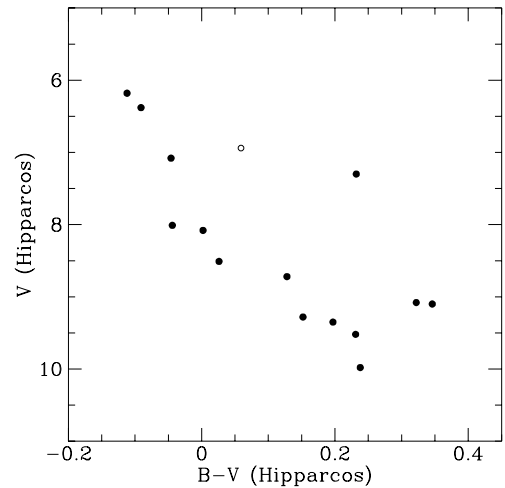
Figure 7. Colour magnitude diagram, uncorrected for reddening, for members of the new group. The earliest spectral type is B6. The scatter of the stars around the main sequence is probably due to varying extinction across the field. The open dot is a star with an extinction of more than 0.5 magnitude, putting it close to the main sequence.

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