Wide-field VLBI imaging of M31 nearby galaxies

Megan Argo
ASTRON

Image courtesy Gedas (http://gedas.me/), used with permission
18 hours, 11,000 exposures
Credit: K. Gordon (U. Arizona), JPL-Caltech, NASA

330 individual images
100' by 50' (200,000 by 100,000 ly)
Credit: NASA/Swift/Stefan Immler (GSFC) and Erin Grand (UMCP)
Existing radio surveys

**Fig. 4.**—Contours of radio-frequency flux observed near the source in Andromeda with a 2-degree beam. (1 unit = $10^{-25}$ watts/square metre/c.p.s. $\lambda = 1.89$ metres.)

The contours do not represent the absolute intensity of the radio flux at each point. As explained in the text the gradient of background flux in declination has been removed and the contours show the intensity for each point above the background flux at $00^h 40^m$ R.A. The gradient of background flux in right ascension has not been removed and therefore distorts the contours.

The broken line shows the outline of the nebula derived from a photograph.

**Ordinates:** Declination (degrees north).

**Abscissae:** Right ascension (1 division represents 10 minutes).
Existing radio surveys

VLA B-, C- and D-configs, 10 pointings, 5”, 30μJy/bm

Braun 1990 ApJS 72 761
Existing radio surveys

VLA D-config, 7 pointings, 20cm, 45'', 75\,\mu\text{Jy}/bm
Observations

- VLBA single pointing, 8 hours, 4 IFs, 16 MHz, nodding to J0038+4137 (~1°), observed July 4th 2010
- EVN four pointings spaced 7.5', 8 hours, same phase cal, observed June 7th 2010
- Sensitivities: see right and Morgan, J., 2010 PoS(10th EVN Symposium)091
- First-look at the VLBA data
Where to correlate?

- Catalogues from NED (inc. NVSS + Beck and Braun sources)
- 1533(!) objects within ~0.5° of the VLBA pointing centre
- Reject anything unlikely to be radio bright
- Reject duplicates
  → List of 192 sources for a first pass
Targeted phase centres (first pass)

- EVN targets
- VLBA targets
The (VLBA) story so far

- Baseband data (~15TB) shipped to Curtin, loaded onto cluster
- Correlated at 192 phase centres with DiFX (128 ch/IF)
- Flagging and calibration (mostly) on dataset correlated in Socorro
- Pipelined calibration and imaging of each new dataset
- Image out to several arcseconds
Calibration and pipeline

- Pipeline* applies flagging and calibration carried out using dataset correlated in Socorro
- Calibration follows standard recipe for VLBA datasets
- Mostly works
- Flagging is not perfect – some bad data may remain

*thank goodness for ParselTongue
Detections?
Detections!
10 above $8\sigma$ ($\sim 5\%$)
Detections!*

- **4145+2623**
  - NVSS: 5.2mJy
  - BA097: 1mJy (~5σ)
- **4251+2633**
  - NVSS: 24mJy
  - Beck98: 22mJy
  - BA097: 2mJy
- **4218+2926**
  - NVSS: 372 mJy
  - Beck98: 307mJy
  - BA097: 1mJy + 2mJy

* as of the EVN Symposium last September
## Detections!

<table>
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<tr>
<th>Name</th>
<th>Peak flux</th>
<th>NVSS</th>
<th>36W</th>
<th>37W</th>
<th>GLG</th>
<th>$\alpha(1412:610)$</th>
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<td>4251+2634</td>
<td>15.9</td>
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<td>-0.8</td>
</tr>
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</table>

NVSS: VLA 1.4 GHz (Condon et al 1998)
36W: Westerbork 1412 MHz (Walterbos et al 1985)
37W: Westerbork 610 MHz (Bystedt et al 1984)
GLG: VLA 325 MHz (Gelfand et al 2004 & 2005)
4251+2634

SNR/PWN/ESE candidate in GLG...

70xCrab (radio)
0.1xCrab (X-ray)

Need higher resolution imaging to confirm...
4251+2634

SNR/PWN/ESE candidate in GLG...

70xCrab (radio)
0.1xCrab (X-ray)

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4218+2926

- Brightest VLA source in the field.
- MERLIN phase cal.
- VLBA detection – multiple components.
4218+2926

Plot file version 1 created 15-OCT-2011 18:56:16
CONT: 4218+292 IPOL 1640.427 MHZ 4218+2927 ICL

Plot file version 2 created 09-FEB-2011 10:58:06
CONT: 1668.009 MHZ 8460.100 MHZ 14939.900 MHZ 1610.489 MHZ

Cont peak flux = 8.9992E-08 JY/BEAM
Levs = 8.9992E-08 (1, 2, 4, 8, 16)
What next?

- More sources with refined (in-beam?) calibration
  - Follow up detected sources
  - Mostly AGN candidates so far
- EVN re-correlation
  - Now complete, but not processed
- Ultimately image the entire field
  - Image and search for sources
  - Compare overlapping regions
What next?