Radio Astronomy for Amateur Astronomers

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4.1. Introduction

Radio astronomy, which is concerned with the analysis of high-frequency radiation arriving on the Earth from distant parts of the Universe, is still a very young branch among the astronomical sciences. Although originally discovered by K. JANSKY in 1930, the importance of this extra-terrestrial radio radiation became apparent only in the years 1940–1944, when a completely new way was opened up for the exploration of astronomical objects. Compared with the intensity we are used to in broadcasting and television, the radiation from cosmic radio sources is very weak; furthermore, special arrangements are necessary to achieve a sufficient resolution in direction. This requires in many cases very large receiving aerials and very powerful receiving instruments. Special precautions are required to achieve interference-free operation of the instruments. Practical work in radio astronomy therefore demands a large and complex instrumental outfit, and thus great financial means, quite apart from a detailed knowledge of the technique of high-frequency work. In spite of this, more and more amateur astronomers prove themselves to be well versed in electronics and high-frequency techniques. However, it has become possible to use homemade receivers with modern components that are sufficiently sensitive; many are also commercially available at quite reasonable prices. In this way, at least the strongest radio sources are now within the reach of the amateur observer. The following sections aim at giving a survey of the methods and objects of radio astronomy; Sec. 4.5 provides some indications as to the construction of simple “radio telescopes.”

4.2. Fundamentals of Radio Astronomy

4.2.1. The Electromagnetic Radiation

Electromagnetic radiation, which—apart from a few exceptions—is the only link between cosmic objects and ourselves, extends over the whole range of wavelengths of the spectrum. Our eye can only receive radiation
of wavelengths between 4000 and 7000 Angström (Å). The neighboring region toward the shortwave side, down to about 200 Å, comprises ultraviolet light; with special lenses and prisms we can manipulate this light and can photograph it with suitable plates and photodetectors. This shortwave limit is further extended by the X-ray and gamma radiation, down to the shortest wavelengths recorded up to now (i.e., about 0.01 Å). These radiations, too, act on photographic plates, but because of the extremely short wavelengths they require a completely different "optics." In the direction toward the long waves we find, first of all, the infrared light. The shortwave part of the infrared is photographically still active and can be recorded with glass optics. From then on, however, we must use photocells as detectors, and the lenses and prisms must be made of material that is transparent to infrared radiation. In a transitional range, at about 0.1 to 0.5 mm, the radiation can still be received by optical means, but at the same time by electrical receivers. If the wavelengths exceed 1 mm, the effects are mainly of an electrical nature, and suitable aerials are used. Here, too, we employ different technical tools for the reception and evaluation of the radiation, we distinguish ultrashort, short, medium, and long waves, respectively. Although the radiation detectors and the "optical" devices used in the various wavelength regions are very different from each other, it is a beautiful fact that the whole complex of phenomena can be fully and accurately described by the same fundamental laws, i.e., essentially by Maxwell's equations.

4.2.2. The Absorption of Electromagnetic Radiation

The absorption in the Earth's atmosphere is the reason why we are unable to utilize the whole range of wavelengths, as long as we observe from the Earth's surface. The various atmospheric gases absorb in very different parts of the spectrum. The superposition of all these effects makes our atmosphere opaque for most rays; it is transparent only in two relatively narrow regions. The classical range lies between about 3000 and 10,000 Å. These limits, particularly the upper one, are not very well defined; bright objects like the Sun can still be observed between the spectral bands of water vapor until up to about 100,000 Å. The shortwave limit is due to the content of ozone in the air; in the far ultraviolet, the Rayleigh scattering is dominant, which increases inversely to the fourth power of the wavelength. In the infrared, the absorption is due mainly to water vapor and reaches far into the millimeter-wavelength range. Radio astronomy has only become possible because there exists a second transparency range in the atmosphere, namely, between about \( \lambda = 1 \) cm and \( \lambda = 30 \) m. Its upper limit is determined by the conditions in the ionosphere. This particular layer has no uniform structure, but rather consists of different layers of appreciable ionization, the lowest of which is at a height of about 100 km, but reaches up to 500 km and higher. Within these layers, the atmospheric gases (\( \text{N}_2 \), \( \text{O} \), and \( \text{N} \)) are ionized by the ultraviolet and high-energy particles radiated from the Sun; the degree of ionization therefore varies with the intensity of this excitation. It shows daily