Common Proper Motion Search for Faint Companions Around Early-Type Field Stars - Progress Report - II.

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RÉSUMÉ. La multiplicité des étoiles précoces n’est aujourd’hui toujours pas bien établie. Les études de régions de formation stellaire individuelles suggèrent une relation avec l’âge et l’environnement. Afin de répondre à ces questions, nous avons engagé le premier relevé détaillé d’imagerie assistée par optique adaptative sur 308 étoiles du champ de type BA, dans un rayon de 300 parsecs autour du Soleil, afin de déterminer leur multiplicité d’une manière homogène. La première époque d’observations a fourni 195 candidats companions autour de 117 étoiles cibles. La deuxième époque d’observations est en cours.

ABSTRACT. The multiplicity of early-type stars is still not well established. The studies of individual star forming regions suggest a connection with the age and the environment. To fill in this gap, we started the first detailed adaptive-optic-assisted imaging survey of 308 BA-type field stars within 300 pc from the Sun, to derive their multiplicity in a homogeneous way. Our first epoch observations yielded 195 companion candidates around 117 sample targets. The second epoch observations are underway.

MOTS-CLÉS : étoiles : binaires : général, étoiles : binaires : binaires visuelles, étoiles : étoiles précoces

L’objet. Volume 8 – n2/2005, pages 1 à 15
KEYWORDS: stars:binaries:general, stars:binaries:visual, stars:early-type
1. Introduction

The binarity fraction (BF) of early type stars is poorly known because traditional spectroscopic searches are undermined by their wide spectral lines. Furthermore, there is evidence that the BF depends on the stellar density. However, the cluster multiplicity studies carried out so far can cover only a limited range of density and age. This prompted us to estimate the binarity fraction of a representative, volume-limited sample of early-type field stars.

We designed a survey able to detect at \( \sim 10\sigma \) level an M4-type companion at the mean distance of our sample (\( \sim 200 \) pc) down to 0.4 arcsec separation from 100 Myr old A-type primary. The companions around B-type stars will be younger (\( \sim 10 \) Myr), brighter, and easier to detect. Most importantly, the physical nature of the candidate companions is verified by their common proper motion. Our goal is to compare the properties such as BF and mass ratio of the multiple stars in the field and in different star-forming regions. The target accuracy for the BF is 3-5%.

2. Sample Selection

The sample stars were selected according to the following criteria:

- spectral types - only BA; most of the stars are B8-A0 because bluer stars are rare and too bright, while redder stars become too faint to make it into the sample
- field stars only - the known OB-association members listed in de Zeeuw et al. (1999) were excluded from the sample
- distance \( \leq 300 \) pc from the Sun as measured by HIPPARCOS; at the maximum distance the telescope's diffraction limit of 0.07 arcsec corresponds to \( \sim 21 \) A.U. (for comparison Shatsky & Tokovinin 2002 probed separations of 45-900 A.U.)
- proper motions \( >27 \) mas yr\(^{-1}\) allowing us to confirm physical companion candidates taking observations at two epoch separated by 1-2 yr
- apparent \( V=5-6 \) mag, so the targets are suitable NACO reference sources even under poor weather, and at the same time they do not saturate the detector
- Dec\( \geq +15 \) deg, i.e. the targets are visible from the VLT

The final sample consists of 308 stars (136 of them are known binaries from the Washington catalog), the average distance is 114 pc and the median distance is 104 pc.

3. Observations

The observations were carried out with NAOS–CONICA (Nasmyth Adaptive Optics System – Near-Infrared Imager and Spectrograph) at the ESO VLT over the last two years. The pixel scale was 27.03 mas px\(^{-1}\), giving \( 27.7 \times 27.7 \) arcsec field of view.
Each target was observed at 9 different positions on the detector, collecting a total of \( \sim 7.5 \) min of integration in \( K_S \) or in the intermediate band filter IB_2.18.

The data reduction includes sky subtraction, flat-fielding, aligning, and combination of the images into a single frame.

4. Current Status

As of March 2006 we have observed 257 objects from our sample. We carried out a visual inspection of the combined frames (with and without PSF subtraction of the target stars), and we found 195 companion candidates around 117 sample targets. The second epoch observations with \( \geq 2 \) yr baseline of the first 16 targets started during ESO Period 77.

5. Analysis: Modeling the Survey

To estimate the sensitivity and the completeness of the survey we have created a Monte-Carlo simulation that takes into account all available information for the survey stars. The model input parameters are:

- the known distances, spectral types and absolute luminosities for all primaries
- adopted binarity fraction of 30%
- secondary star mass - randomly sampled from the Kroupa IMF; preferences in the mass ratio of the two components will be included in the future
- secondary star’s spectral type and absolute magnitude - calculated from the mass
- orbital periods - randomly generated from the Duquennoy & Mayor (1991) distribution
- major axis - calculated from the Kepler’s law and the period
- random ellipticity and random orbital inclination
- visibility criterion based on the magnitude difference and the angular separation between the primary and the companion - based on the available observations

The model predicts: the distributions of periods, angular separations, magnitude differences and spectral types for the detected binaries. The simulations indicate that we will detect \( \sim 2/3 \) of the physical companions.

Remerciements

We are grateful to our colleagues from the ESO-Paranal Science Operations Department who carried out these observations in Service Mode.
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   L’objet. Volume 8 – n2/2005

2. AUTEURS :
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   C. Foellmi* — M. Hartung* — N. Huelamo** — C. Melo* —
   M. Sterzik* — X. Haubois***

3. TITRE DE L’ARTICLE :
   Common Proper Motion Search for
   Faint Companions Around Early-Type
   Field Stars - Progress Report - II.

4. TITRE ABRÉGÉ POUR LE HAUT DE PAGE MOINS DE 40 SIGNES :
   Mode d’emploi de article-hermes.cls

5. DATE DE CETTE VERSION :
   20 mars 2022

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