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8.4 / 43-GHz opacity effects in VLBI astrometry

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Standard models for relativistic jets in AGNs predict shifts of the brightness peak related to the core with observed frequencies. However, this position shift has been measured directly only in a few sources. From multifrequency VLBA precision astrometry observations, we have measured the position shift between 8.4 and 43 GHz for a number of sources. Here we report the results for the radio sources 1928+738 and 1803+784.

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1. Introduction

We are conducting a VLBA astrometric study at 8.4, 15 and 43 GHz of the “complete S5 polar-cap sample”, consisting of thirteen radio sources from the S5 survey ([3,5] and references therein). The astrometric study is based in a wide-field, differenced phase-delay technique [2] that ensures astrometric precisions from 20 to 100 μas, depending both on the observing frequency and the relative source separation (less than 20° in this sample). The goal of this programme is to determine the absolute kinematics and opacity effects on all the sources using properly registered maps from different epochs and frequencies. Regarding the opacity effects, standard models for relativistic jets in AGNs predict shifts of the position of the peak of brightness associated to the VLBI core when observed at different frequencies; however, this frequency-dependent position shift has been measured directly only in a few sources. From quasi-simultaneous 8.4 and 43-GHz observations of this programme, we have measured this shift for the radiosources of the S5 polar-cap sample. Here we show the results for two of these sources, 1928+738 and 1803+784.

2. Opacity effects in 1928+738

The 8.4-GHz map of 1928+738 (fig. 1) displays several jet components extending southwards. The brightest feature does not correspond to the core, but to a recurrent emission of components travelling down the jet (this motion has been already astrometrically traced [1,4]). Apparently, all features in the 43-GHz map appear blended together in no more than two components at 8.4 GHz. Actually, even the 43-GHz brightest knot is not the core, but a jet component.

For the global phase-delay astrometry, we followed a similar procedure to that used in [2] to obtain the position of 1928+738 with respect to 2007+777 at both 8.4 and 43 GHz. According to our results, the peak at 43 GHz is shifted -0.07±0.15 mas in right ascension and 0.45±0.15 mas in

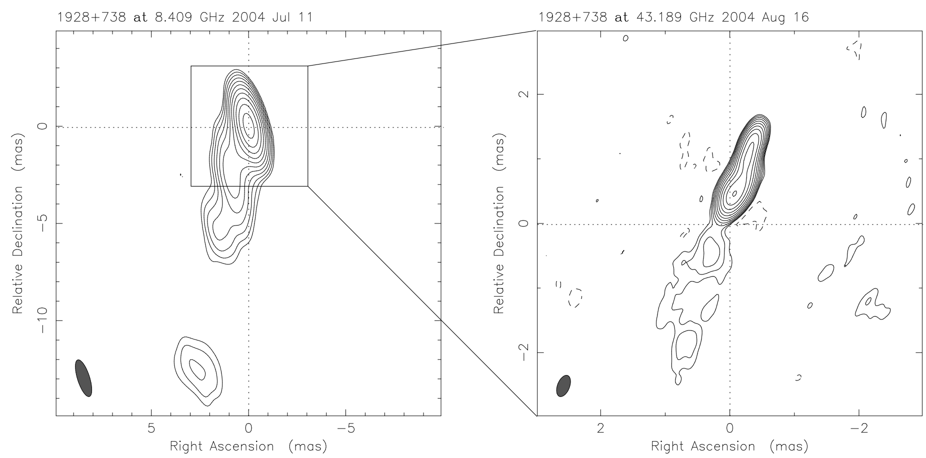

Figure 1: Maps of 1928+738 at 8.4 GHz (left) and 43 GHz (rigth). Contours are $(-3, 3, 3\sqrt{3}, 9...)$ times the rms for each map. The center of the map at 8.4 GHz is marked in both maps by crossing dotted lines to better visualize the frequency shift. Since we are specially interested in comparing the maps at different frequencies, we have selected a uniform weighting for the 8.4-GHz maps in order to enhace the resolution, and a natural weighting for the 43-GHz maps in order to enhace the sensitivity.

declination with respect to the peak of brightness at 8.4 GHz. Since most of the shift occurs in declination, it seems likely that this change corresponds entirely to 1928+738; we therefore assume that 2007+777 behaves as a stationary source within uncertainties (certainly, transverse motions in the eastward-directed jet of 2007+777 are not probable).

In fig. 1, we show the 8.4-GHz and 43-GHz structures aligned according to the registration discussed above. The origin of the maps corresponds to the (astrometrically adjusted) position of the peak of brightness at 8.4 GHz. The observed change in separation is likely a combination of opacity effects and blending of the components at 8.4 GHz. Actually, the contribution of the former should be larger than the latter, as can be shown if we restore the 43-GHz map with the resolution used at 8.4 GHz.

3. Opacity effects in 1803+784

Regarding the source 1803+784, we followed a similar procedure to that described for 1928+738. After the astrometric analysis, we measure a shift of the 43-GHz peak of 0.23$\pm$0.08 mas in right ascension and 0.14$\pm$0.10 mas in declination with respect to the 8.4-GHz peak (see fig. 2). This shift places the 43-GHz peak westwards the 8.4-GHz position, that is, towards the true core of 1803+784. Unlike 1928+738, the brightness peak of both maps of 1803+784 can be assigned to the VLBI core and, therefore, the 8.4 / 43-GHz shift can be easily explained in terms of pure opacity effects of the core of this radio source.

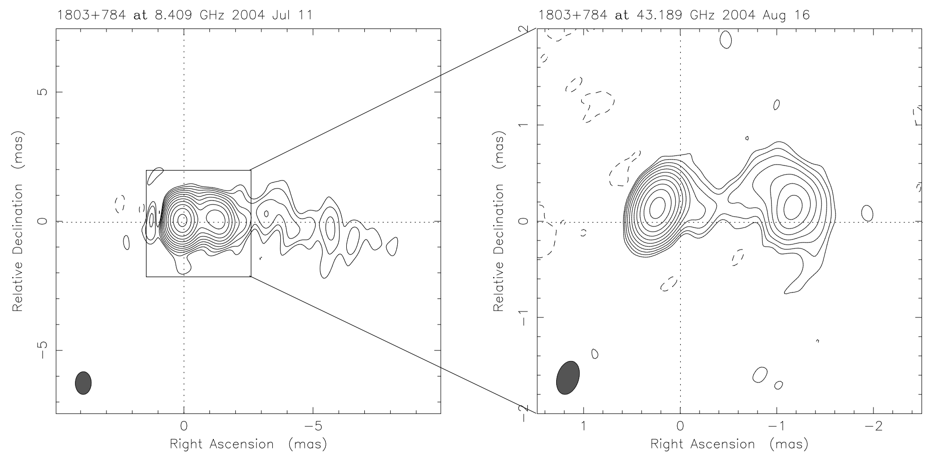

Figure 2: Same as fig. 1 for the radio source 1803+784.

References

[1] Guirado et al., 1998, A&A, 336, 385

[2] Martí Vidal et al., 2007, in press, arXiv:0711.1959

[3] Pérez-Torres et al., 2004, A&A, 428, 847

[4] Ros et al., 1999, A&A, 348, 381

[5] Ros et al., 2001, A&A, 376,1090

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