The Parkes Radio Telescope how technological developments have driven discoveries in radio astronomy

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Ronald D Ekers and Claire Hooker 8 Sep 2023, Florence, Italy

CSIRO SPACE & ASTRONOMY www.csiro.au



Claire Hooker & Ron Ekers

• Site of the original (1958) Parkes Telescope pegging event







Introduction

History of science tends to be history of ideas and discoveries

hence historical change is imagined in these terms

- But what would a history of science in terms of instrumentation innovations look like?
- History of radio astronomy shows that engineering innovations were often crucial drivers of scientific advances
 but they are less easily tracked historically
 they occur in unrecorded trial-and-error settings
 the people that create them are less visible in the historical record.
- This talk addresses these issues through a discussion of the Parkes radio telescope and shows how critical technical innovations played a crucial role in radio astronomy discoveries
- It is not possible to cover all such episodes

we have selected out a few cases in which technology innovations have had critical and sometimes unforeseen consequences.



Sources

We draw heavily on two publications:

Peter Robinson, "Beyond Southern Skies: Radio Astronomy and the Parkes Telescope." (1992) Cambridge University Press and

Goss, Hooker and Ekers, "Joe Pawsey and the Founding of Australian Radio Astronomy" (2023) Springer, open access

 Many aspects of historical Parkes can be explored in space and time using GatherTown:

https://gather.town/app/uUZhK6tXbUAzIRuJ/Parkes%20history





Joe Pawsey and the Founding of Australian Radio Astronomy

Early Discoveries, from the Sun to the Cosmos





The First Dish

Grote Reber Wheaton, Illinois 1937





The Parkes Dish





Bruce Thomas hybrid mode feed





The NASA Dish

Used the Parkes 64m design as prototype

Voyager

CSIRO

Cassini

Parkes Telescope

Conceived 1954

> A bigger dish than Jodrell Bank





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- Barnes Wallis
 - Invented the bouncing bomb used in WW2
 - The Master Equatorial coordinate converter





Parkes Telescope

Conceived 1954

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- Barnes Wallis
 - Invented the bouncing bomb used in WW2
 - The Master Equatorial coordinate converter
- Opened 1961 first results
 First Faraday rotation observation
 3C273 occultation
 - Discovery of quasars
 - First evidence for blackholes
 - Population of flat spectrum sources
 - Magellanic stream
 - Neutral hydrogen Streaming outside the nearest galaxies





Many different instruments and receivers all use the same expensive basic structure which has hardly changed in 60 years.

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Add an interferometer







Big dishes v Array debate circa 1957

- CSIRO split: Parkes 64m dish or a Super Mills Cross
 - > The dish will be confusion limited at low frequencies
 - At high frequencies it will only see thermal emission which is boring!
 - The array has high resolution at low frequency and you can map the distant universe

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- Bolton (Caltech and Parkes "dishmaster") build an interferometer with large dishes
 - This was the path to the VLA

- 11 Oct 2019
- IEEE President-Elect Toshio Fukuda

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Reception of First Communication to Earth from a Human Walking on the Moon, 1969

Parkes radiotelescope and Honeysuckle Creek stations in Australia received voice and video signals from the Apollo 11 moonwalk, which were redistributed to millions of viewers. Parkes' televised images were superior to other ground stations, and NASA used them for much of the broadcast. One of the first to use the newly developed corrugated feed horn, Parkes became the model for the NASA Deep Space Network large aperture antennas.

October 2019

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Bruce Thomas hybrid mode feed IEEE MILESTONE IN ELECTRICAL ENGINEERING AND COMPUTING

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Parkes Multibeam Receiver

- 21 Jan 1997
- Installing the Parkes 21cm Multibeam Receiver
- 13 beams
 - Same as having 13 64m telescopes for surveys!
- HI survey
- Pulsar survey

Parkes Multibeam Receiver

Pulsar discovery rate tripled

- Parkes Pulsar Survey
- Two neutron stars in 2.4 hour orbit
- General Relativity tested to 0.05%
 - 6 General Relativity parameters tested
 - Kramer et al (2006)

Double Pulsar Tests General Relativity

Discovery of Fast Radio Bursts

2007 discovery of the Lorimer burst

Parkes multibeam: 13 beams = 13 x FoV!

- ➤ A single beam may have never discovered the Lorimer burst, even though the s/n was huge
- ➤A new class of radio source the FRBs
- ➤A new area of astronomy
 - Msec pulses transverse the universe

➤ Would any FRBs be discovered yet!

. .

Bailes

Lorimer

McLaughlan

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Bailes

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Time after UT 19:50:01.63 (ms)

equency (GHz

Parkes Ultra Wideband Receiver

Parkes Ultra Wideband Receiver

Future - Parkes CryoPAF

- Cryogenically cooled phased array feed
- Frequency 0.7-2.0 GHz
- 98 dual polarization elements
- 1250 MHz bandwidth
- Tsys = 15K
- 72 beams
- Being installed at Parkes TODAY!

Parkes the CryoPAF engineering team The future - 72 beams

The Rainbow Dish

"My heart leaps up when I behold a rainbow in the sky."

- Willam Wordsworth

CSIRO Parkes Radio Telescope