Radio Interferometers Around the World

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A somewhat biased view of current interferometers

• Limited to telescopes that exist or are in the process of being built (i.e., I am not going to talk about SKA).
• Will only talk about one millimeter telescope, ALMA
  – There are others the SMA, KARMA etc..
• Will have a slight emphasis on NRAO telescopes mostly because that is what I know the most about and I want to encourage you to apply for them.
• Only include ones I remember, so I could be missing a few.
Telescopes that exist: General interest for the most part

- Westerbork Radio Synthesis Array (WRST)*
- Australia Telescope Compact Array (ATCA)
- Giant Metrewave Radio Telescope (GMRT)
- Expanded Very Large Array (EVLA)*
- eMerlin*
- Very Long Baseline Array (VLBA)*
- Other VLBI arrays*

* Currently in the process of being upgraded
WRST

• Located in the Netherlands
• 14 x 25 meter antennas arranged on a 2.7 km East-West line
  – 10 fixed 4 can be moved
• Observes between 3.5-92 cm
• Upgrade called Apertif
  – APERture Tile In Focus
(WRST) Apertif

- Aim is to replace single pixel detector with an array
  - Focal plane array
- This turns single disk into a camera
- Enlarges the field of view
  - Increasing survey speed by a factor of 20-40
- Prototyped and funding done
- Plan to have it on sky 2012-2013
- For surveys only, data will be public
ATCA

- 6 x 22 meter telescopes located in Australia
- 5 antennas are movable on a 3km track. 6\textsuperscript{th} antenna is fixed.
- 3mm-20cm
GMRT

- 30 x 45meter antennas in India
  - 12 dishes in compact array
- Spread over 25 km in a Y-array.
- Operational since 2001 at 150, 235, 325, 610, 1000-1450 MHz.
- Largest radio telescopes at low frequencies
EVLA

- 27 x 25 meter telescopes in a Y shaped array in the USA
  - 4 configurations, $B_{\text{max}} \approx 1, 3, 11, 36 \text{ km}$
- Upgrade started in 2001, completed in 2013
  - Full frequency coverage from 1 to 50 GHz.
  - Up to 8 GHz instantaneous bandwidth, per polarization
  - $\sim 3 \ \mu\text{Jy (1-}\sigma, \text{1-Hr) point-source continuum sensitivity at most bands.}$
  - $\sim 1 \ \text{mJy (1-}\sigma, \text{1 km/sec, 1 Hr) line sensitivity at most bands.}$
EVLA (cont.)

Early Science Programs

- Open Shared Risk Observing (OSRO)
  - 258 MHz maximum bandwidth
  - 512 channels
- Resident Shared Risk Observing (RSRO)
  - Allows access to more extensive observing capabilities.
  - Participants will assist NRAO staff in expanding capabilities
  - Observing time proportional to length of residency.
  - Current RSRO bandwidth 2GHz
e-MERLIN

- 7 telescopes spread across the UK
- $B_{\text{max}} = 220\text{km}$
  - Only array with baselines of intermediate length (between EVLA-type arrays and VLBI).
- Currently being upgraded
  - New receivers
  - New correlator
  - New fiber optic links
  - 0.4 to 2 GHz bandwidths
- 1.4, 5 and 22 GHz receivers
VLBA

- 10 x 25 meter telescopes spread from Hawaii to the Virgin Islands
- Observing frequencies from 1.4-45 GHz (not continuous)
- Resolutions of 0.1-5mas
- World’s only dedicated VLBI array
- Excellent for astrometry
  - 0.02 mas accuracy routine
- Undergoing upgrade to increase sensitivity by a factor of 4
  - Should be available early next year
Other VLBI arrays: EVN, LBA

European VLBI Network
• Various telescopes in Europe
  – From 25-100 meter telescopes
• Get together a few times a year for a few weeks to do VLBI
• Leading the development of e-VLBI

Long Baseline Array (LBA)
• In Australia
• Mix of telescopes, most baselines < 1000 km
• 1 week block schedules, several times per year
• Frequencies up to 22 GHz
• Only Southern Hemisphere array
• e-VLBI development
Telescopes that are being built

- Atacama Large Millimeter Array (ALMA)
- Survey instruments:
  - Australian Square Kilometre Array Pathfinder (ASKAP)
  - Allen Telescope Array (ATA)
- Epoch of Reionization, ionosphere studies:
  - LOw Frequency Array (LOFAR)
  - Long Wavelength Array (LWA)
ALMA

• 50 x 12m antennas (up to 64)
  – plus 4 x 12m (total power)
  – plus ACA: compact array of 12 x 7m antennas
• 5000m site in Chilean Atacama desert
• A global partnership
  • North America (US, Canada)
  • Europe (ESO)
  • East Asia (Japan, Taiwan)
• Up to 15 km baselines
• Sensitive, precision imaging between 84 to 950 GHz (3 mm to 350 µm)
• Receivers: low-noise, wide-band (8 GHz)

ALMA will be 10-100 times more sensitive and have 10-100 times better angular resolution compared to current millimeter interferometers
ASKAP

- 36 x 12 meter telescopes in Australia
- $B_{\text{max}} = 6 \text{ km}$
- Observing frequency 700-1800 MHz
- Large field of view
  - Focal plane array
  - Allow fast surveys
- Similar survey speed to Apertif (in the North)
- Sensitivity $\sim 0.05 \text{ mJy/beam in one hour}$
- Operations start in 2014
ATA

- Currently 42 x 6.1 meter telescopes in US
  - Goal 350 telescopes
- Collaboration between UC Berkeley and the SETI Institute
- Log-Periodic Feed, which receives from 0.4-10GHz
- Beam forming
  - 16 pencil beams anywhere on sky
  - Can use active nulling
- Surveys and transient searches
LOFAR

• Combination of:
  – Low band dipoles, 30-80 MHz
    • 48-96 antennas/station
  – High band tiles, 120-240 MHz
    • 96 antennas/station
• 40 Netherlands and 8 EU stations
• Digital beam forming
LWA

- 52 stations of 256 phased dipoles serve as 'antennas'
- Intermediate array will have core plus 10 outlier sites
- Multi-beam, multi-frequency electronic array