VLBI detection of nearby (<100 pc) young stars

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Radio interferometer with baselines above 1000 km may provide angular resolution ~1 mas. Furthermore, the phase corrections of their observations are performed using background quasars, whose accurate positions are known in the international celestial reference frame, and the position of the target sources are linked to them, reaching astrometric accuracies of ~0.1 mas. Thus, radio observations with interferometers are an excellent tool for stellar astrometry. We aim to increase the number of sources with astrometric measurements with Very Long Baseline Interferometry (VLBI) and compare them with the Gaia results. We observed 31 young stars with reported radio emissions using the very long baseline array (VLBA) at two epochs separated for two to seven days. The stars were chosen based on their likelihood of being nonthermal radio emitters and that they have astrometric results from Gaia.

ULTRA HIGH PRECISION STELLAR RADIO ASTROMETRY WITH VLBI

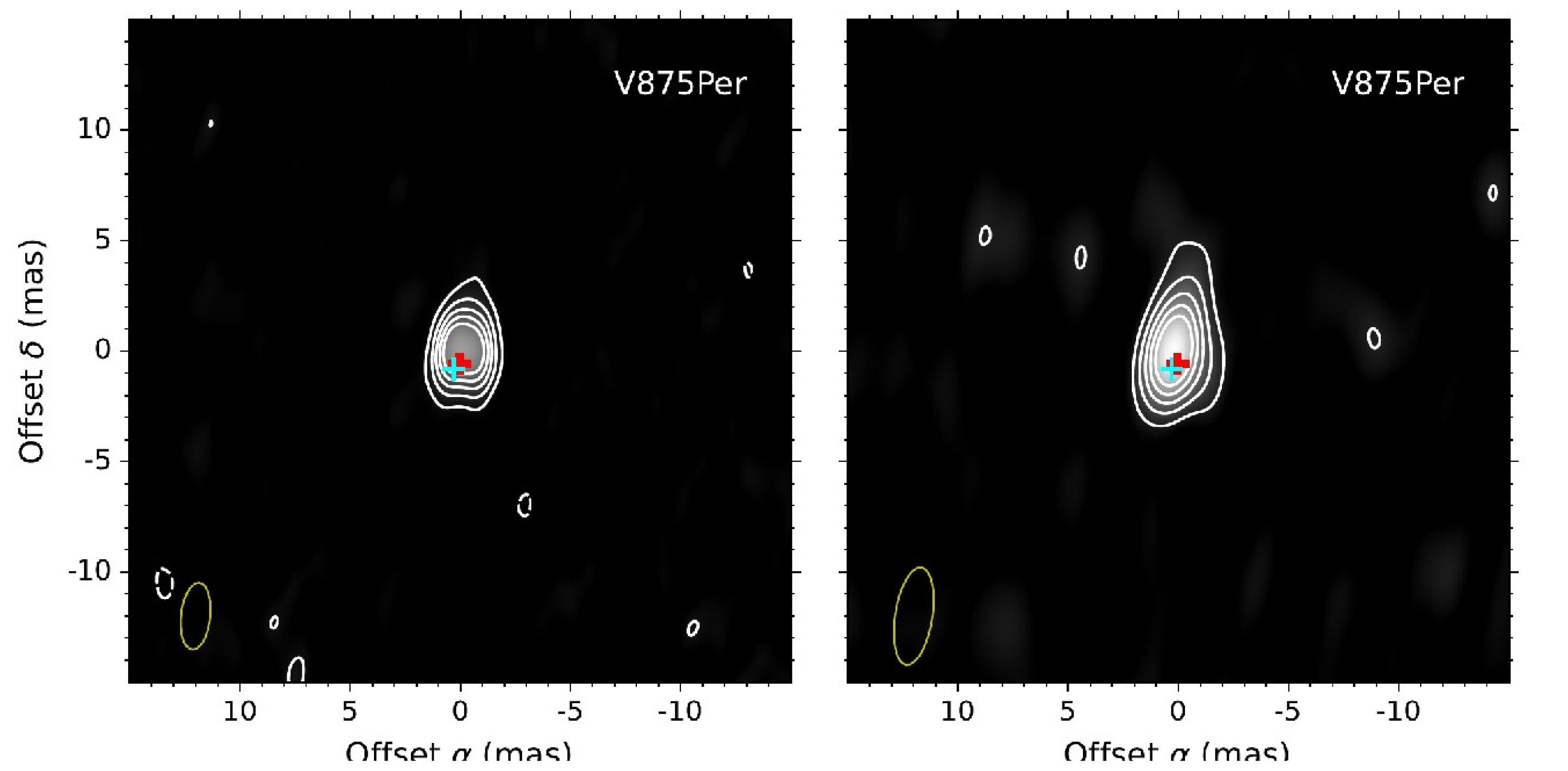


Fig. 1. VLBA images of the radio source related to V 875 Per. Contour levels are –3, 3, 6, 9, 12, and 15 times the noise level of the image (~30 uJy/beam). The predicted optical position in epochs 1 and 2 are shown as red and cyan crosses, respectively.

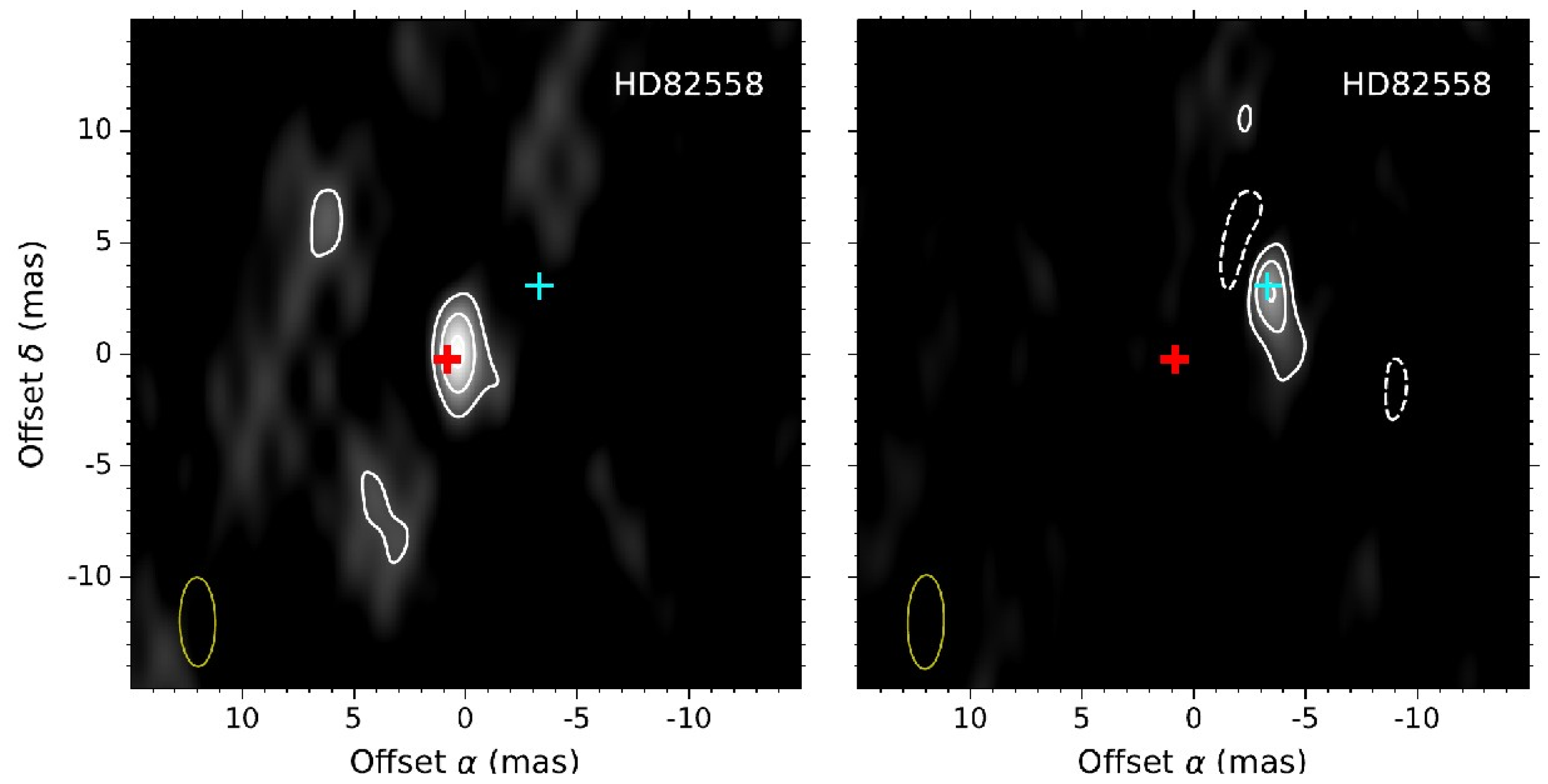


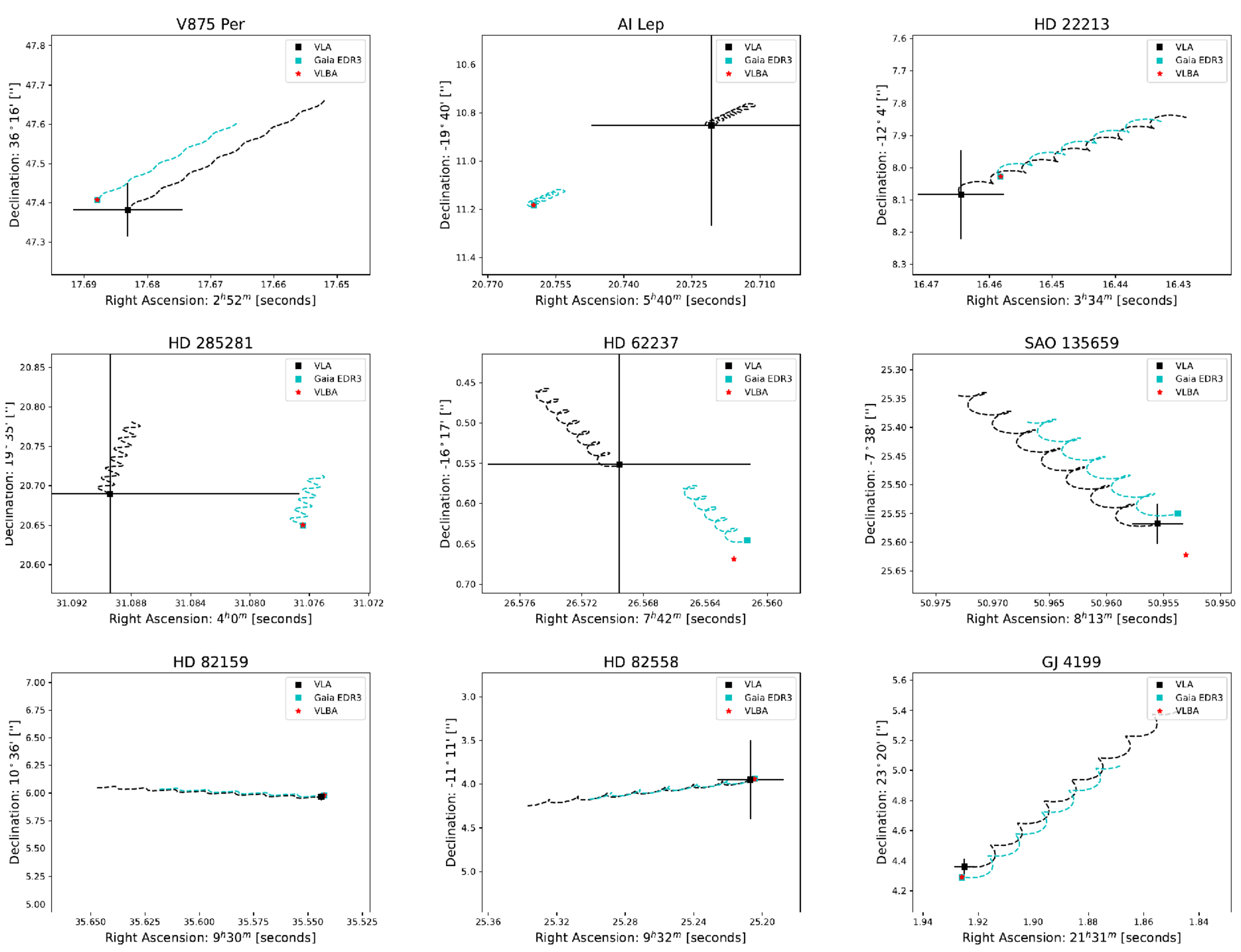
Fig. 2. Similar to Fig. 1, in this case for star HD 82558.

Radio emission was detected for ten of our 31 targets. In the plots of Fig. 1 and Fig. 2, we show examples of detected radio sources. In most cases, single sources are detected in the images and at very similar positions. Sources HD 82558 (Fig. 2) and HD 82159 are single sources in both epochs, but their **positions change appreciably from one epoch to the next due to their high proper motion**

The radio sources are rapidly variable, and in several cases, their flux density changes by a factor larger than two in a few days. This high variability was also noticed in the VLA observation of the same sources (Launhardt et al. 2022) and is typical of stellar sources with magnetic activity (e.g., Güdel 2002)

The source positions were measured and the estimated errors were < 0.3 mas, comparable with Gaia results.

Comparison with Gaia



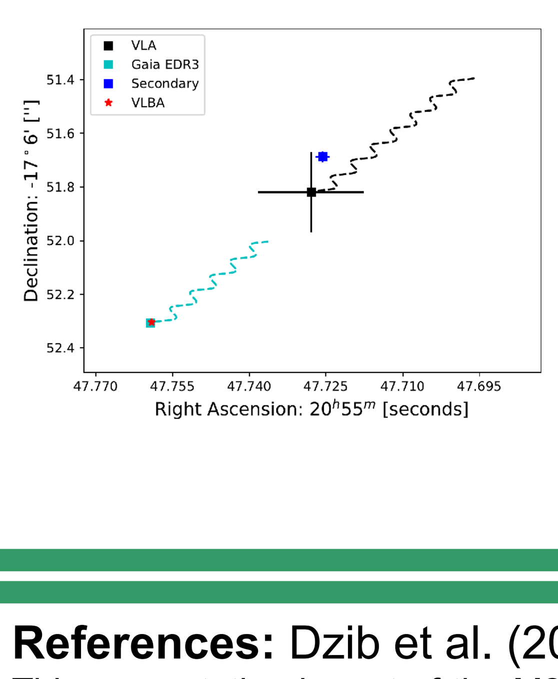


Fig. 3. Fig. B.1. Positions of radio and optical sources related to our target sources. Red stars indicate the position of the radio source in the first detected epoch by the VLBA observations. The black line is the trajectory followed by the radio source detected with the VLA (Launhardt et al. 2022), assuming the derived astrometry at optical wavelengths. The black cross size indicates the VLA positional error. The cyan line indicates the trajectory of the Gaia DR3 results to the epoch of VLBA detection.

Table 1. VLBA detected stars. We list the known companions, the angular separation from Gaia position , Pma, RUWE, and the Suggested Origin of the Radio Source (SORS).

Star ID	Companion name	Angular separation	$\Delta\theta$ (mas)	PMa[(a)] (SNR)	RUWE	SORS[(b)]	SORS This work
V 875 Per	WDS 02523+3617 B[(c)]	5.″4	0.6 ± 0.2	...	1.2	Main	Main
HD 22213	WDS 03343–1204 B	1.″7	1.1 ± 0.3	...	1.1	Main	Main
HD 285281	WDS 04005+1935 B	0.″8	0.9 ± 0.5	...	1.5	Main	Main
AI Lep	WDS 05403–1940 B	8.″4	0.5 ± 0.2	...	1.0	Main	Main
HD 62237	...	...	26.6 ± 0.6	...	7.3	Main	New companion
SAO 135659	WDS 08138–0738 B	0.″1	73.3 ± 1.0	...	13.8	Main/Companion	Companion
HD 82159	WDS 09306+1036 B	13.″8	1.3 ± 0.3	1.74	1.6	Main	Main
HD 82558	...	...	0.7 ± 0.2	0.79	1.1	Main	Main
HD 199143	HD 199143 B	0.″84	4.4 ± 0.5	56.68	1.0	Companion	New Companion
GJ 4199	WDS 21310+2320 B	9.″2	1.4 ± 0.3	0.99	1.0	Main	Main

Seven of the ten radio sources are consistent with the expected position from Gaia results. We argue that, in these cases, the radio emission is tracing the stellar corona of the stars seen at optical wavelengths. On the other hand, the measured positions of **three radio sources are not consistent with the results from Gaia.**

We notice that most of detected stars are known wide binaries; however, typical separations are >1" (see Table 1), not affecting the proper motion determination of Gaia (thus RUWE~1.0). In contrast, the three sources where the VLBA and Gaia positions do not coincide, however, have large RUWE value or large PMa.

Then, **we attribute the VLBA-Gaia position discrepancies for three stars to the presence of close companions.**

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References: Dzib et al. (2024A&A...686A.176D). Launhardt et al. (2022ApJ...931...43L). Kervella et al. (2019A&A...623A..72K)

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