Test of Phase-reference Mapping for Switched Observations

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ABSTRACT. An observing scheme and software for single frequency switched phase-referencing observations have been developed and tested on a source pair separated by 0.5° (0248+430, 0249+436). The phase connection was done utilizing closure properties of phase and phase-rate. A comparison of the phase-reference map with a hybrid map shows the success of the method.

1. Motivation for Phase-reference Mapping

Self calibration algorithms for the interferometer visibility have proven to work well in the high signal-to-noise case. When the signal-to-noise is low, however, the interferometer phase cannot be determined unambiguously. And below a flux limit imposed by relatively short coherence times no signal can be detected at all.

To be able to map very weak radio sources we wanted to explore the feasibility and the limitations of phase-reference mapping for switched observations. Our aim was to develop a technique for single frequency observations, which would be easy to use, and could hopefully work without the need for additional atmospheric/ionospheric calibration measurements.

2. Switched Observation of 0248+430 and 0249+436

We conducted a first test of the phase-reference mapping technique for single frequency switched observations in the spring of 1984. The source pair 0248+430 (~1.2 Jy at 6 cm) and 0249+436 (~0.2 Jy at 6 cm) with a separation of 33′ was observed with the radio telescopes in Onsala, Effelsberg, Westerbork, Green Bank, and Owens Valley. We chose the observing frequency of 5 GHz in order to minimize the combined atmospheric and ionospheric effects. The data were recorded using the Mk3 system in mode E, so that one tape could record four 13-minute intervals of data.

In order to remove structural phase effects from the reference source 0248+430 we mapped it with high dynamic range (see fig. 1). The phases of the reference source were connected using closure properties of the phase and the phase rate to eliminate ambiguities. The remaining instrumental phase variations are due only to atmospheric and oscillator instabilities. Subtracting these from the visibilities of the weak source provided an interferometer signal, approximately free from phase corruptions, which contains information about the source structure and position only. The data were gridded, inverted, and CLEANed using standard mapping programs. The resulting phase-reference map is displayed in fig. 2.

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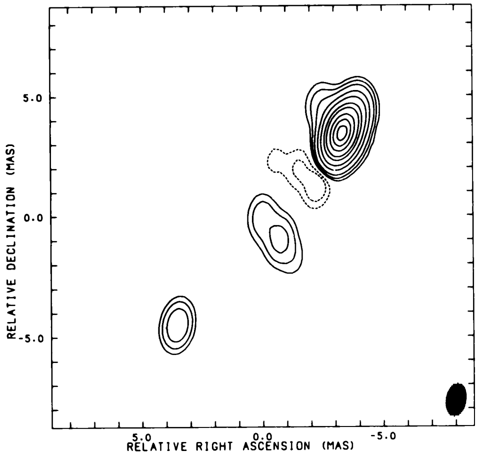
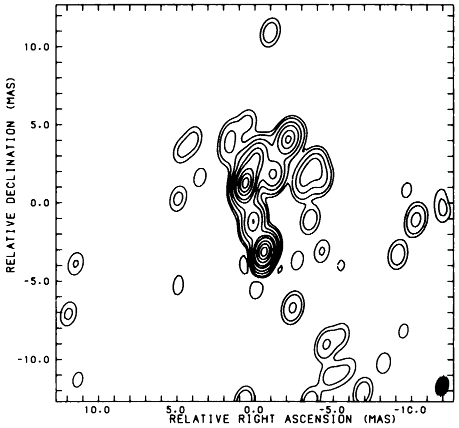
A comparison with a hybrid map of the same source (fig. 3) shows that both maps agree well down to the 10% level. The higher noise level in the phase-reference map and its seemingly more complex structure are due to additional phase noise which is introduced by interpolating the reference phase (errors of the order of ±30°), and systematic errors which are caused by inaccuracies of the correlator models for the interferometer geometry, atmosphere, earth rotation, etc. The largest systematic errors are introduced by not modelling the behaviour of the ionosphere and the troposphere, which show up as spurious structures in a phase-reference map. From the low level of such false components we can conclude that our phase-reference mapping test was not dominated by systematic phase errors. However, it is difficult to give an estimate of their magnitude. We believe that typical phase offsets are of the order of 30° to 50°.

0248+430 HYBRID MAP OF REFERENCE SOURCE



0249+436 HYBRID MAP OF SIGNAL SOURCE



Contour levels:

In Reference source:
0.5, 1, 2, 5, 10, 20,
30, 50, 70, 90% of peak
0.64 Jy/beam

Signal source both maps:
1, 2, 5, 10, 20, 30,
50, 70, 90% of peak
0.031 Jy/beam

0249+436 PHASE-REFERENCE MAP