A Brief History of Radio Astronomy

Sponsored By: New Jersey Astronomical Association

Presentation By: Ali Daneshmand

Agenda

- What Is Radio Astronomy?
- The Late 1800's
- Karl Jansky
- Post WW2 Radio Astronomy in Holmdel & Bell Labs
- Doing Radio Astronomy
- Thank You

What Is Radio Astronomy?

Astronomers around the world use radio telescopes to observe the naturally occurring radio waves that come from stars, planets, galaxies, clouds of dust, and molecules of gas.

Most of us are familiar with visible-light astronomy and what it reveals about these objects.

Visible " light – also known as optical light – is what we see with our eyes, however, **visible light** doesn't tell the whole story about an object.

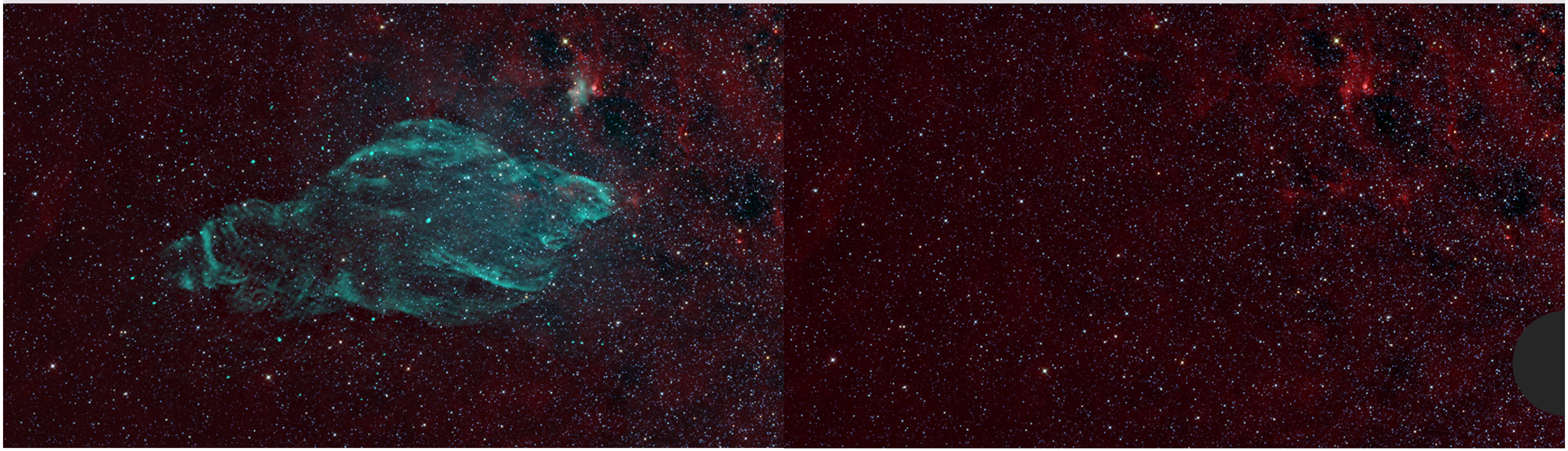
To get a complete understanding of a distant **quasar** or a planet, for example, astronomers study it in as many wavelengths as possible, including the radio range.

What Is Radio Astronomy?

There's a hidden universe out there, radiating at wavelengths and frequencies we can't see with our eyes.

Each object in the cosmos gives off unique patterns of radio emissions that allow astronomers to get the whole picture of a distant object.

Radio astronomers study emissions from gas giant planets, blasts from the hearts of galaxies, or even precisely ticking signals from a dying star.



The Late 1800's

- In the 1860s, James Clerk Maxwell's (shown on right) equations had shown that electromagnetic radiation is associated with electricity and magnetism and could exist at any wavelength.
- Several attempts were made to detect radio emission from the Sun including an experiment by German astrophysicists Johannes Wilsing and Julius Scheiner in 1896 and a centimeter wave radiation apparatus set up by Oliver Lodge between 1897 and 1900.
- These attempts were unable to detect any emission due to technical limitations of the instruments.
- The discovery of the radio reflecting ionosphere in 1902, led physicists to conclude that the layer would bounce any astronomical radio transmission back into space, making them undetectable.

Karl Guthe Janske

- Born in Red Bank, NJ
- Researcher at Bell Laboratories in Holmdel, NJ
- Karl Jansky made the discovery of the first astronomical radio source serendipitously in the early 1930s.
- As an engineer with Bell Telephone Laboratories, he was investigating static that interfered with short wave transatlantic voice transmissions. Using a large directional antenna, Jansky noticed that his analog pen-and-paper recording system kept recording a repeating signal of unknown origin.
- Since the signal peaked about every 24 hours, Jansky originally suspected the source of the interference was the Sun crossing the view of his directional antenna.

Karl Guthe Janske

- Continued analysis showed that the source was not following the 24-hour daily cycle of the Sun exactly, but instead repeating on a cycle of 23 hours and 56 minutes. Jansky discussed the puzzling phenomena with his friend, astrophysicist and teacher Albert Melvin Skellett, who pointed out that the time between the signal peaks was the exact length of a sidereal day; the time it took for "fixed" astronomical objects, such as a star, to pass in front of the antenna every time the Earth rotated.
- By comparing his observations with optical astronomical maps, Jansky eventually concluded that the radiation source peaked when his antenna was aimed at the densest part of the Milky Way in the constellation of Sagittarius

Karl Guthe Janske

- He concluded that since the Sun (and therefore other stars) were not large emitters of radio noise, the strange radio interference may be generated by interstellar gas and dust in the galaxyJansky announced his discovery in April 1933 and the field of radio astronomy was born
- He wanted to investigate the radio waves from the Milky Way in further detail, but Bell Labs reassigned him to another project, so he did no further work in the field of astronomy
- Grote Reber was inspired by Jansky's work and built a parabolic radio telescope 9m in diameter in his backyard in 1937. He began by repeating Jansky's observations, and then conducted the first sky survey in the radio frequencies.
- On February 27, 1942, James Stanley Hey, a British Army research officer, made the first detection of radio waves emitted by the Sun.[11] Later that year George Clark Southworth,[12] at Bell Labs like Jansky, also detected radiowaves from the sun.

Karl Guthe Janske

- Both researchers were bound by wartime security surrounding radar, so Reber, who was not, published his 1944 findings first.[13] Several other people independently discovered solar radiowaves, including E. Schott in Denmark[14] and Elizabeth Alexander working on Norfolk Islandy.
- At Cambridge University, where ionospheric research had taken place during World War II, J.A. Ratcliffe along with other members of the Telecommunications Research Establishment that had carried out wartime research into radar, created a radiophysics group at the university where radio wave emissions from the Sun were observed and studied.
- This early research soon branched out into the observation of other celestial radio sources and interferometry techniques were pioneered to isolate the angular source of the detected emissions. Martin Ryle and Antony Hewish at the Cavendish Astrophysics Group developed the technique of Earth-rotation aperture synthesis.

Karl Guthe Janske

- The radio astronomy group in Cambridge went on to found the Mullard Radio Astronomy Observatory near Cambridge in the 1950s.
- During the late 1960s and early 1970s, as computers (such as the Titan) became capable of handling the computationally intensive Fourier transform inversions required, they used aperture synthesis to create a 'One-Mile' and later a '5 km' effective aperture using the One-Mile and Ryle telescopes, respectively.
- They used the Cambridge Interferometer to map the radio sky, producing the Second (2C) and Third (3C) Cambridge Catalogues of Radio Sources

Post WW2 Radio Astronomy in Holmdel & Bell Labs

- Grote Reber [shown in image on the left] was inspired by Jansky's work and built a parabolic radio telescope 9m in diameter in his backyard in 1937.
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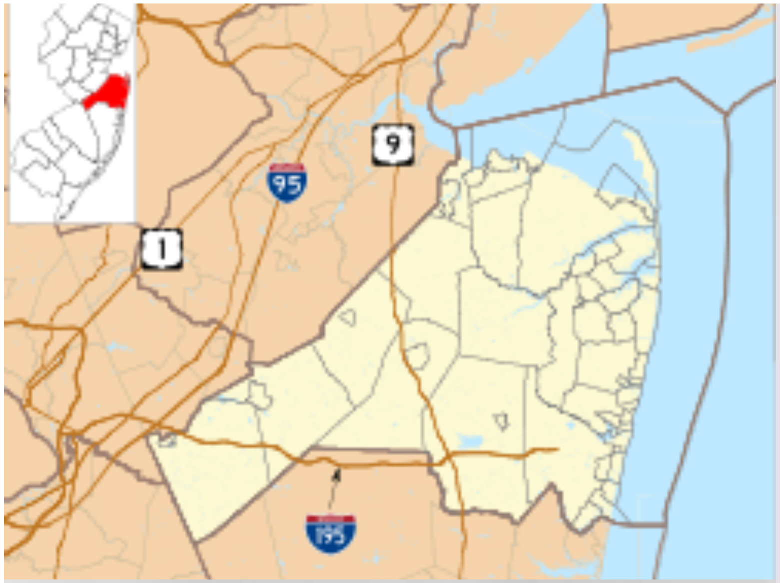
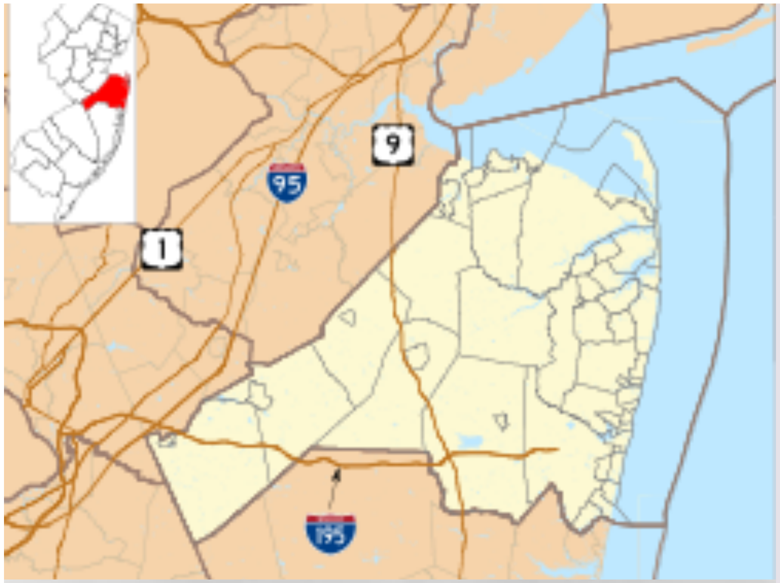


Post WW2 Radio Astronomy in Holmdel & Bell Labs

- The horn antenna at Bell Telephone Laboratories in Holmdel, New Jersey, was constructed in 1959 to support Project Echo, the National Aeronautics and Space Administration's passive communications satellites,[8][5] which used large aluminized plastic balloons (satellite balloon) as reflectors to bounce radio signals from one point on the Earth to another
- The antenna is 50 feet (15 m) in length with a radiating aperture of 20 by 20 feet (6 by 6 m) and is constructed of aluminum. The antenna's elevation wheel, which surrounds the midsection of the horn, is 30 feet (10 m) in diameter and supports the weight of the structure by means of rollers mounted on a base frame. All axial or thrust loads are taken by a large ball bearing at the narrow apex end of the horn.
- The horn continues through this bearing into the equipment building or cab.



Post WW2 Radio Astronomy in Holmdel & Bell Labs

- The triangular base frame of the antenna [bottom image] is made from structural steel. It rotates on wheels about a center pintle ball bearing on a turntable track 30 feet (10 m) in diameter. The track consists of stress-relieved, planed steel plates individually adjusted to produce a track that is flat to about 1/64 inch (0.4 mm). The faces of the wheels are cone-shaped to minimize contact friction. A tangential force of 100 pounds (400 N) is sufficient to start the antenna rotating on the turntable. The antenna beam can be directed to any part of the sky using the turntable for azimuth adjustments and the elevation wheel to change the elevation angle or altitude above the horizon

- Except for the steel base frame, which was made by a local steel company, the antenna was fabricated and assembled by the Holmdel Laboratory shops under the direction of Mr. H. W. Anderson, who also collaborated on the design. Assistance in the design was also given by Messrs. R. O'Regan and S. A. Darby. Construction of the antenna was completed under the direction of A. B. Crawford from Freehold, Monmouth County, New Jersey

- A plastic clapboarded utility shed 10 by 20 feet (3 by 6 m) with two windows, a double door, and a sheet-metal roof, is located on the ground next to the antenna. This structure houses equipment and controls for the antenna and is included as a part of the designation as a National Historic Landmark. The antenna has not been used for several decades

Doing Radio Astronomy

The radio portion of the electromagnetic spectrum can come from energetic objects and processes in the universe as well as cold, dark objects that emit no visible light.

Because different wavelengths are given off by different objects, radio astronomers use a variety of methods and instruments to detect them.

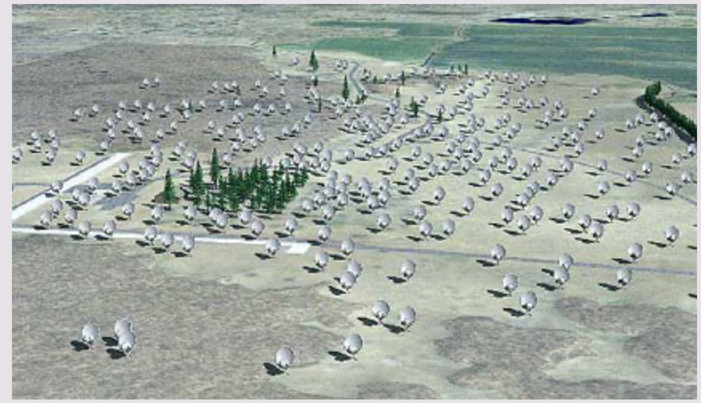
One type of instrument is a large antenna that looks like a satellite TV dish. It's called a radio telescope.

While single-dish radio telescopes are essential, NRAO's telescopes consist of many dishes linked together in giant arrays to gather detailed radio images of distant objects.

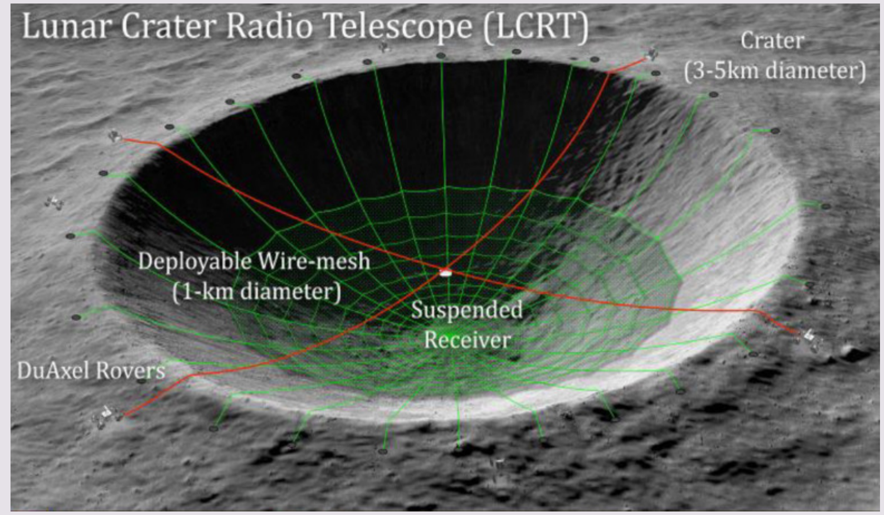
Doing Radio Astronomy

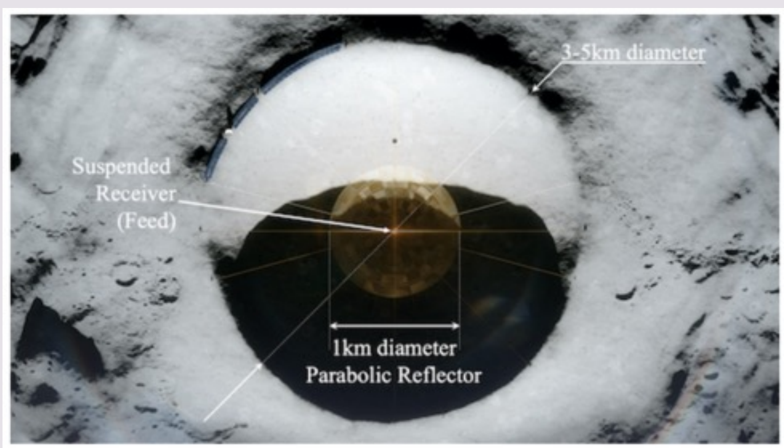
- While radio telescopes don't take pictures in the same way that visible-light telescopes do, the radio signals they detect are converted into data that can be used to make images.
- Radio astronomy data streams are brought together and processed in a supercomputer.
- The output can be turned into images that are colored in different ways to show characteristics of the object such as its temperature, "clumpiness", or the strength of radio emissions from different regions.
- The resulting images let scientists and the public see the otherwise invisible radio objects.

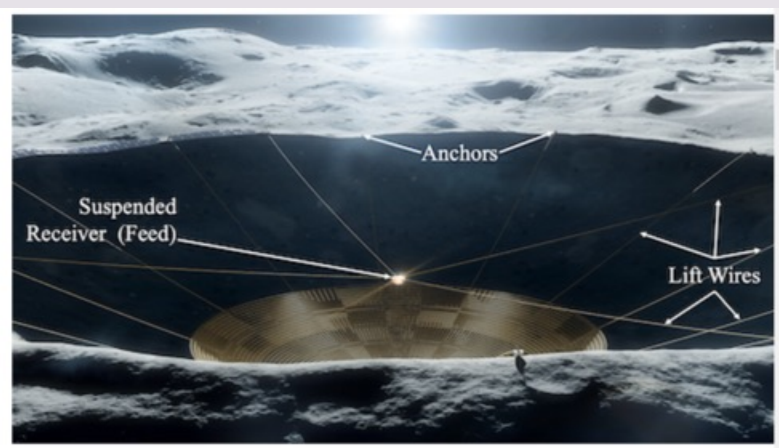
Doing Radio Astronomy



Doing Radio Astronomy







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