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VLTI/AMBER detection of a K=9.5 very low mass star*

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Abstract. The precise determination of both the dynamical mass and infrared photometry of the close companion to AB Dor A, AB Dor C (0.090 $M_{\odot}$), has provided an important benchmark for calibration of theoretical evolutionary models of low-mass young stars. However, comparison of the observed magnitudes of AB Dor C with these models suggests that they could overpredict the flux of this object, a trend also found in other young systems. One of the ambiguities remaining in AB Dor C is the possible binary nature of this star; in fact, should AB Dor C be close binary (∼10 mas separation), it could reconcile observations and models. We will report on VLTI/AMBER observations of AB Dor C addressed to discriminate between both scenarios: AB Dor C as a single object or a binary brown dwarf. We used a non-standard "off-axis" fringe tracking that allowed the detection of AB Dor C. This is, to our knowledge, one of the weakest object detected by an infrared interferometer (K_s = 9.5).

Key words. stars: low-mass stars – techniques: interferometry – stars: individual: AB Doradus C

1. Introduction

Studies of fundamental parameters of very low-mass objects are relevant since they provide tests of stellar evolution models that are used to derive the theoretical masses of brown dwarfs and planets. Only a handful of stellar systems, those with dynamically-determined masses, can effectively evaluate the predictions of the models. One of these systems is the pair AB Dor A (K_s = 4.686) and the low-mass companion AB Dor C (K_s = 9.5; Close et al. 2005, 2007). Independent measurements of the infrared photometry and the dynamical mass of AB Dor C make this object appropriate to calibrate mass-luminosity relations. Actually, comparison of observed magnitudes with theoretical mass-luminosity relationships (DUSTY models; Chabrier et al. 2000) suggests that the models tend to underpredict the mass of AB Dor C, or equivalently, overpredict the flux of the object, specially at J and H bands (Close et al. 2007). A similar trend has been found in other young binary systems (Reiners et al. 2005). Given the need for an accurate calibration of the models, any possible ambiguity or

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uncertainty affecting these few calibrating objects should be studied in detail.

Regarding AB Dor C, most of the difficulty to validate model predictions comes from the uncertainty in the age, and the confirmation that this star is, or not, a binary object. Regarding the former, the age is still a matter of discussion, with different estimates ranging from 75±25 Myr (Nielsen et al. 2005; Janson et al. 2007; Boccaletti et al. 2006) to 120±20 Myr (Luhman et al. 2005; Ortega et al. 2007). In this sense, our recent VLTI/AMBER observations of AB Dor A, addressed to measure its radius, favour the younger side of the age range considered for this system (40-50 Myr; Guirado et al. 2011). Regarding the latter, Marois et al. (2005) pointed out that if we consider itself AB Dor C a binary brown dwarf, the overluminosity shown by the models could be easily corrected assuming reasonable mass ratios. In essence, the JHK magnitudes would agree overall statistically better to the isomasses corresponding the the binary hypothesis; even more, the permanent disagreement in J and H filters (Close et al. 2007) would be removed. Indeed, the possible binary nature of AB Dor C is an important concern for an object acting as calibrator of young low mass objects that needs to be addressed.

2. Observations and results

Nielsen et al. (2005) predicted that a binary brown dwarf in AB Dor C would only be stable with a maximum apoastron of 0.138 AU, that is, ~10 mas at 14.9 pc; the perturbations induced by the proximity of AB Dor A (0.86 $M_{\odot}$) would make unstable binary configurations with a larger apoastron. This separation, ~10 mas, is ideal for the capabilities and resolution of VLTI/AMBER with the adequate configuration.

With this in mind, we observed AB Dor C with the VLTI using the AMBER instrument at low spectral resolution mode in the J, H, and K bands. The observation were performed on 27 December 2012, using the telescopes UT1, UT3, and UT4. The magnitude of AB Dor C is outside the limiting magnitudes for VLTI/AMBER (K_s = 7.5). Therefore we had to use a non-standard configuration that basically consisted on using AB Dor A as a fringe tracker to increase the integration time on AB Dor C. To achieve this, first we set AMBER in low-resolution mode with a DIT of 0.1 s; second, we found and locked the fringes of AB Dor A in the fringe tracker FINITO; and third, we offset AMBER (through tip/tilt correction) to find the fringes of AB Dor C. This "off-axis" fringe tracking allowed a exposure time on AB Dor C longer than that imposed by the atmospheric piston. Fringes are seen in every single frame, which can be properly averaged to obtain the visibility data. This is, to our knowledge, one of the weakest object detected by an infrared interferometer (K_s = 9.5). Admittedly, our observations did benefit from *(i)* a precise knowledge of the orbit of AB Dor C (Guirado et al. 2006), which allowed us to predict with milliarcsecond precision the relative position AB Dor A/C, and *(ii)* an optimum observing epoch, December 2012, with AB Dor C near apoastron, thus minimizing the possible contamination from the brighter star AB Dor A. In addition, we had extremely good atmospheric conditions (seeing of 0.″5).

A full analysis of the data will be published elsewhere. Should AB Dor C be a single star, we would rule out an important uncertainty which would make AB Dor C a much better calibrator for young, low-mass objects. Should AB Dor C be a binary brown dwarf, we would have two new, well-defined points to validate theoretical models. Our result shows the extraordinary performance of AMBER/VLTI and opens the possibility of studies of other binary brown dwarf systems with milliarcsecond resolution.

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