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Improving the parallaxes of OH bearing Miras

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Abstract. We have carried out observations with the Very Long Baseline Array (VLBA) to measure the parallaxes of Mira variables and are able to improve the distance estimates significantly for a fraction of our sample (U Her, S CrB and RR Aql). This is predominantly because we have enhanced our technique by making use of nearby, in-beam calibrators. Additionally, the observing conditions have improved during the current solar minimum. The distances of these stars are of fundamental importance for studying the physical properties of Asymptotic Giant Branch (AGB) stars with high mass loss.

Keywords. astrometry, stars: AGB, masers

1. Introduction

Astrometric observations of the circumstellar OH masers can be used to determine the proper motion and parallax of maser bearing stars (van Langevelde *et al.* 2000; Vlemmings *et al.* 2003, hereafter V03). This will for instance allow the inclusion of the more extreme Mira stars in studies of the fundamental properties of these stars, like the pulsation and mass-loss mechanism. In order to use the maser positions to monitor the stellar trajectory, an assumption has to be made about the motion of the masers with respect to the star. In V03, it was shown that for several stars the brightest, most blue-shifted circumstellar maser spot corresponds to the *Amplified Stellar Image*. However, not all stars show such a maser spot, depending on for instance an inhomogeneous distribution of the masing gas (Vlemmings 2002). Still the observations in V03 indicate that even without an amplified stellar image, Very Long Baseline Interferometry astrometry of OH masers yields accurate results for sources up to $\sim 1-2$ kpc.

2. Observations

The 1665 and 1667 GHz OH masers of S CrB, U Her and RR Aql were observed using the NRAO† VLBA for 6 epochs between February 2004 and March 2005. For each of our sources we observed a regular nodding phase-reference calibrator at up to $\sim 4.5^\circ$ from the target source as well as an in-beam calibrator source (except for U Her, where no compact source was available). The in-beam calibrators are within $30'$ of the maser source, inside the 1.6 GHz primary beam of the VLBA telescopes, and are used to calibrate the remaining differential phase fluctuations between the nodding calibrator and the maser

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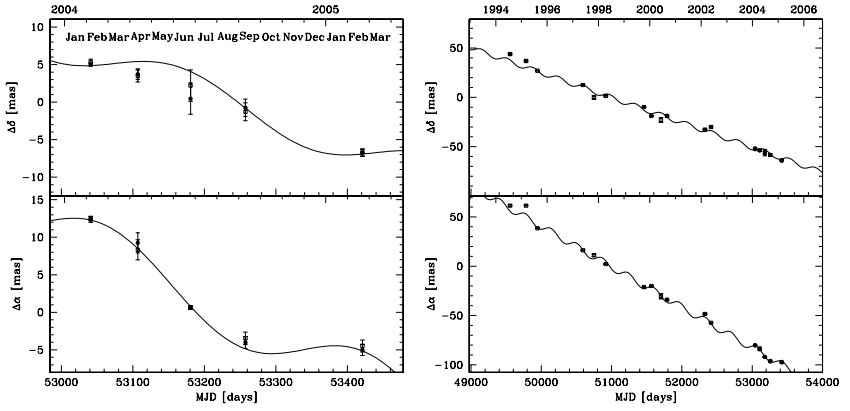

Figure 1. The position of the most blue-shifted 1665 and 1667 MHz maser spots of U Her that have been found to correspond to the stellar image. Drawn is the best fitting parallax and proper motion trajectory combining the results on both maser transitions for the 5 recent epochs of observations (left), and combining the new observations with the 12 previous epochs (right).

Table 1. Improved VLBI astrometry

Source	Period (days)	VLBI parallax (mas)	Hipparcos parallax (mas)	d_{P-L} (pc)	$d_{\rm VLBI}$ (pc)
S CrB	360	2.39 ± 0.17	2.40 ± 1.17	470	418^{+21}_{-18}
U Her	406	3.76 ± 0.27	1.88 ± 1.31	380	266^{+32}_{-28}
RR Aql	394	1.58 ± 0.40	2.48 ± 2.57	540	633^{+214}_{-128}

line of sight. As it has been shown that the astrometric errors are proportional to the target-calibrator separation (Chatterjee *et al.* 2004), in-beam calibration significantly improves the maser astrometry. Additional improvements over the results in V03 were due to the improved conditions during the current solar minimum.

3. Results

Fig. 1 shows the results of our observations and model fitting for U Her. The complete results for to parallax measurements of our sources, presented in Vlemmings & van Langevelde (2007), is given in Table 1, which also contains the revised Hipparcos parallax (Knapp *et al.* 2003) and the Period-Luminosity distance using the P-L relation from Whitelock & Feast (2000).

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