EVLA Phase II
Scientific Overview

Michael P. Rupen
New Mexico Array

• Three arrays in one:
  – NMA+VLA: more than just dots
    • Milliarcsecond imaging of thermal sources
      – Rms 20-40 K from 2-40 GHz, with resolution 6-60mas
    • 0.1 arcsecond imaging of 10 µJy sources at 1.5 GHz
  – Joining the VLA and the VLBA
    • High-fidelity imaging from a few mas to ¼ degree
    • Identical uv-coverage from 0.3 to 45 GHz
  – A stand-alone instrument
    • Sensitivity of current VLA, with 10x the resolution
    • Always available!
NMA Science: novae

• Imaging every nova in the Galaxy, within a few days of the explosion:

  \[ \Theta = 0.57\text{mas} \left( \frac{v}{1000} \right) \frac{t_{\text{day}}}{d_{\text{kpc}}} \]

  \[ \rightarrow \text{Evolution from optically thick to thin} \]
  \[ \rightarrow \text{Mass estimates} \]
  \[ \rightarrow \text{3D temperature/density distributions} \]
NMA Science: nearby galaxies

- Resolve UCHII s throughout M31/M33 ($\Theta=0.03\text{pc}$)
- Map Tycho/Kepler analogues in M81/M82 ($\Theta=0.1\text{pc}$)
- Image $>50$ star clusters in the Antennae ($<10\text{pc}$ resolution)
• Distinguishing AGNs from starbursts:
  – HII regions have $T_b < 10^5$ K
  $\Rightarrow$ sources $> 3.3$ mJy which aren’t resolved by the NMA, must be AGN

• 1 kpc $> 0.1 - 0.15$arcsec at all z
  – $\Theta = 0.125$arcsec at 1.5 GHz !
• Ubiquity of jets
• Monitoring: continuous multi-freq. coverage
• Quiescent source imaging
• Check jet “prejudices” (one-sided, flip-flopping, pattern speeds, orientations)
NMA Science: AGNs

• Spectral index imaging
• Milli-halos
• Small-scale diffuse emission (central starbursts?) (cf. Mrk 231)
Low frequencies offer:

- Long-lived electrons → relics & halos
- High-z sources (radio continuum, HI, OH)
- Free-free & synchrotron-self absorption
- Faraday rotation & scattering (scale as $\nu^{-2}$ & $\nu^{-4}$)
Relics and Halos

Abell 754

NGC 253
High-z Steep-Spectrum Sources

Figure 2.1 Spectral index against redshift (left) for two flux-limited samples (3CR and MRC) illustrating the spectral index-redshift relation and two USS samples (4C and the WN/TN sample), illustrating the effectiveness in finding very high redshift objects from such samples. The star denotes the newly discovered radio galaxy 0924-2201. A Keck I LRIS spectrum of TN J0924-2201 is shown on the (right). The emission line has been identified with Ly$\alpha$, indicating that this galaxy has a redshift of z=5.19.
Redshifted HI: EVLA vs. GMRT

- Assuming no evolution:

### Number of Galaxies Detected in 400 hrs
(dV=150 km/s, S/N=5)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Redshift</th>
<th>EVLA Cass Focus</th>
<th>EVLA Prime Focus</th>
<th>GMRT</th>
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### Number of Galaxies Detected in 2700 hrs
(dV=150 km/s, S/N=5 over line)

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<th>EVLA Prime Focus</th>
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Low-Frequency Science

Damped Lyα Systems:
HI absorption

• Opacity & optical $N_H \rightarrow T_{\text{spin}}$
• 21cm profile $\rightarrow$ gas kinematics
• NMA $\rightarrow$ image absorption
  $\rightarrow$ rotation curves!
Low-Frequency Science

ISM Polarimetry

• Linearly polarized signals are rotated during ISM propagation
  – Faraday rotation goes as $\lambda^2$
  – See detailed structure of ISM
  – Sensitive to very small fluctuations

• Trace regions of turbulence, e.g. near supernova remnants

• Monitor polarization for time variability
  $\Rightarrow$ track size scales, velocities in ISM
Low-Frequency Science

Extragalactic sources
Diffuse emission
SNRs
H II regions

Michael Rupen
EVLA Phase II Definition Meeting
E Configuration Science

- Surface brightness sensitivity
  - Factor 1.5-2 in speed vs. tapered VLA/D (factor 56 vs. untapered)
- Image quality
  - Denser uv-coverage $\rightarrow$ lower sidelobes at low resolution
  - Fidelity improved by factor $\sim 7$ (Holdaway 1996)

$\Rightarrow$ Mosaics would be faster & produce superior images
E Configuration Science

Mapping (mosaicing) speed for $\sigma_T = 1$ K, $\delta v = 0.8$ km/s

- Unique combination of resolution, mapping speed, and fidelity
- Especially important for spectroscopy of thermalized lines
The Local HI Web

• Theory + opt. studies suggest there should be a “web” of low column density gas joining nearby galaxies.

• A deep (2700hr) integration with VLA/E would yield an rms of $3 \times 10^{15} \text{ cm}^{-2} (dv=1 \text{ km/s})$
Large-scale Mosaics

Galactic chimney GSH277+0+36
Large-scale Mosaics

High-density ridges of ammonia in Orion
Conclusions

• Phase I brings all the radiation home, with sufficient spectral resolution to use it
• Phase II…
  – provides resolution commensurate with the improved sensitivity
  – builds on the success of the 74 and 330 MHz systems, to create a truly flexible & high-resolution low-frequency array
  – turns the VLA into a high-fidelity mosaicing instrument