A PROPOSAL TO OBTAIN SHORT SPACING INFORMATION BY INTERPOLATION

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1. INTRODUCTION

For a short description of the problem posed by missing information at short interferometer spacings in aperture synthesis we would like to refer to the introduction of the previous paper by Ekers and Rots. The solution that is suggested in this paper is not a true interpolation but somewhat intermediate between interpolation and Clean.

If we confine ourselves for a moment to one dimension, it can be understood quite easily that sampling at baselines which are multiples of 36 m is adequate for sources that are relatively small. For several reasons, however, one may choose to observe with an increment of 18 m so that one is left with the problem of the missing 18 m spacing (see also previous paper). Since the 36 m increment fulfils the sampling criterium, however, one can interpolate this 18 m visibility, provided one has a sample at 0 m. The latter can usually be obtained in a variety of ways, so we shall assume in this paper that it is available.

The consideration outlined in the preceding paragraph is the basis of the method, but in a two-dimensional case we would not like to do a straight interpolation. As a priori knowledge of the source we shall use spatial confinement and positivity.

2. THE METHOD

We first assume that the source as it appears in the map obtained from the available spacings ($n \times 18$ m, $n = 0,2,3,\ldots,N$) is a reasonable approximation of the true brightness distribution. The part of the map in which we believe the source to be confined is cut out and all negative intensities in that area are set to zero.

This first approximation is then Fourier Transformed (by direct transformation) onto an 18 m spacing track in the (u,v)-plane. This visibility function is transformed back and added to the map, with the proper

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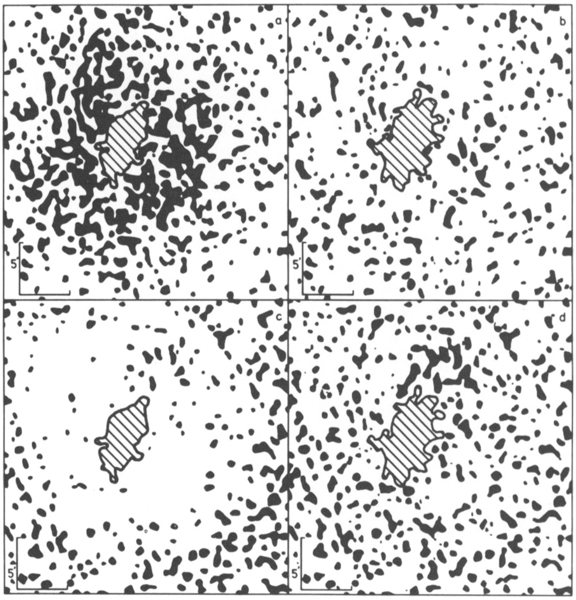
a. b.



c. d.

Fig. 1a-d. The effect of adding short baseline information obtained by one iteration of the procedure described in section 2. This example is taken from WSRT observations of M81 in the 21-cm line of neutral hydrogen; the figure shows a single channel map at half resolution (50 arcsec). Panels (a) and (b) display all areas in black where the brightness temperature $T_b < -\sigma$; (c) and (d) show $T_b > +\sigma$, where σ is the r.m.s. noise. The main body of the source has been hatched in all panels. The straight WSRT map is shown in (a) and (c); (b) and (d) display the same map after adding 0 m and 18 m spacing information.

weight. One can actually view this process as an interpolation where the interpolating function in the (u,v)-plane is optimized for the source under consideration: it is the Fourier Transformation of the source shape.

We have used the procedure described so far for the neutral hydrogen observations of M81 (A.H.Rots, 1974, Dissertation, University of Groningen; A.H.Rots and W.W.Shane, 1975, Astron. Astrophys. 45, 25). An example is shown in Fig. 1.

At that time Ekers already suggested to iterate on the process. One takes the same area of the map again, sets the negative intensities to zero, repeats the two transformations, and adds the fresh part of the 18 m baseline contribution into the map.

Recently we have done some simulations with model sources in such an iterative scheme. At 1.4 GHz the primary beam of the WSRT has a FWHP of 37 arcmin; the radius of the first point source grating response is 40 arcmin. We have tried circular pillbox sources with diameters of 20 and 30 arcmin, a bar of 10 x 35 arcmin, and circular Gaussians with FWHP's of 10 and 20 arcmin. One cannot extend the sources beyond the grating ring radius since the grating response of one side is then affecting the other side of the source. All results were satisfactory. The next section is a compilation of comments and conclusions based on these experiments.

3. COMMENTS AND CONCLUSIONS

(i) Apparently not both dimensions of the source have to be smaller than a certain size in order to fulfil the sampling criterium; it can be quite large in one direction. What seems to be important is the area over which the source extends: the 20' pillbox and the 10' x 35' bar gave similar results notwithstanding the length of the bar; their areas are very close. This obviously is an advantage over the one-dimensional case.

(ii) Rather precise knowledge (probably 5-10%) of the zero spacing flux is very important; not only for its own sake, but also because it appears to be useful to monitor the integral over the map and stop the iteration process when it equals the zero spacing flux. There is, however, a connection with the next point.

(iii) A good estimate of the area in which the source is confined is of equal importance. Under certain conditions a wrongly defined area may lead to spurious results. On the other hand, a good estimate may relax the requirements for the accuracy of the zero spacing flux. For "small" sources ($\lesssim$ 400 square armin at 1.4 GHz) where the exact shape is known the iteration process will converge to the correct value even without knowing the zero spacing flux; one can obtain that flux at the same time.

(iv) For obtaining the 18 m visibility function a smoothed version of the map can be used. Notwithstanding the use of direct Fourier Transforms the CPU time per iteration can easily be less than 1 sec. and all data can be kept in core. Hence the process is suitable for interactive use; this should actually be encouraged.

(v) It should be ackowledged that other techniques than direct Fourier Transforms can be used, like convolution with the zero order Bessel function corresponding to 18 m, or Clean. Application of the latter may very well face serious problems in the presence of noise.

(vi) The advantage of the method described in this paper is that one does not need separate observations requiring special treatment to obtain the 18 m spacing visibilities. It is reduced to a rather straightforward data processing problem.

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(vii) We have to make the proviso, however, that the process really works. The method should now be tested on real data, and extensively be compared with other schemes. To us it seems that it will probably work quite satisfactorily in many cases.

DISCUSSION

Comment J.E. BALDWIN
Do you believe that your procedure is logically different from CLEAN?
Reply A.H. ROTS
To a certain extent the procedures are logically similar, except that CLEAN does not use the positivity constraint.

Comment J.P. HAMAKER
I think what your scheme does is to develop a solution that is compatible with your data and equal to zero outside your window. Isn't that correct?
Reply A.H. ROTS
No, not in the sense that I am forcing the resultant map to zero outside the window.
Comment J.P. HAMAKER
Well, by zeroing the area outside your window in every iteration, you force your solution into that direction.
Reply A.H. ROTS
Yes, in so far that there is not supposed to be any contribution to the 18 m spacing visibilities from outside the window.

Comment C. van SCHOONEVELD
Did you consider to apply your method to the missing long spacings, rather than to the short spacings?
Reply A.H. ROTS
No. I would like to refer to the work that Trevor Cole has done in that field.
Reply T.W. COLE
I cannot now remember the actual reference in A&A but yes, I did a matrix inversion to exploit redundancy and get missing spacings. It works for missing innerspacings but the linear algebraic computer implementation could be much, much better.

Comment U.J. SCHWARZ
The noise inherent to the observation or interpolation plays an important role. Short baselines are more difficult to measure accurately, due to all sorts of non-random effects (confusion, interference), than long base-lines. If one makes the optimistic assumption, that the short spacings can at best be measured as accurately as the long spacings, is then an interpolation scheme competing with observations (that means, are systematic effects smaller than the random errors)? I made an analysis of this problem and the answer is yes, except in the case of a strong complex source outside the extended region of interest.