

# 8.1 An Aladin-Based Search for Proper-Motion Companions to Young Stars in the Local Association, Tucana-Horologium and $\beta$ Pictoris

Francisco Javier Alonso-Floriano<sup>1</sup>, J. A. Caballero<sup>2</sup>, and D. Montes<sup>1</sup>

<sup>1</sup> Departamento de Astrofísica y Ciencias de la Atmósfera, Facultad de Física, Universidad Complutense de Madrid, E-28040 Madrid, Spain

<sup>2</sup> Centro de Astrobiología (CSIC-INTA), PO Box 78, E-28691 Villanueva de la Cañada, Madrid, Spain

## Abstract

We have used the Aladin sky atlas of the Virtual Observatory to look for new common proper-motion pairs in three young stellar kinematic groups: Local Association ( $\tau \sim 10 - 120$  Myr), Tucana-Horologium ( $\tau \sim 30$  Myr) and  $\beta$  Pictoris ( $\tau \sim 12$  Myr). We have found 9 new and 14 known common proper-motion companions to the 210 investigated stars. With the CAFOS instrument at the 2.2 m Calar Alto telescope, we have investigated in detail one of the new pairs, the HD 143809 AB system, which is formed by a bright G0V primary star and a previously unknown young M1.0–1.5Ve star.

## Introduction

Young nearby late-type stars are excellent targets for high-contrast imaging surveys for brown dwarf and planetary companions. Many of these young low-mass stars in the solar neighbourhood belong to stellar kinematics groups with ages younger than the Pleiades, such as the Local Association and its kinematic subgroups (Montes et al. [2001b]; Song et al. [2003]; Zuckerman & Song [2004]). One way of identifying such stars is searching for faint proper-motion companions at wide separations to already-known members in young stellar kinematic groups.

We followed the procedure described by Caballero et al. [2010a] and used a powerful Virtual Observatory tool, the Aladin sky atlas (Bonnarel et al. [2000]), to look for proper-motion companions to stars in the Local Association (LA,  $\tau \sim 10 - 120$  Myr), Tucana-Horologium (Tuc-Hor,  $\tau \sim 30$  Myr) and  $\beta$  Pictoris ( $\beta$  Pic,  $\tau \sim 12$  Myr) stellar kinematic groups.

## Analysis

We searched for either primary (i.e., brighter) and secondary (i.e., fainter) companions to 210 nearby young stars in the three different moving groups compiled by Montes et al. [2001b] and Torres et al. [2008]: 116 in LA, 44 in Tuc-Hor, and 50 in  $\beta$  Pic. We used the interactive software Aladin v5 to load 2MASS (Skrutskie et al. [2006]) and USNO-B1 (Monet et al. [2003]) astro-photometric catalogues and cross-matched them in a circular area of radius 30 arcmin centred on each target. Next, we constructed a proper-motion diagram with the Aladin application VOPlot and searched for sources with USNO-B1 proper motions different from those of the target stars by less than 10 mas/yr.

For each proper-motion candidate, we searched the literature for previous claims of membership in multiple systems (e.g., the Washington Double Star catalogue; Mason et al. [2001]) and for better proper-motion determinations (e.g., Tycho-2; Høg et al. [2000]). We derived photometric distances for both primaries and secondaries, based on available spectroscopy or photometry, of the candidate pairs without parallactic distance measurements and discarded those with no coincident values.

## Results

Of the 210 investigated stars, we identified 23 multiple system candidates, of which 14 were known common proper-motion companions and 9 were unknown multiple systems (see Table 8.1 and Fig. 8.1).

Table 8.1: The nine unknown proper-motion pairs (SKG indicates the stellar kinematic group).

Name	Sp. type	$\rho$ [arcsec]	$\theta$ [deg]	$s$ [kAU]	SKG
HD 82939	G5V	$162.28 \pm 0.17$	$121.49 \pm 0.07$	$6.3 \pm 0.2$	LA
GJ 9303	K7V				
EX Cet	G5V	$612.10 \pm 0.11$	$258.66 \pm 0.02$	$14.7 \pm 0.3$	LA
G 271–110	M3.5V				
HD 143809 A	G0V	$86.40 \pm 0.11$	$252.57 \pm 0.09$	$7.1 \pm 0.9$	LA
HD 143809 B	M1.0–1.5V				
HD 13183	G7V	$705.99 \pm 0.10$	$103.761 \pm 0.009$	$36.0 \pm 1.2$	Tuc-Hor
CD–53 413	G5V				
CD–53 544	K6Ve	$22.06 \pm 0.08$	$11.11 \pm 0.17$	$0.93 \pm 0.09$	Tuc-Hor
AF Hor	M2Ve				
HD 207964 AB	F1III+...	$1412.75 \pm 0.11$	$245.020 \pm 0.005$	$64.0 \pm 1.9$	Tuc-Hor
HD 207575	F6V				
HD 173167	F5V	$550.31 \pm 0.10$	$290.244 \pm 0.011$	$29 \pm 3$	$\beta$ Pic
TYC 9073–0762–1	M1Ve				
$\eta$ Tel AB	A0Vn+M7.5V	$416.26 \pm 0.13$	$170.691 \pm 0.012$	$20.1 \pm 0.2$	$\beta$ Pic
HD 181327	F6V				
HD 199143 AB	F7V+...	$325.04 \pm 0.08$	$138.35 \pm 0.02$	$14.8 \pm 0.5$	$\beta$ Pic
AZ Cap	K6Ve				

One of nine of them was a suspected multiple system ( $\eta$  Tel AB and HD 181327; Schneider et al. [2006]). At the measured or derived distances, the angular separations of 0.37 to 24 arcmin translate into projected physical separations between 0.0045 and 0.31 pc. Interestingly, some of the proper-motion companions had already been tabulated as members in the same stellar kinematic group as their target stars (e.g., HD 207964 AB and HD 207575 in Tucana-Horologium).

One of the new multiple systems was formed by a young solar analogue and an anonymous high proper-motion red dwarf never described in the literature before, and was subject of a dedicated astrometric, photometric and spectroscopic follow-up study. First, we confirmed the common proper motion of the “HD 143809 AB” system using 11 astrometric epochs separated by over 56 years as in Caballero et al. [2010b]. Next, we collected  $B$ ,  $V$ ,  $R$  and  $I$  images and low-resolution spectra (grating G100) with the CAFOS instrument at the 2.2 m Calar Alto telescope. While the primary is a known G0V star with a high lithium abundance ( $EW(\text{Li I}) = 103 \text{ m\AA}$ ; López-Santiago et al. [2010]), an estimated age of  $\tau \sim 80 - 120 \text{ Myr}$  and kinematics consistent with membership in the Local Association Montes et al. [2001a], the new companion at  $s = 7.1 \pm 0.9 \text{ kAU}$  is an M1.0–1.5Ve star with chromospheric  $H\alpha$ ,  $H\beta$  and  $H\gamma$  emission. The heliocentric distance derived from its spectral type and photometry matches the one of the primary measured by *Hipparcos* at  $d = 78 \pm 8 \text{ pc}$ . Using this distance, its  $J$ -band apparent magnitude ( $J = 10.35 \pm 0.03 \text{ mag}$ ) and the NextGen models (Baraffe et al. [1998]) for an age of 100 Myr, HD 143809 B has a most probable mass of  $0.57 - 0.60 M_{\odot}$ .

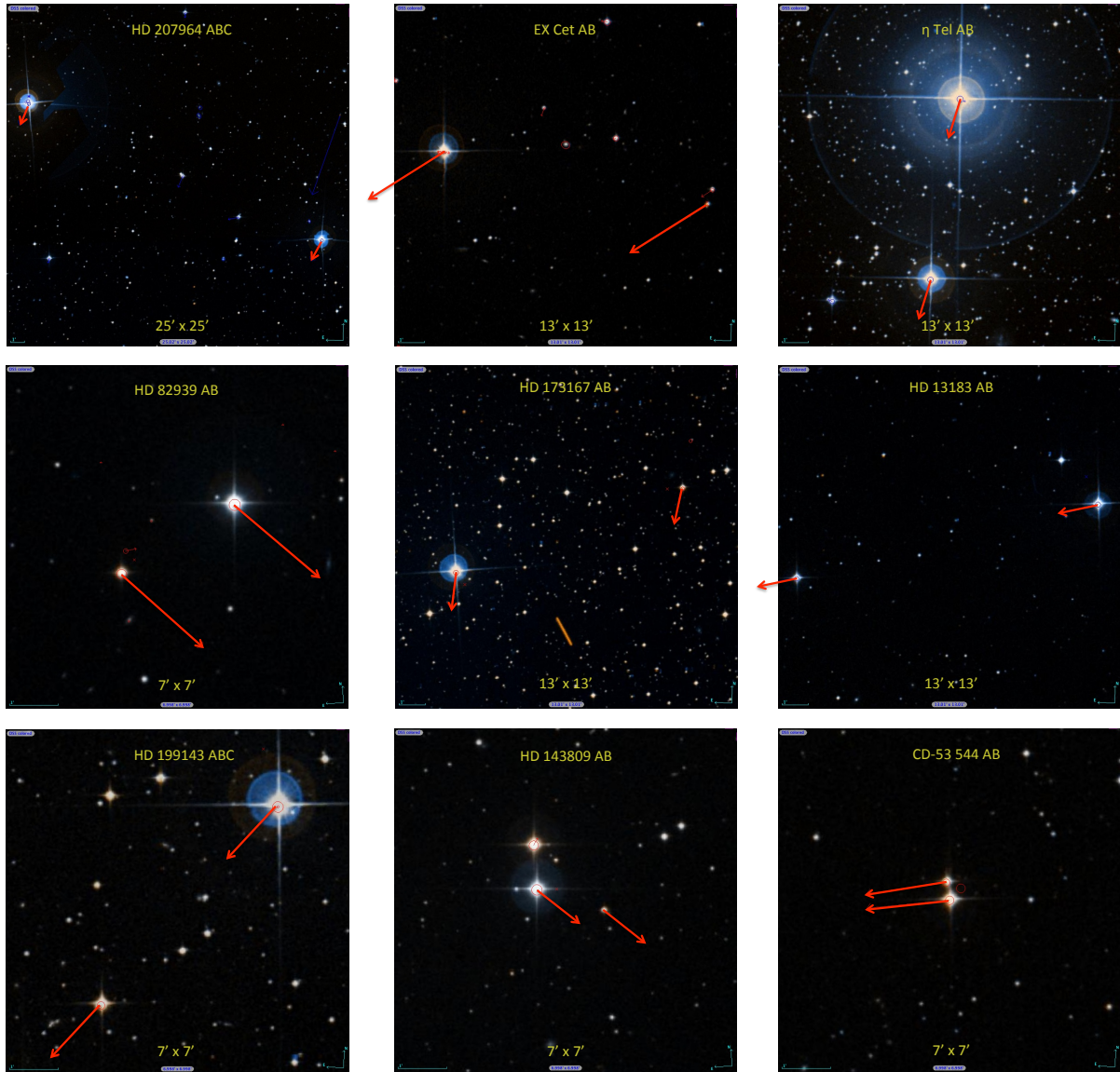


Figure 8.1: False-colour images combining DSS POSSII  $B_J$ ,  $R_F$  and  $I_N$  photographic plates of the nine new pairs. Labelled are the multiple system names and field-of-view sizes. North is up and east is to the left. The red arrows show the proper motion.

## Acknowledgments

We thank J. Genebriera for providing us unpublished images of the HD 143809 AB system. This research has made use of Aladin. This work is supported by the Universidad Complutense de Madrid, the Spanish Ministerio de Ciencia e Innovación (MICINN) under grant AYA2008-0695, and the Comunidad de Madrid under PRICIT project S2009/ESP-1496 (AstroMadrid).

## Bibliography

- Baraffe, I., Chabrier, G., Allard, F., & Hauschildt, P. H. 1998, *A&A*, 337, 403  
 Bonnarel, F., Fernique, P., Bienaymé, O., et al. 2000, *A&A*, 143, 33  
 Caballero, J. A., Miret, F. X., Genebriera, J., et al. 2010a, in *Highlights of Spanish Astrophysics V*, ed. J. M. Diego, L. J. Goicoechea, J. I. González-Serrano, & J. Gorgas, 379  
 Caballero, J. A., Montes, D., Klutsch, A., et al. 2010b, *A&A*, 520, A91  
 Høg, E., Fabricius, C., Makarov, V. V., et al. 2000, *A&A*, 355, L27  
 López-Santiago, J., Montes, D., Gálvez-Ortiz, M. C., et al. 2010, *A&A*, 514, A97

- Mason, B. D., Wycoff, G. L., Hartkopf, W. I., Douglass, G. G., & Worley, C. E. 2001, *AJ*, 122, 3466  
Monet, D. G., Levine, S. E., Canzian, B., et al. 2003, *AJ*, 125, 984  
Montes, D., López-Santiago, J., Fernández-Figueroa, M. J., & Gálvez, M. C. 2001a, *A&A*, 379, 976  
Montes, D., Lopez-Santiago, J., Galvez, M. C., et al. 2001b, *MNRAS*, 322, 45  
Schneider, G., Silverstone, M. D., Hines, D. C., et al. 2006, *ApJ*, 650, 414  
Skrutskie, M. F., Cutri, R. M., Stiening, R., et al. 2006, *AJ*, 131, 1163  
Song, I., Zuckerman, B., & Bessell, M. S. 2003, *ApJ*, 599, 342  
Torres, C. A. O., Quast, G. R., Melo, C. H. F., & Sterzik, M. F. 2008, *Handbook of Star Forming Regions*,  
Volume II: The Southern Sky, ASP Monograph Publications, Vol. 5, ed. Reipurth, B., 757  
Zuckerman, B. & Song, I. 2004, *ARA&A*, 42, 685