Radio Telescopes Around the World

Lincoln Greenhill

Thirteenth Synthesis Imaging Workshop
2012 May 29–June 5
Radio Telescopes Around the World

• What drives location?
  – m/cm-wave
    • RF quiet conditions
      – e.g., the AU SKA site: 600 km into the WA desert
  – mm/submm
    • dry conditions
      – Atacama, Greenland, Antarctica, Mauna Kea
      – baloons, space
    • absent tropospheric O₂ line
  – VLBI
    • geographic distribution (diversity a/o filling)
    • super-terrestrial baselines
Radio Telescopes Around the World

CMB polarization
Kinetic SZ effect
South Pole Station
Radio Telescopes Around the World

- Telescopes at extremes
  - Antarctica:
    - Syowa, O’Higgins
  - Arctic:
    - Ny Alesund
  - VLBI stations

Radio Telescopes Around the World

Opting for Altitude

SAO Submillimeter Array
Mauna Kea (180-700 GHz)

ALMA
Atacama (84-950 GHz)
Radio Telescopes Around the World

Opting for Altitude

CSO
JCMT
Radio Telescopes Around the World

RadioAstron/Spektr-R (1-22 GHz)
10,000-390,000 km orbit
Radio Telescopes Around the World

WMAP (23-94 GHz)  Planck (100-857 GHz)  Herschel (>480 GHz)
“Radio Telescopes Around the World”

How many are there?
First stop … Google

2nd Hit

10 Spectacular Radio Telescopes around the World ~ Kuriositas
www.kuriositas.com/.../10-spectacular-radio-telescopes-around.html

Mar 24, 2012 – Radio telescopes can be found the world over. They are used in radio astronomy, the science of studying, at radio frequencies, celestial objects …
Radio Telescopes Around the World

10 Spectacular Radio Telescopes around the World

www.kuriositas.com/2012/03/10-spectacular-radio-telescopes-around.html

Take a whistle stop tour of some of the most spectacular radio telescopes in the world and find out about what actually goes on there. On almost all of the continents these giants command the landscape as they survey the skies.
Radio telescopes can be found the world over. They are used in radio astronomy, the science of studying, at radio frequencies, celestial objects such as galaxies and stars as well as more difficult to understand phenomena such as Masers and Pulsars. They also collect and track data from space probes and satellites that we have shot up in the atmosphere and space. Here are some of the more significant and - in terms of design - beautiful radio telescopes in the world.

www.kuriositas.com/2012/03/10-spectacular-radio-telescopes-around.html

Image Credit: Flickr User CHUCKage
Radio Telescopes Around the World

Now for the science - the VLA has investigated any number of astronomical issues. Radio galaxies are studied there, as are gamma ray bursts and black holes. It has also been used to receive data from the Voyager 2 spacecraft as it went past Neptune. It is something of a film star in its own right - with an impressive filmography that would induce jealousy in many an upcoming actor. It upstaged Jodie Foster in Contact and was the setting for the start of 2010. You can also see it in the sci-fi films Arrival, Terminator Salvation and Independence Day. It has even featured in a number of pop videos.

Image Credit Flikr User CPG Grey

not rec. for Rick Perley
Radio Telescopes Around the World

It operates in several modes. Normal mode is when it is properly and fully functioning. It also has a safe mode which is used for maintenance and effectively shuts the whole thing down. Finally there is snow mode which is used to combat the severe West Virginian winters. In this mode it heats up enough to melt off the snow from its structure. It has been the site of numerous discoveries, including that of three millisecond pulsars and a large magnetic field in the Orion Cluster. It also discovered a hydrogen gas superbubble (a cavity in space that can measure hundred of (light years across) over twenty three thousand light years away.
Radio Telescopes Around the World

The Lovell Telescope at Jodrell Bank

It was originally known, on its completion in 1957 as the Mark 1, but is now known the world over as the Lovell Telescope. The dish had a diameter of just over seventy six meters and it is the third largest movable radio telescope on planet earth. Amazingly, it is a symbol of recycling as well - one would imagine that these enormous beasts would have to be made from scratch. However, Britain in the 1950s was not cash rich and the motor systems of the Lovell were made from the gun turret mechanisms of two retired battleships.
Radio Telescopes Around the World

For the experts: do you recognize this antenna?

The telescope has been used to track a number of probes, including the Pioneer 5, to which it sent commands. It also tracked the soviet Luna 9 probe that landed on the moon in 1966. In an extraordinary cheeky bit of Britishness the chaps at Lovell ‘stole’ the facsimile transmissions of pictures from the moon and they were published by the British press before the Russians had a chance to release them. It has also been used for a large variety of scientific observations, including SETI and measuring the distance between bodies in the solar system.
Radio Telescopes Around the World

To give it its full name, the Parkes Radiotelethermal Telescope is the pride of Australia. It was put in to play in 1961 and has a sixty-four meter dish. Like some of the other telescopes featured here, it has also been in the movies, the most notable being The Dish, a fictional account of its involvement in relaying the images of the Apollo 11 landing on the moon around the world.

Image Credit: Flickr User TonFish

www.kuriositas.com/2012/03/10-spectacular-radio-telescopes-around.html
Radio Telescopes Around the World

Digression: what do these telescopes have in common?

Canberra 70m

Caption: CSIRO’s Parkes radio telescope. Credit: David McClunagham, CSIRO
Radio Telescopes Around the World

The heritage of a Master Equatorial

Innovative solution to a difficult engineering problem

www.jeffstanger.net
Radio Telescopes Around the World

“unusual” configurations

Nancay

transit instr.
tilting flat refl.
Radio Telescopes Around the World

“unusual” configurations
innovative solution to building $A_e$

Molonglo
steerable synthesis instr.
multiple feeds fan beam
Radio Telescopes Around the World

Northern Cross
steerable synthesis instr.
multiple feeds
fan beam
off-axis
Radio Telescopes Around the World

How many are there?
First stop ... Google

About 2,040,000 results (0.32 seconds)

1st Hit

Telescopes around the world
www.astro.uni-bonn.de/~rcbruens/links/world_map.html

Radio telescopes around the world. Click on the images to access the homepages of the telescopes.
Radio Telescopes Around the World – 40

Obvious omissions
Some additions

IVS Network
Radio Telescopes Around the World – 45

Image Gallery - World Radio Telescopes

This gallery contains thumbnail images of some of the world's most important radio telescopes. Click on an individual image for the full size version.

- VLBA Mauna Kea
- VLBA Brewster
- Owens Valley 130-ft
- VLBA Owens Valley
- DSN Goldstone
- VLBA Kitt Peak
- VLBA Pie Town
- VLA
- VLBA Los Alamos
- VLBA Fort Davis
- VLBA North Liberty
- NRAO 140-ft
- VLBA Hancock
- Haystack
- VLBA St Croix
- Yebes
- Jodrell Bank Lovell
- Jodrell Bank Mk2
- Cambridge 32-m
- Westerbork Array

mainly VLBI apertures

www.jb.man.ac.uk/vlbi/gallery/radtel.html
Radio Telescopes Around the World – 108

Some retired
Some perhaps not well instrumented
Excludes: geodetic network, VLBA, VERA, EAVN, KVN, …
Excludes: WMAP, Planck, Herschel
Excludes: imaging riometers

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>HartRAO 26m</td>
<td>Hartbeesthoek Radio Astronomy Observatory, Johannesburg, South Africa</td>
<td>26 m dish[1]</td>
</tr>
<tr>
<td>HartRAO XDIM</td>
<td>Hartbeesthoek Radio Astronomy Observatory, Johannesburg, South Africa</td>
<td>15m Experimental Demonstrator Model (originally built as a technology demonstrator for MeerKAT)[2]</td>
</tr>
<tr>
<td>Indabe</td>
<td>Durban University of Technology, Durban, South Africa</td>
<td>6 meter parabolic reflector[2]</td>
</tr>
<tr>
<td>KAT-7</td>
<td>Camarvon, South Africa</td>
<td>Seven, 12 meter dishes, measuring 1200-1550 MHz.</td>
</tr>
<tr>
<td>Meer-KAT</td>
<td>Camarvon, South Africa</td>
<td>A pathfinder for the Square Kilometre Array[3]</td>
</tr>
<tr>
<td>Precision Array for Probing the Epoch of Reionization (PAPER)</td>
<td>Camarvon, South Africa</td>
<td>Sixty-four, two-meter dishes, measuring 100-200 MHz. Currently, this interferometer has more dishes than any other.</td>
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<td>Degree Angular Scale Interferometer (DASI)</td>
<td>Amundsen-Scott South Pole Station</td>
<td>12-element interferometer measuring anisotropies in the cosmic microwave background[3]</td>
</tr>
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Radio Telescopes Around the World

• What is an imaging riometer?
  – relative ionospheric opacity …
  – low frequency array
    • 20, 30, 38 MHz
  – measures apparent changes in galactic emission due to plasma variability
  – obtain ‘quiet day’ data (a map of the galaxy) and subtract it
    • aeronomy pursues the residual
  – a curiosity from our perspective (perhaps)
    • angular resolution O(1-10°)
    • ≪300 kHz bandwidth
Radio Telescopes Around the World

South Pole Station
UMd - Rosenberg

Kilpisjarvi, Finland
Lancaster Univ.
Radio Telescopes Around the World

LWA (10-88 MHz)
Radio Telescopes Around the World

PAPER @ 25%
Radio Telescopes Around the World

MWA 25% prototype
Radio Telescopes Around the World

Hypothetical Large-N Configuration
Summary

• How many are there?
  – over 100
  – amazing
• space, ground
• mid-latitude, polar
• individual dishes, interferometers