A Giant Step: from Milli- to Micro-arcsecond Astrometry
Proceedings IAU Symposium No. 248, 2007
W. J. Jin, I. Platais & M. A. C. Perryman, eds.

doi:10.1017/S1743921308018851

Finding orbital motion of sub-stellar companions - the case of TWA 5B

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Abstract. TWA 5B is a brown dwarf companion of H= 12 mag, 2" off the ∼5 mag brighter triple star CoD-33° 7795 (=TWA 5), a member of the TW Hydrae association of T Tauri stars at ∼55 pc. This object is the first brown dwarf around a pre-main-sequence star (confirmed by common proper motion) ever found. In the last year we have newly reduced VLT NaCo data originally taken in 2003 and combined it with all the available astrometric data of the system to investigate possibly detectable orbital motion of the system. Indeed we were able to find linear orbital motion of the system combining data from HST, VLT and Gemini-North.

Keywords. stars: low-mass, brown dwarfs, stars: pre-main-sequence, stars: imaging, binaries: close, stars: individual (TWA 5A, TWA 5B)

1. Introduction

In 1999, at the time when only two brown dwarfs were confirmed to be companions to normal stars by both spectroscopy and proper motion [Gl 229B (Nakajima *et al.* 1995), G 196-3 B (Rebolo et al. 1998)], Lowrance *et al.* (1999) (here L99) and Webb *et al.* (1999) (W99) suggested independently a sub-stellar companion of TWA 5 in the ∼ 8–10 Myr young TW Hydrae association (Fig. 1). The companion TWA 5B is ∼5 mag fainter than the primary star in the infrared, and its IHJK colors are consistent with spectral type M8 to M8.5 (L99, W99). Weintraub *et al.* (2000) presented additional HST NICMOS narrow-band filter photometry, also consistent with a young late M-type brown dwarf. Neuhäuser *et al.* (2000) presented for the first time infrared spectra and proper motion of the H=12 mag object 2" off the brighter spectroscopic binary star TWA 5 finding the object to be co-moving with TWA 5A from observations with FORS and ISAAC and hence to be the 4th brown dwarf companion around a normal star confirmed by spectrum and proper motion. They derived the mass of TWA 5B to be between ∼15 and 40 M_{Jup} assuming a distance of 55 ± 16 pc estimated from the observation of four other members of the TW Hydrae association by Hipparcos and taking into account the age of TWA. After TWA 5A was resolved as binary (Macintosh *et al.* 2001) with ∼ 55 mas separation, recently Torres *et al.* (2003) and Mohanty *et al.* (2003) reported that TWA 5A is a triple, with one of the resolved stars being a spectroscopic binary. Here, we present first evidence for orbital motion of the young brown dwarf companion TWA 5B.

2. Methods and instruments

We gathered all the available archival observation results from Lowrance *et al.* (1999), Weintraub *et al.* (2000), Lowrance *et al.* (2001), Macintosh *et al.* (2001), Neuhäuser *et al.* (2000), Brandeker *et al.* (2003) and Neuhäuser *et al.* (2001). From these publications we took separation and position angle (measured from north over east to south) data and

combined it with a new data point from data taken at VLT-UT4 with NaCo by Masciadri *et al.* (2005) and rereduced by us to look for first indications of orbital motion of the brown dwarf TWA 5B around its primary.

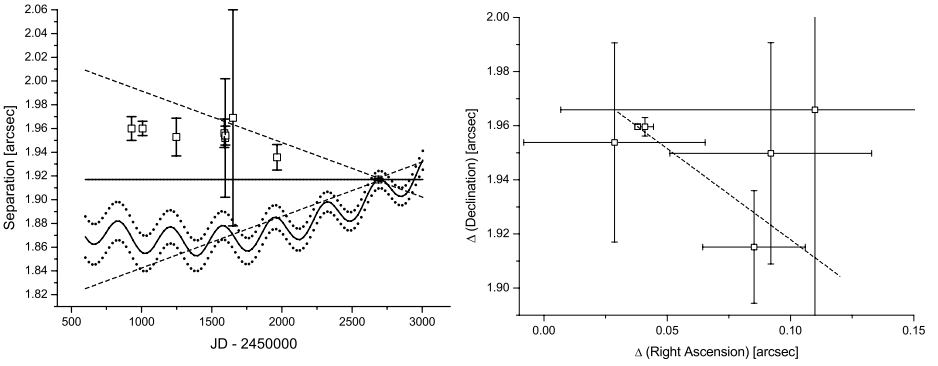

Figure 1. Left: Separations from the literature and our reduction of the 2003 data. The constant straight line indicates the case of bound motion (common proper motion). The wavy continuous line is the change expected if the sub-stellar B component is a non-moving background star. The opening cone enclosed by the dotted lines are its estimated errors. The waves of this cone show the differential parallactic motion which has to be taken into account if one of the components is a non-moving background star. The opening short dashed cone indicates the amplitude of possible orbital motion in the case of circular edge-on orbit. Right: Position of TWA 5B relative to TWA 5A.

3. Conclusions

From separation measurements the background hypothesis can be rejected by $6\,\sigma$ and from position angle by $25\,\sigma$. The deviations from the co-moving case of constant separation and position angle give more than $7\,\sigma$ & $10\,\sigma$ significance respectively for the presence of orbital motion. A linear fit to the nine separation measurements found give a reduced χ^2 of 0.2833 for a declining separation of 9.71 mas/yr corresponding to a probability of 96.1 %. In the near future curvature may be observable in the orbital motion of TWA 5B as final proof of companionship.

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https://doi.org/10.1017/S1743921308018851 Published online by Cambridge University Press