The complete S5 polar cap sample: en route to phase-delay global astrometry

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We report on the present status of our S5 polar cap phase-connected astrometry program. We observe 13 radio sources in the northernmost 20° of the sky at the wavelengths of 3.6 cm and 2 cm, and we plan to extend the program to 0.7 cm. We phase-connect jointly all our data successfully. We image the radio sources and some of them show morphological changes, in which astrometric registration is needed to determine the kinematics of the source components. We aim at unprecedented astrometric accuracy and at a check of the jet standard model at the 5-10 μas/yr level.

IERS and USNO maintain the International Celestial Reference Frame (ICRF) using at radio frequencies the VLBI group-delay observable. We aim to implement in the reference frame determination process the most precise VLBI observable: the phase-delay, which should improve astrometric precisions at centimeter wavelengths. A phase-connection is necessary to overcome the 2π ambiguous nature of the phase-delay. The final source position determinations are based on a weighted least-squares analysis of the connected phase-delays.

Recently, the phase-connection process has been extended to sources 15° apart, with astrometric precisions well below one milliarcsecond (Pérez-Torres *et al.* (2000)). The avenue of mm-VLBI astrometry (with precisions higher than cm-VLBI) is now also open, after Guirado *et al.* (2000) successfully demonstrated phase-delay astrometry at λ0.7 cm over 5°. Furthermore, the ionosphere can be modeled and removed from the astrometric observables from the results provided by the Global Positioning System network (Ros *et al.* (2000) and Pérez-Torres *et al.* (2000)).

These developments encourage us to aspire to a more ambitious program: phase-delay astrometry between 13 radio sources to get accuracies better than 0.1 milliarcseconds. We have an ongoing VLBA astrometric program to test the absolute kinematics of components in the complete S5 polar cap sample. It consists of the BL-Lac objects 0454+844, 0716+714, 1749+701, 1803+784, and 2007+777, and the QSOs 0016+731, 0153+744, 0212+735, 0615+820, 0836+710, 1039+811, 1150+812, and 1928+738. It is possible to phase-connect all the data jointly by using bootstrapping techniques: these results are reported in Ros *et al.* (1999). To date we have carried out observations at four epochs, two at λ3.6 cm (1997.93 and 1999.43), and two at λ2.0 cm (1999.57 and 2000.46).

In Fig. 1 we show VLBA images at different wavelengths for two radio sources selected from our observations. For a better comparison, they are convolved with the same beam and show the same contour levels. Comparing the left and central panels for both sources, the peaks of brightness belong to different features evolving in the jets. It is obvious that the image registration based on the position of the peak of brightness (at the same observing frequency) is not correct, and that an astrometric registration is needed to identify components from one epoch to another (left and central panels), and to perform spectral studies of the whole sample for nearby epochs (central and right panels). This

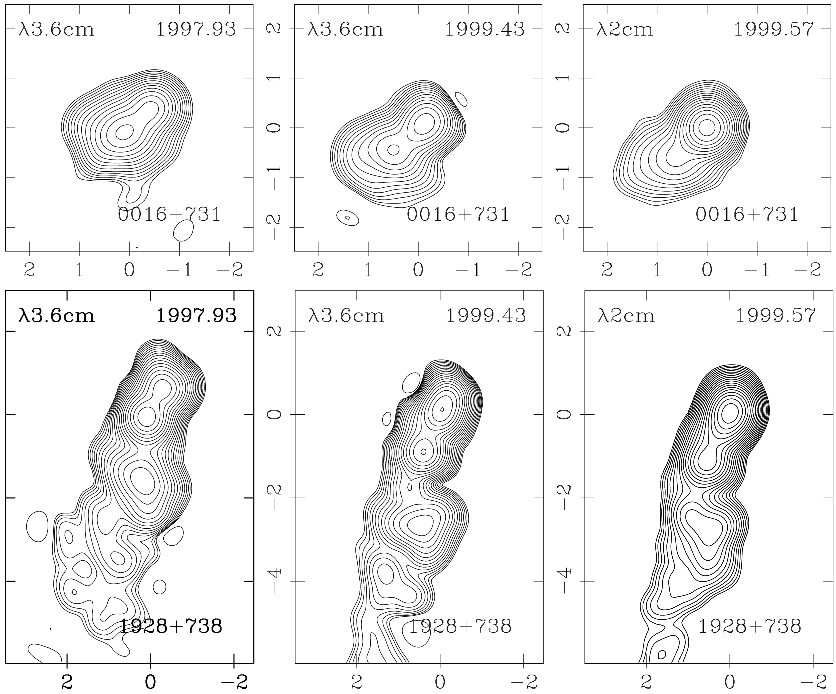

FIGURE 1. Images of QSO 0016+731 and QSO 1928+738 selected from our observations, convolved with a circular beam of 0.6 mas diameter. Contours are 2 mJy $\times(-2, 2, 2\sqrt{2}, 4, \cdots)$. Peaks of brightness are –from left to right– of 0.203, 0.162, and 0.442 Jy/beam for 0016+731 and 0.961, 1.307, and 1.356 Jy/beam for 1928+738.

absolute registration, only available from phase-delay astrometry, is needed to study the absolute kinematics of the components.

We plan to extend the astrometric monitoring of the 13 radio sources in the polar cap sample to $\lambda 0.7$ cm. After several years, this program should provide higher precision than any foreseeable astrometric program, and will check the standard jet model in the complete sample at the 5-10 μas/yr level. Accurate registration of maps at the highest available resolution will allow a study of jet components with unprecedented precision and spectral information. This project may be considered a first step to extend phase-delay astrometry to the entire sky, and thus as a complement, with a higher accuracy, to the effort of ICRF.

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