Radio waves

Radio waves are very long-wavelength light. Astronomers study radio waves to learn about topics as varied as our own sun, the center of the Milky Way, and the expansion of the universe. Radio waves come through our atmosphere and measurements can be made even when it’s cloudy out.

Historical importance of radio waves

Although radio waves were intentionally produced by scientists beginning in the 19th century, it wasn’t until the 20th century that scientists first noticed that radio waves are emitted from astronomical sources. In 1932, a Bell Laboratories engineer named Karl Jansky was investigating problems in overseas telephone static. He noticed a source of radio waves that appeared regularly once a day. He correctly guessed that these waves were coming from stars. Specifically, he determined the source of the radio waves to be the center of the Milky Way galaxy. The field of radio astronomy was born but not yet fully appreciated.

A high-point in the history of radio astronomy was a discovery by Penzias and Wilson. In 1963, Penzias and Wilson were trying to pin down the source of radio wave interference. Everywhere they looked in the sky, they found the same pervasive radio wave “static.” They tried everything they could think of, but they could not eliminate the effects of the static. Legend has it that they even cleaned pigeon droppings out of the dish to see if it would improve their results. What seemed like misfortune turned out to be fortuitous—the background noise was actually a remnant from the Big Bang called cosmic background radiation. For this discovery, Penzias and Wilson shared the Nobel Prize in physics.

Radio wave sources and what we learn from them

In the 1950’s, radio astronomers used the fact that hydrogen is the main element in the galaxy to determine the shape and motion of the galaxy. Neutral hydrogen emits radio waves when the electron in the hydrogen changes to a lower-energy configuration (this is called spin-flip). The radio waves coming from stationary neutral hydrogen have a very specific frequency. When the hydrogen is moving toward us, the frequency is higher. When it is moving away from us, the frequency is lower. This phenomenon is called the Doppler Effect. Using this information, the galaxy can be mapped. Some stars in the galaxy move toward us and some move away. In general, it was discovered that most objects in the universe are moving away from the earth. This is strong evidence for the expansion of the universe.

In the late 1960’s, periodic bursts of radio waves were noticed. Since these sources pulsed radio waves at us regularly, they were named radio pulsars. It was determined that pulsars are neutron stars (extremely dense, dead stars) that are spinning and emitting radio waves along their magnetic axes (see picture below, taken from NASA’s website). As a result, the emission frequently sweeps past us and we notice a burst of radio waves.
Pulsars are like lighthouses—they are only detectable when the beam of light sweeps past the observer.

In the 1970’s, carbon monoxide radio emission was discovered. Carbon monoxide helps astronomers locate molecular clouds, the birthplaces of stars.

**Current and future experiments**

The very large array (VLA) in New Mexico is a premier site for radio astronomy (see picture below). It is also the only site that can boast that Jodie Foster filmed much of the movie Contact there. The VLA uses the technique of interferometry. Many dishes are used and the interference patterns of the waves received from all the dishes are studied.

LOFAR (low frequency array) is an experiment set to begin taking data within the next ten years. It is an array of multiple antennas that also use the technique of interferometry. LOFAR intends to study radio waves with very low frequencies. LOFAR scientists are hopeful that they can contribute to diverse areas such as extrasolar planet discovery and cosmic ray airshowers.

**For more information . . .**

1) [http://imagers.gsfc.nasa.gov/ems/radio.html](http://imagers.gsfc.nasa.gov/ems/radio.html)
This is quite possibly the best site for a simple and interesting explanation of what radio waves are and how they’re used.
2) [http://www.astrocappella.com/songs.shtml](http://www.astrocappella.com/songs.shtml)
This site has a catchy, astronomically correct song about radio astronomy. Lyrics are included. The song is titled “Cosmic Radio Show,” but there are many great other astronomically correct songs (including one with music written by Cyndi Lauper).

3) [http://faculty.erau.edu/ericksol/projects/universe/kelly/niestzck_paper.html](http://faculty.erau.edu/ericksol/projects/universe/kelly/niestzck_paper.html)
This site details the discovery and importance of radio waves.

4) [http://www.aoc.nrao.edu/intro/](http://www.aoc.nrao.edu/intro/)
An introduction to radio astronomy by the National Radio Astronomy Observatory.

5) [http://www.radiosky.com/faq.html](http://www.radiosky.com/faq.html)

6) [http://imagine.gsfc.nasa.gov/docs/science/know_l1/pulsars.html](http://imagine.gsfc.nasa.gov/docs/science/know_l1/pulsars.html)
A NASA site focusing on neutron stars and pulsars.

**Sources**