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/S1743921308019923

Precise measurement of the dynamical masses in AB Doradus

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Abstract. The radio stars ABDor A and ABDor B (=Rst137B) are the main components of the AB Doradus system. Both stars are double (ABDor A/ABDor C and ABDor Ba/ABDor Bb) and usual targets of astrometric instruments at optical (Hipparcos), infrared (VLT), and radio (VLBI) wavelengths. From a combination of all astrometric data available, we have obtained precise limits to the dynamical mass of both binaries in AB Doradus. The determination of the mass of ABDor C ($0.090{\pm}0.003\,M_{\odot}$) is important, since this object constitutes one of the few calibration points used to test theoretical evolutionary models of low-mass young stars. Follow-up observations both in radio (VLBI) and optical wavelengths (VLT) should determine with high precision the dynamical mass of the four components of this system.

Keywords. astrometry, binaries: close, stars: individual (AB Doradus)

1. Introduction

Precise astrometry of the orbital motion of stars in binary systems provides precise, model-independent estimates of the masses of the individual components. The case of the PMS star AB Doradus is of particular interest. Hipparcos/VLBI astrometry of the main star ABDor A (Guirado *et al.* 1997) revealed the presence of a low-mass companion, ABDor C, which was later imaged by VLT infrared observations (Close *et al.* 2005). ABDor A has also a wide separation companion 9″ away, ABDor B, which is actually a close binary (ABDor Ba/ABDor Bb, at 0.070″ separation; Close *et al.* 2005; Janson *et al.* 2007). The combination of all astrometric observations of AB Doradus (Hipparcos, VLBI and VLT) provides precise limits to the dynamical masses of the components of this system. In this contribution, we report the status of astrometry for different pairs in AB Doradus and the plans to further constrain the dynamical mass of its four stars.

2. Dynamical masses in AB Doradus

The pair ABDor A/ABDor C. The infrared image of ABDor C (Close *et al.* 2005) provided a valuable astrometric information on the separation of this pair. The relative astrometry data were sufficient to constrain the elements of the reflex orbit of ABDorA reported in Guirado *et al.* (1997). Recently, we have re-estimated the mass of ABDor C using an improved method that calculates the reflex orbit of ABDor A using the existing Hipparcos/VLBI astrometric data of ABDor A and the near-infrared relative positions of ABDor C (Guirado *et al.* 2006). In essence, we redefined the χ^2 of our fit to include both types of data in the orbit calculation. Despite the wide range of parameter space investigated, the only acceptable period is 11.76 ± 0.15 yr. With the reflex orbit determined, and using the mass of ABDor A of $0.865 \pm 0.034 M_{\odot}$ (extrapolated from empirical PMS tracks; Close *et al.* 2005), we obtained a precise estimate of the mass of the companion ABDor C to be $0.090 \pm 0.003\,M_{\odot}$.

The pair ABDor A/ABDor B. The 9″-separation binary ABDor B is physically associated to ABDor A and, consequently, it shows a long-term orbital motion. We attempted to constrain this orbit using the relative positions of ABDor A/ABDor B available in the literature (Guirado *et al.* 2006). We sampled all periods up to 5000 years and eccentricities from 0 to 1. The poor coverage of the orbit results in correlations between the period and semimajor axis, which imposes a constraint on the total mass. According to this, the total mass of the four components in AB Doradus is in the range 0.95–1.35 $M_\odot$.

The pair ABDor Ba/ABDor Bb. Preliminary fits that combine VLBI absolute positions of ABDor Ba and VLT relative positions of ABDor Ba/ABDor Bb do not yield useful limits to the orbital parameters of this pair (probably these observations do not sample properly the expected short period of this binary). However, from the combination of 1) the constraint to the mass of the 9″ pair ABDor A/ABDor B (0.95–1.35 $M_\odot$), and 2) the dynamical mass of the pair ABDor A/ABDor C (0.955 ± 0.035 $M_\odot$), we can derive an upper limit to the mass of the pair Ba/Bb of 0.4 $M_\odot$. This is in good agreement with the 0.38 $M_\odot$ reported in Janson *et al.* (2007). The period of this close binary is yet to be determined; however, the combination of the 0.4 $M_\odot$ upper limit of the Ba/Bb mass, with the lower limit to the relative semimajor axis (0.9 AU; Janson *et al.* 2007) suggests that the period of this binary should be longer than 1.5 yr. On the other hand, a series of VLT infrared images (Close *et al.* 2007) favor a period of 0.9 yr. Clearly, a better sampling of the relatively fast orbital motion in this pair is needed.

3. Future work and conclusions

Among the four components of AB Doradus, the precise determination of the dynamical mass of ABDor C is perhaps the most relevant. With independent measurements of both the mass ($0.090 \pm 0.003\,M_\odot$) and the infrared photometry, ABDor C constitutes one of the few calibration points that can be used to test theoretical evolutionary models of low-mass young objects (i.e. those used to calibrate planets and brown dwarf candidates; Close *et al.* 2005, 2007; Luhman *et al.* 2005). Ongoing VLBI and VLT observations of AB Doradus should refine the estimates of the dynamical masses of this system. In particular, further monitoring of the reflex motion of ABDor A, via VLBI observations with the antennas of the Australian Long Baseline Array, will provide a model-independent estimate of the mass function of this pair ($f_{ac} = m_c^3/(m_a + m_c)^2$, with m_a and m_c the mass of ABDor A and ABDor C, respectively). Once combined with the infrared relative astrometry (which in turn provides $m_a + m_c$) it will result in independent estimates of the mass of ABDor A and ABDor C. Likewise, with adequate monitoring, other components of AB Doradus (ABDor Ba/ABDor Bb) may provide new calibration points for models of slightly larger masses.

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