Topic Page: radio astronomy

Definition: **radio astronomy** from *The Penguin Dictionary of Science*

The study of radio-frequency emissions from astronomical objects, such as stars or ➤radio galaxies. ➤Radio telescopes are used for the observations, which extend to the sub-millimetre range (➤microwaves) as well as radio frequencies as normally defined. A low ➤signal-to-noise ratio is inevitable in such observations, and substantial effort goes into the processing of experimental results.

Image from: **pulsar This schematic illustration of a pulsar...** in *Astronomy Encyclopedia*

Summary Article: **radio astronomy**
From *The Columbia Encyclopedia*

study of celestial bodies by means of the electromagnetic radio frequency waves they emit and absorb naturally.

Radio Telescopes

Radio waves emanating from celestial bodies are received by specially constructed antennas, called radio telescopes, whose use corresponds to that of the optical telescope in observing visible light. In the most common design, a parabolic “dish” replaces the mirror of the reflecting optical telescope. This dish serves to focus the radio waves into a concentrated signal that is then filtered, amplified, and finally analyzed using a computer. The radio signals received from outer space are extremely weak, and long observing times are required to collect a useful amount of energy. Therefore, most radio telescopes are mounted so that they can automatically track a given object as its position changes because of the rotation of the earth.

Galactic Sources of Radio Waves

Naturally occurring radio emission from the sky was accidentally discovered in 1931 by Karl Jansky. An inexplicable source of radio noise was identified in 1940 by Gröte Reber, using a radio telescope in the backyard of his home, as originating from our own galaxy, the Milky Way. This radiation is spread over a wide band of radio frequencies and originates in the ionized interstellar gases surrounding hot, bright stars. In these so-called H II regions, free electrons emit radio waves when they are scattered by collisions with the heavier ions. Other sources of radio waves within our galaxy are the remnants of supernovas, or exploding stars. The most famous example of a supernova remnant is the Crab Nebula in Taurus.

Because there are strong magnetic fields (see magnetism) in the vicinities of supernovas remnants, an additional mechanism is present for producing radio waves. This is the synchrotron radiation emitted by energetic electrons as they rapidly spiral around the magnetic lines of force, instead of simply being deflected by collisions with ions.

A third source of radio waves within our own galaxy consists of the atoms and molecules in the interstellar matter. This radiation is at discrete frequencies instead of over a broad band, or continuum, of frequencies. The first of these “radio lines” to be discovered was the line at a wavelength of 21 cm produced by the hydrogen atom (as opposed to the hydrogen molecule, which is composed of two atoms). The intensity of this line in the radiation from a given region is a direct measure of the amount of hydrogen there. Because hydrogen is a major constituent of the interstellar medium, the 21-cm line has provided astronomers with a means of mapping the spiral structure of the Milky Way. The visible

light is blocked off by the same interstellar material in which the hydrogen giving rise to a 21-cm line lies, so that the view of the galaxy is obscured in certain directions, particularly in the direction of the center of the galaxy. Thus, before the advent of radio astronomy, the spiral structure of the Milky Way had not actually been observed but was only inferred from comparison with the Andromeda Galaxy and from other indirect studies. Besides atomic hydrogen, certain simple organic (carbon-based) molecules, including cyanogen (CN) and formaldehyde (H_2CO), have been discovered in the interstellar medium by means of their radio lines.

Extragalactic Sources of Radio Waves

Radio waves also come from outside the Milky Way. These extragalactic radio sources have great implications for cosmology, the theory of the overall structure of the universe. Spiral and barred spiral galaxies, such as the Milky Way, are only weak sources of radio waves, but certain giant elliptical and irregular galaxies emit more than a million times as much radio energy as ordinary galaxies. Such galaxies are usually marked by dust lanes, which are unusual for galaxies lacking spiral arms. Some of these objects can be detected only by their radio emission, but in other cases the position of the radio source has been determined accurately enough to allow astronomers to identify the radio source with a galaxy visible in an image taken with a large optical telescope.

Other radio sources were optically identified with what at first appeared to be faint blue stars. However, it was discovered that these “stars” had enormous red shifts (shifting of the spectral lines toward the red end of the spectrum) that implied, according to Hubble's law, that they were the most remote objects ever detected and that their intrinsic intensities were about 1000 times greater than an entire galaxy. These extraordinary objects were named quasi-stellar radio sources, which was soon shortened to quasars. Their nature is still not completely understood.

Many thousands of extragalactic radio sources are known. Of those optically identified radio sources, roughly one third are quasars, and the remainder are radio galaxies. In addition to these localized radio sources, there is uniform low-level radio noise from every direction in the sky. This cosmic background radiation is believed to be an indication that the universe began with an explosive big bang rather than having always existed in an unchanging steady state. More recently radio astronomy has discovered pulsars, thought to be rapidly spinning neutron stars that radiate bursts of energy on and off regularly between 1 and 30 times a second.

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