The Mopra Telescope

A History, overview and future?

Jeff Hodgson, KASI, in close collaboration with
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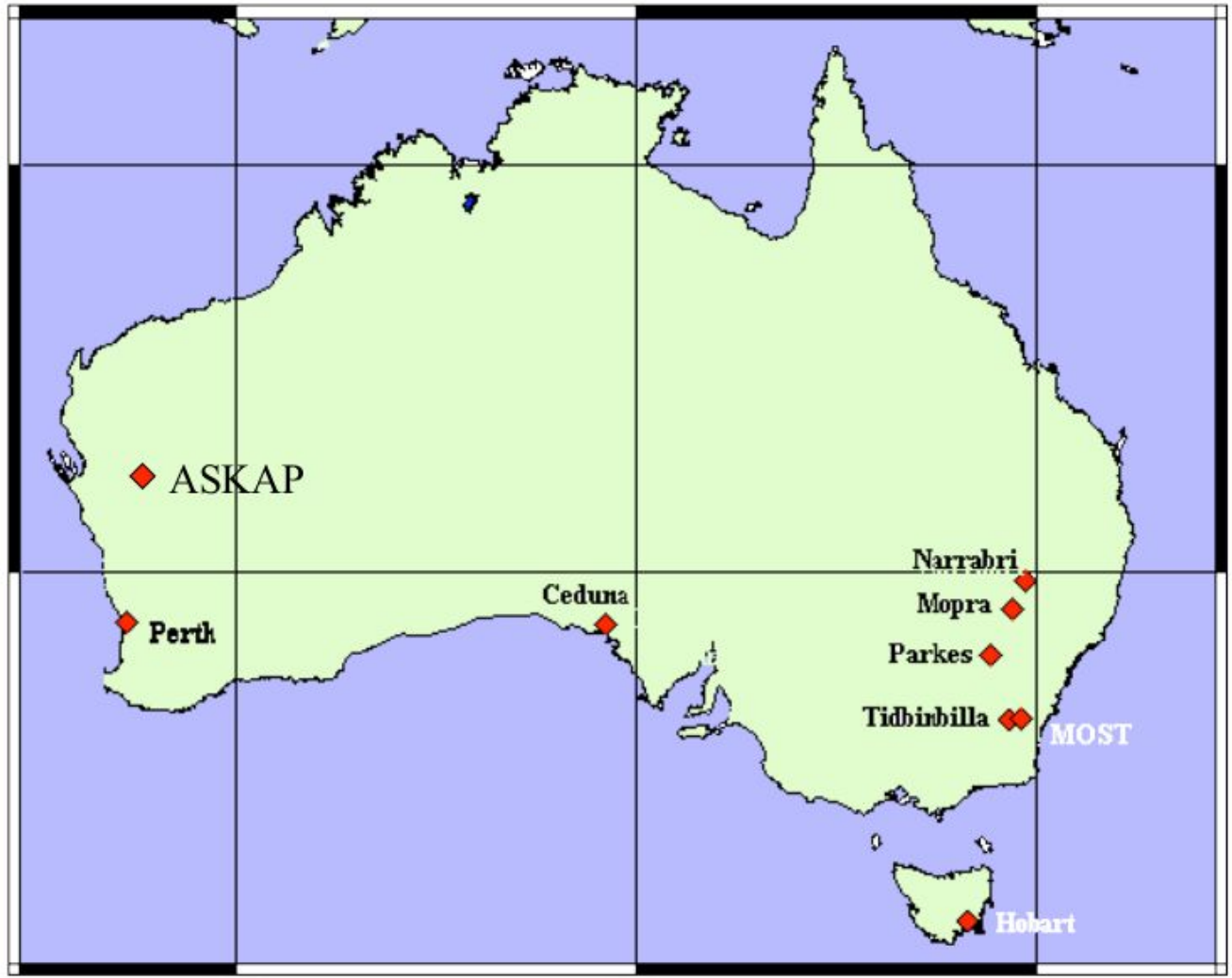
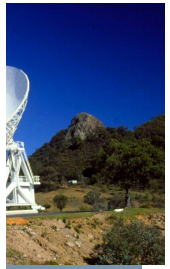
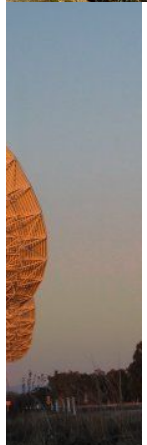
Australia's East Coast Radio Telescopes (LBA + single

ɔast
(LBA +


Coonab
Parke
Bourke
Brewarrina
Byrock
Nyngan
Nymagee
Gilgunnia
Condobolin
Lake Cargelligo
Wyalong
Leeton
Narrandera
WAGGA WAGGA
Lockhart
Urana
Culcairn
Holbrook
ALBURY


-15°
-30°
ASKAP
Perth
Ceduna
Narrabri
Mopra
Parkes
Tidbinbilla
MOST
Hobart





ATCA + Mopra = Australia Telescope

The ATCA

- 6 x 22-m Telescopes 20 cm, 13 cm, 6 cm, 3 cm, 1 cm, 12 mm, 7mm, 3 mm
- 84–105 GHz MMIC receivers at 3 mm
- Bandwidth 2 GHz, zoom modes.
- 2 Polarizations

Mopra = “7th ATCA dish”

Operates in single-dish mode

VLBI

Mopra

- 22-m Telescope
- Opened 1988 as part of the **Australia Telescope**
- 15-m inner surface suitable for 3mm
- Used for HI mapping of the LMC
- Used as part of the VLBI network
- 1994: 3 mm-wave receiver
- Not a national facility.
- 1999: UNSW takes over Mopra for 3 months each year. mm surface extended to 22 metres.
- 2004: On-the-Fly mapping.
- 2006: MMIC receiver and digital correlator.

Mopra

- 2012: Closed as National facility
- Pay for time – NAOJ, UNSW
- 2013: Bushfire!
- 2015: Last year of NAOJ Funding
- 2018: Last year of UNSW Funding
- 2019: Korea?

Mopra

- 22-m Telescope for λ > ~3mm
- 84–116 GHz (monolithic microwave integrated circuit) MMIC receiver (2.6 – 3.5 mm)
- ***36” beam @ 100 GHz***
  - η_{mb} (86 GHz) = 0.49,
  - η_{mb} (115 GHz) = 0.42
- Bandwidth 8 GHz, zoom modes.
- Velocity resolution ~ 0.1 km/s
- 2 Polarizations
- Must Nod – No chopping
- OTF Mapping
- Also 7 & 12 mm bands, plus cm C, X, L and S bands.

The Mopra Telescope is very lucky to be alive

The Mopra [redacted] be alive

The Mopra Telescope

- http://www.youtube.com/watch?feature=player_embedded&v=WlHP9J1UPrs#t=36
- Aft

&v=WlHP9J1UPrs

The Mopra Telescope capabilities

Frequency	20cm	3cm - 13 cm	3 - 12 mm
Range (GHz)	1.25 - 1.78	2.2 - 2.5 4.4 - 6.9 8.0 - 9.2	16.0 - 25.0 83.5 - 106.0
Some Examples	HI spectral line Diffuse synchrotron SNRs Maser lines Active galaxies VLBI Lunar Cerenkov	HII regions Maser lines Active galaxies SNRs VLBI	Molecular gas Thermal dust emission Maser lines Red-shifted CO Active galaxies SZ effect

Mopra Spectrometer: MOPS

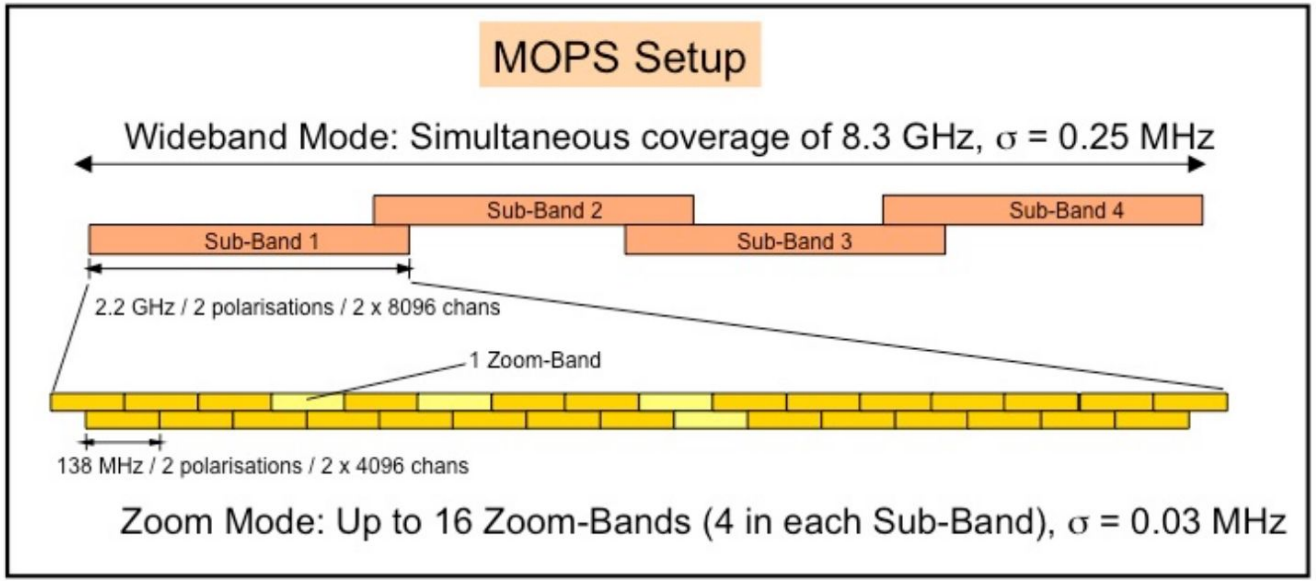
The Mopra spectrometer (MOPS) is a digital filterband.

The 8-GHz broadband signal from the receivers is transmitted to MOPS, which splits the 8-GHz IF into four 2.2-GHz channels, then down-converts and digitises the signal.

MOPS has two standard configurations:

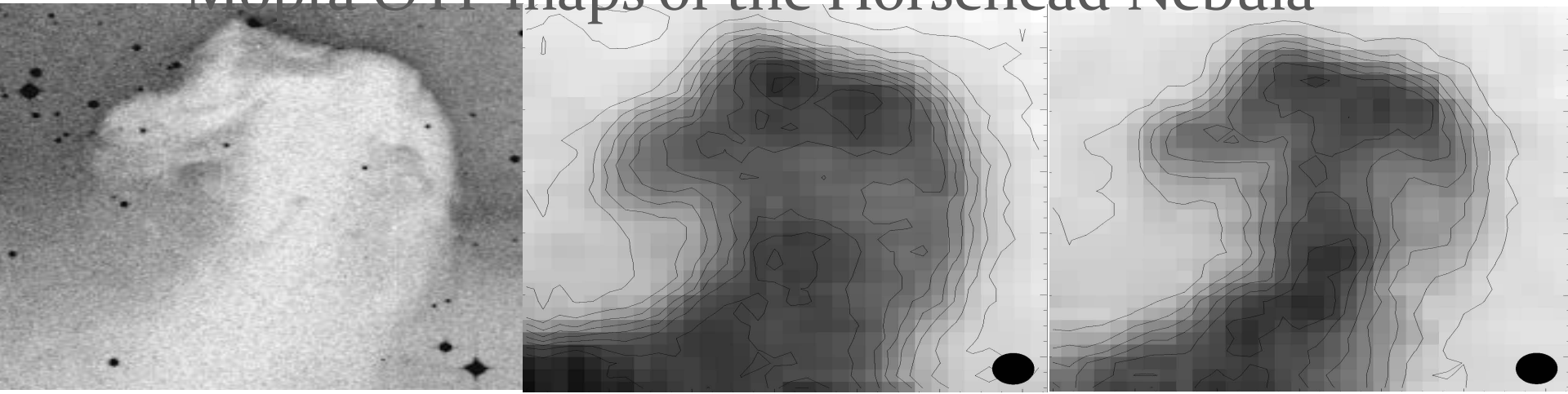
- 8 GHz BW (32384 x 0.25 MHz channels) - “broadband mode”
- 16 zoom windows within 8 GHz, each with 138 MHz BW (4096 x 0.03 MHz channels) - “narrowband mode”

Mopra Spectrometer: MOPS



	Wideband Mode		Zoom Mode	
Receiver	Bandwidth	Resolution	Bandwidth	Resolution
12-mm (22 GHz)	112 050 km/s	3.38 km/s	1 863 km/s	0.41 km/s
7-mm (44 GHz)	56 025 km/s	1.69 km/s	932 km/s	0.21 km/s
3-mm (90 GHz)	30 378 km/s	0.915 km/s	505 km/s	0.11 km/s

Mopra OTF maps of the Horsehead Nebula



Optical ^{12}CO ^{13}CO

6 arcmin

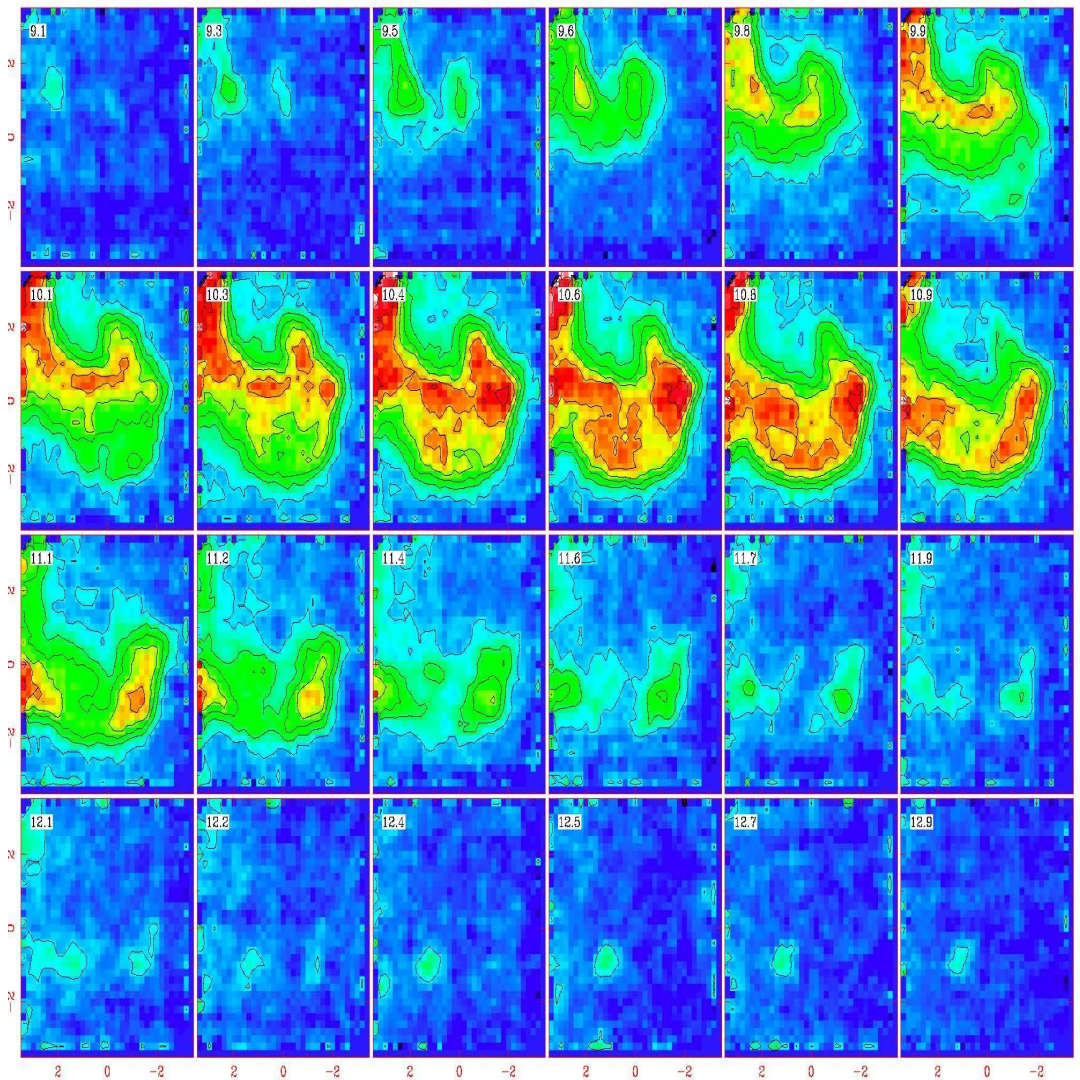
In 2004 on-the-fly (OTF) mapping with Mopra was developed by Ned Ladd and Tony Wong.

(OTF maps courtesy of Tony Wong)

OTF Mapping Specifications

- For a 300” x 300” map:
  - ~1400 spectra (31 x 46)
  - ~35” resolution
  - 0.1 km/s resolution
  - σ ~ 0.3K per channel, per beam
  - ~70 minutes / grid
  - Processed with LIVEDATA + GRIDZILLA packages
  - Now an even faster mapping CO mode available

(OTF maps courtesy of Tony Wong)



The future for Mopra

- Funding needs to be secured for 2019 onwards – currently several funding requests being prepared.
  - Linkage
  - Samsung
- VLBI is still very active using Mopra, but the Australian VLBI community cannot fund the telescope alone
- Large potential for VLBI maser surveys at 12 and 7-mm using Mopra and ATCA.
- KVN style quasi-optics conversion for Mopra?

Why should Korea care about Mopra?

- Provides a long (~8000 km) baselines extension to the KVN/KaVA/EAVN
- Thailand Telescope provides fills a nice uv-gap
- 22 GHz “sweet spot” for VLBI with East Asia?
- Currently only telescope in southern hemisphere with this set of capabilities.
  - Can see the Milky Way, small and large Magellenic Clouds, Cen A
- Completely remote operation – very efficient use of time
- Many more regions of the Southern Sky can be mapped.
- Deep molecular line surveys can be done.
  - Complements northern telescopes that Korean astronomers have access to
  - KVN, JCMT (and APEX)

Projects using Mopra

- Cosmological QUOKKAS project - VLBI from Korea to Australia to measure cosmological distances
- 100 GHz observations with SRAO?
- Measuring the cosmic ray ionisation rate (CRIR) across the galaxy
  - Measuring relative abundances of common molecules infers the CRIR because cosmic rays ionise molecules, which effects chemical reactions, compare with Gamma-rays from HESS/CTA
  - Need Mopra for Southern Hemisphere compliment to JCMT and APEX
- What else?