LINKING THE RADIO AND OPTICAL FRAMES WITH MERLIN

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Abstract. MERLIN positions of 12 radio stars are used to link the provisional Hipparcos reference frame to the International Celestial Reference Frame. The accuracy of the link using these radio stars is 2.3 milliarcseconds. Further observations are planned to check the accuracy of the link in the future.

1. Introduction

The challenge for astrometrists working at wavebands other than radio is to link their reference frames to the International Celestial Reference Frame (ICRF) which, though very accurate, is defined by VLBI positions of several hundred quasars. These are usually very weak or even absent at other wavelengths.

The high-precision Hipparcos astrometric catalogue is the obvious choice for the optical counterpart of the ICRF. This catalogue has positions, proper motions and parallaxes of 120,000 stars with a mean accuracy of 1.5 mas at 1991.25.

There are several methods of establishing the link and these have been reviewed by Lindegren and Kovalevsky (1995). Potentially, one of the most accurate methods is to compare the optical positions and proper motions of radio stars in the Hipparcos catalogue with their radio counterparts which are measured with respect to the ICRF. The difficulty is that apart from a few stars, the sources are weak and very variable at radio wavelengths, with peak intensities of less than 10 mJy. Notwithstanding, a team led by J.-F. Lestrade began an observational campaign in 1984 to measure the differential positions of radio stars using VLBI phase-referencing from adjacent ICRF sources. By this method, the radio positions and proper

B.J. McLean et al. (eds.), New Horizons from Multi-Wavelength Sky Surveys, 389–391.

motions of 11 radio stars in the northern hemisphere have been determined and the link of Hipparcos to the ICRF established with an accuracy of 0.6 mas at the epoch 1991.25 and the residual rotation reduced to the level of 0.3 mas yr^{-1} (Kovalevsky and Lindegren, 1996).

In order to obtain an independent check on this VLBI solution for the link, and with a view to extending the number of stars used, an astrometric programme using MERLIN was established.

We report here on the astrometry of 13 radio stars, nine of which are not in the VLBI programme. The stars observed are given in Table 1.

2. Radio Star Candidates

The targets in this investigation were chosen for several reasons:

- A small radio emission cross-section (~1–2 mas) *i.e.*, single stars or close binaries.
- Known radio emitters at the several mJy level.
- Preferably not in the VLBI list of Lestrade *et al.* (1994).

TABLE 1. Post-fit residuals, ICRF-MERLIN

Star	HIC	$\Delta\alpha\cos\delta$ (mas)	$\Delta\delta$ (mas)	Star	HIC	$\Delta\alpha\cos\delta$ (mas)	$\Delta\delta$ (mas)
LSI 61° 303	12,469	−3.1	−0.3	σ^2 CrB	79,607	0.0	+1.7
Algol[1]	14,756	−3.7	+2.4	29 Dra[2]	85,852	–	–
HD22403[3]	16,879	+4.9	−10.3	BY Dra	91,009	−1.4	−1.8
EI Eri[4]	19,431	−9.7	−14.8	FF Aqr	108,644	−3.8	+0.7
DM UMa[5]	53,425	+14.9	+1.3	λ And	116,584	−1.6	+4.8
FK Com	65,915	+6.6	−8.8	II Peg	117,915	−0.9	−0.5
HR5110	66,257	−1.3	−2.3	II Peg	117,915	+4.3	−4.9

[1] The line of nodes in Pan *et al.* (1993) is wrong by 180° .
[2] 29 Dra = DR Dra; rejected because of relatively high χ^2 value notified by Hipparcos team. (It is a 2.5 year period spectroscopic binary).
[3] HD22403; lowest signal to noise ratio.
[4] EI Eri = HD26337; resolution in declination is worst near the equator, although FF Aqr produces a small residual.
[5] DM UMa; calibrator is a double source, 33 mas across.

3. Discussion

The MERLIN solution for the (x, y, z) axes of the frame can be compared with that for the finally adopted version of the Hipparcos catalogue. These offsets in milliarcseconds, in the sense MERLIN *minus* Hipparcos, are:

https://doi.org/10.1017/S0074180900129122 Published online by Cambridge University Press

$$\Delta\epsilon_x = +1.5 \pm 2.3; \qquad \Delta\epsilon_y = -0.6 \pm 2.0; \qquad \Delta\epsilon_z = +0.5 \pm 2.2.$$

The final orientation of the published Hipparcos catalogue is very close to the VLBI determination. Therefore, the offsets above effectively show how close the MERLIN solution is to that of the VLBI. Only three stars are common to the VLBI and MERLIN datasets (LSI 61° 303, HR5110, Algol); so the two solutions are virtually independent and their close agreement lends confidence to the stability of the link, which could have been distorted by significant offsets between the optical and radio emission in some of the binary stars.

4. Conclusions

The accuracy of the link has clearly demonstrated the potential of MERLIN for differential astrometry over several degrees. In the best cases MERLIN may achieve sub-mas accuracy, but even for weak radio stars of only a few mJy and separations of several degrees, MERLIN can achieve accuracies of a few mas.

The VLBI solution for the rotation of the Hipparcos frame relative to the ICRF has an uncertainty of $\pm 0.3\,\mathrm{mas\,yr^{-1}}$. The maintenance of the Hipparcos frame will therefore depend on regular checks on its alignment to the ICRF. By the year 2000 the misalignment could reach $\sim$3 mas. By doubling the number of radio stars to $\sim$20, MERLIN will be capable of measuring such an offset.

Acknowledgements

Hans Schrijver provided the pre-publication Hipparcos information on possible astrometric binaries in the MERLIN list of radio stars, and Lennart Lindegren provided the astrometric information on the Algol triple system. MERLIN is a national facility operated by the University of Manchester on behalf of PPARC.

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