The Need for Complete Spatial Frequency Coverage
With the SKA

Speaker:  John Dickel, U. Illinois and NFRA
THE NEED FOR COMPLETE
SPATIAL FREQUENCY COVERAGE
WITH THE SKA

OR

A TALE OF SIDELOBBES

JOHN DICKEL

U. ILLINOIS AND NFRA
STUDIES OF EXTENDED SOURCES

EXAMPLES:
WHAT IS THE MASS DISTRIBUTION AND DYNAMICS OF A GALAXY?
HOW DO SUPERNOVA REMNANTS ACCELERATE RELATIVISTIC PARTICLES AND AMPLIFY MAGNETIC FIELDS?

SAMPLE SPECIFIC PROGRAMS
Hydrogen Line Mapping of Galaxies.
Spectral Index Maps of Complex Regions.
  Overlapping components with different sizes and different spectral indices.
Polarimetry at Several Frequencies.
  Faraday rotation and depolarization.
  Magnetic field patterns.
Monitoring SNR Expansions.
  Overall.
  Fine scale features.

NEEDS
Image Large Fields (> 10 degrees across).
Get Fine Structure (< 1 arcsec).
Several Wavelengths Across a Large Range.
Similar Coverage for All Spatial Frequencies at Each Wavelength.
SHORT SPACINGS

OFTEN FORGOTTEN IN CURRENT ARRAYS

Not interesting.
Shadowing.
Possibility of Collisions.
No large single dish available.

CONSEQUENCES

Cannot detect smoothly distributed emission which can dominate the total surface brightness.
Cannot get accurate baselines under individual sources or components of a complex source.

CONCLUSION

Need *intra*-station correlations for *one* extra-sized station.

Easy for arrays of dipoles.
For dishes, you need a field of smaller ones so they can be packed closely together.
This can be tested with CARMA which will have dishes of 2, 6, and 10 meter diameters.
LMC in HI (303 km/s) ATCA

LMC ATCA+Parkes multibeam
Figure 3. — Channel maps at $-125.3 \text{ km s}^{-1}$ and $-211.8 \text{ km s}^{-1}$ smoothed to eight times the original resolution. Vertical cross cuts through the map centers are shown below each map. Panels (a) and (d): These maps only include the Westerbork data. Notice the "bowl" like feature in which the emission appears. Panels (b) and (e): These maps include both the Westerbork and Effelsberg data. There is no trace of any "bowl" like feature, but there is a slight hint for large scale, low brightness emission. Panels (c) and (f): These maps include the Westerbork data and are corrected using the Fourier fitting method. Only a slight hint of a "bowl" like feature can be seen in the crosscut plots.
(Some movement of features in 5 years)
M31* BLACK HOLE CANDIDATE VARIES FROM <10 TO \sim 30 \mu Jy IN TIMESCALES OF DAYS CURRENTLY TAKES ABOUT 4 DAYS TO GET THE NECESSARY 48 HOURS OF VLA TIME FOR AN ACCURATE MEASUREMENT BY WHICH TIME, IT HAS ALREADY VARIED
Figs 1a–1d. From (a) it can be seen that the instrumental polarization does not exceed about 0.2% of the peak temperature in these observations. For (b) the unlabelled contours show only the source position (see text).
LONGER SPACINGS

NEED TO SEE THE FAINT FINE STRUCTURE ON TOP OF THE SMOOTH EMISSION
This is often the part that matches the optical and x-ray images.
How small can magnetic field structures be?
Is this where all the action is?

NEED IMAGES AT MULTIPLE FREQUENCIES
Spectral indices.
Faraday rotation.

PROBLEMS
Bandwidth synthesis only works for relatively simple sources.
Cannot do for sources which have spatially changing spectral indices with several power laws or curved continuum spectra.
Cannot do for Q and U maps with variable Faraday rotation across the band.
Extended sources affect the confusion limit worse than points.

CONCLUSIONS
The best possible image at each frequency seems to be more important than ones with identical spacings.
Need as many stations at the correlator will allow.
They can be individually small and many can tap into one fiber.
Fig. 4. Hα emission from IC 443 superposed as a grey scale on the 18.4 cm B + D total-intensity radio contours. Peak intensity in the radio = 2.65 \times 10^5 Jy/sr. Contour levels: (0.25, 0.50, 0.75, 1.0) \times 3.3 \times 10^5 Jy/sr. Grey scale has a dynamic range of 2.5:1. Line at \( \alpha = 06^h 14^m 43^s \) is an artifact.

Mulfon et al. (see page 1352)
For the optical filaments, this picture works well. Basically, the thickness of the filaments is the recombination/cooling length of the shocked clump gas. The recombination/cooling length in the nonequilibrium region in a shocked clump can be estimated using the model of Seab and Shull (1985), as shown in Fig. 3 of the paper by Shull and Draine (1987). This model, however, describes a shock with a speed of 100 km s$^{-1}$ into a preshock density of $n_e = 10$ cm$^{-3}$. To correct for a shock speed of 70 km s$^{-1}$ and a preshock cloud density of $n_e = 50$ cm$^{-3}$, we use the work of Shull and McKee (1979), which shows that $\tau_{cool} \propto n_e^{-1}$ and is only weakly dependent on shock speed. Assuming that the cooling length is the region over which the temperature of the shocked cloud gas falls significantly below $10^3$ K, we estimate that $\tau_{cool} \approx 600$ yr and $d_{cool} \approx 10^7$ cm. For the optical filaments at least, the picture is a consistent one—the hot,

<table>
<thead>
<tr>
<th>Filament</th>
<th>Peak surface brightness (mJy beam$^{-1}$)</th>
<th>FWHM (arcsec)</th>
<th>Peak surface brightness (normalized to a)</th>
<th>FWHM (arcsec)</th>
<th>Peak surface brightness (normalized to a)</th>
<th>FWHM (arcsec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0.052 ± 0.004</td>
<td>4.7 ± 0.2</td>
<td>1.0 ± 0.04</td>
<td>4.4 ± 0.2</td>
<td>1.0 ± 0.04</td>
<td>4.4 ± 0.2</td>
</tr>
<tr>
<td>b</td>
<td>0.043 ± 0.006</td>
<td>4.1 ± 0.2</td>
<td>0.53 ± 0.04</td>
<td>4.6 ± 0.2</td>
<td>0.34 ± 0.04</td>
<td>4.3 ± 0.2</td>
</tr>
<tr>
<td>c</td>
<td>0.030 ± 0.006</td>
<td>4.4 ± 0.2</td>
<td>0.62 ± 0.06</td>
<td>4.6 ± 0.2</td>
<td>0.60 ± 0.06</td>
<td>4.9 ± 0.2</td>
</tr>
<tr>
<td>d</td>
<td>0.031 ± 0.012</td>
<td>4.4 ± 0.6</td>
<td>0.34 ± 0.06</td>
<td>4.3 ± 0.2</td>
<td>0.31 ± 0.06</td>
<td>4.1 ± 0.2</td>
</tr>
</tbody>
</table>
N 19 Area – ATCA w/ PSPC contours

- SNR Designations in B1950 (Mathewson et al.; Rosado et al.)
- SNR Designations in J2000 (current work)

ROSAT PSPC contours at 2, 4, 8, 16 sigma over background, assuming Poisson statistics.
RA, DEC, FREQ = 0.48 00 00, -73.14 00 00, 2.38000000E+00 GHz at pixel (1025.00, 1025.00, 1.00)
Spatial region: 1.1 to 2048.2048
Pixel map image: noisy13l (smcl) Min/max = -3.625x10^{-3}/3.842x10^{-3} Range = -10^{-3} to 5x10^{-3} JY/BEAM (lin)
RA, DEC, FREQ = 0:48:00.000, -73:13:59.99, 2.396605768+00 GHz at pixel (1025.00, 1025.00, 1.00)
Spatial region: 761,820 to 1261,1320
Pixel map image: 13r.clip.pbc (smc1) Min/max = -1.961×10^-3/0.01666 Range = -10^-3 to 0.01 JY/BEAM (u.a.)
SUMMARY

SENSITIVITY: 0.1 mJy

FREQ RANGE: NONE DECADE WITHIN 300 MHz - 30 GHz

RESOLUTION: 0.1 arcsec - 1 degree or spacings of meters to hundreds of km depending on frequency full coverage

POLN PURITY: BETTER THAN 1% OVER FULL FIELD OF VIEW

YESTERDAY ABOUT ⅓ DOZEN PEOPLE ASKED FOR 10 OF THE 100 AVAILABLE BEAMS. IF ONLY A FEW MORE PEOPLE DO, THE OTHER 40 PEOPLE HERE WILL BE IN FIERCE COMPETITION FOR BEAM 101. CAN ONLY BE DONE FOR AN ARRAY LOADED DIPOLES OR OMNIS - NOT DISHES