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BACKGROUND CONFUSION AND THE A.T.

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Introduction

Low frequency mapping is an important objective of the AT's scientific programme. The purpose of this ATDOC is to consider the effects of random background extragalactic sources within the AT primary beam, the background "confusion". In particular, it seems clear that if mapping down to anything approaching the theoretical point source sensitivity level, is to be achieved, then the whole primary beam may need to be mapped.

What is the "Confusion"?

"Confusion" is the presence of random background radio sources distributed within the antenna beam. Away from the galactic plane it is usually adequately described by a single statistic, σ confusion. Close to the plane, the source distribution is a strong function of l and b and cannot be so simply described. Here the discussion is limited to the extra-galactic case, though it is well to remember that the galactic confusion is usually much worse than the extragalactic.

The following Table lists the calculated confusion and sensitivity as a function of frequency, for one 22m antenna.

TABLE 1

Frequency GHz	hpbw degrees	Confusion Jy	3xSensitivity m Jy	($\frac{\text{Confusion}}{\text{3xSensitivity}}$)	Comments
0.327	2.9	5	1	5000	T_s=100K,B=10MHz
0.843	1.1	1.2	0.5	2500	=70K, 20MHz
1.42	0.66	0.5	0.16	3000	=35K, 50MHz
2.30	0.41	0.1	0.16	625	=35K, 50MHz
5.00	0.19	0.012	0.16	75	=35K, 50MHz

The confusion flux density has been scaled from measurements made with larger antennas at the same or nearby frequencies. Specifically Arecibo 305 m at 318 MHz (Condon and Jauncey, 1974), Green Bank 91 m at 1400 MHz (Maslowski, 1972) and Tidbinbilla 64 m at 2.3 GHz (Jauncey unpublished). Scaling was done from the relationship

$$\sigma \text{ confusion} \quad \propto \quad (\text{beam area})^{1/\alpha}$$

where α = integral N(S) slope (Condon, 1974), and a mean spectral index of 0.7 was used. Above 2 GHz, $\alpha = 1$ was used, whereas below 2 GHz, $\alpha = 1.5$ is more appropriate at those flux density levels (e.g. Jauncey 1975).

<u>What does this "Confusion" imply?</u>

Roughly speaking, half of the confusion flux lies within the half power points and half outside. Thus, if mapping is carried out only to the half power points, then the flux density inside the primary beam, but not in the mapped area, is roughly half of the value given in Table 1.

While the background sources inside the hpbw can be "cleaned" the sources outside cannot, though they still contribute directly to the observed phases and amplitudes.

Can this be corrected for simply?

Clearly, if the position, flux density and angular structure of each of the sources inside the beam but outside the map, were known, then they could be "cleaned" in the usual manner. It has been suggested that existing catalogues, the Molonglo 408 MHz Catalogue (Large et al. 1981) in particular, could be used. However, it is complete only to 1 Jy at .408 GHz (~1.2 Jy at 0.327 GHz). The combination of such a high completeness flux density and the unknown angular structures, implies that this sort of correction is quite inadequate even at 0.327 GHz.

For example, at 0.327 GHz, there are an estimated 30 sources with flux densities $\gtrsim$0.37 Jy, outside the hpbw but within the primary beam area. The attenuation of the primary beam pattern reduces this total flux to the ~ 2.5 Jy that is half of the entry in Table 1. Of these confusing sources, roughly half are below the Molonglo completeness cut off. Moreover, the angular structure of the Molonglo sources at the AT resolution is simply not known.

Does "bandwidth smearing" help?

If the final map is to extend to the primary hpbw then "bandwidth smearing" does not appear to improve the situation significantly.

For a 10 MHz bandwidth, the delay beam is 0°.31 on a 6 Km baseline. This is significantly less than the hpbw at all of the frequencies in Table 1 except 5.0 GHz. Consequently, the requirement to map to the hpbw suggests that bandwidth smearing cannot be used. Remember, the disparity between the outer confusion flux density and the sensitivity is in excess of 2500 at the three lowest frequencies in Table 1.

Conclusion

It looks as though the whole field should be mapped, even at 1400 MHz, since there are too many sources in the primary beam.

References

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AT/10.1/026

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Dear Dave,

I have read your confusion memo for the AT (AT/10.1/026 and I would like to make a few additional points. Firstly I agree with most of your analysis but I think you have omitted an important factor. It is not the confusion level itself outside the mapped area which matters, but how much of the effect of this gets into the mapped area. It can get in by two mechanisms; either by the aliasing involved in the gridding procedure, or by the sidelobes of the synthesized beam (aliasing with the UV coverage if you wish). The aliasing due to gridding can now be reduced to a very low level (for example see lecture 2 in our synthesis mapping workshop) and will certainly be less then the effect of sidelobes. The sidelobe effect is harder to estimate and will depend on uv coverage, calibration errors, and the distance of the confusing sources from the region mapped. For a fairly complete synthesis you may have an additional attenuation of a factor of 100 over the values you quote. It is important to look at this as an array problem and not as a problem of confusion level for a simple interferometer, which is I think, the problem you have answered.

Although this factor will help a lot one still reaches the conclusion that a large area will have to be mapped for frequencies less then 1.4GHz. However even mapping this large area may not suffice since clean has only limited ability to correct for the error sidelobes which will also be present.

My second point refers to the the bandwidth synthesis I don't understand your comment since the smaller the delay beam the better the suppression you get from bandwidth smearing. However I do agree that for 6km and 10 MHz it still won't do a lot good. But why the 10MHz limit? I assume much more bandwidth will be used at the higher frequencies, and at lower frequency bandwidth synthesis by frequencies switching might be considered. Incidently it is useful to look at the bandwidth smearing in terms of the improved UV coverage (in wavelengths) achieved with a finite bandwidth. This results in lower sidelobe levels coming from sources outside the mapped area.

Sincerely yours,

Ron

R. D. Ekers

RDE/ef

cc: R. Frater