NATIONAL RADIO ASTRONOMY OBSERVATORY
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M E M O R A N D U M

To: Interferometer Users

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Subj: On Combining Large Dish and Aperture-Synthesis Observations

I. INTRODUCTION

Large, single antennae and interferometer observations of an extended source are complementary in that the large dish is able to sample th low spatial frequencies of the source brightness distribution which the interferometer is unable to sample. This note is a reminder as to the scop and limitations of combining these observations.

II. IN PRINCIPLE

The mathematics are straightforward. Observations with the singl dish yield a map, M(r) given by

$$M(r) = B(r) * T(r) \qquad (1)$$

where B(r) is the beam of the single dish, T(r) is the sky brightness, r is a vector giving the direction in the sky and * denotes convolution.

Similarly the synthesized beam of the interferometer, B'(r) gives a map:

$$M'(r) = B'(r) * T(r) \qquad (2)$$

We can add the two maps together and the resulting map is just the sky convolved with the summed beams:

$$M + M' = (B + B') * T \qquad (3)$$

The resulting beam may have an undesirable shape, but this is to some extent under our control. The Fourier transforms of (1) and (2) are

$$m(w) = b(w) \times t(w) \tag{4}$$

and

$$m'(w) = b'(w) \times t(w) \tag{5}$$

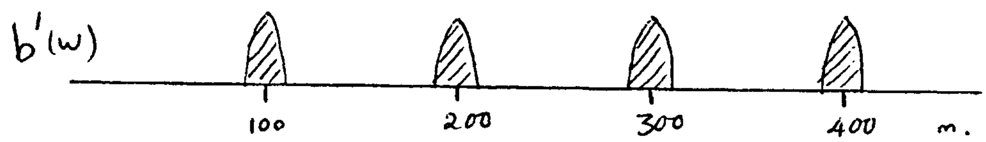
where m, b, t are the Fourier transforms of M, B, T as functions of the spatial frequency, $w \equiv (u,v)$.

In the case of equation (5), m'(w) and b'(w) are the actual observations with the interferometer of the mapped source, and an unresolved source respectively, and are well determined.

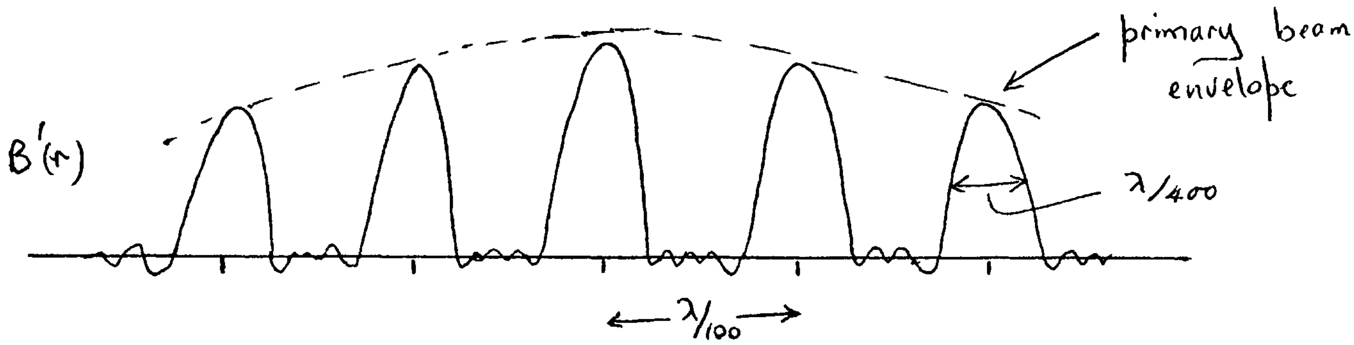
We can synthesize any beam whose Fourier components are a linear combination of the sampled b(w), b'(w). We must of course determine the b(w) for the single dish.

Example

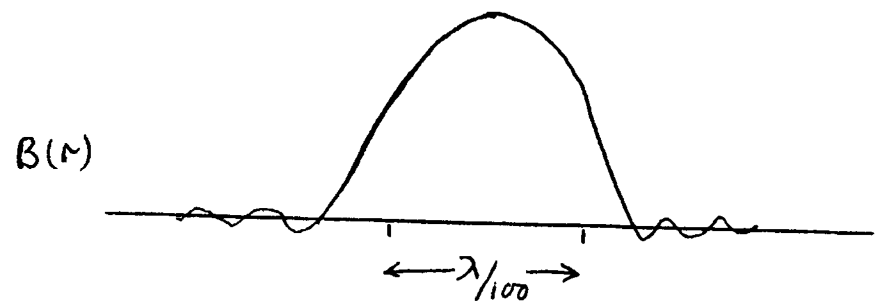
w.r.t. the NRAO 300-foot dish and interferometer, suppose that we have observed with the interferometer and sampled the (u,v) plane at 100 m intervals, to a maximum of 400 m.



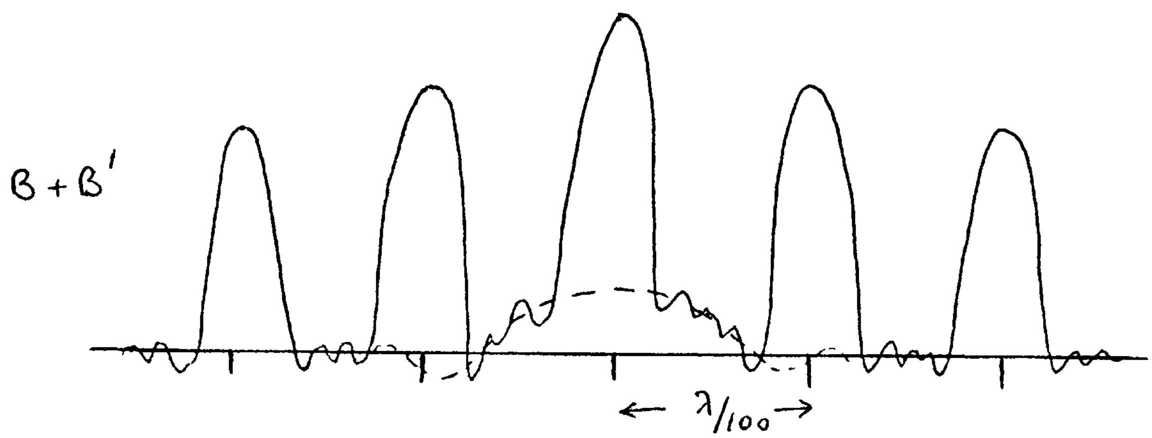
In one dimension this gives a beam:



The 300-foot (≡ 100 m) dish has a beam:



If we combine these observations with equal weight, we obtain a beam as in Figure 4.



A smoother beam and a more realistic map may be obtained by reducing the weight of the high spatial frequencies of the interferometer beam (this is easily done), and increasing the weight of the high spatial frequencies of the 300-foot beam. The latter are ill-determined and, as there is not much dish area contributing, are noisy. We cannot do much about the noise, but the method outlined by Bates in a recent NRAO colloquium should give a better method of determining the spatial frequencies than measuring the beam directly.

Although we have sampled spatial frequencies between 0 and 100 m, it is important to note that we still have a large grating sidelobe response due to the missing information between the other 100 m spacings and we are still not able to synthesize a map of a source larger than λ/100 without risk of confusion.

MCHW/pj