Chapter 1
Introduction to Radio Astronomy and Radio Telescopes

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ABSTRACT

Radio astronomy studies the physics and chemistry of cosmic sources and cosmic phenomena at the radio wave spectrum. Radio telescopes are built to detect radiation within this spectrum. This chapter provides a historical walkthrough on the development of radio astronomy and radio telescopes. Significant discoveries and works pioneered by scientists in radio astronomy are highlighted. Nobel laureates who have led to groundbreaking contributions in this field are listed.

INTRODUCTION TO RADIO ASTRONOMY

Astronomy is the branch of science which studies the physical and chemical properties of cosmic sources and phenomena. It applies the laws of physics and chemistry in an attempt to explain the behavior of these sources and phenomena. Being one of the oldest fields of science, the history of astronomical study can probably be dated back to as early as 3000 years ago, when the ancient Egyptians, Chinese, Mayans and Babylonians studied the sky by observing the stars at night with their naked eyes. The observa-

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tions were believed to serve the purposes of religious ceremonial and agricultural activities. The oldest evidence of astronomical observation is the Nebra sky disk which was found in northern Europe. The 30 cm circular bronze disk is believed to be constructed in the 1600s BC. Images of the sun, crescent moon, and stars were engraved on the disk. Hence, most conjectured that the disk is an instrument once used for astronomical purposes.

Although Galileo Galilei was not the inventor of optical telescopes (the invention of which is credited to German-Dutch spectacle-maker Hans Lippershey, Dutch spectacle-maker Zacharias Janssen, and Dutch lens-maker Jacob Metius), the Italian astronomer and physicist was known to be the person who has enhanced the design of the optical telescope so that it was sophisticated enough for astronomical observation. Being the pioneer of astronomical observation in the modern era in early 1600s, Galileo earned himself the name "the father of observational astronomy". Since the advent of optical telescopes, a wealth of information related to cosmic sources and events – particularly those in our solar system have been discovered.

The optical telescope, however, renders limitations. The signals detected by the optical telescope are only restricted to those within the visible region of the electromagnetic spectrum. It is to be noted that cosmic sources, such as stars, galaxies, planets, quasars, pulsars, etc. do not only radiate naturally occurring signal within this region; important spectral and spatial information is also found in the radio wave region. The radio image of the Centaurus A galaxy at 1.4 GHz is depicted in Figure 1 (Feain, Cornwell, Ekers, Morganti, & Junkes, n.d.). Since radio waves can penetrate molecular dust clouds and that cosmic sources emit more radio waves than visible light, the detection of signals in the radio wave region very often unravels information failed to be accounted for by the visible light. The signal emission detected from the dust clouds in the interstellar medium (ISM), for example, allows astrophysicists to study the physical and chemical conditions during the formation of a star. Also, the cosmic microwave background (CMB) radiation, which is believed to be the remnant of the Big Bang, consists of information of the early universe when it was merely 375,000 years old (Planelles & Biffi, 2017). Studying cosmic sources at radio waves therefore opens the realm of radio astronomy.

Radio telescopes, which consist primarily of a parabolic reflector antenna, a receiver, a detector circuit, amplifiers, and a data processing unit, are built to detect radio waves. Figure 2 depicts the structure of a 70 m radio telescope antenna at the Canberra Deep Space Communication Complex (CDSCC) (Kerton, 2009). Since the wavelengths of radio waves are larger than the visible light, i.e. larger than 1 mm, the size of a radio telescope is much larger than its optical counterpart. As a matter of fact, the larger is the size of the parabolic reflector antenna, the higher is the sensitivity and resolution of the telescope. This is to say that, if the antenna is to collect more energy radiated from a faint object or to resolve very close objects, then the reflector of which has to be sufficiently large.

HISTORICAL HIGHLIGHTS OF RADIO ASTRONOMY

The history of radio astronomy has gone a long way since the framework of electromagnetism was formed more than 100 years ago. In this section, the work and discovery made by the pioneers of radio astronomy throughout all these years are progressively highlighted.