A&A 485, 931–949 (2008)
DOI: 10.1051/0004-6361:200809595

Astronomy & Astrophysics

Young stars and brown dwarfs surrounding Alnilam (ϵ Orionis) and Mintaka (δ Orionis)*

J. A. Caballero[1,2] and E. Solano[3]

[1] Dpto. de Astrofísica y Ciencias de la Atmósfera, Facultad de Física, Universidad Complutense de Madrid, 28040 Madrid, Spain
e-mail: caballero@astrax.fis.ucm.es
[2] Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany
[3] Laboratorio de Astrofísica Espacial y Física Fundamental, INSA, Apdo. 78, 28691 Villanueva de la Cañada, Madrid, Spain

Received 17 February 2008 / Accepted 9 April 2008

ABSTRACT

Aims. We look for new regions to search for substellar objects.

Methods. Two circular areas, 45 arcmin-radius each, centred on the young massive star systems Alnilam and Mintaka in the Orion Belt, were explored. The regions are very young (less than 10 Ma), have low extinction, and are neighbours to σ Orionis (~3 Ma), a young open cluster very rich in brown dwarfs and planetary-mass objects. We used Virtual Observatory tools, the astro-photometric Tycho-2, DENIS and 2MASS catalogues, 10 control fields at similar galactic latitudes, as well as X-ray, mid-infrared, and spectroscopic data from the literature.

Results. We compiled exhaustive lists of known young stars and new candidate members in the Ori OB1b association and of fore- and background sources. A total of 136 stars display features of extreme youth, like early spectral types, lithium in absorption, or mid-infrared flux excess. Other two young brown dwarf and 289 star candidates have been identified from an optical/near-infrared colour–magnitude diagram. We list another 74 known objects that might belong to the association. This catalogue can serve as input for characterising the stellar and high-mass substellar populations in the Orion Belt. Finally, we investigated the surface densities and radial distributions of young objects surrounding Alnilam and Mintaka and compared them with those in the σ Orionis cluster. We report on a new open cluster centred on Mintaka.

Conclusions. Both regions can be analogues to the σ Orionis cluster, but more massive, more extended, slightly older, and less radially concentrated.

Key words. astronomical data bases: miscellaneous – Galaxy: open clusters and associations: individual: Ori OB1b – Galaxy: open clusters and associations: individual: Collinder 70 – stars: low mass, brown dwarfs – stars: individual: Alnilam – stars: individual: Mintaka

1. Introduction

The knowledge of the frequency and characteristics of brown dwarfs (substellar objects with masses below the hydrogen burning limit) is essential for the most advanced scenarios of the fragmentation of molecular clouds and very low-mass star formation (Reipurth & Clarke 2001; Bate et al. 2003; Whitworth et al. 2007). In particular, they provide valuable information on the bottom of the initial mass function (e.g. Luhman et al. 2000). Brown dwarfs are found in the field, both as companions to stars (Nakajima et al. 1995; Rebolo et al. 1998; Goldman et al. 1999) and free-floating (Delfosse et al. 1997; Ruiz et al. 1997; Kirkpatrick et al. 1999). Brown dwarfs are much brighter when younger (Chabrier & Baraffe 2000); they are, thus, very common in young open clusters and star-forming regions, such as the Pleiades (Rebolo et al. 1995), ρ Ophiuchi (Luhman et al. 1997), Chamaeleon I+II (Neuhäuser & Comerón 1998), Taurus-Auriga (Briceño et al. 1998), or the Orion Nebula Cluster (Hillenbrand & Carpenter 2000). There are, however, limitations in the search for brown dwarfs in these regions and in others. In the youngest ones (e.g. Chamaeleon, Ophiuchus), there is variable extinction that hinders the characterisation of the recently-born brown dwarfs, while in the others (e.g. Pleiades, Hyades), the relatively old brown dwarfs have dimmed down to faint magnitudes that require the use of very large, expensive, astronomical facilities.

There exists, nevertheless, a cornerstone in the search for brown dwarfs and objects below the deuterium burning-mass limit: the σ Orionis cluster in the Ori OB1b association (Garrison 1967; Lyngå 1981; Walter et al. 1997). This cluster is very young (~3 Ma), practically free of extinction ($A_V \lesssim 0.3$ mag), and relatively close ($d \sim 385$ pc); see Caballero (2007a, 2008c) for extensive bibliographic and data compilations on the cluster. It harbours not only a rich population of OB-type and T Tauri stars, but also Herbig-Haro objects, X-ray emitters, and substellar objects (Wolk 1996; Reipurth et al. 1998; Oliveira & van Loon 2004; Franciosini et al. 2006). Indeed, the σ Orionis cluster possesses the best spectroscopically investigated and most numerous population of brown dwarfs and planetary-mass objects down to a few Jupiter masses (Zapatero Osorio et al. 2000; Béjar et al. 2001; Caballero et al. 2006). Besides, an important fraction of the σ Orionis area has already been covered or is being currently investigated by very deep, wide photometric surveys, screening the whole brown dwarf and part of the planetary-mass regimes (González-García et al. 2006; Caballero et al. 2007; Bihain et al., in prep.).

To compare substellar mass functions, spatial distributions, or disc frequencies of different clusters and to look for

* Tables A.1 to A.18 are only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via
http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/485/931

Article published by EDP Sciences

new brown dwarfs and planetary-mass objects, it is therefore necessary to search for new locations. Youth, closeness, and low extinction, just like in σ Orionis, are definitely required. Since the new hunting grounds in the search for substellar objects must resemble σ Orionis, it is natural to look for them close to home, such as in the Ori OB1b association.

1.1. Alnilam and Mintaka

A "clustering of early-type stars elongated roughly parallel to the Galactic plane" (Guetter 1979) was firstly noticed by Pannekoek (1929). Later, in his classical review of nearby O-type associations, Blaauw (1964) described an Ori OB1 complex split into four divisions, being Ori OB1b (the "Orion Belt") one of them. Wide survey observations with Schmidt telescopes have shown a patent overdensity of Hα emission stars in the area (Haro & Moreno 1953; Wiramihardja et al. 1989). Canonical age and heliocentric distance are in the intervals 1–7 Ma and 350–500 pc (e.g. Anthony-Twarog 1982; Lyngå 1987; Blaauw 1991; Brown et al. 1994; de Zeeuw et al. 1999; Harvin et al. 2002). The most representative stars in the Ori OB1b association are the bright O-type supergiants Alnitak, Alnilam and Mintaka (ζ Ori, ϵ Ori and δ Ori, respectively), which constitute the celebrated asterism of the Orion Belt. At least one star of the trio (Alnilam) was depicted in the Farnese Atlas and, therefore, tabulated in the original Hipparchus catalogue (Schaefer 2005). The easternmost supergiant, Alnitak, is nearly embedded in the core of the L1630/Orion B molecular cloud complex, which contains, among other nebulosities and H II regions, the Flame Nebula (NGC 2024) and the Horsehead Nebula. The high variable extinction and emission in the area (Jaffe et al. 1994; Lacy et al. 1994; Kramer et al. 1996) prevent from suitably studying its stellar and substellar populations *à la* σ Orionis.

The stellar populations in the Ori OB1b association have been characterised after Blaauw's (1964) seminal work by many authors (Hardie et al. 1964; Warren & Hesser 1978; Guetter 1981; Brown et al. 1994; Hernández et al. 2005). In contrast to the hypothesis of Sharpless (1962), who claimed a lack of noticeable excess of members in Ori OB1b later than A5, at least two nearby clusters are known within the association: σ Orionis, centred on the eponym σ Ori Trapezium-like star system (see above), and Collinder 70, centred on Alnilam (Collinder 1931). There is an additional open cluster in the background, to the north of Mintaka: Berkeley 20. It is a unusual, low-metallicity, old open cluster at $d \sim 8.4$ kpc, and about 2.5 kpc below the Galactic plane (Lyngå 1987; MacMinn et al. 1994).

While the size of σ Orionis is well-determined at 20–30 arcmin (Béjar et al. 2004; Sherry et al. 2004; Caballero 2008a), the actual size of Collinder 70 has not been ascertained. Some authors (e.g. Gieseking 1983; Dias et al. 2001) have identified the Collinder 70 cluster, sometimes called the "ϵ Orionis cluster", as the whole Ori OB1b association. Markarjan (1951) (and, therefore, Lyngå 1987) tabulated an angular diameter of 149 arcmin, which would make the cluster comprise the stellar populations surrounding Mintaka and σ Ori. Subramaniam et al. (1995) proposed that both Collinder 70 and NGC 1981 (to the north of the Orion Nebula Cluster) form a "probable binary open star cluster in the Galaxy". Some classical works also catalogued a bright diffuse galactic nebulae centred on Alnilam, and with an apparent size of 50 arcmin (Dreyer 1888 – NGC 1990; Cederblad 1946 – Ced 55h). The existence of (numerous) small cometary globules, remnant molecular clouds and giant outflows close to Alnilam and Mintaka, even in larger amounts than close to σ Ori (Cernicharo et al. 1992; Yun et al. 1997; Ogura & Sugitani 1998; Mader et al. 1999), favours the hypothesis of a wide region with a rather homogeneous age of no more than ~7 Ma. See also Wolk (1996) and Scholz & Eislöffel (2005) for other age determinations. The recent determinations of heliocentric distances to VV Ori AB, a double-lined eclipsing binary in a detached configuration close to Alnilam (d = 388 ± 30 pc; Terrell et al. 2007), and to σ Ori AB, one of the most massive binaries known ($d \sim 385$ pc assuming the hierarchical triple scenario – Caballero 2008b; Peterson et al., in prep.), seem to support the homogeneity of the region. There are hints, nonetheless, of substructure and overlapping populations within the association, as first noticed by Hardie et al. (1964); Warren & Hesser (1977), and later by Jeffries et al. (2006); Caballero (2007a); Caballero & Dinis (2008).

Searches for low-mass young stars in the central and western regions of the Ori OB1b association (the σ Orionis cluster is to the east) have already been carried out by Sherry et al. (2000), Sherry (2003) and Briceño et al. (2005). Several very low-mass star and brown dwarf candidates have also been identified surrounding Alnilam by Béjar (2001), Pérez-Garrido et al. (2005) and Scholz & Eislöffel (2005). These works are, however, biased towards very low-mass objects or are incomplete. On the one hand, Pérez-Garrido et al. (2005) selected brown dwarf candidates in the 2MASS catalogue (Skrutskie et al. 2006) without an optical counterpart in the USNO-A2.0 catalogue (Monet et al. 1998); nonetheless, the majority, if not all, of their 23 objects are identified in the red optical passbands of the most recent, deeper USNO-B1.0 and DENIS catalogues (Epchtein et al. 1999; Monet et al. 2003). On the other hand, Béjar (2001) and Scholz & Eislöffel (2005) selected their cluster member candidates from deep optical surveys (IZ, RI) in ~1000 arcmin^2-wide areas to the southeast and the northwest of Alnilam, respectively. Each of them might have surveyed less than one quarter of the minimum size of Collinder 70, and only for objects fainter than I = 14–16 mag. Béjar et al. (2003a) and Béjar et al. (2003b) carried out the spectroscopic follow-up of nine "ϵ Orionis cluster" photometric member candidates presented in Béjar (2001). Derived spectral types ranged between M4.5 and M8, at the expected star-brown dwarf boundary. Some of the spectra also showed features of extreme youth (Li I λ6707.8 Å in absorption, Hα λ6652.8 Å in emission, and/or faint alkali lines – a signpost of low surface gravity, low g). No searches for brown dwarfs have been carried out in the Mintaka region yet.

In the present work, we compile lists of confirmed very young stars, association member candidates, and fore- and background sources in two wide survey areas centred on Alnilam and Mintaka, using tools of the Virtual Observatory. The final catalogue, ranging from the two massive OB-type supergiants to intermediate M-type substellar objects, is useful for the next studies that characterise stars and brown dwarfs, initial mass function, frequency, and properties of discs and multiplicity in the Ori OB1b association, and complements past and future works (e.g. Béjar et al., in prep.; Pérez-Garrido et al., in prep.). Finally, we present a preliminary study of the spatial distribution of association members and candidates.

2. Analysis and results

2.1. Data and survey areas

The search for stellar and substellar members of the Ori OB1b association around Alnilam and Mintaka were conducted using the Tycho-2 (Høg et al. 2000), DENIS, and 2MASS catalogues and photometric, spectroscopic, and astrometric

Table 1. Observed fields (45 arcmin-radius each).

Name	α (J2000)	δ (J2000)	l [deg]	b [deg]
Mintaka	05 32 00.40	–00 17 56.7	203.9	–17.7
Alnilam	05 36 12.81	–01 12 06.9	205.2	–17.2
c_1	05 59 46.51	–11 57 00.3	218.0	–16.8
c_2	05 55 49.69	–13 26 39.1	219.0	–18.3
c_3	06 03 04.36	–13 41 16.2	220.0	–16.8
c_4	05 59 03.14	–15 10 29.9	221.0	–18.3
c_5	06 06 20.78	–15 25 51.3	222.0	–16.8
c_6	06 02 15.03	–16 54 41.1	223.0	–18.3
c_7	06 09 36.11	–17 10 44.3	224.0	–16.8
c_8	06 05 25.67	–18 39 11.3	225.0	–18.3
c_9	06 12 50.69	–18 55 53.7	226.0	–16.8
c_{10}	06 08 35.37	–20 23 59.1	227.0	–18.3

information from the literature. The two main survey fields were defined as 45 arcmin-radius circles centred on the stars. Since the two circular fields are almost tangent, the size choice simultaneously allows exploring a large manageable area of about 3.5 deg^2 and prevents overlapping between them. There is, however, a tiny overlapping of a few arcmin^2 between both circular fields. The radius of investigation is roughly twice the radius of the core of the σ Orionis cluster, which is expected to be a model. To discard background and foreground objects in the two main fields, we selected ten nearby, same-size comparison fields, c_i (i = 1, 2... 10), fulfilling the following requirements:

- data availability (i.e. $\delta < +2$ deg; there is no DENIS data for larger declinations);
- separation from the Orion region to avoid gas clouds and dispersed young stellar populations;
- same galactic latitude to the main fields ($b \sim -17.5$ deg);
- similar galactic longitude to the main fields, but keeping away from the Galactic bulge to minimise the number of background giant stars ($l \sim 215$–230 deg).

Central coordinates (equatorial and Galactic) of the twelve fields are given in Table 1. Both main and comparison fields were explored down to limiting magnitude V_T = 11.5 mag (Tycho-2), i = 18.0 mag (DENIS), J, H, K_s = 17.1, 16.4, 14.3 mag (2MASS). In Tables A.3 and A.4, there are Tycho-2 stars fainter than the indicated V_T-band limiting magnitude. A pictogramme of the survey areas is given in Fig. 1, while Fig. 2 shows the images of the fields surrounding Alnilam and Mintaka and of one comparison field.

In what follows, information retrieval, data manipulation, filtering, and selection has taken advantage of Virtual Observatory[1] standards and tools, in particular Aladin[2] (Bonnarel et al. 2000) and TOPCAT[3]. The Virtual Observatory is an international, community-based initiative to provide seamless access to the data available from astronomical archive and services, as well as to develop state-of-the-art tools for the efficient analysis of this huge amount of information. Padovani et al. (2004), Tsalmantza et al. (2006), and Caballero & Solano (2007) are examples of the efficiency of such tools in helping astronomers produce scientific results.

[1] http://www.ivoa.net
[2] http://aladin.u-strasbg.fr/aladin.gml
[3] http://www.star.bris.ac.uk/~mbt/topcat/

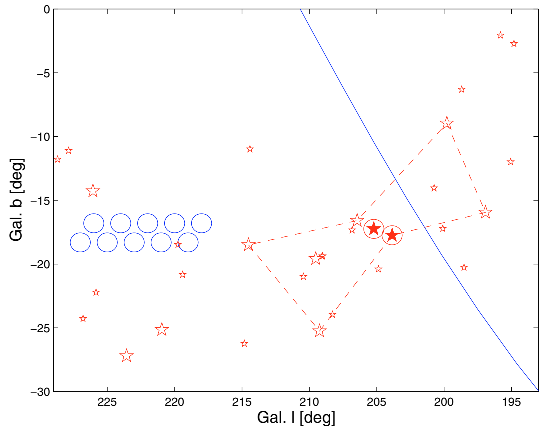

Fig. 1. Pictogramme showing the Orion-Lepus region and the survey area. *Stars*: some of the brightest stars of Orion, Lepus and adjacent constellations (sizes are roughly proportional to brightness). The filled stars are Alnilam and Mintaka. *Circles*: comparison fields and the survey area around Alnilam and Mintaka. *Solid line*: parallel of constant declination δ = +2 deg. There are no DENIS data northern (i.e. to the right) of the parallel. Colour versions of all our figures are available in the electronic publication.

2.2. Bright early-type stars

We followed a procedure very similar to the one in Caballero (2007a) to identify bright very young stars using Tycho-2 and 2MASS astrometric and photometric data. First, we loaded the data within the twelve 45 arcmin-radius fields. Second, a cross-correlation between Tycho-2 and 2MASS was done using the Catalog Cross Match tool implemented in Aladin. For each Tycho-2 source, the 2MASS counterpart was defined as the nearest source found in a circle centred on the Tycho-2 source and radius of 4 arcsec (the default threshold). A total of 1276 Tycho-2 sources with 2MASS counterpart were identified within the ten comparison fields, which yielded $\overline{N}$ = 130 objects per field [$\sigma(N)$ = 30]. The actual number of Tycho-2/2MASS sources per c_i field varies between 83 (c_2) and 169 (c_7), while there are N = 111 and 113 stars in the Alnilam and Mintaka fields, respectively. The B_T, V_T, J, H and K_s magnitudes of the 224 stars are provided in Tables A.1 and A.2, one for each main field.

Although the number N of Tycho-2/2MASS stars surrounding Alnilam and Mintaka does not a priori support the hypothesis of a stellar overdensity, there is an evident overdensity of bright *blue* stars surrounding the two supergiants (as expected from an OB association). In the ten comparison fields, there are only six stars bluer than $V_T - K_s$ = 0.0 mag and brighter than V_T = 10.0 mag. Two of them have accurate determinations of the parallax ($\pi/\delta\pi > 3$) and are significantly closer to the Sun than the Ori OB1b association: HD 40071 (d = 250 ± 70 pc) and HD 40355 AB (d = 180 ± 30 pc). The four other stars (HD 41367 AB, HD 41488, HD 41737, and HD 42263) are B8–9 dwarfs, subdwarfs and subgiants located at tens of degrees from the young Orion associations that seem to populate the interstellar field. Therefore, ~0.6 (between 0 and 1) interloper stars bluer than $V_T - K_s$ = 0.0 mag and brighter than V_T = 10.0 mag are expected in each of the Alnilam and Mintaka fields. However, there are actually 17 and 11 such stars, respectively. Hence, there are between 20 and 30 more bright blue stars surrounding the two supergiants than in other regions at the same Galactic latitude and far from the Orion star-forming region. Given the Tycho-2 limiting magnitudes and the expected spectral types (i.e. colours) of young stars at d ~ 385 pc, we

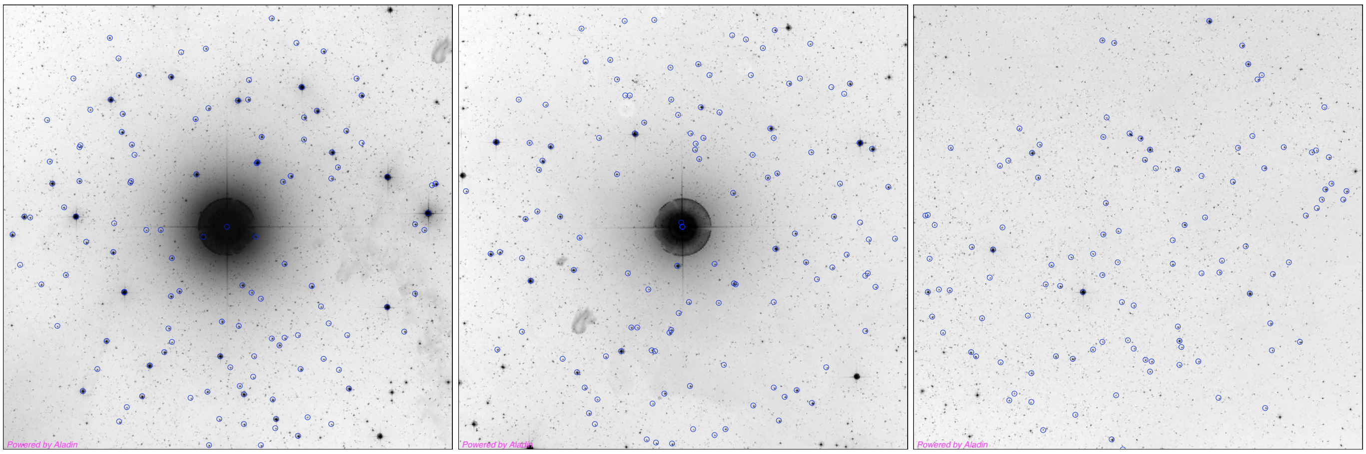

Fig. 2. Inverted–colour, SERC B_J (photographic blue) DSS1 images of the Alnilam (*left*), Mintaka (*centre*), and c_1 (*right*) fields. Circles (in blue) indicate Tycho-2/2MASS stars. Approximate sizes are 1.5×1.5 deg^2. North is up, east is left. A tonge-shaped nebula appears in both Alnilam and Mintaka images (IC 434; see Fig. A.1).

could only detect an overdensity of blue (i.e. early-type) stars. This calculated overdensity is similar to that in the σ Orionis cluster (Caballero 2007a) and justifies the next steps.

We added other 21 Tycho-2/2MASS stars with blanks in the Tycho-2 proper motion that were not considered by the Aladin Catalog Cross Match tool to the list of 224 correlated Tycho-2/2MASS stars. In those cases, we took the proper motions from the USNO-B1 and Tycho-1 catalogues (Høg et al. 1998). This addition makes the sample of bright stars to increase up to 245.

With the help of optical-near infrared, colour–magnitude diagrams, the Tycho-2 proper motions, *IRAS* fluxes, spectroscopic data from the literature and data from Vizier catalogues obtained using UCD[4]-based searches (Ochsenbein et al. 2000), we have classified the stars in the Alnilam and Mintaka fields into three groups, separated by decreasing probability of membership in the Ori OB1b association. On the one hand, the classification is illustrated with the six panels in Fig. 3. On the other hand, Tables A.3 to A.8 show the results of the classification. The three groups are:

- Stars with signposts of youth (Tables A.3 and A.4). By features of youth we understand early spectral types (O and B), Li I in absorption, *strong* X-ray or Hα emission (possibly associated to accretion processes), and infrared excesses by circumstellar material. We have also included low proper-motion, early A-type stars that follow the sequence defined by the remaining young stars in the colour–magnitude diagrams. There are only two stars with previously determined spectral type later than A: RX J0535.6–0152 AB and SS 28. Both of them display, however, features common to the T Tauri phase (see notes in Tables A.3 and A.4). We have also considered additional youth features, like the star being in the Herbig Ae/Be phase (HAeBe) or having a Vega-like disc.
- Stars with unknown association membership status (Tables A.5 and A.6). They are stars with proper motions $\mu < 12$ mas a^{-1} that do not deviate very much from the young-star sequence in the colour–magnitude diagrams but have no known, clear, signposts of youth. Some A-type stars with $\mu \sim 5$–12 mas a^{-1} that do not follow the sequence of the confirmed young stars are in this class. The threshold for the maximum μ of 12 mas a^{-1} is higher than in Caballero (2007a), who used $\mu > 10$ mas a^{-1} to identify stars with high tangential velocities among a list of photometric member candidates of the Ori OB1b association (the difference in the mean proper motion of the association, almost null, is not significant). The new conservative threshold allows us to recognise some bona-fide young stars with relatively large proper motions.
- Stars that do not belong to the association (Tables A.7 and A.8). This class comprises: (i) foreground stars with proper motions $\mu > 12$ mas a^{-1}; (ii) foreground G-, K-, and M-type stars with spectral type determination; (iii) *Hipparcos* stars with $\pi/\delta\pi > 3$ and heliocentric distances less than 250 pc; (iv) red stars without spectral type determination, and with colours $V_T - K_s > 2.5$ mag and spectral energy distributions of K–M-type stars; (v) very red objects with colours $V_T - K_s > 4.5$ mag and without flux excess due to discs in the mid-infrared (see notes in Appendix A). There are stars that simultaneously satisfy more than one criterion. For example, HD 36443 in the Mintaka field is a high proper motion ($\mu \approx 488$ mas a^{-1}) G5V star located at $d \sim 38$ pc and with a radial velocity $V_r \approx 9$ km s^{-1} discordant with association membership (Adams et al. 1929; Roman 1955; Perryman et al. 1997).

Provided coordinates and proper motions in Tables A.3 to A.8 are from Tycho-2 (some exceptions are indicated). The majority of the spectral types and features of youth listed in the tables have been borrowed from the literature. The references are indicated in the last column. Abundant notes and remarks on the discussed stars are also provided in Appendix A. The most familiar works have been the spectroscopic studies in the Orion Belt by Guetter (1976, 1979) and the Henry Draper Extension Charts by Nesterov et al. (1995). These authors compiled positions, proper motions, photographic magnitudes, and spectral types from the original works by Cannon and Cannon & Pickering (e.g. Cannon & Pickering 1918–1924). Table 2 summarises the number of stars in each class and the total number of correlated Tycho-2/2MASS stars.

From the comparison with the c_i fields, between 0 and 1 late B-type stars surrounding Alnilam and Mintaka may actually be fore- or background B8–9-type stars. The contamination rate in the group of stars with signposts of youth is, therefore, ~3.5–5.5 % for these spectral types, and null for late O- and early

[4] Unified Content Descriptor.

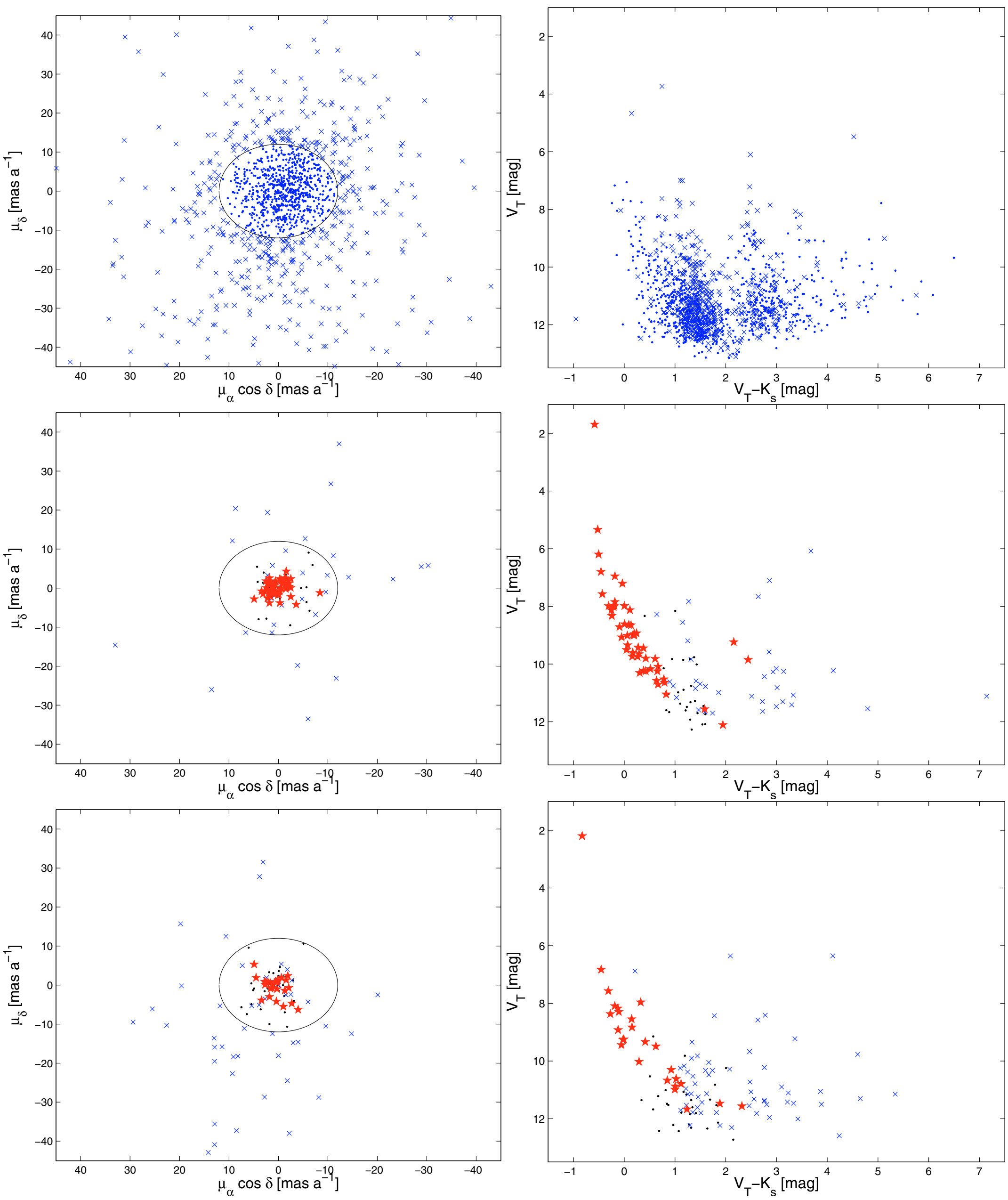

Fig. 3. The Tycho-2/2MASS cross-match in the 10 comparison fields (*top*), and Alnilam (*middle*) and Mintaka (*bottom*) fields. Stars classified as association Ori OB1b non-members are marked with (blue) crosses. The remaining stars are marked with (blue) dots, except for stars with signposts of youth that are marked with (red) filled stars. *Left panel*: proper motion diagrams. Big circles separate stars with proper motions larger than 12 mas a^{-1}. *Right panel*: V_T vs. $V_T - K_s$ colour–magnitude diagrams.

Table 2. Number of bright stars per group and field.

Field	*N* members	*N* non-members	*N* unknown	*N* all
Alnilam	49	39	34	122
Mintaka	29	63	31	123
Total	78	102	65	245

B-type stars. On the other hand, from the number of stars in the comparison fields with colours 0.0 mag < $V_T - K_s$ < 0.5 mag (28 of the 1276 stars in the ten fields), it is expected that only ~3 early A-type stars in the foreground contaminate the Alnilam and Mintaka fields. It leads to estimating the contamination by such stars in Tables A.3 to A.6 at less than 10%.

2.3. Intermediate- and late-type stars and brown dwarfs

We performed a correlation between the DENIS and 2MASS catalogues identical to the Tycho-2/2MASS one. In this case, we analysed the optical *i* (DENIS) and near-infrared JHK_s (2MASS) counterparts of more than 10^5 sources distributed amongst the ten comparison and the two Orion Belt fields. In particular we compiled the coordinates and four-band photometry of 10 523 and 8288 sources respectively.

A total of 50 DENIS/2MASS stars with spectroscopic features of youth (i.e. with Li I, Hα, low *g*; see Sect. 1.1) found in the literature have been identified in the Orion fields. Most of them are located surrounding Alnilam and come from wide prism-objective surveys of Hα emitters by, e.g., Haro & Moreno (1953; Haro objects) and Wiramihardja et al. (1989, 1991; Kiso

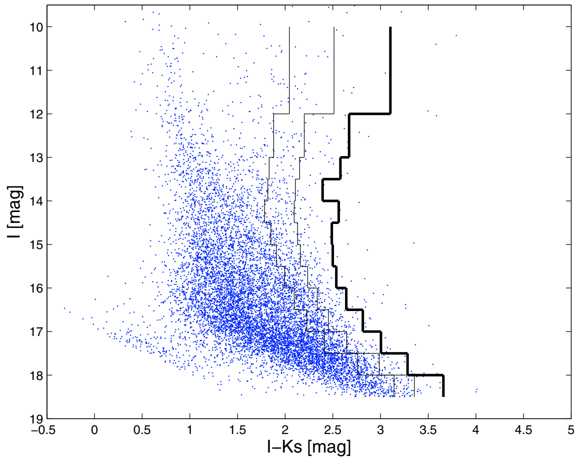

Fig. 4. i vs. $i - K_s$ colour–magnitude diagrams of one comparison field. Solid lines are for $i - K_s$ percentiles x = 0.90, 0.97, 0.995, *from left to right*.

objects), and from the spectroscopic analyses by Béjar et al. (2003a,b; E Ori objects). We have not been able to identify V1299 Ori, a hypothetical B-type star close to the remnant molecular cloud [OS98] 40B. In contrast, we have identified 8 DENIS/2MASS stars without known spectroscopic features of youth, but with *strong* X-ray emission detected by the *Einstein* and *ROSAT* satellites, which can be ascribed to a young age. Only three of them had been previously catalogued (MacDowell 1994; Ueda et al. 2001). Their colours are typical of young stars close to the main sequence. The results of *XMM-Newton* observations centred on Alnilam will be described in Caballero et al. (in prep.).

The names, coordinates, i- and K_s-band magnitudes, features of youth and, references of the 58 young stars are provided in Tables A.9 and A.12. We list other spectro-photometric signposts of youth, such as Ca II $\lambda\lambda$3933.7,3968.5 Å (H and K lines), Hβ λ4861.3 Å, and [O I] λ6300.3 Å in emission (indicative of strong magnetic activity and/or outflows), and mid-infrared flux excess (mIR; suggestive of the presence of a circumstellar disc). Other 17 DENIS/2MASS stars in the literature have unreliable features of youth, such as faint Hα emission with the $i - K_s$ colour typical of field stars, conservative upper limits of the strength of the Na I doublet $\lambda\lambda$8183.3,8184.8 Å, or *faint* X-ray counterparts with a large uncertainty ellipse. They are tabulated in Table A.11. Among them, we have not accounted for Kiso A–0904 62, a star-like source with blue colours and very faint Hα emission in only one epoch out of three in Wiramihardja et al. (1989).

We looked for new cluster member candidates without known features of youth. Since the number of confirmed young objects in the analysed regions (58) is relatively low, we cannot define a lower envelope of association members as Caballero (2008c) did in the σ Orionis cluster (he used 241 young objects). Besides, we also want to avoid the uncertainties at very young ages associated to theoretical models (Baraffe et al. 2003) and choose a selection criterion as conservative, neutral, reproducible, and objective as possible. For the photometric selection, we used the data of the ~87 000 sources in the comparison fields to determine the locations in the i vs. $i - K_s$ colour–magnitude diagrams of the Alnilam and Mintaka fields where the probability of contamination by fore- and background sources is minimum. Figures 4 and 5 illustrate the selection procedure.

First, we divided the i vs. $i - K_s$ diagram (Fig. 4) of all the comparison fields into eleven horizontal strips of width Δi = 0.5 mag between i = 13.0 and 18.5 mag, and two wider strips between i = 10.0 and 13.0 mag. Since the DENIS catalogue fails to provide accurate photometry for the brightest stars (due to saturation and non-linear effects in their detectors), we only investigate sources with $i > 10.0$ mag in this section. Second, we computed for each strip the $i - K_s$ colour of the source that leaves redwards of it the $100(1 - x)$% of the remaining objects, where $x \lesssim 1$ (e.g. the percentiles x = 0.90, 0.97, and 0.995 separate the 10, 3, and 0.5 % reddest objects, respectively). For a colour–magnitude diagram and a fixed value of x, there are 13 different values of $i - K_s$, one for each strip. The collection of the 13 values determines a boundary for the selection of association member candidates. Third, we counted the number of objects redder than the selection boundary for different values of the percentile x. We plot in Figs. 4 and 5 the boundaries for x = 0.90, 0.97, 0.995 in the comparison colour–magnitude diagram, and only for x = 0.995 in the Alnilam and Mintaka diagrams. This is the value actually used for the selection. The percentile x = 0.995 maximises the ratio between the number of objects redder than the boundary in the Orion Belt fields and the number of expected contaminants. As a first-order approximation, there should be about 44 objects that are redder than the x = 0.995 boundary in each of the Alnilam and Mintaka fields ($\sim 87\,000 \frac{1}{10} 0.005 \approx 44$). The actual figures of sources redder than the x = 0.995 boundary are 272 and 157 in the Alnilam and Mintaka fields, respectively. Accounting for the incomplete coverage of the DENIS survey (see Sect. 3.1), we estimate average frequencies of contamination at ~25 and ~33 % for the two Orion Belt fields. Using higher (lower) values of x would lead to lower (higher) frequencies of contamination, but also to smaller (larger) number of photometric association member candidates.

The frequencies of contamination actually are lower, since many of the sources to the red of the selection criterion are at different heliocentric distances to the Ori OB1b association. We complemented our DENIS/2MASS data with information in the literature, astro-photometric data from the USNO-B2.0 catalogue, and visual inspection of digitized phtographic plates. The 429 sources were investigated, one by one, to ascertain their membership in the association. Eventually, we classified 167 of them as DENIS/2MASS fore- and background sources in the Alnilam and Mintaka areas based on different criteria (optical/near-infrared colours, proper motions, location in a cometary globule, extended point spread functions):

- Table A.12 shows three intermediate and late F-type stars in the foreground, one nearby high-proper motion star (G 99–18), one distant Mira Cet variable star (X Ori), and two previously unknown sources with very red colours (Ruber 1 and 2). While the first five stars were already known to contaminate the Orion field, the last two stars are identified here for the first time. One of them (Ruber 1) is a very late M dwarf in the foreground, with an appreciable proper motion, while the other star (Ruber 2) seems to be a pulsating giant in the distant Berkeley 20 open cluster (see details in the notes to Table A.12).
- Seven probable reddened sources in the direction of two dense cometary globulae are listed in Table A.13. Six of them fall in the direction of the IC 423 Bok globule. This molecular cloud harbours the T Tauri star IRAS 05307–0038 and has also been classified as a reflection nebula ([RK68] 29; see note on IRAS 05307–0038 in Table A.10). The globule and the corresponding reddened sources are shown in Fig. A.1. The remaining, probably reddened source lies close to the centre of the Ori I–2 globule. There is not enough

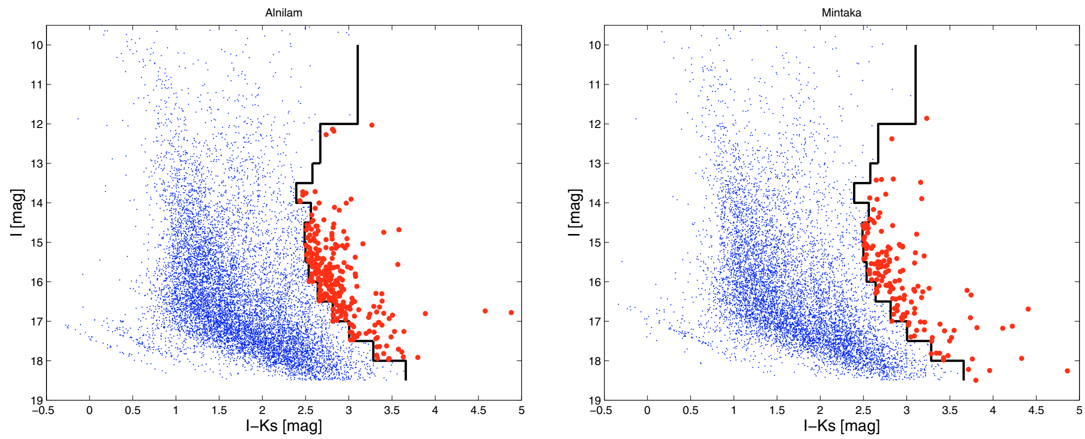

Fig. 5. Same as Fig. 4, but for the Alnilam (*left*) and Mintaka (*right*) fields. Solid lines are for $i - K_s$ percentile $x = 0.995$. Objects to the red of this line are marked with (red) filled circles.

information to determine whether the seven sources are reddened background stars or very young (Class I/II-like) objects embedded in the globules. A spectroscopic follow-up is necessary to ascertain their actual status.

- Tables A.14 and A.15 provide the 2MASS/2MASX designations of 152 galaxies. The vast majority of them appear tabulated in the Two-Micron All Sky Survey Catalog of Extended Sources, 2MASX (Jarret et al. 2000), and are, therefore, catalogued in the NASA/IPAC Extragalactic Database (NED). Some of them also appeared in the works by Paturel et al. (1989) & Monnier Ragaigne et al. (2003) or in radio catalogues (see notes on PMN J0534–0044 in Table A.15). The red colours of many galaxies can be ascribed to their intrinsic nature (starsbursts, ellipticals, bulges of spirals, and mergers). The extragalactic radio source complex 4C–01.06 could not be identified by us.
- Finally, there is one additional red DENIS/2MASS source with poor photometry, 2MASS J05380010–0122377. It was rejected during a visual inspection, because it is a binary object partially resolved in the Digital Sky Survey images that probably does not belong to the Ori OB1b association.

Accounting for the known young stars in the association, foreground dwarfs, background giants, reddened stars, and galaxies in Tables A.9 to A.15 that are redwards of the $i - K_s$ percentile $x = 0.995$, there remain 189 and 102 photometric association member candidates in the Alnilam and Mintaka fields, respectively (all published stars of unknown status – Table A.11 – are bluewards of the selection criterion). The 291 sources are tabulated in Tables A.16 and A.17[5].

Ten of them were photometric member candidates of the "ϵ Orionis cluster" in Scholz & Eislöffel (2005). They classified three of these sources, with identification numbers 44, 120 and 126, as candidates with significant periodic variability (see details in notes to Tables A.16 and A.17). V993 Ori is also a bright photometric variable (V993 Ori; Luyten 1932). Photometric variability is a very common feature in young stars in general and T Tauri stars in particular (e.g. Bertout 1989). There are also variable T Tauri substellar analogues (Caballero et al. 2006). The 280 remaining red DENIS/2MASS sources are first shown in our work. We use the acronyms "Annizam" and "Mantaqah" plus running numbers for naming the objects in the Alnilam and Mintaka fields, respectively[6]. The running numbers indicate the position of the association members and candidates with respect to the two supergiants. The three last digits are for the position angle, while the three or four first digits are for the angular separation; for example, Annizam 1751268 is located at $\rho \approx 1751$ arcsec [20.8 arcmin] and $\theta \approx 268$ arcsec with respect to Alnilam. This designation is similar to the Mayrit nomenclature for σ Orionis cluster members and candidates (Caballero 2008c).

2.4. Remarkable fore- and background objects

For completeness, in Table A.18 we list four very bright nearby stars ($K_s \leq 4.5$ mag; 19 Lep, HD 43429, θ Lep, η Lep), a recently-identified, very bright He-B subdwarf (Albus 1 – Caballero & Solano 2007; Vennes et al. 2007), two unknown Tycho-2 high proper motion stars with $\mu > 120$ mas a^{-1}, and six optical counterparts of *IRAS* sources with very red colours ($V_T - K_s > 5.4$ mag) that fall in the comparison fields. Only one of the *IRAS* sources had previously been investigated in the literature, CSS 205, which was classified as an S-type star by Stephenson (1984). Some of the other five stars are even redder than CSS 205, indicating that they could be C- or S-type stars as well. Their very red colours and strong mid-infrared flux excess indicate that they might be stars in the last stages of the AGB phase, or close to the post-AGB stage and evolving into the planetary nebula phase (van der Veen et al. 1989; Trams et al. 1991; Riera et al. 1995).

3. Discussion

Accounting for stars in the tiny overlapping region between the Alnilam and Mintaka fields, we identified 78 bright early-type (Tables A.3 and A.4) and 58 intermediate and late-type stars (Tables A.9 and A.10) with signatures of youth. Many of the 65 Tycho-2/2MASS (Tables A.5 and A.6) and 17 DENIS/2MASS (Table A.11) published stars of unknown association membership status may also be young. Together with the 291 DENIS/2MASS photometric member candidates

[5] Since there are known young stars in the association and foreground dwarfs bluewards of the selection criterion, and photometric association member candidates in the overlapping region between survey areas, the count of DENIS/MASS sources does not *seem* to coincide: 50 + 167 + 291 ≠ 429.

[6] The name Alnilam derives from the Arabic *an-nižām*, related to the word *nažm*, "string of pearls". The name Mintaka comes from the Arabic *manţaqah*, "belt".

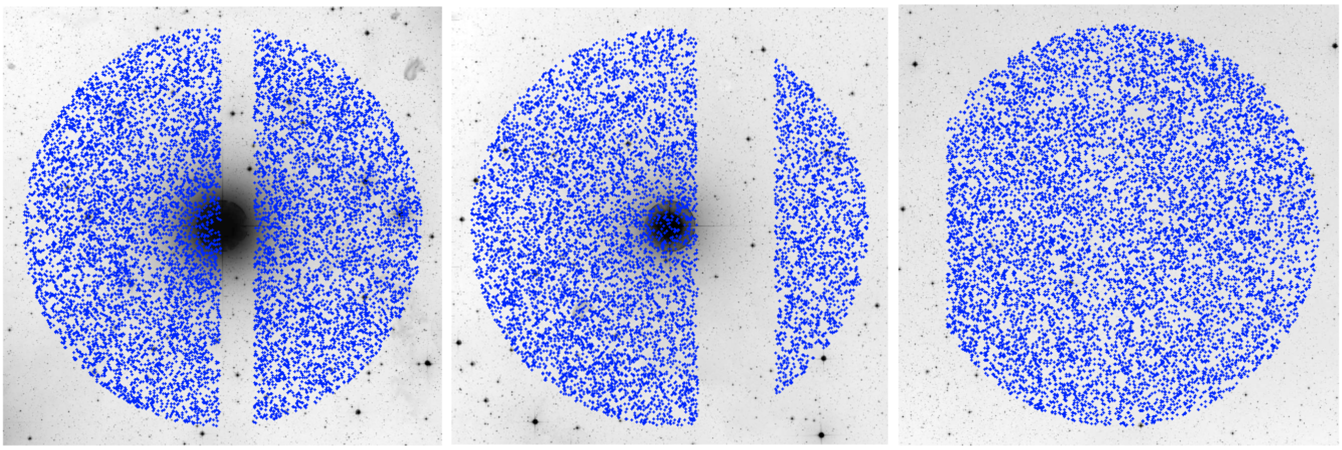

Fig. 6. Same as Fig. 2, but for the DENIS/2MASS sources. Note the missing DENIS strips.

of the Ori OB1b association (Tables A.16 and A.17), this makes a catalogue of 509 confirmed and candidate young stars and brown dwarfs.

For the canonical age of 5 Ma for the Ori OB1b association, the heliocentric distance of $d = 388 \pm 30$ pc to the spectroscopic eclipsing binary VV Ori (Terrell et al. 2007) and the colour excess of the supergiant Alnilam $E(B-V) = 0.09$ mag (Lee 1968), and using the DUSTY00 models of the Lyon group (Chabrier et al. 2000), we estimate that the star-brown dwarf boundary (at $M \approx 0.072\,M_\odot$ for solar metallicity) in the region is at $J \approx 15.5 \pm 0.2$ mag. The estimation is identical if the NEXTGEN98 models are used (Baraffe et al. 1998). The objects [SE2005] 126 and Mantaqah 2691223, which are fainter than this magnitude, are the only candidate young brown dwarfs in our work. The star-brown dwarf boundary in the Alnilam-Mintaka region is ~1 mag fainter than in the σ Orionis cluster (at about $J \sim 14.5$ mag; Caballero et al. 2007), which is younger and *supposed to be* slightly closer. A different heliocentric distance to Ori OB1b, d' (e.g. 330 pc, 440 pc; see Sherry 2003), would simply shift the star-brown dwarf boundary by a factor $\Delta J = 5 \log d/d'$ (about 0.3 mag in the examples above), which is of the order of the uncertainty in the magnitude limit. Since we have *not* used the heliocentric distance in any step of the association member selection, a different d' would only affect the actual number of substellar objects in our catalogue (the closest distance would lead to have 11 and 5 brown dwarfs in the Alnilam and Mintaka regions, respectively; there would be no brown dwarfs for the farthest distance).

Apart from being 20–40% more massive than σ Orionis members of the same apparent magnitude, the young objects in the Alnilam-Mintaka region are also distributed along a wider area. Caballero (2008c) identified 75 very low-mass stars, brown dwarfs, and candidates fainter than $J = 14.0$ mag from a DENIS/2MASS correlation, very similar to the one presented here, but in a smaller area (a circle of radius 30 arcmin) centred on the Trapezium-like σ Ori system. Accounting for the factor 2.25 of the different survey areas ($\pi 45^2/\pi 30^2$), we expected to have found ~170 young objects with $J > 14.0$ mag in each Orion Belt field within the completeness *if* the surface densities there and in σ Orionis were identical. Actually, a total of 131 and 63 intermediate- and late-type photometric member candidates of the Ori OB1b association in Tables A.16 and A.17 are fainter than $J = 14.0$ mag (i.e. $M \lesssim 0.09\,M_\odot$). We have identified, therefore, ~70 and ~40 % less of the expected number of low-mass stars in the Alnilam and Mintaka fields, respectively. Assuming also a similarity in mass functions, it is deduced, therefore, that the surface density of brown dwarfs in Alnilam-Mintaka should be ~70–40 % of the one in σ Orionis. In this computation, we have not taken into account the different location of the star-brown dwarf boundaries. Far from being pessimistic, the lower (sub)stellar density surrounding the two supergiants suggests surveying only ~1.3 (Alnilam) and ~2.7 (Mintaka) times more area to find the same number of brown dwarfs than in σ Orionis. A coarse extrapolation of the number of brown dwarf candidates and possible contaminants in Béjar et al. (2003b) and Scholz & Eislöffel (2005) supports our estimations of a relatively high substellar surface density surrounding Alnilam.

The depth of the DENIS survey ($i_{5\sigma} \sim 18.0$ mag) and the expected red colours of young brown dwarfs in the Ori OB 1b association ($i - J \geq 2.5$ mag) has allowed our search to be only complete down to $M \sim 0.08$–$0.07\,M_\odot$ ($M \sim 0.05$ and $0.10\,M_\odot$ for $d' = 330$ and 440 pc, respectively). Besides, the spatial coverage is incomplete (some strips of the DENIS survey are absent; see Fig. 6) and an important fraction of the actual intermediate- and late-type members of the association may lie bluewards of the conservative $i - K_s$ selection criterion used in Sect. 2.3. Even accounting for these incompletenesses and for possible contamination among the photometric association member candidates, our work is by far the most comprehensive star compilation in the Alnilam-Minataka region.

Our compilation is not only useful for probing the stellar and substellar populations in the Alnilam-Mintaka region, but also for investigating the mass function in the whole stellar domain from ~15 to ~0.08–0.07 $M_\odot$, the spatial distribution, or the frequency of discs (there are a lot of association members and candidates with *IRAS* flux excess and/or red near-infrared colours, $J - K_s > 1.15$ mag). Some of these works will be carried out in the near future (Caballero & Solano, in prep.). In the next section, we present a preliminary study of the radial distribution of young stars and candidates surrounding Alnilam and Mintaka.

3.1. Spatial distribution

In total, we have catalogued 89 confirmed stars and 189 DENIS/2MASS photometric association member candidates in the Alnilam field. In the Mintaka field, we have catalogued 47 confirmed stars and 102 DENIS/2MASS photometric association member candidates. The spatial distribution of both types of objects, displayed in top panels in Fig. 7, shows no *clear* radial

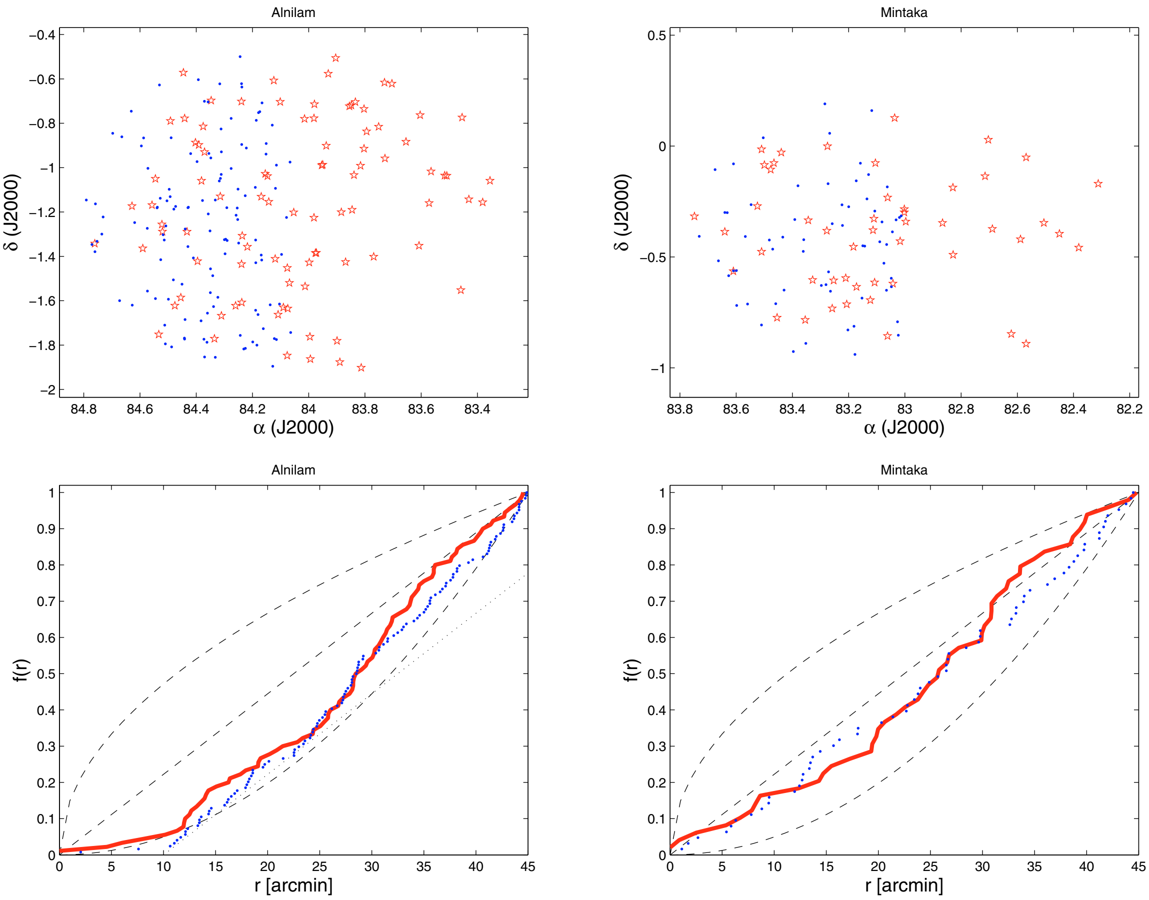

Fig. 7. Radial distribution of young stars and brown dwarfs surrounding Alnilam (*left*) and Mintaka (*right*). *Top panels*: spatial distribution of confirmed young stars (– red – open stars) and photometric candidates to the east of the supergiants (– blue – dots). *Bottom panels*: normalized cumulative number, $f(r)$, of confirmed young stars (– red – thick solid line) and photometric candidates (– blue – dotted line). The – black – dashed lines indicate the theoretical power-law distributions for $f(r) \propto r^{1/2}$, r^1, r^2 (*from top to bottom*). Compare with Figs. 3 and 4 in Caballero (2008a).

concentration towards the supergiants. Following the σ Orionis cluster parallelism, we expected a radial density gradient centred on the massive OB-type stars.

We have investigated the normalized cumulative number of confirmed stars and photometric association member candidates in projection within a distance r to Alnilam and Mintaka, $f(r)$. Here, we follow the procedure detailed by Caballero (2008a). Given the incomplete coverage of DENIS in the survey fields (evident in Fig. 6) and maintaining the *radial* symmetry, we have only accounted for the association member candidates to the east of the supergiants. The radial distributions for both confirmed and candidate young objects, shown in the bottom panels of Fig. 7, resemble each other within Poissonian errorbars (not shown for clarity). This resemblence suggests that there is no clear bias in our data compilation; e.g., there has not been a tendency in the literature to survey close to the central OB-type stars, like in σ Orionis. In the bottom panels, we also plot three theoretical power-law distributions. The distribution $f(r) \propto r^2$ corresponds to a uniform distribution of objects in the survey area. The observed radial distribution in σ Orionis is much more radially concentrated, with $f(r) \propto r^1$ in the innermost 20 arcmin-radius cluster core. This distribution corresponds to a volume density proportional to r^{-2}, which is consistent with the collapse of an isothermal spherical molecular cloud (see again details in Caballero 2008a). Next, we show our results for the Alnilam and Mintaka regions.

3.1.1. Alnilam

Within the uncertainties and the incompleteness of our catalogue, the distribution of young stars and candidates surrounding Alnilam clearly departs from a radially concentrated distribution, as found in σ Orionis. The distribution at less than 25 arcmin to Alnilam is fairly fit by a uniform spacing, while there is a hint of an overdensity of young stars at larger separations. This result accords with the classical view of Collinder 70 (see Sect. 1.1) as a sparse, very wide clustering that might extend to, and overlap with, neighbouring regions (e.g. Mintaka or the "halo" of the σ Orionis cluster – Caballero 2008a). Clues of a σ Orionis-like cluster around Alnilam were not found by Sherry (2003) either; his survey had, however, a less extensive spatial coverage, which would increase the difficulty in identifying a "weak cluster".

It is important to notice the big difference between the "cores" of Collinder 70 and σ Orionis. While there are ~130 known stars and brown dwarfs in the innermost 10 arcmin of the latter cluster (most of them with features of youth), we estimate that there are no more than 50 stars in the same area centred on Alnilam. This is not an observational bias, because this abrupt deficiency is not detected in the Mintaka field (Alnilam and Mintaka have roughly the same magnitudes, and so do the sizes of their optical glares – an intense background by a nearby bright star may prevent the detection of sources within the completeness in a photometric survey). However, the frequency of young stars and brown dwarfs at intermediate separations from Alnilam (e.g. 25–45 arcmin) can be larger than in the same corona centred on σ Ori. In either case, a broather study of the radial distribution of young stars, covering the whole Orion Belt, is needed to ascertain the real nature of the Collinder 70 cluster.

3.1.2. Mintaka

The radial distribution of young stars surrounding Mintaka follows, in contrast to Collinder 70, a power law with an odd exponent midway between 1 and 2. This radial concentration may suggest that there is actually a clustering of young stars surrounding the supergiant. This is the first time that the existence of a cluster in the area has been proposed, one we call "Mintaka cluster". A radial distribution with a power law $f(r) \propto r^{1.5}$ would correspond to a volume density proportional to $r^{-1.5}$. A lower central concentration than in the scenario of collapse of an isothermal spherical molecular cloud may suggest that (i) the Mintaka cluster formed from a non-isothermal molecular cloud, (ii) it formed from an isothermal molecular cloud but then suffered from dynamical evolution (and the Mintaka cluster would be, in this scenario, a dynamically-evolved analogue to σ Orionis), or (iii) there is significant overlapping between the stellar population of Ori OB1b and Ori OB1a. The Ori OB1a sub-association is expected to have a spatial distribution that completely overlaps with the region near Mintaka. Ori OB1a is older than Ori OB1b, but also up to ~100 pc nearer (Sherry 2003). As a result, the isochrones for Ori OB1a and b fall roughly on the same location in the colour–magnitude diagram. Stars from Ori OB1a would have indicators of youth as well, but would not follow the clustering around Mintaka. They would also be difficult to distinguish from proper motions due to the unfavourable direction of Orion and the Sun's relative motions. The combination of a clustered population (the "Mintaka cluster" in Ori OB1b) with a nearly uniformly distributed population (Ori OB1a) would take an $f(r)$ spatial distribution middway between r^1 and r^2. Obviously, further work is required to derive any conclusion.

4. Summary

In our search for new hunting grounds for substellar objects, we investigated the stellar populations surrounding two bright supergiants in the Ori OB 1b association (the Orion Belt). The two very young supergiants are Alnilam (ϵ Ori) and Mintaka (δ Ori). Accounting for all the Tycho-2, DENIS, and 2MASS sources in the twelve 45 arcmin-radius main and comparison fields, we examined 107 434 sources in total. After a comprehensive, inclusive, massive Virtual Observatory analysis and bibliographic data compilation, we list:

- 78 bright (Tycho-2/2MASS) stars with features of extreme youth (i.e. with very early spectral types or HAeBe signatures).
- 58 intermediate- and late-type (DENIS/2MASS) stars with features of extreme youth (i.e. with Li I in absorption, Hα in emission, low g spectroscopic signatures, X-ray emission).
- 289 intermediate- and late-type (DENIS/2MASS) young star candidates with very red $i - K_s$ colours.
- 2 brown dwarf candidates with very red $i - K_s$ colours: [SE2005] 126 (Mantaqah 1582164) and Mantaqah 2691223 (their actual substellar nature depends on the heliocentric distances and ages).
- 82 (Tycho-2/2MASS and DENIS/2MASS) stars without clear signposts of youth that might also belong to the Ori OB 1b association.
- 117 (Tycho-2/2MASS and DENIS/2MASS) stars in the fore- or the background based on their proper motions, spectral types, parallactic heliocentric distances, radial velocities, and/or colours.
- 152 extended galaxies, and
- 13 remarkable fore- and backgound stars in the comparison fields.

We report for the first time X-ray emission, *IRAS* flux excess, and possible resolved multiplicity for dozens young stars and candidates in the Alnilam-Mintaka region. This abundance represents an excellent compilation of candidates for further follow-up, dedicated studies. The vast majority of the listed association member candidates are new. A wealth of detailed information is provided in Appendix A for about one hundred investigated sources.

Finally, we investigate the spatial distribution of stars surrounding Alnilam and Mintaka, and discuss the possibilities of searching for brown dwarfs. Collinder 70, the cluster that surrounds Alnilam, *if* it exists, must be larger than our search radius of 45 arcmin. Its (sub)stellar population may, therefore, spatially overlap with neighbouring star-forming regions, like the σ Orionis cluster, which is one of the richest regions in substellar objects. The evidence for a real cluster surrounding Mintaka is, however, more apparent but not conclusive from our data analysis. The "Mintaka cluster", which is presented here for the first time, is less concentrated than the σ Orionis cluster and might represent a next evolutionary stage of it. Accounting for the fainter star-brown dwarf boundary and the lower spatial density of stars very close to the supergiants with respect to σ Orionis, the clusters surrounding Alnilam and Mintaka can be considered as "elder brothers" (in contraposition to "fraternal twins") of σ Orionis.

Acknowledgements. We appreciate the skillfull referee report by W. H. Sherry and the exhaustive language editing by L. J. Adams. We also thank V. J. S. Béjar, F. Fontanot, S. More, R. Mundt, A. Sicilia-Aguilar, and S. Wolf for helpful comments. J. A. C. formerly was an Alexander von Humboldt Fellow at the MPIA and currently is an Investigador Juan de la Cierva at the UCM. Partial financial support was provided by the Universidad Complutense de Madrid, the Spanish Virtual Observatory and the Spanish Ministerio Educación y Ciencia under grants AyA2005–02750, AyA2005–04286 and AyA2005–24102–E of the Programa Nacional de Astronomía y Astrofísica and by the Comunidad Autónoma de Madrid under grant CCG07–UCM/ESP–2679 and PRICIT project S–0505/ESP–0237 (AstroCAM). This research has made use of: the SIMBAD, operated at Centre de Données astronomiques de Strasbourg, France; TOPCAT (Tool for OPerations on Tables And Catalogues), provided by the AstroGrid Virtual Observatory project; the NASA's Astrophysics Data System as bibliographic service; and the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA.

Appendix A: The Annizam/Mantaqah catalogue

Notes to Table A.3:

* HD 36980 AB is a close binary with $\rho \approx 0.7$ arcsec, $\theta \approx 61$ deg (catalogue of Components of Double and Multiple stars; Dommanget & Nys 1994 – there are no fundamental differences between this edition and the second one (Dommanget & Nys 2002), except for the number of considered sources).
* RX J0535.6–0152 AB is a T Tauri star with a red $V_T - K_s$ colour. It is a G6V-type spectroscopic binary with lithium

in absorption (pEW(Li I) = +0.32 Å), partially filled Hα line (pEW(Hα) = +2.40 Å) and X-ray in emission (Alcalá et al. 1996, 2000). RX J0535.6–0152 AB was the third strongest X-ray source in the investigation of 40 weak-line T Tauri stars in Orion by Marilli et al. (2007), with $\log L_X = 30.7^{+0.2}_{-0.7}$ (erg cm^{-2} s^{-1}). These authors found it to be a photometric variable with a period of 1.74 d.

* HD 37285 AB is a visual binary star with $\rho \approx 0.4$ arcsec, $\theta \approx 263$ deg (Dommanget & Nys 1994).
* HD 37389 is embedded in the Ori I–2 Cometary Globule (Ho et al. 1978; Cernicharo et al. 1992; Mader et al. 1999). Oudmaijer et al. (1992) and Coulson et al. (1998) have reported infrared and submillimetre flux excesses due to a Vega-like disc. The star has appreciable polarization in the optical (Bhatt & Manoj 2000). Some catalogues tabulate a hypothetical companion, BD–01 985B, at $\rho \sim 5.0$ arcsec, $\theta \sim 350$ deg.
* HD 37149 is a helium-weak star (Bernacca & Ciatti 1972; Renson 1988) with Hα in medium emission (Bidelman 1965). It is likely the UV-emission source [SC93b] 328 (Schmidt & Carruthers 1993).
* HD 290770 was discovered as an emission-line star by Bidelman (1965) and has been classified as a B8–9Ve Herbig Ae/Be star by many other authors (Guetter 1976; Gieseking 1983; Dong & Hu 1991; Nesterov et al. 1995; Thé et al. 1994). Vieria et al. (2003) found [O I]+[S II] in emission and measured the Hα line in double-peak emission, with the secondary peak having more than half the strength of the primary. Yudin & Evans (1998) found negligible polarization in the optical. Previously unnoticed, HD 290770 has one of the most apparent flux excesses at the *IRAS* passbands in the Ori OB 1 b association (Caballero & Solano, in prep.). Here we report a close visual companion to the star at $\rho \sim 6.8$ arcsec, $\theta \sim 340$ deg, and $\Delta K_s = 4.46 \pm 0.03$ mag fainter. From its $I - J$ and $J - K_s$ colours from DENIS and 2MASS, it seems to be a F–G:-type star in the fore-/background.
* HD 37344 is embedded in the bright-rimmed cloud complex Ori I–2N, close to cloud [OS98] 40C (Ogura & Sugitani 1998).
* HD 290602 is also BD–01 947.
* HD 290674 is also BD–01 977.
* HD 37321 AB is a well-known helium-weak star with a high rotational velocity ($v \sin i \approx 100$ km s^{-1}; Mermilliod 1983) and spectrum variability (Molnar 1972; Garrison 1994 – but see Pedersen & Thomsen 1977). Blaauw & van Albada (1963) proposed that the star is a long-period spectroscopic binary; Morrell & Levato (1991) measured, however, a constant radial velocity of 24 ± 6 km s^{-1} during their monitoring. It is a close binary with $\rho = 0.756 \pm 0.002$ arcsec, $\theta = 14 \pm 1$ deg ($\Delta H_p = 1.62 \pm 0.01$ mag; Perryman et al. 1987). It was only resolved by Tycho-2. We accounted for the $B_T V_T$ magnitude of the A component and the near infrared K_s magnitude of both A and B components as a single object. The system could have a faint, red, third component ($H = 10.98 \pm 0.02$ mag), at $\rho \approx 17.7$ arcsec, $\theta \approx 32$ deg. HD 37321 AB may also be the far-ultraviolet emission source [SC93b] 341 (Schmidt & Carruthers 1993).
* HD 36955 is a peculiar magnetic star with abnormal abundances of Si, Cr, and Eu (Gray & Corbally 1993; Kudryavtsev et al. 2006).
* V1247 Ori is a Herbig He/Be star (García-Lario et al. 1997; Fujii et al. 2002) whose non-banded Hα emission was found by McConell (1982). Spectral types from A5III, through A7, to F0V have been provided (Schild & Cowley 1971; Nesterov et al. 1995; Vieira et al. 2003). Vieira et al. (2003) found no forbidden lines in its optical spectrum, but identified an Hα symmetric profile without, or with only very shallow, absorption features. No H_2O, NH_3 or CO radio lines were found by Wouterloot et al. (1986; 1988; 1989). V1247 Ori is, besides, a well-studied δ Scuti star, with $P = 0.096967$ d and peak-to-peak amplitude in the V band of 0.050 mag (Lampens & Rufener 1990; García et al. 1995; Handler 1999). Its SED shows clear excesses from the J band to 60–100 μ (Caballero & Solano, in prep.), and is composed of two components, one warm (1.2–2.2 μm) and the other cool (12–100 μm).
* Alnilam (ϵ Ori, 46 Ori, HD 37128; $V = 1.70$ mag) is one of the brightest supergiants in the sky and, therefore, one of the best known stars. The first spectroscopic study was carried out more than a century ago by Campbell (1894) and Keeler (1894). It is a hot, massive, single star in the hydrogen shell-burning phase (Lamers 1974; Jarad et al. 1989) with photometric and spectroscopic variability (Stebbins 1915; Ebbets 1982; Prinja et al. 2004), Hα, X-ray and radio emission (Cherrington 1937; Abbott et al. 1980; Berghöfer et al. 1996; Blomme et al. 2002), and strong stellar wind and mass loss (Groenewegen & Lamers 1989; Prinja et al. 2001; Crowther et al. 2006). Alnilam is one of the few early-type stars with determination of the angular diameter using optical interferometry (Hanbury Brown et al. 1974). It illuminates the NGC 1990 reflection nebula. Last, it has been used as a bright spectrophotometric standard (B0Ia in the MK classification by Johnson & Morgan 1953), to investigate the interstellar extinction (e.g. Whitford 1958; Bohlin et al. 1978), and to compare with other early-type supergiants (Humphrey 1978). A review of "classic" works on Alnilam can be found in Lamers (1972). The status of "Alnilam B" (BD–01 969B; see Table A.11), at 3 arcmin to the northeast, is unknown.
* HD 37397 is a low-amplitude variable star ($P = 0.572885$ d, $A(V) = 0.00089$ mag; Koen & Eyer 2002) with a constant radial velocity of 22–23 km s^{-1} (Morrell & Levato 1991; Duflot et al. 1995; Grenier et al. 1999).
* VV Ori AB is a double-lined eclipsing binary in a detached configuration (Miller Barr 1904; Adams 1912; Daniel 1916; Struve & Luyten 1949). The two early-type stars, B1.0V+B4.5V, are separated by $13.49 \pm 0.05\, R_\odot$ ($P \approx 1.48$ d; Terrell et al. 2007). The mid-infrared source IRAS 05309–0111 is located at $\rho \sim 16$ arcsec, $\theta \sim 180$ deg, to VV Ori. Friedemann et al. (1996) had been the only investigators before us to notice the *IRAS* thermal emission of VV Ori, and attributed it to circumstellar dust. This is very important, because: (i) stars with very early spectral types, just as the primary in VV Ori, are not expected to have circumstellar discs at the age of the Ori OB 1 b association, and (ii) the disc would surround the binary system (i.e. the inner part of the disc would be at several – tens – astronomical units, while the binary components are separated by ~0.64 AU). VV Ori may also be associated to the X-ray sources [NYS99] A–01 and 1AXG J053331–0110 (Nakano et al. 1999; Ueda et al. 2001).
* HD 36684 AB is a close binary with $\rho \approx 0.2$ arcsec, $\theta \approx 200$ deg (Dommanget & Nys 1994). It also has a high rotational velocity ($v \sin i \approx 160$ km s^{-1}; Sharpless 1974).
* HD 290750 is a low-amplitude suspected variable (Rufener & Bartholdi 1982).
* HD 36779 AC forms, together with the post-T Tauri star HD 36779 B, a likely Lindroos system (Lindroos 1985).

HD 36779 AC is, in its turn, a spectroscopic binary (Morrell & Levato 1991).

* HD 37187 might form a new (very wide) Lindroos system, together with V583 Ori ($\rho \approx 29.0$ arcsec, $\theta \approx 212$ deg).
* HD 37076 and HD 290671 form the STF 751 double system, with $\rho \approx 15.6$ arcsec, $\theta \approx 124$ deg (Dommanget & Nys 1994). They share Tycho-2 proper motion within the uncertainties. The X-ray emission found by *ROSAT* (with HRI and PSPC) is associated to the faintest component (HD 290671, B9.5V; Caballero et al. in prep.).
* HD 290665 is an SiCrEuSr chemically peculiar star (Bartaya 1974; Schild & Cowley 1971; Guetter 1976; Joncas & Borra 1981; Gieseking 1983). It is also a strong magnetic star ($\langle B_z \rangle \approx -0.17$ T; Bagnulo et al. 2006). Last, HD 290665 has a radial velocity discordant with association membership (Gieseking 1983). It could be, however, a spectroscopic binary.
* V1379 Ori is a slowly pulsating B star (Waelkens et al. 1998).
* HD 290662, a peculiar Vega-like star, was proposed as a spectroscopic binary by Gieseking (1983) based on low quality data.
* HD 36954 AB is a spectroscopic binary (SB1) with a period $P \sim 4.6$ d (Neubauer 1936; Morrell & Levato 1991).
* HD 37235 is a spectroscopic variable B7–A0:V according to Bernacca & Ciatti (1972). Renson (1992) tabulates it as an He-weak star. The origin of the mid-infrared source IRAS 05344–0044, located at a separation $\rho \sim 35$ arcsec to the south of the star, probably lies on the extended source 2MASX J05365804–0042413, whose spectral energy distribution resembles those of starburst galaxies with large dust content (see, e.g., Chary & Elbaz 2001)
* HD 290648, HD 290660 and HD 290650 are also BD–00 1004, BD–00 1020 and BD–00 1012, respectively.

Notes to Table A.4:

* HD 290515 is at a projected angular separation of 34 arcsec to the background RR Lyr star [VZA2004] 28 (Vivas et al. 2004).
* HD 290492 AB is a close binary with $\rho = 0.739 \pm 0.005$ arcsec, $\theta = 63.9 \pm 1.9$ deg ($\Delta b = 0.6 \pm 0.2$ mag – Rossiter 1955; Marchetti et al. 2001). It is a non-variable, mild λ Boo star candidate (Paunzen & Gray 1997; Paunzen et al. 2002 – but see Gerbaldi et al. 2003 and Faraggiana et al. 2004). Paunzen (2001) derived a photometric distance of $d = 279 \pm 20$ pc, but he erroneously assumed no contamination by the secondary in the spectrum of the primary. HD 290492 AB and the G8III star GSC 04766–02124, which is ~3 mag fainter in the V band and at ~24 arcsec to the west, do not share a common proper motion, as has been proposed in the literature.
* SS 28 is a T Tauri star. It has been only investigated by Stephenson & Sanduleak (1977), Bopp (1988), Wiramihardja et al. (1989) and Kogure et al. (1989). It has a double-peaked Hα emission line with intensity about three times that of the continuum, Hβ also in emission and an apparently "filled in" Ca II H and K. According to Bopp (1988), SS 28 resembles some unusual interacting F+B binary systems. It is, besides, an *Einstein* Observatory soft X-ray source. The *ROSAT* Satellite afterwards measured 18 events associated to SS 28 (ROSAT 1955; White et al. 2000). SIMBAD tabulates a quadruple identification (it is also Kiso A–0904 6, Kiso A–0903 234 and 2E 1299).
* BD–00 984 is a chemically peculiar star based on their abnormal abundances of Hg, Mn (Woolf & Lambert 1999 – they classified it as one of the youngest HgMn stars) and Si (Brown & Shore 1986). It forms a curious perfect alignement with two nearby radio sources: [LPZ94] 147 ($\rho \approx 31.5$ arcsec, $\theta \approx 177.0$ deg – $S_\nu(3.9\,\mathrm{GHz}) = 48 \pm 24$ mJy, Larionov et al. 1994) and TXS 0529–004 ($\rho \approx 1.8$ arcmin, $\theta \approx 178$ deg – $S_\nu(1.4\,\mathrm{GHz}) = 82.2 \pm 2.5$ mJy, Condon et al. 1998; $S_\nu(0.365\,\mathrm{GHz}) = 214 \pm 24$ mJy, Douglas et al. 1996). The spectral index of TXS 0529–004 is –0.9, consistent within the uncertainties with thermal Bremsstrahlung emission.
* HD 290500 was classified as a Herbig Ae/Be star by Vieira et al. (2003). They derived A2 spectral type and detected Hα in double-peaked emission, with the secondary peak having less than half the strength of the primary. No forbidden lines were identified. Codella et al. (1995) gave an upper limit for the 22.2 GHz H_2O maser emission of the star. HD 290500 has a mid-infrared flux excess, as measured by *IRAS* (Caballero & Solano, in prep.).
* HD 36841 has been widely used for determining ultraviolet interstellar extinction curves (e.g. Savage et al. 1985; Barbaro et al. 2001). It was formerly considered a late-O-type star (Mannino & Humblet 1955; Goy 1973; Cruz-González et al. 1974).
* V1093 Ori AB (HD 36313) is a variable of α^2 CVn type (North 1984; Catalano & Renson 1998), a helium-weak, silicon, magnetic peculiar (Guetter 1976; Borra 1981; Bychkov et al. 2005), and a close binary star ($\rho \approx 0.22$ arcsec, $\theta \approx 172.6$ deg – Couteau 1962; van Biesbroeck 1974).
* Mintaka AE–D (δ Ori, 34 Ori, HD 36486; $V = 2.23$ mag) is the most famous star in the Orion belt. It is a very bright triple within a hierarchical quintuple system. Mintaka D (δ Ori Ab) is an early-B-type star at $\rho = 0.267$ arcsec, $\theta = 140$ deg ($\Delta H_P = 1.35 \pm 0.02$ mag), from the tight AE binary (Heintz 1980; McCalister & Hendry 1982; Perryman et al. 1997), it may be a rapid rotator or a spectroscopic binary (Harvin et al. 2002). Mintaka A (O9.5II, δ Ori Aa1) and E (B0.5III, δ Ori Aa2) form an eclipsing spectroscopic binary with a peak-to-peak amplitude $A(H_P) = 0.01$ mag and a period $P = 5.7325$ d (Hartmann 1904; Jordan 1914; Pismis et al. 1950; Koch & Hrivnak 1981; Harvey et al. 1987; Harvin et al. 2002; Kholtygin et al. 2006). The binary has suffered from an intense mass loss. The other two components, Mintaka B and C, are described below.
* Mintaka C (δ Ori C, HD 36485) is at $\rho \approx 52.2$ arcsec, $\theta \approx 0.1$ deg to Mintaka AE ($\Delta V_\mathrm{T} = 4.417 \pm 0.012$ mag; Høg et al. 2000). It is a helium-strong star (Morgan et al. 1978; Walborn 1983; Bohlender 1989) with nonthermal radio emission (Drake et al. 1987).
* HD 290491 is also TYC 4766 2264 1.
* HD 36726 A is a λ Boo star (Abt & Levato 1977; Paunzen 2001) and has quite high rotational velocity, $v \sin i$ (about 120 km s^{-1}; Abt 1979). It is the brightest component of a triple system tabulated by Aitken & Doolittle (1932). The secondary is BD–00 993B (Table A.11). The system could be quadruple, since there is an additional 2MASS source at $\rho \approx 5.7$ arcsec, $\theta \approx 3$ deg to HD 36726 A with $J = 15.109 \pm 0.137$ mag.
* HD 290572 is a B8V and a K0V (sic) according to Cannon & Pickering (1924) and Nesterov et al. (1995), respectively. An intermediate A spectral type matches the $B_\mathrm{T} - K_\mathrm{s}$ colour better.

* HD 290569 is an A0V according to Nesterov et al. (1995); however, the relatively red colour $B_T - K_s = 1.29 \pm 0.12$ mag matches a later spectral type better (i.e. intermediate A).

Notes to Table A.5:

* HD 37038 AB is a binary whose components are separated by $\rho \approx 0.6$ arcsec, $\theta \approx 265$ deg. The secondary is 2 mag fainter than the primary (Dommanget & Nys 1994). It could actually be a hierarchical triple, since Nordström et al. (1997) found the F-type dwarf to be a double-lined spectroscopic binary with evident radial-velocity variations in scales of a few days (the resolved binary cannot be responsible for such variations).
* HD 36863 has a radial velocity that deviates more than 25 km s^{-1} from the average radial velocity of the association (Gieseking 1983). It satisfies, however, the photometric and proper motion criteria of very young stars in Orion. HD 36863 might be a very young single-line spectroscopic binary (SB1). Guetter (1976) classified it as an A7-type star.
* [NYS99] A–06 is an X-ray source identified by *ASCA* and *ROSAT* (1AXG J053448–0131, 1RXS J053450.5–013120). We estimate F: spectral type from its $V_T - K_s$ colour.
* HD 290673 is also BD–01 975.
* TYC 4767 1130 1 seems to be a close ($\rho \sim 3$ arcsec) binary from the 2MASS data.
* HD 37172 is a probable non-member of the association according to Guetter (1976), although other authors consider it to be a real member (Warren & Hesser 1977, 1978; Hesser et al. 1977; Gieseking 1983; de Geus & van de Grift 1990). It has a peculiar Mn I λ4030–4035 Å blend (Gray & Corbally 1993) and falls slightly to the red of the association sequence in the $V_T - K_s$ vs. V_T diagram (Fig. 3). It is at $\rho \approx 5.0$ arcmin, $\theta \approx 115$ deg, to Alnilam.
* TYC 4766 2371 1 is the third closest bright star to Alnilam ($\rho \approx 6.0$ arcmin, $\theta \approx 250$ deg).
* TYC 4766 2150 1 (CCDM J05375–0103B) has been repeatedly proposed to form a binary system together with HD 290749 ($\rho \approx 29.0$ arcsec, $\theta \approx 344$ deg – Burnham 1906; Dommanget & Nys 1994). However, they do not share a common proper motion.
* TYC 4766 542 1 might be the X-ray source 1RXS J053447.9–010224 (1AXG J053446–0102; Ueda et al. 2001). The nearby binary 2MASS J05344642–0102340 ($\rho \approx 4.0$ arcsec, $\theta \approx 220$ deg, $\Delta H = 1.89 \pm 0.05$ mag), at ~35 arcsec to the west of TYC 4766 542 1 could also be the X-ray source.
* HD 290746 is a G0V according to Nesterov et al. (1995); however, the relatively blue colour $B_T - K_s = 1.38 \pm 0.09$ mag better matches with an earlier spectral type (i.e. late A or early F).

Notes to Table A.6:

* HD 290585 has a debris disc according to MIPS/*Spitzer* observations at 24 μm by Hernández et al. (2006). It is a double binary resolved by 2MASS ($\rho \approx 5.6$ arcsec, $\theta \approx 132$ deg, $\Delta H = 2.05 \pm 0.05$ mag); the secondary is not in the Tycho-2 catalogue.
* HD 290513 is an F0V dwarf according to Nesterov et al. (1995); a G–K spectral type matches the observed colours better.
* TYC 4766 790 1 has a visual companion at $\rho \approx 8.5$ arcsec, $\theta \approx 190$ deg ($\Delta H = 0.69 \pm 0.04$ mag).
* HD 290583 A has a visual companion of roughly the same brightness. HD 290583 B, not identified by Tycho-2, is at $\rho \approx 7.44$ arcsec, $\theta \approx 3.8$ deg ($\Delta H = 0.40 \pm 0.03$ mag).
* HD 290507 and HD 290504 are A5V dwarfs according to Nesterov et al. (1995); F–G spectral types match the observed colours better.
* TYC 4766 528 1 is the brightest component of a visual triple system. The other two components are located at $\rho \approx 3.4$ arcsec, $\theta \approx 165$ deg ($\Delta H = 0.36 \pm 0.07$ mag), and $\rho \approx 7.4$ arcsec, $\theta \approx 195$ deg ($\Delta H = 2.07 \pm 0.06$ mag).
* TYC 4766 1168 1 has a visual companion at $\rho \approx 9.4$ arcsec, $\theta \approx 10$ deg ($\Delta H = 0.98 \pm 0.04$ mag).
* TYC 4766 2424 1 has a low proper motion of less than 5 mas a^{-1} and a blue colour $B_T - K_s = 0.63 \pm 0.09$ mag, typical of early A-type stars in the association.
* TYC 4753 49 1 is at $\rho \sim 46$ arcsec, $\theta \sim 288$ deg to the radio source [LPZ94] 146 (Larionov et al. 1994).

Notes to Table A.7:

* IRAS 05354–0142 has the reddest $V_T - K_s$ colour among the ~1500 Tycho-2/2MASS investigated stars in the survey area ($V_T - K_s = 7.1 \pm 0.3$ mag). The closeness of IRAS 05354–0142 to the Ori I–2 globule may explain part of its reddening, but not all. It might be an S-type or a C-type giant with a very late spectral type and very low effective temperature. The absence of a mid-infrared excess (Kraemer et al. 2003) rules out the hypothesis of IRAS 05354–0142 being a protostar in the upper part of the Hayashi track of collapse associated to the Bok globule.
* HD 290680 has a $V_T - K_s$ colour that matches a K spectral type better.
* HD 290679 is also GSC 04766–01466.
* HD 36780 is a K5III giant as tabulated in SIMBAD. It has a (variable) radial velocity inconsistent with association membership ($V_r = +91$ km s^{-1}, Griffin 1972; $V_r = +73.2$ km s^{-1}, Bois et al. 1988). The star has a *Hipparcos* distance of 260 ± 50 pc.
* HD 290675 has a discordant radial velocity (Gieseking 1983). It is also BD–01 967.
* HD 37491 is likely associated to the mid-infrared source IRAS 05363–0111.
* HD 290749 is a B8V star according to Nesterov et al. (1995). With proper motion of 13.8 mas a^{-1} and colour $V_T - K_s \sim 1.0$ mag, it is likely a late A- or an early F-type star in the foreground. See also the note for TYC 4766 2150 1 (Table A.5).
* HD 36882 is at $d = 220 \pm 50$ pc (Perryman et al. 1997). Because of a transcription error, SIMBAD tabulates HD 36882 as one of the early-type stars associated to the H II region Sh 2–264, close to λ Ori, in Sharpless (1959); the actual early-type star is ϕ^{01} Ori (HD 36822, B0III).
* HD 290667 and StHA 46 were catalogued by Stephenson (1986) as Hα emission stars. However, Downes & Keyes (1988) and Maheswar et al. (2003) failed to detect the (sporadic?) emission. StHA 46 is at 18 arcsec to the southwest of the early-A star AG–00 669.
* HD 290647 falls in the tiny overlapping region between the Alnilam and Mintaka fields. It is also BD–00 1001.
* TYC 4767 2257 1 has a colour $V_T - K_s > 4.5$ mag, typical of intermediate M stars. Its proper motion is, however, very low ($\mu \lesssim 1$ mas s^{-1}).

Notes to Table A.8:

* HD 290647 falls in the tiny overlapping region between Alnilam and Mintaka fields. It is also BD–00 1001.
* TYC 4766 516 1 has a very red colour of $V_T - K_s = 5.44 \pm 0.09$ mag and no *IRAS* excess. It could be a mid-M-type giant or subgiant in back-/foreground.
* HD 290576 is also BPM 71736.
* TYC 4766 2124 1 is also GSC 04766–02124.
* HD 290568 is also BD–00 987 and IRAS 05303–0009.
* HD 36117 is a nearby ($d = 170 \pm 30$ pc; Perryman et al. 1997), peculiar, A-type star (Gray & Corbally 1993) with X-ray emission
* HD 36139 is a nearby ($d = 124 \pm 13$ pc; Perryman et al. 1997), high rotation-velocity, radial-velocity variable (Morrell & Levato 1991), A-type star with no known companion.
* HD 36840 is at a *Hipparcos* distance of $d = 380 \pm 120$ pc, which is probably incorrect, given the spectral type of the star (G5V).
* HD 36558 has a discordant radial velocity of $V_r = +42.1 \pm 4.8$ km s^{-1} (Nordström et al. 2004).
* HD 36443 (LHS 5107, G 99–16; Roman 1995) is a well-known, solar-like, high-velocity star at only $d = 38.2 \pm 1.9$ pc and with radial velocity $V_r \approx -9.1$ km s^{-1} (Wilson 1953).
* HD 290486 AB is a visual binary star with $\rho \approx 1.7$ arcsec, $\theta \approx 304$ deg (Dommanget & Nys 1994).

Notes to Table A.9:

* E Ori 2–1328 is a young M 4.5-type very low-mass star with lithium in absorption (pEW(Li I) = +0.40 ± 0.05 Å) and Balmer lines in faint (chromospheric) emission (pEW(Hα) = −8.2 ± 0.5 Å). The sodium line in the red optical is weak in comparison with field dwarfs of the same spectral type (pEW(Na I) = +3.4 ± 0.5 Å; Béjar et al. 2003a).
* E Ori 2–1868 is a young M6.0-type very low-mass star with faint alkali lines (pEW(Na I) < 3 Å; Béjar et al. 2003b). The *i*-band magnitude has been taken from the SuperCOSMOS Science Archive (Hambly et al. 2001).
* E Ori 1–388 is a young M6.0-type very low-mass star with faint alkali lines (pEW(Na I) = +3.9 ± 0.5 Å; Béjar et al. 2003a) and Balmer lines in faint (chromospheric) emission (pEW(Hα) = −6.5 ± 2.0 Å). It is embedded in the [OS98] 40B remnant molecular cloud.
* E Ori 1–1644 is a young M5.0-type very low-mass star with Balmer lines in faint (chromospheric) emission (pEW(Hα) = −7.6 ± 1.0 Å; Béjar et al. 2003a).
* E Ori 2–878 is a young M5.5-type very low-mass star with faint alkali lines (pEW(Na I) < 3 Å; Béjar et al. 2003b).
* E Ori 2–705 is a young M5.0-type very low-mass star with faint alkali lines (pEW(Na I) < 4 Å; Béjar et al. 2003b). The *i*-band magnitude is from SuperCOSMOS.
* E Ori 2–603 is a young M5.5-type very low-mass star with faint alkali lines (pEW(Na I) < 3 Å; Béjar et al. 2003b).
* Kiso A–0904 41 and Kiso A–0904 42 form a binary system with $\rho \approx 11.0$ arcsec, $\theta \approx 277$ deg. The *i*-band magnitudes are from SuperCOSMOS. They have been identified in *XMM-Newton* observations (Caballero et al., in prep).
* V469 Ori is proably associated to the [OS98] 29J, [OS98] 29H, and [OS98] 29K remnant molecular clouds.
* Kiso A–0904 76 is a K6-type variable ($\Delta V = 0.33$ mag) star with pEW(Hα) = −20.2 Å and pEW(Li I) = +0.5 Å (Briceño et al. 2005). It has a visual companion at $\rho \approx 5.3$ arcsec, $\theta \approx 321$ deg ($\Delta H = 2.91 \pm 0.05$ mag).
* Haro 5–80 is a variable, emission-line star (Haro & Moreno 1953; Fedorovich 1960; Wiramihardja et al. 1989). It has a very nearby ($\rho \sim 3$ arcsec, $\theta \sim 15$ deg) companion or a small jet (possibly associated to an unknown Herbig-Haro object)
* 2E 1398 is an X-ray source tabulated in at least six catalogues from *Einstein*, *ROSAT* and *XMM-Newton* data (Harris et al. 1994; McDowell 1994; Moran et al. 1996; Voges et al. 1999; *ROSAT* Consortium 2000; *XMM-Newton* Survey Science Centre Consortium 2007). It is located at 4.5 arcmin to the west of Alnilam. The *i*-band magnitude is from SuperCOSMOS.
* Kiso A–0904 37 has rather blue $I - J$ and $J - K_s$ colours. Besides, it has a faint, red, visual companion at $\rho \approx 5.6$ arcsec, $\theta \approx 144$ deg, unresolved by Wiramihardja et al. (1989). It is likely that the actual emission-line star or brown dwarf (and the only truly young objects) is the visual companion (J2000 coordinates: 05 35 32.38 –01 12 08.2).
* StHA 47 is a mid-K-type T Tauri star according to Downes & Keyes (1988). It is the fourth strongest X-ray emitter at less than 20 arcmin to Alnilam, from *XMM-Newton* observations.
* CVSO 162 is an M1-type variable ($\Delta V = 0.23$ mag) star with pEW(Hα) = −3.9 Å and pEW(Li I) = +0.5 Å (Briceño et al. 2005).
* Annizam 363062 is a visual binary with $\rho \approx 6.3$ arcsec, $\theta \approx 243$ deg ($\Delta H = 2.41 \pm 0.06$ mag). Five X-ray events in the surrounding area were tabulated in the catalogue of *ROSAT* HRI Pointed Observations (ROSAT Team 2000). It might also be the *Einstein* source 2E B0534–0111. It is not known which component is the actual X-ray emitter.
* Haro 5–67 is a G:-type, photometrically variable, T Tauri star with strong Balmer emission detected by several Hα objective-prism surveys (Haro & Moreno 1953; Sanduleak 1971; Stephenson 1986) and with *IRAS* flux excess (Weaver & Jones 1992). It has been spectroscopically followed up by Herbig & Kaneswara Rao (1972) and Downes & Keyes (1988).
* Kiso A–0904 50 has rather blue $I - J$ and $J - K_s$ colours. It might be a variable young star or an active object in the fore-/background.
* Kiso A–0904 61 could also be the Hα emitter Haro 5–77 (suspected variable NSV 2465; Kukarkin et al. 1981).
* V583 Ori (Haro 5–74) is a variable, emission-line star (Haro & Moreno 1953; Fedorovich 1960; Wiramihardja et al. 1989). It is possibly the X-ray source 2E 1423 and might form a Lindroos system with the B9V star HD 37187 (Table A.3).
* HD 36779 B is a K5IV with Li I in absorption in a likely Lindroos system with the B-type star HD 36779 (Table A.3 – Lindroos 1985; Pallavicini et al. 1992; Martín et al. 1992), see, however, a brief discussion of the position in the H-R diagram and the radial velocity of HD 36779 B in Gerbaldi et al. (2001).
* 2E 1357 is a K3-type star with pEW(Hα) = −2.75 Å and pEW(Li I) = +0.470 ± 0.008 Å (Alcalá et al. 1996, 2000).
* Kiso A–0904 28 is also the X-ray source 2E 1340 (McDowell 1994). The star was detected by Kraemer et al. (2003) at 8.3 μm, which suggests a possible flux excess in the mid-infrared.
* Kiso A–0904 30 was previously identified with a fainter, much bluer source 24 arcsec to the east.

* 2E 1449 is a K4-type star with pEW(Hα) = +0.35 Å and pEW(Li I) = +0.410 ± 0.010 Å (Alcalá et al. 1996, 2000).
* Kiso A–0904 60 is a K6-type variable (ΔV = 0.51 mag) star with pEW(Hα) = −61.9 Å and pEW(Li I) = +0.3 Å (Briceño et al. 2005). It could be a tight binary ($\rho \lesssim$ 1.0 arcsec) based on the 2MASS photometry quality flags.
* Kiso A–0904 65 is a variable (ΔV = 0.87 mag) star with a very strong Balmer emission, pEW(Hα) = −400 Å, and lithium in absorption, pEW(Li I) = +0.3 Å (Briceño et al. 2005).
* CVSO 124 is an M3-type variable (ΔV = 0.19 mag) star with pEW(Hα) = −17.3 Å and pEW(Li I) = +0.4 Å (Briceño et al. 2005). It also falls in the Mintaka field.
* Kiso A–0904 34 is also [SE2005] 104. It does not show significant periodic variability.
* Kiso A–0904 33 has a faint, red, visual companion at $\rho \approx$ 4.9 arcsec, $\theta \approx$ 14 deg, with near-infrared magnitudes J = 12.55 ± 0.03 mag and K_s = 11.55 ± 0.03 mag.
* PU Ori is a pre-main sequence star with Hα in strong two-lobe emission (Haro & Moreno 1953; Herbig et al. 1972; Cohen & Kuhi 1979; Wiramihardja et al. 1989), photometric variability (Fedorovich 1960; Briceño et al. 2005), mid-infrared flux excess at the *IRAS* passbands (Weintraub 1990; Weaver & Jones 1992) and forbidden emission lines ([O I] λ 6300.3 Å; Hirth et al. 1997). It has an extraordinarily red colour of $J - K_s$ = 1.77 ± 0.03 mag.
* StHA 48 is a K4-type T Tauri star according to Maheswar et al. (2003).

Notes to Table A.10:

* CVSO 124 is an M3-type variable (ΔV = 0.19 mag) star with pEW(Hα) = −17.3 Å and pEW(Li I) = +0.4 Å (Briceño et al. 2005). It also falls in the Alnilam field.
* Kiso A–0903 221 has a faint red visual companion at $\rho \approx$ 6.4 arcsec, $\theta \approx$ 49 deg (ΔH = 5.1 ± 0.2 mag).
* Kiso A–0904 4 is a K7-type variable (ΔV = 0.66 mag) star with pEW(Hα) = –34.2 Å and pEW(Li I) = +0.3 Å (Briceño et al. 2005). It is also Kiso A–0903 228.
* IRAS 05307–0038 (also known as YSO CB031YC1 and YSO–C CB031YC1–I) is a bright (K_s = 8.63 ± 0.02 mag) T Tauri star embedded in the IC 434 Bok globule/reflection nebula (Dreyer 1895; Hubble 1922; Cederblad 1946; Dorschner & Gürtler 1963; Magakian 2003). This star has an extended and fuzzy nebulosity in the J band and was classified as a Class II object because of a flux excess at 25 μm (Yun & Clemens 1994, 1995). Yun et al. (1997) measured Hα and Hβ in emission and Li I in absorption, and characterised its SED from the B band to the mid-infrared. Yun et al. (1996) discovered two nearby radio sources that could be associated to the star (there are other two additional radio sources in the surrounding area, found by Condon et al. 1998). Gómez et al. (2006), in a very sensitive survey using NASA 70 m antenna at Robledo de Chavela (Spain), failed to detect water maser emission from these sources. See Fig. A.1.
* Kiso A–0904 22 has a nearby visual companion identified as a photometric young star candidate, Mantaqah 2385113 (Table A.17).
* Kiso A–0904 13 is also Kiso A–0903 245.
* Mantaqah 487126 displayed 14 X-ray events during *ROSAT* observations (White et al. 2000 – 8 events –; ROSAT 2000 – 6 events –).
* 1AXG J053127–0021 appears in numerous X-ray catalogues from *ROSAT* and *ASCA* data. The i-band magnitude is from SuperCOSMOS.
* Mantaqah 148186 is an X-ray source in several catalogues (e.g. Voges et al. 1999).
* Mantaqah 400105 is an X-ray source in several catalogues (e.g. White et al. 2000).
* Mantaqah 320042 displayed 12 X-ray events during *ROSAT* observations (White et al. 2000 –5 events–; ROSAT 2000 –7 events–).
* Kiso A–0904 18 has a $J - K_s$ colour redder than 2.0 mag.

Notes to Table A.11:

* E Ori 2–1982 has no DENIS or SuperCOSMOS counterpart. The i-band magnitude (actually I) is from Béjar et al. (2003b).
* [OSP2002] OriI–2N 4 has a tiny (chromospheric?) Balmer emission (pEW(Hα) ≈–2.6 Å; Ogura et al. 2002).
* BD–01 969B (“Alnilam B”, ϵ Ori B; V = 10.5 mag) is located at $\rho \approx$ 179.0 arcsec, $\theta \approx$ 58 deg, to Alnilam (this value coincides with the original measurements by Burnham in 1879 – Burnham 1906). No spectral type has been tabulated or measured.
* AG–00 669 forms a visual double with the foreground solar-like star StHA 46 (Jeffers 1963). See Table A.7.
* BD–00 983B (“Mintaka B”, δ Ori B; V = 14.0 mag) is located at $\rho \approx$ 33.0 arcsec, $\theta \approx$ 229 deg, to Mintaka AE–D (this value coincides with the original measurements by Burnham in 1878 – Burnham 1906). No spectral type has been tabulated or measured. The star shows no evidence of any significant X-ray emission in deep observations with the *Chandra* Space Telescope (Miller et al. 2002).
* BD–00 993B (“HD 36726 BC”; V = 13.7 mag) is located at $\rho \sim$ 19.8 arcsec, $\theta \sim$ 213 deg (ΔH = 1.30 ± 0.05 mag) to the A0Vm-type star HD 36726 (Table A.4). BD–00 993B is, in its turn, a close binary with $\rho \sim$ 0.8 arcsec, $\theta \sim$ 64 deg (Dommanget & Nys 1994).

Notes to Table A.12:

* X Ori is the reddest object in the studied area. It is an M8–9-type Mira Cet variable found by Wolf (1904) with P = 424.15 ± 1.77 d (Templeton et al. 2005) and silicate dust emission (Sloan & Price 1998; Speck et al. 2000). Although X Ori is even brighter in the near- and mid-infrared than Alnilam and Mintaka (K_s ~ 0.9 mag), its extremely red colours ($V - K_s$ > 10 mag) prevented its detection in the Tycho-2 catalogue.
* Ruber 1 has a proper motion of –12 ± 5, –49 ± 2 mas s^{-1}, measured by us using POSSI, UKST blue, red, and infrared, DENIS and 2MASS (the six epochs cover 47 years; see method details in Caballero 2007b). Ruber 1 probably is a late M dwarf in the foreground.
* G 99–18 is a high proper-motion star, with μ = 280 mas a^{-1}. It falls in the tiny overlapping region between the Alnilam and Mintaka fields.
* Ruber 2 has very peculiar colours: the near-infrared colours are very red (e.g. $J - K_s$ = 1.33 ± 0.04 mag), typical of early and intermediate L dwarfs, very late M giants or carbon stars. Its $I - J$ colour is red enough, as well, to be selected as an association member candidate. The optical colours are, however, contradictory and variable. The SuperCOSMOS Science Archive tabulates

photographic magnitudes $B(1988.0) = 17.643$ mag, $R_1(1951.9) = 19.148$ mag and $R_2(1989.0) = 15.713$ mag. Photographic R bands are separated by 37.1 years and probably reflect intrinsic (high-amplitude, long-time-scale) photometric variability of the object. SuperCOSMOS and USNO-B1 tabulate appreciable proper motions for Ruber 2. However, after a careful astrometric study using the original plate digitisations, DENIS and 2MASS, we conclude that the proper motion of the object is null within uncertainties of 10 mas s^{-1}. Ruber 2 is at a separation of only ~9 arcmin to the core of the unusual Berkeley 20 cluster (see Sect. 1). Therefore, Ruber 2 probably is a pulsating late M giant of that cluster, at a heliocentric distance of 8.4 kpc.

Notes to Table A.14:

* 2MASS J05345451–0143256 has a 2MASS double detection, with quality flags AUU and UEA. It is not in the NASA/IPAC Extragalactic Database (NED). It could be an unresolved stellar binary instead of a galaxy.
* 2MASX J05332498–0106242 is also the NED object LCSB S0895N (Monnier Ragaigne et al. 2003).
* 2MASX J05365804–0042413 is the infrared source IRAS 05344–0044, very close to the young early-type star HD 37235.
* 2MASX J05364723–0039144 is also the NED object LCSB S0899N (Monnier Ragaigne et al. 2003).
* 2MASS J05364746–0039110 is located at 4.3 arcsec to the centre of 2MASX J05364723–0039144 (see just above), in the plane of the galaxy. This source is probably an artifact.

Notes to Table A.15:

* 2MASX J05322266–0000555 is also the NED object LEDA 147610 (Klemola et al. 1987; Paturel et al. 1989).
* 2MASS J05341337–0044087 is PMN J0534–0044, a powerful radio source discovered in many surveys (e.g. Becker et al. 1991; Griffith et al. 1995; Douglas et al. 1996; Condon et al. 1998). Its optical/near infrared counterpart is faint ($i = 16.82 \pm 0.11$ mag) and relatively blue ($i - K_s = 1.2 \pm 0.2$ mag).

Notes to Table A.16:

* Annizam 2473146 is at ~4 arcsec to the east of an extended source with a galactic appearance.
* Annizam 2464138 could be reddened by the nearby Ori I–2 Bok globule and be a background star.
* Annizam 1840146 was subject of a dedicated astrometric study using public data (plate digitisations, DENIS and 2MASS). There seems to be an artifact in the POSSI Schmidt plate of 1951 that causes a false proper motion of more than 100 mas s^{-1} in the astrometric catalogues USNO-B1 and SuperCOSMOS Science Archive. The very red object has, however, null proper motion within the uncertainty of 10 mas s^{-1} using seven astrometric epochs between 1987 and 2000 (see Caballero 2007b for details of the astrometric analysis).
* Annizam 1106127 has 2MASS photometry quality flags "EEE"; it might indicate that it is an unresolved binary with $\rho \sim 1$–2 arcsec.
* Annizam 1415101 is surrounded by a galaxy arm-like structure. It could be the point-like core of a background galaxy.

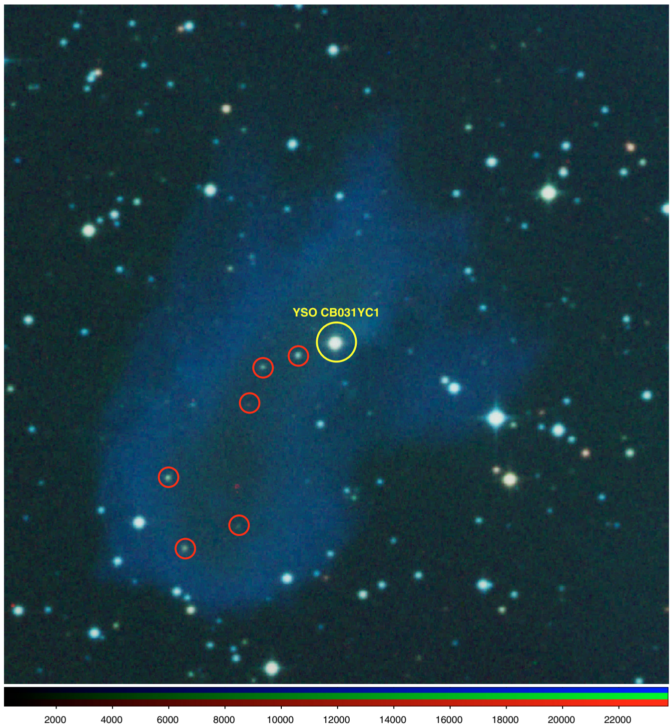

Fig. A.1. False–colour composite image, 7.5 × 7.5 arcmin^2 wide, of the IC 434 Bok globule, centred on IRAS 05307–0038 (labelled as YSO CB031YC1). Blue, green and red are for photographic B_J, R_F and I_N, respectively. North is up, east is left. The six reddened sources in the IC 434 Bok globule (Table A.13) are indicated with (red) circles.

* Annizam 2042095 has a bluer, fainter, visual companion at about 3 arcsec to the northeast.
* Annizam 2611268 is at ~8 arcsec to the south of a probable foreground star, about ~3.3 mag brighter in the i band.
* Annizam 123132 is in the glare of Alnilam ($\rho \sim 2.0$ arcmin, $\theta \sim 130$ deg).
* Annizam 1751268 is probably the *Einstein* X-ray source 2E 1458.
* Annizam 1748267 is at only $\rho \sim 8.4$ arcsec, $\theta \sim 340$ deg to Annizam 1751268 (see just above).
* V993 Ori is a long-time-known variable star discovered by Luyten (1932). It has a very red colour $J - K_s = 1.26 \pm 0.04$ mag for its brightness ($H = 9.82 \pm 0.02$ mag).
* Annizam 798196 could be associated to the X-ray source 1WGA J0536.4–0059, found in several *ROSAT* HRI and PSPC catalogues (Moran et al. 1996; *ROSAT* Consortium 2000; Flesch & Hardcastle 2004). It might be a background source associated to the (extragalactic?) radio source NVSS 053627–005937 in the 1.4 GHz NRAO VLA Sky Survey (Condon et al. 1998), located at $\rho \sim 18$ arcsec, $\theta \sim 200$ deg.
* [SE2005] 120 (Mantaqah 1357158) is a photometric candidate member of the "ϵ Orionis cluster" firstly identified by Scholz & Eislöffel (2005). It is the most variable star of the five objects with high-amplitude ($A_I = 0.952$ mag), irregular variations. It also have a significant periodic variability of $P = 82 \pm 3$ h, with superimposed short-term fluctuations. Scholz & Eislöffel (2005) classified it as very low-mass analogue of the classical T Tau stars affected by intrinsic reddening. For explaining the large variations, they proposed two possible scenarios involving a eclipsing "hot Jupiter" in

close orbit and "hot spots formed by matter flow from an accretion disc onto the central object". It might be, however, a typical eclipsing binary in the fore-/background.

* [SE2005] 126 (Mantaqah 1582164) is another photometric candidate member of the "ϵ Orionis cluster" with significant periodic variability in the work by Scholz & Eislöffel (2005). In this case, the object has a low-amplitude variability (A_I = 0.016 mag) with a very short period (P = 4.06 ± 0.05 mag). The values are consistent with pulsations induced by deuterium-burning in young brown dwarfs (Caballero et al. 2004; Palla & Baraffe 2005).
* [SE2005] 71 (Annizam 2446149) is a non-variable photometric candidate member of the "ϵ Orionis cluster" (Scholz & Eislöffel 2005). It is located at $\rho \sim$ 14 arcsec, $\theta \sim$ 270 deg, to V472 Ori.

Notes to Table A.17:

* Mantaqah 2041159 is surrounded by galaxy arm-like structures. It could be the point-like core of a background galaxy.
* [SE2005] 44 (Mantaqah 2627125) is a photometric candidate member of the "ϵ Orionis cluster" with significant periodic variability (A_I = 0.027 mag, P = 31.0 ± 1.8 h; Scholz & Eislöffel 2005).
* Mantaqah 2216132 has a fainter redder visual companion at $\rho \sim$ 5.6 arcsec, $\theta \sim$ 210 deg.
* Mantaqah 2385113 is at $\rho \approx$ 6.87 arcsec, $\theta \approx$ 352 deg to Kiso A–0904 22, together with it could form a ~2700 AU-wide low-mass binary.
* Mantaqah 941101 has a brighter bluer visual companion at $\rho \sim$ 4.5 arcsec, $\theta \sim$ 230 deg.
* Mantaqah 1926266 is at $\rho \approx$ 15.1 arcmin, $\theta \approx$ 224 deg, to Kiso A–0903 183.
* Mantaqah 161138 is in the glare of Mintaka ($\rho \sim$ 2.7 arcmin, $\theta \sim$ 140 deg).
* Mantaqah 104142 is in the glare of Mintaka ($\rho \sim$ 1.7 arcmin, $\theta \sim$ 140 deg).
* Mantaqah 67144 is in the glare of Mintaka ($\rho \sim$ 1.1 arcmin, $\theta \sim$ 145 deg). Its J-band magnitude is strongly affected.
* Mantaqah 1982094 has a blue visual companion at $\rho \sim$ 6.6 arcsec, $\theta \sim$ 60 deg.

Notes to Table A.18:

* Albus 1 has by far the bluest colour among all the investigated objects ($V_{\rm T} - K_{\rm s} = -0.95 \pm 0.14$ mag) and a measurable proper motion μ = 19 mas a^{-1}. Although Albus 1 was detected from the data presented in this work, it was followed-up with additional photometric data and discussed in detail in Caballero & Solano (2007). Very recently, Vennes et al. (2007) obtained a series of optical spectra, showing that it is a peculiar, bright, helium-rich B3 subdwarf ($n_{\rm He} = 0.6 \pm 0.1$).
* TYC 5360 681 1, the stellar counterpart of an *IRAS* source, has an appreciable proper motion tabulated by Tycho-2: $(\mu_\alpha \cos\delta, \mu_\delta) = (-4 \pm 2, +16 \pm 3)$ mas a^{-1}. Assuming an heliocentric distance of $d \gtrsim$ 1 kpc, typical of a giant, it would have a very large tangential velocity of $V_{\rm t} \gtrsim$ 80 km s^{-1}.
* BD–13 1293 is the reddest *IRAS* source in this list. The star, investigated here for the first time, displays very strong wide absorption bands, especially at ~1 μm (between the i and J bands). It is a photometric variable: from the Hipparcos catalogue, its $V_{\rm T}$ magnitude varies between $V_{\rm T}$ = 9.41 and 10.00 mag (15 and 85% percentiles, respectively).

References

Abbott, D. C., Bieging, J. H., Churchwell, E., & Cassinelli, J. P. 1980, ApJ, 242, 1183
Abt, H. A. 1979, ApJ, 230, 485
Abt, H. A., & Levato, H. 1977, PASP, 89, 797
Adams, W. S. 1912, ApJ, 35, 163
Aitken, R. G., & Doolittle, E. 1932, New general catalogue of double stars within 120 deg of the North pole... (Washington, DC: Carnegie institution of Washington)
Alcalá, J. M., Terranegra, L., Wichmann, R., et al. 1996, A&AS, 119, 7
Alcalá, J. M., Covino, E., Torres, G., et al. 2000, A&A, 353, 186
Álvarez, C., Hoare, M., Glindemann, A., & Richichi, A. 2004, A&A, 427, 505
Andrillat, Y., & Jaschek, C. 1998, A&A, 337, 512
Anthony-Twarog, B. J. 1982, AJ, 87, 1213
Artyukhina, N. M., & Karimova, D. K. 1959, SvA, 3, 122
Bagnulo, S., Landstreet, J. D., Mason, E., et al. 2006, A&A, 450, 777
Baraffe, I., Chabrier, G., Barman, T. S., Allard, F., & Hauschildt, P. H. 2003, A&A, 402, 701
Barbaro, G., Mazzei, P., Morbidelli, L., Patriarchi, P., & Perinotto, M. 2001, A&A, 365, 157
Bartaya, R. 1974, ATsir, 845, 3
Bate, M. R., Bonnell, I. A., & Bromm, V. 2003, MNRAS, 339, 577
Becker, R. H., White, R. L., & Edwards, A. L. 1991, ApJS, 75, 1
Béjar, V. J. S. 2001, Ph.D. Thesis, Universidad de La Laguna, Spain
Béjar, V. J. S., Zapatero Osorio, M. R., & Rebolo, R. 1999, ApJ, 521, 671
Béjar, V. J. S., Rebolo, R., Zapatero Osorio, M. R., & Caballero, J. A. 2003a, The Future of Cool-Star Astrophysics: 12th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun (2001 July 30–August 3), ed. A. Brown, G. M. Harper, & T. R. Ayres, University of Colorado, 651
Béjar, V. J. S., Caballero, J. A., & Rebolo, R. 2003b, unpublished contribution at Science with the GTC 10 m telescope, Granada, Spain, 5–8 February 2002
Berghoefer, T. W., Baade, D., Schmitt, J. H. M. M., et al. 1996, A&A, 306, 899
Bernacca, P. L., & Ciatti, F. 1972, A&A, 19, 482
Bertout, C. 1989, ARA&A, 27, 351
Bhatt, H. C., & Manoj, P. 2000, A&A, 362, 978
Bidelman, P. W. 1965, PASP, 77, 388
van Biesbroeck, G. 1974, ApJS, 28, 413
Blaauw, A. 1964, ARA&A, 2, 213
Blaauw, A. 1991, The Physics of Star Formation and Early Stellar Evolution, NATO Advanced Science Institutes (ASI) Series C, 342, held in Agia Pelagia, Crete, Greece, May 27–June 8 (Dordrecht: Kluwer), ed. C. J. Lada, & N. D. Kylafis, 125
Blaauw, A., & van Albada, T. S. 1963, ApJ, 137, 791
Blomme, R., Prinja, R. K., Runacres, M. C., & Colley, S. 2002, A&A, 382, 921
Bohlender, D. A. 1989, ApJ, 346, 459
Bohlender, D. A., Landstreet, J. D., Brown, D. N., & Thompson, I. B. 1987, ApJ, 323, 325
Bohlin, R. C., Savage, B. D., & Drake, J. F. 1978, ApJ, 224, 132
Bois, B., Lanning, H. H., & Mochnacki, S. W. 1988, AJ, 96, 157
Bonnarel, F., Fernique, P., Bienaymé, O., et al. 2000, A&AS, 143, 33
Bopp, B. W. 1988, AJ, 95, 1543
Borra, E. F. 1981, ApJ, 249, L39
Briceño, C., Hartmann, L., Stauffer, J., & Martín, E. L. 1998, AJ, 115, 2074
Briceño, C., Calvet, N., Hernández, J., et al. 2005, AJ, 129, 907
Brown, D. N., & Shore, S. N. 1986, NIA, 86, 365
Brown, A. G. A., de Geus, E. J., & de Zeeuw, P. T. 1994, A&A, 289, 101
Burnham, S. W. 1879, Double star observations made in 1877–8 at Chicago with the 18 1/2-inch refractor of the Dearborn observatory, London
Burnham, S. W. 1906, A general catalogue of double stars within 121 deg of the North pole, Carnegie institution of Washington (Chicago: University of Chicago press)
Bychkov, V. D., Bychkova, L. V., & Madej, J. 2005, A&A, 430, 1143
Caballero, J. A. 2007a, A&A, 466, 917
Caballero, J. A. 2007b, A&A, 462, L61
Caballero, J. A. 2008a, MNRAS, 383, 375
Caballero, J. A. 2008b, MNRAS, 383, 750
Caballero, J. A. 2008c, A&A, 478, 667
Caballero, J. A., & Solano, E. 2007, ApJ, 665, L151
Caballero, J. A., & Dinis, L. 2008, A&A, submitted
Caballero, J. A., Béjar, V. J. S., Rebolo, R., & Zapatero Osorio, M. R. 2004, A&A, 424, 857
Caballero, J. A., Martín, E. L., Zapatero Osorio, M. R., et al. 2006, A&A, 445, 143
Caballero, J. A., Béjar, V. J. S., Rebolo, R., et al. 2007, A&A, 470, 903
Campbell, W. W. 1894, AstAP, 13, 476
Cannon, A. J., & Pickering, E. C. 1924, Henry Draper (HD) catalog and HD extension, Annals of the Astronomical Observatory, Cambridge: Harvard College, Astronomical Observatory [VizieR On-line Data Catalog: III/135A]

Catalano, F. A., & Renson, P. 1998, A&AS, 127, 421
Cederblad, S. 1946, Lund Medd. Astron. Obs. Ser. II, 119, 1
Cernicharo, J., Bachiller, R., Duvert, G., González-Alfonso, E., & Gómez-Gonzalez, J. 1992, A&A, 261, 589
Chabrier, G., & Baraffe, I. 2000, ARA&A, 38, 337
Chary, R., & Elbaz, D. 2001, ApJ, 556, 562
Cherrington, E., Jr. 1937, ApJ, 85, 139
Ciatti, F., Bernacca, P. L., & D'Innocenzo, A. 1978, A&A, 69, 171
Codella, C., Palumbo, G. G. C., & Pareschi, G. 1995, MNRAS, 276, 57
Cohen, M., & Kuhi, L. V. 1979, ApJS, 41, 743
Collinder, P. 1931, Ann. Obs. Lund, 2, 1
Condon, J. J., Cotton, W. D., & Greisen, E. W. 1998, AJ, 115, 1693
Coulson, I. M., Walther, D. M., & Dent, W. R. F. 1998, MNRAS, 296, 934
Couteau, P. 1962, JO, 45, 43
Crawford, D. L., & Barnes, J. V. 1966, AJ, 71, 611
Crowther, P. A., Lennon, D. J., & Walborn, N. R. 2006, A&A, 446, 279
Cruz-González, C., Recillas-Cruz, E., Costero, R., Peimbert, M., & Torres-Peimbert, S. 1974, RMxAA, 1, 211
Daniel, Z. 1916, Publications of the Allegheny Observatory of the University of Pittsburgh, 3, 179
Delfosse, X., Tinney, C. G., Forveille, T., et al. 1997, A&A, 327, L25
Dias, W. S., Lépine, J. R. D., & Alessi, B. S. 2001, A&A, 376, 441
Dommanget, J., & Nys, O. 1994, Com. de l'Observ. Royal de Belgique, 115, 1
Dommanget, J., & Nys, O. 2002, VizieR On-line Data Catalog: I/274. Originally published in: Observations et Travaux 54, 5
Dong, Y. S., & Hu, J. Y. 1991, AcApS, 11, 172
Dorschner, J., & Guertler, J. 1963, AN, 287, 257
Douglas, J. N., Bash, F. N., Bozyan, F. A., Torrence, G. W., & Wolfe, C. 1996, AJ, 111, 1945
Downes, R. A., & Keyes, C. D. 1988, AJ, 96, 777
Drake, S. A., Abbott, D. C., & Bastian, T. S. 1987, ApJ, 322, 902
Dreyer, J. L. E. 1888, MmRAS, 49, 1
Dreyer, J. L. E. 1895, MmRAS, 51, 185
Duflot, M., Figon, P., & Meyssonnier, N. 1995, A&AS, 114, 269
Ebbets, D. 1982, ApJS, 48, 399
Eggen, O. J. 1985, PASP, 97, 807
Epchtein, N., de Batz, B., Capoani, L., et al. 1997, Msngr, 87, 27
Faraggiana, R., Bonifacio, P., Caffau, E., Gerbaldi, M., & Nonino, M. 2004, A&A, 425, 615
Fedorovich, V. P. 1960, Perem. Zvezdy, 13, 166
Flesch, E., & Hardcastle, M. J. 2004, A&A, 427, 387
Frost, E. B. 1909, ApJ, 29, 233
Franciosini, E., Pallavicini, R., & Sanz-Forcada, J. 2006, A&A, 446, 501
Friedemann, C., Gürtler, J., & Löwe, M. 1996, A&AS, 117, 205
Fujii, T., Nakada, Y., & Parthasarathy, M. 2002, A&A, 385, 884
García, J. R., Cebral, J. R., Scoccimarro, E. R., et al. 1995, A&AS, 109, 201
García-Lario, P., Manchado, A., Pych, W., & Pottasch, S. R. 1997, A&AS, 126, 479
Garrison, R. F. 1967, PASP, 79, 433
Garrison, R. F. 1994, RMxAA, 29, 111
Gerbaldi, M., Faraggiana, R., & Balin, N. 2001, A&A, 379, 162
Gerbaldi, M., Faraggiana, R., & Lai, O. 2003, A&A, 412, 447
de Geus, E. J., Lub, J., & van de Grift, E. 1990, A&AS, 85, 915
Giclas, H. L., Burnham, R., & Thomas, N. G. 1961, LowOB, 5, 61
Gieseking, F. 1983, A&A, 118, 102
Goldman, B., Delfosse, X., Forveille, T., et al. 1999, A&A, 351, L5
Gómez, J. F., de Gregorio-Monsalvo, I., Suárez, O., & Kuiper, T. B. H. 2006, AJ, 132, 1322
González-García, B. M., Zapatero Osorio, M. R., Béjar, V. J. S., et al. 2006, A&A, 460, 799
Goy, G. 1973, A&AS, 12, 277
Gray, R. O., & Corbally, C. J. 1993, AJ, 106, 632
Grenier, S., Baylac, M.-O., Rolland, L., et al. 1999, A&AS, 137, 451
Griffin, R. F. 1972, MNRAS, 155, 449
Griffith, M. R., Wright, A. E., Burke, B. F., & Ekers, R. D. 1995, ApJS, 97, 347
Grillo, F., Sciortino, S., Micela, G., Vaiana, G. S., & Harnden, F. R., Jr. 1992, ApJS, 81, 795
Groenewegen, M. A. T., & Lamers, H. J. G. L. M. 1989, A&AS, 79, 359
Guetter, H. H. 1976, AJ, 81, 537
Guetter, H. H. 1979, AJ, 84, 1846
Guetter, H. H. 1981, AJ, 86, 1057
Hambly, N. C., MacGillivray, H. T., Read, M. A., et al. 2001, MNRAS, 326, 1279
Hanbury Brown, R., Davis, J., & Allen, L. R. 1974, MNRAS, 167, 121
Handler, G. 1999, IBVS, 4817, 1
Hardie, R. H., Heiser, A. M., & Tolbert, C. R. 1964, ApJ, 140, 1472
Haro, G., & Moreno, A. 1953, BOTT, 1g, 11
Harris, D. E., Forman, W, Gioa, I. M., et al. 1994, Einstein Observatory catalog of IPC X-ray sources, SAO HEAD CD-ROM Series I (Einstein), Nos. 18–36 [VizieR On-line Data Catalog: IX/13]
Hartmann, J. 1904, ApJ, 19, 268
Harvey, A. S., Stickland, D. J., Howarth, I. D., & Zuiderwijk, E. J. 1987, Obs, 107, 205
Harvin, J. A., Gies, D. R., Bagnuolo, W. G., Penny, L. R., & Thaller, M. L. 2002, ApJ, 565, 1216
Heintz, W. D. 1980, ApJS, 44, 111
Herbig, G. H., & Kameswara Rao, N. 1972, ApJ, 174, 401
Hernández, J., Calvet, N., Hartmann, L., et al. 2005, AJ, 129, 856
Hernández, J., Briceño, C., Calvet, N., et al. 2006, ApJ, 652, 472
Hernández, J., Hartmann, L., Megeath, T., et al. 2007, ApJ, 662, 1067
Hesser, J. E., McClintock, W., & Henry, R. C. 1977, ApJ, 213, 100
Hillenbrand, L. A., & Carpenter, J. M. 2000, ApJ, 540, 236
Hirth, G. A., Mundt, R., & Solf, J. 1997, A&AS, 126, 437
Ho, P. T. P., Martin, R. N., & Barrett, A. H. 1978, ApJ, 221, L117
Høg, E., Kuzmin, A., Bastian, U., et al. 1998, A&A, 335, L65
Høg, E., Fabricius, C., Makarov, V. V., et al. 2000, A&A, 335, L27
Hubble, E. P. 1922, ApJ, 56, 162
Humpreys, R. M. 1978, ApJS, 38, 309
Jaffe, D. T., Zhou, S., Howe, J. E., et al. 1994, ApJ, 436, 203
Jarad, M. M., Hilditch, R. W., & Skillen, I. 1989, MNRAS, 238, 1085
Jarrett, T.-H., Chester, T., Cutri, R., et al. 2000, AJ, 120, 298
Jeffers, H. M., van den Bos, W. H., & Greeby, F. M. 1963, Index catalogue of visual double stars, 1961.0, Publications of the Lick Observatory, Mount Hamilton: University of California, Lick Observatory
Jeffries, R. D., Maxted, P. F. L., Oliveira, J. M., & Naylor, T. 2006, MNRAS, 371, L6
Johnson, H. L., & Morgan, W. W. 1953, ApJ, 117, 313
Joncas, G., & Borra, E. F. 1981, A&A, 94, 134
Jordan, F. C. 1914, Ph.D. Thesis, University of Chicago
Keeler, J. E. 1894, AstAp, 13, 476
Keenan, P. C., & Hynek, J. A. 1950, ApJ, 111, 1
Kholtygin, A. F., Burlakova, T. E., Fabrika, S. N., et al. 2006, ARep, 50, 887
Kirkpatrick, J. D., Reid, I. N., Liebert, J., et al. 1999, ApJ, 519, 802
Klemola, A. R., Jones, B. F., & Hanson, R. B. 1987, AJ, 94, 501
Koch, R. H., & Hrivnak, B. J. 1981, ApJ, 248, 249
Koen, C., & Eyer, L. 2002, MNRAS, 331, 45
Kogure, T., Yoshida, S., Wiramihardja, S. D., et al. PASJ, 41, 1195
Kraemer, K. E., Shipman, R. F., Price, S. D., et al. 2003, AJ, 126, 1423
Kramer, C., Stutzki, J., & Winnewisser, G. 1996, A&A, 307, 915
Kudryavtsev, D. O., Romanyuk, I. I., Elkin, V. G., & Paunzen, E. 2006, MNRAS, 372, 1804
Kukarkin, B. V., Kholopov, P. N., Artiukhina, N. M., et al. 1981, Catalogue of suspected variable stars. Moscow, 1951. Acad. of Sciences USSR
Lacy, J. H., Knacke, R., Geballe, T. R., & Tokunaga, A. T. 1994, ApJ, 428, L69
Lamers, H. J. G. L. M. 1972, A&A, 17, 34
Lamers, H. J. G. L. M. 1974, A&A, 37, 237
Lampens, P., & Rufener, F. 1990, A&AS, 83, 145
Larionov, M. G., Parijskij, Y. N., Zhuravlev, V. I., et al. 1994, A&AS, 106, 119
Lee, T. A. 1968, ApJ, 152, 913
Lindroos, K. P. 1985, A&AS, 60, 183
Luhman, K. L., Liebert, J., & Rieke, G. H. 1997, ApJ, 489, L165
Luhman, K. L., Rieke, G. H., Young, E. T., et al. 2000, ApJ, 540, 1016
Luyten, W. J. 1932, AN, 245, 211
Lyngå G. 1981, The Catalogue of Open Star Clusters, ADCBu, 1, 90
Lyngå G. 1987, PAICz, 69, 121
Mader, S. L., Zealey, W. J., Parker, Q. A., & Masheder, M. R. W. 1999, MNRAS, 310, 331
MacMinn, D., Phelps, R. L., Janes, K. A., & Friel, E. D. 1994, AJ, 107, 1807
Magakian, T. Y. 2003, A&A, 399, 141
Maheswar, G., Manoj, P., & Bhatt, H. C. 2003, A&A, 402, 963
Mannino, G., & Humblet, J. 1955, AnAp, 18, 237
Marchetti, E., Faraggiana, R. & Bonifacio, P. 2001, A&A, 370, 524
Marilli, E., Frasca, A., Covino, E., et al. 2007, A&A, 463, 1081
Markarjan, B. J. 1951, Biurakan Soob, 9, 6
Martín, E. L., Magazzù, A. & Rebolo, R. 1992, A&A, 257, 186
McAlister, H. A., & Hendry, E. M. 1982, ApJS, 49, 267
McConell, D. J. 1982, A&AS, 48, 355
McDowell, J. C. 1994, Einstein Observatory Unscreened IPC Data Archive, SAO HEAD CD-ROM Series I (Einstein), Nos. 18–36
McGehee, P. M. 2006, AJ, 131, 2959
Mermilliod, J. C. 1983, A&A, 128, 362
Miller Barr, J. 1904, AN, 24, 145
Miller, N. A., Cassinelli, J. P., Waldron, W. L., et al. 2002, ApJ, 577, 951
Molnar, M. R. 1972, ApJ, 175, 453

Monet, D., Canzian, B., Harris, H., et al. 1998, The PMM USNO-A1.0 Catalogue, VizieR On-line Data Catalog: I/243. Originally published in US Naval Observatory Flagstaff Station (1997)
Monet, D. G., Levine, S. E., Canzian, B., et al. 2003, AJ, 125, 984
Monnier Ragaigne, D., van Driel, W., Schneider, S. E., Jarrett, T. H., & Balkowski, C. 2003, A&A, 405, 99
Morgan, W. W., Keenan, P. C., & Kellman, E. 1943, An atlas of stellar spectra, with an outline of spectral classification, (Chicago (IL): The University of Chicago Press)
Morgan, W. W., Abt, H. A., & Tapscott, J. W. 1978, Revised MK Spectral Atlas for stars earlier than the Sun, Williams Bay: Yerkes Observatory, and Tucson: Kitt Peak National Observatory
Moran, E. C., Helfand, D. J., Becker, R. H., & White, R. L. 1996, ApJ, 461, 127
Morrell, N., & Levato, H. 1991, ApJS, 75, 965
Nakajima, T., Oppenheimer, B. R., Kulkarni, S. R., et al. 1995, Nature, 378, 463
Nakano, M., Yamauchi, S., Sugitani, K., Ogura, K., & Kogure, T. 1999, PASJ, 51, 1
Nesterov, V. V., Kuzmin, A. V., Ashimbaeva, N. T., et al. 1995, A&AS, 110, 367
Neubauer, F. J. 1936, Lick Observatory Bulletin, 17, 185
Neubauer, F. J. 1943, ApJ, 97, 300
Neuhäuser, R., & Comerón, F. 1998, Science, 282, 83
Nordström, B., Stefanik, R. P., Latham, D. W., & Andersen, J. 1997, A&AS, 126, 21
Nordström, B., Mayor, M., Andersen, J., et al. 2004, A&A, 418, 989
North, P. 1984, A&A, 141, 328
Ogura, K., & Sugitani, K. 1998, PASA, 15, 91
Ogura, K., Sugitani, K., & Pickles, A. 2002, AJ, 123, 2597
Oliveira, J. M., & van Loon, J. Th. 2004, A&A, 418, 663
Ochsenbein, F., Bauer, P., & Marcout, J. 2000, A&AS, 143, 221
Oudmaijer, R. D., van der Veen, W. E. C. J., Waters, L. B. F. M., et al. 1992, A&AS, 96, 625
Padovani, P., Allen, M. G., Rosati, P., & Walton, N. A. 2004, A&A, 424, 545
Palla, F., & Baraffe, I. 2005, A&A, 432, L57
Pallavicini, R., Pasquini, L. & Randich, S. 1992, A&A, 261, 245
Pannekoek, A. 1929, Publ. Astron. Inst. Amsterdam, 2, 63
Paturel, G., Fouquée, P., Bottinelli, L., & Gouguenheim, L. 1989, A&AS, 80, 299
Paunzen, E. 2001, A&A, 373, 633
Paunzen, E. & Gray, R. O. 1997, A&AS, 126, 407
Paunzen, E., Handler, G., Weiss, W. W., et al. 2002, A&A, 392, 515
Pedersen, H., & Thomsen, B. 1977, A&AS, 30, 11
Pérez-Garrido, A., Díaz-Sánchez, A., & Villo, I. 2005, AN, 326, 1028
Perryman, M. A. C., Lindegren, L., Kovalevsky, J., et al. 1997, A&A, 323, L49
Pismis, P., Haro, G., & Struve, O. 1950, ApJ, 111, 509
Prinja, R. K., Rivinius, Th., Stahl, O., et al. 2004, A&A, 418, 727
Rebolo, R., Zapatero Osorio, M. R. & Martín, E. L. 1995, Nature, 377, 129
Rebolo, R., Zapatero Osorio, M. R., Madruga, S., et al. 1998, Science, 282, 1309
Reipurth, Bo, & Clarke, C. 2001, AJ, 122, 432
Reipurth, Bo, Bally, J., Fesen, R. A., & Devine, D. 1998, Nature, 396, 343
Renson, P. 1988, A&AS, 76, 127
Renson, P. 1992, BICDS, 40, 97
Roman, N. G. 1955, ApJS, 2, 195
Rossiter, R. A. 1955, Catalogue of Southern Double Stars, Publications of the Observatory of the University of Michigan, Ann Arbor: University of Michigan
ROSAT Consortium (*) 2000, ROSAT News, 71 [VizieR On-line Data Catalog: IX/28A] (*: Max-Planck-Institut für extraterrestrische Physik, Goddard Space Flight Center, Smithsonian Astrophysical Observatory, Leicester University, Astrophysikalisches Institut Potsdam)
Rufener, F., & Bartholdi, P. 1982, A&AS, 48, 503
Ruiz, M. T., Leggett, S. K. & Allard, F. 1997, ApJ, 491, L107
Salim, S., & Gould, A. 2003, ApJ, 582, 1011
Sanduleak, N. 1971, PASP, 83, 95
Savage, B. D., Massa, D., Meade, M., & Wesselius, P. R. 1985, ApJS, 59, 397
Schaefer, B. E. 2005, J. History Astron., 36, 1667
Schild, R. E., & Chaffee, F. 1971, ApJ, 169, 529
Schild, R. E., & Cowley, A. P. 1971, A&A, 14, 66
Schmidt, E. G., & Carruthers, G. R. 1993, ApJS, 89, 259
Scholz, A., & Eislöffel, J. 2005, A&A, 429, 1007
Sharpless, S. 1952, ApJ, 116, 251
Sharpless, S. 1959, ApJS, 4, 257
Sharpless, S. 1962, ApJ, 136, 767
Sharpless, S. 1974, AJ, 79, 1073
Sherry, W. H. 2003, Ph.D. Thesis, State University New York at Stony Brook
Sherry, W. H., Walter, F. M., & Wolk, S. J. 2000, 197th AAS Meeting, #10.03; Bulletin of the AAS, 32, 1412
Sherry, W. H., Walter, F. M., & Wolk, S. J. 2004, AJ, 128, 2316
Skrutskie, M. F., Cutri, R. M., Stiening, R., et al. 2006, AJ, 131, 1163
Sloan, G. C., & Price, S. D. 1998, ApJS, 119, 141
Speck, A. K., Barlow, M. J., Sylvester, R. J., & Hofmeister, A. M. 2000, A&AS, 146, 437
Stebbins, J. 1915, ApJ, 42, 133
Stephenson, C. B. 1986, ApJ, 300, 779
Stephenson, C. B., & Sanduleak, N. 1977, ApJS, 33, 459
Struve, O., & Luyten, W. J. 1949, ApJ, 110, 160
Subramaniam, A., Gorti, U., Sagar, R., & Bhatt, H. C. 1995, A&A, 302, 86
Templeton, M. R., Mattei, J. A., & Willson, L. A. 2005, AJ, 130, 776
Terrell, D., Munari, U., & Siviero, A. 2007, MNRAS, 374, 530
Thé, P. S., de Winter, D., & Pérez, M. R. 1994, A&AS, 104, 315
Tsalmantza, P., Kontizas, E., Cambrésy, L., et al. 2006, A&A, 447, 89
Ueda, Y., Ishisaki, Y., Takahashi, T., Makishima, K., & Ohashi, T. 2001, ApJS, 133, 1
Vennes, S., Kawka, A., & Allyn Smith, J. 2007, ApJ, 668, L59
Vieira, S. L. A., Corradi, W. J. B., Alencar, S. H. P., et al. 2003, AJ, 126, 2971
Vivas, A. K., Zinn, R., Abad, C., et al. 2004, AJ, 127, 1158
Voges, W., Aschenbach, B., Boller, T., et al. 1999, A&A, 349, 389 [VizieR On-line Data Catalog: IX/10A]
Voges, W., Aschenbach, B., Boller, T. et al. 2000, IAU Circ., 7432, 3. ed D. W. E. Green [VizieR On-line Data Catalog: IX/29]
Waelkens, C., Aerts, C., Kestens, E., Grenon, M., & Eyer, L. 1998, A&A, 330, 215
Walborn, N. R. 1983, ApJ, 268, 195
Walter, F. M., Wolk, S. J., Freyberg, M., & Schmitt, J. H. M. M. 1997, MmSAI, 68, 1081
Warren, W. H., Jr., & Hesser, J. E. 1977, ApJS, 34, 115
Warren, W. H., Jr., & Hesser, J. E. 1978, ApJS, 36, 497
Weaver, W. B. & Jones, G. 1992, ApJS, 78, 239
Weintraub, D. A. 1990, ApJS, 74, 575
White, N. E., Giommi, P. & Angelini, L. 2000. Originally published in Laboratory for High Energy Astrophysics (LHEA/NASA), Greenbelt (2000) [VizieR On-line Data Catalog: IX/31]
Whitford, A. E. 1958, AJ, 63, 201
Whitworth, A., Bate, M. R., Nordlund, A., Reipurth, Bo, & Zinnecker, H. 2007, Protostars and Planets V, ed. B. Reipurth, D. Jewitt, & K. Keil (Tucson: University of Arizona Press), 459
Wilson, R. E. 1953, General Catalogue of Stellar Radial Velocities, Carnegie Inst. Washington DC Publ., 601 (XXBH)
Wiramihardja, S. D., Kogure, T., Yoshida, S., Ogura, K., & Nakano, M. 1989, PASJ, 41, 155
Wiramihardja, S. D., Kogure, T., Yoshida, S., et al. 1991, PASJ, 43, 27
Wolf, M. 1904, 165, 29
Wolk, S. J. 1996, Ph.D. Thesis, State University New York at Stony Brook
Woolf, V. M., & Lambert, D. L. 1999, ApJ, 520, L55
Wouterloot, J. G. A., & Walmsley, C. M. 1986, A&A, 168, 237
Wouterloot, J. G. A., Walmsley, C. M., & Henkel, C. 1988, A&A, 203, 367
Wouterloot, J. G. A., Walmsley, C. M., & Henkel, C. 1989, A&A, 215, 131
XMM-Newton Survey Science Centre Consortium 2007. XMM-SSC, Leicester, UK [VizieR On-line Data Catalog: IX/39]
Yudin, R. V., & Evans, A. 1998, A&AS, 131, 401
Yun, J. L., & Clemens, D. P. 1994, AJ, 108, 612
Yun, J. L., Moreia, M. C., Alves, J. F., & Storm, J. 1997, A&A, 320, 167
Zapatero Osorio, M. R., Béjar, V. J. S., Martín, E. L., et al. 2000, Science, 290, 103
de Zeeuw, P. T., Hoogerwerf, R., de Bruijne, J. H. J., Brown, A. G. A., & Blaauw, A. 1999, AJ, 117, 354