Multiplicity of early-type stars in the field: progress report

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1 Introduction

The multiplicity of early-type stars is still not well established. Several works have tried to derive the binary fraction of early-type stars in young clusters and OB associations (e.g. Preibisch et al. 2000, Shatsky & Tokovinin 2002, Kouwenhoven et al. 2005). The main result from these studies is that the multiplicity of early-type stars is different for individual star forming regions, i.e., it seems to depend on the star forming environment. However, the statistical basis is still not solid enough to understand the environmental effects on the binary fraction, mass ratio and separations of multiple systems with early-type primaries.

The age of stellar systems can also affect their multiplicity: older systems are expected to have undergone more dynamical interactions than younger ones resulting in a smaller binary fraction. Again, this has not been statistically confirmed with the study of large enough samples. Moreover, the multiplicity of early-type stars in the field has never been determined. To fill in this gap, we have started a project to derive the multiplicity of a volume-limited sample of early-type field stars. The idea is to look for companions through a common proper motion search.

This is an on-going project. In this paper we present preliminary results from the first epoch observations.

2 Sample selection

The sample under study contains early-type (B- and A-type) field stars which have been selected according to the following criteria:

- Stars from the HIPPARCOS Catalogue with DEC ≤ 0 and any RA.
- The apparent color $B - V \leq 0.2$ mag. This is a conservative criterion met by all unreddened BA-type stars as well as a small number of contaminating later-type stars. To exclude the later-type stars, we have cross-correlated this preliminary sample with the SIMBAD database, and retained only stars classified as BA dwarfs.

– The apparent V-magnitudes range between V=5-6, so they are suitable reference stars for the adaptive optics system at the Very Large Telescope (VLT), even under poor atmospheric conditions.

– The stars are within 300 pc from the Sun. The limit was chosen to ensure that we probe the local volume. The distances to individual stars were taken from the HIPPARCOS catalog.

– The sample contains only field stars. In order to discriminate between the field and clusters stars, we excluded from our list all members of OB-associations listed by de Zeeuw et al. (1999) and sources that belong to nearby associations (d<100 pc) like TW Hydrae.

– All stars in the sample show proper motions larger than 27 mas/yr. In this way, we will be able to confirm or reject any companion candidate as physical or background object, taking second-epoch data one or two years after the first-epoch observations.
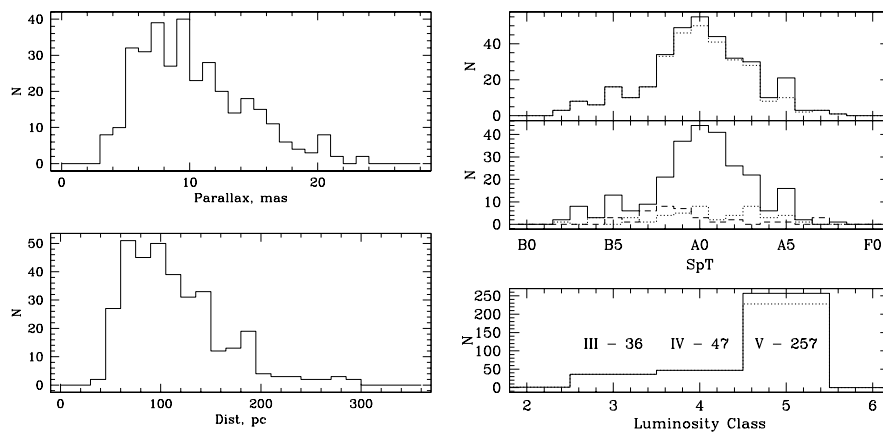

Fig. 1. Main properties of the sample of early-type field stars. The distributions of parallax, distance, spectral type and luminosity class are displayed. The spectral type distribution is plotted (i) for the whole sample and (ii) for different luminosity classes: MS stars (solid line), subgiants (dotted line) and giants (dashed line).

The final sample contains 307 early-type stars in the field. The main properties are summarized in Figure 1.

3 Observations

The observations are performed with NAOS-CONICA (NACO), the adaptive optics facility at the VLT. All the targets are observed with the S27 objective,

which provides a total field of view of $27''\text{x}27''$ (plate scale of 27 mas/pix). The observations are taken in the K-band and, depending on the brightness of the target, we use two different setups: the brightest objects are observed with a broad-band (K_s) plus a neutral density (ND) filter, while the faintest ones are observed with an intermediate-band filter (IB 2.18). The total exposure time on-source is ~ 5 minutes. Some of the obtained NACO images are displayed in Figure 2.

The predicted detection limit for a companion to an early-type star with $K = 6\,\text{mag}$ and $d = 200\,\text{pc}$ is displayed in Figure 3. The figure shows the K-band magnitude difference between the primary and a companion versus their separation in arcseconds. In this example, the $5\,\sigma$ detection limit refers to a five minutes exposure with the $K_s + ND$ filters.
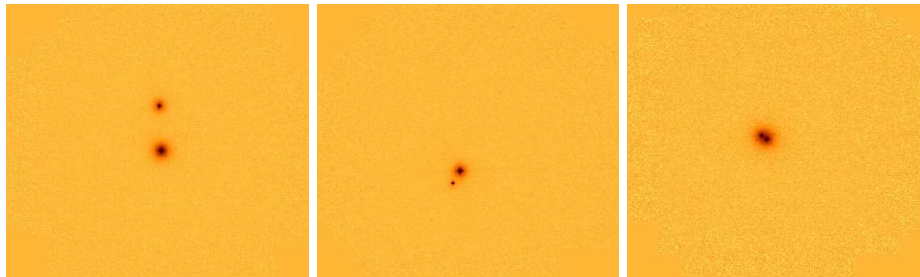
Fig. 2. NACO images of early-type field stars with companion candidates. The images have been taken in the K-band with the S27 objective (plate scale of $0.027''/\text{pix}$) which provides a field-of-view of $27'' \text{ x } 27''$.

Table 1. Preliminary results from the analyzed data

	Number of sources	Fraction (%)
Total	307	100
Observed	180	59
Analyzed	143	46
Single[1]	75	52
Binary and Multiple Candidates[1]	68	48

Note: [1] Derived from the 143 analyzed sources

4 Current status

–   We have already obtained first epoch observations of 180 (out of 307) targets. The data of 143 sources have been already processed: 75 are single
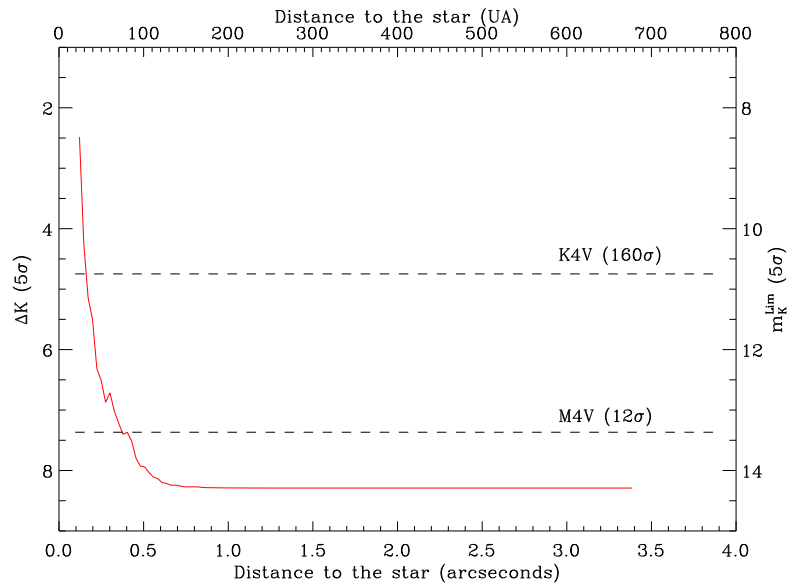
Fig. 3. Detection limit calculation for a five minutes exposure with the $K_S +$ ND filters. The primary is a $K = 6$ mag B-type star at a distance of 200 pc. The difference in magnitudes (K-band) between the early-type star and a companion is plotted versus their separation in arcseconds. Two horizontal lines indicate the magnitude difference between the primary and two companions of spectral type K4 and M4. They would be detected at a 5σ level at separations of $0.2''$ and $0.4''$, respectively.

and 68 are candidates for double or multiple systems. These preliminary results are summarized in Table 1.

– First epoch observations of the remaining targets (127) are scheduled for the upcoming semester (October 2005 - March 2006).

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