PHASE CALIBRATORS FOR MERLIN

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ABSTRACT   The VLA was used to derive a catalogue of phase–
reference sources for MERLIN. These sources can also be used for other
interferometer arrays such as the VLBA. The positions of the sources in
the catalogue are repeatable to about 5 milliarcsec rms.

INTRODUCTION

The MERLIN array has so far been almost exclusively used as a hybrid
mapping instrument, enabling only relatively strong, point–dominated
sources to be mapped using the closure technique. MERLIN is currently
being upgraded in several important areas, including the addition of a new
32m antenna at Cambridge, a new broad–band correlator system with full
polarisation capabilities, and cooled receivers (Wilkinson, this volume). The
sensitivity of the upgraded MERLIN is expected to be about 3 mJy per
baseline in a 1–minute integration at 5 GHz. The capabilities of MERLIN
can be further enhanced by phase–reference observations, which will permit a
substantial increase in the coherent integration time on target sources. This
will enable MERLIN to map sources with peak brightnesses of a few mJy per
beam area at 1.6 and 5 GHz. Thus, sources mappable with the VLA could also
be mapped with MERLIN, with its higher angular resolution of 50 milliarcsec
(mas) at 5 GHz and 200 mas at 1.6 GHz. In addition, phase–referencing
fixes the positions of the MERLIN maps, something which will be inceasingly
important in the era of the Hubble Space Telescope. MERLIN has a resolution
intermediate between the VLA and the EVN and thus will provide unique
information about a wide range of radio sources.

CHARACTERISTICS OF PHASE CALIBRATORS

We have carried out test phase–reference observations with MERLIN at 1.6
GHz and our results indicate that:

1. It is desirable to have a phase calibrator within about 2° of the target source because MERLIN's phase stability at 1.6 GHz is dominated by the ionosphere. The temporal variation of phase indicates that the calibrator should be observed frequently, with a cycle time $\leq$ 5 minutes.

2. The phase calibrator should have $\geq$ 50 mJy correlated flux density on all baselines and should have simple structure (point or point–like) which can be mapped to recover the 'structure phase'.

3. The positional accuracy of the phase calibrator should be as high as possible for astrometric reasons and to maximise the coherent integration time.

WHERE TO FIND THEM?

In general, the flat spectrum radio sources satisfy the above requirements, and can be considered as promising phase calibrator candidates. To find flat spectrum sources with the required density on the sky, sources must be selected down to about 200 mJy at 5 GHz. We have derived a list of phase calibrator candidates from the Green Bank surveys at 1.4 and 5 GHz (Condon *et al.* 1985, 1986 and 1989) by using the software package DAOPHOT available in STARLINK. We selected 905 sources with the following criteria.

1. $S(5 \text{ GHz}) \geq 200$ mJy,
2. Spectral index flatter than 0.5,
3. $35° \leq \delta \leq 75°$ and,
4. $|b| \geq 2.5°$.

Since the positional accuracies of the Green Bank surveys (20–30 arcsec) were not adequate for our purposes, and also the structures of most of the sources were not known, we decided to measure source positions and structures using the VLA.

VLA OBSERVATIONS

Observations were carried out in the A configuration at 8.4 GHz with a bandwidth of 25 MHz using 23 antennas. We used phase calibrators from the VLBI calibrator list of Ma *et al.* (1990), for which the positional accuracies are good to one mas. Each target source was observed for 2 minutes including antenna drive times, giving an on–source integration time of about 1 to 1.5 minutes. Phase calibrators were observed after every two target sources. The total observing time was 60.5 hours. We observed the group of sources around 3C345, whose positions are known from the VLBI list, to determine the positional accuracies of our observations. Also, to check the repeatability of our measurements we reobserved some sources. In general, the data were of good quality except for a few hours at the beginning of our run which were affected by a snow storm. The sources observed during the storm were reobserved later in the programme.

After careful calibration of the data, images were made using the a simple procedure involving two cycles of phase self–calibrations. The resulting images had typical rms noise levels of 0.2 mJy per beam area, or a dynamic range of about 1000:1. The positions were measured before self–calibration, from either the first dirty map or the first clean map.

RESULTS

Of the 905 sources, 84% have a total flux density at 8.4 GHz $\geq$ 100 mJy and also have $\geq$ 80% of that flux density in a compact component. These sources are suitable phase calibrators for MERLIN. We find the following positional accuracies:

a) from the repeated sources, an rms of 5 mas,
b) from the 3C345 group of sources, an rms somewhat better than 5 mas,
c) from the data affected by the snow storm, an rms of 18 mas.

It is our intention to make this list of MERLIN phase calibrators available to the radio astronomical community through dBase IV. This work is in progress and will be reported in more detail elsewhere.

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