CHAPTER I

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CHAPTER I

INTRODUCTION

1 - COSMIC RADIO NOISE

Cosmic radio noise was discovered in 1932 by Karl G. Jansky\(^1\) of the Bell Telephone Laboratories in the course of observations of the direction of arrival of atmospherics. His observations on 20 Mc/s showed that in addition to atmospherics, there was a steady source of radio waves in the direction of the Milky Way with a pronounced maximum near the centre of the galaxy. Jansky's work was followed up by Grote Reber\(^2,3,4\) who carried out galactic surveys on 160 and 480 Mc/s. In 1946-47, Hey, Parsons and Phillips\(^5\) and Bolton and Stanley\(^6\) discovered the existence of discrete sources of radio noise. Cosmic radio waves are composed of different distinct types of radiation: a hydrogen line emission restricted to a narrow frequency range (Ewen and Purcell\(^7\)) near 1420 Mc/s, and emission of a broad spectrum extending over practically the whole of the radio frequency range and arising both from temperature radiation and from synchrotron radiation. The continuous radiation from the milky way is similar to random noise and is unpolarised. The radiation from discrete sources show marked fluctuations both in intensity and direction. These fluctuations are analogous to the twinklin
of stars and have been shown to be caused by irregularities in the ionosphere. Radio observations are now extensively employed to study both galaxies and discrete sources. Radio waves have an advantage over light in such studies, because they are not absorbed by dust-clouds of interstellar space.

2 - APPLICATION OF COSMIC RADIO NOISE FOR IONOSPHERIC STUDIES

Since cosmic radio waves have to pass through the atmosphere before they reach the earth, they are subject to deviation and absorption in the atmosphere. The atmosphere may be considered to be partially transparent from about 20 Mc/s to 3000 Mc/s. At the lower frequencies the ionosphere can modify the intensity by absorption, scattering, and emission and by producing divergence or convergence of beams. From the point of view of astronomical studies, these effects are an inconvenience as they complicate the interpretation of observations. But from the standpoint of geophysics they provide a means for studying the terrestrial ionosphere. The method supplements the usual techniques of studying the ionosphere by echo sounding, in that the waves pass through the whole of the ionosphere, including the part above the level of maximum ionization of the F2 layer.
3 - SUMMARY OF THE IONOSPHERIC STUDIES USING COSMIC-NOISE METHOD

In one of the earliest observations of cosmic radio noise on 20 Mc/s Jansky noticed that during the day, the intensity of cosmic radio noise was lower than that during night and he attributed this to ionospheric absorption. In 1949, a series of observations were made at 18.3 Mc/s in Australia. He measured the intensity of cosmic radio waves from the zenith over a substantial fraction of the year. During this interval, different parts of the sidereal sky passed overhead at different times of the day, and so under different ionospheric conditions. Shain observed that the intensity for any part of the sky was high when the critical frequency of the F2 region at the time in question was less than 9 Mc/s. If it exceeded this figure, the observed intensity showed a progressive decrease. Although the ionospheric attenuation was small under certain conditions, it could be measured without difficulty. Mitra and Shain made a detailed study of ionospheric absorption on 18.3 Mc/s at Hornsby (lat. 34°S, long. 151°E). They showed that the total attenuation could be divided into two components one, a symmetrical day-time effect with maximum at about noon, which they attributed to absorption in the D-region, and the other an absorption in the F2-region. The observations of the so-called D-region absorption showed diurnal and seasonal variations similar to those observed by other methods. The F2-absorption depended on the critical
frequency of $F_2$ but not on the height of base of the $F_2$ layer. They noticed an excess of night-time $F_2$-attenuation over daytime attenuation for the same value of the critical frequency of the $F_2$-region and attributed it to the scattering of radio waves by the irregularities in the electron distribution in the $F_2$-region. On comparing the curves of $F_2$-absorption, they found that the measured absorption increased more rapidly with $f_0F_2$ than what was expected on theoretical grounds.

Blum and others\textsuperscript{10}, working on 29.5 Mc/s, at Marcoussis (lat. 48°58'N, long. 2°12'E) found that the absorption varied linearly with $f_0F_2$, while according to Mitra and Shain a curvilinear relation held good. At these temperate latitudes the total absorption of extra-terrestrial signals received from the zenith at frequency 18.3 Mc/s was of the order of 0.5 to 2 db, of which approximately 1 db took place in the D-region at noon. There was a dependence on solar zenith angle with exponent 'n' equal to 1.1 in summer, 0.9 in equinoxes and 0.5 in winter at 18.3 Mc/s. At 29.5 Mc/s at Marcoussis, the total zenith absorption rarely exceeded 0.5 db with a maximum of about 0.2 db assignable to the D-region.

Warwick and Zirin\textsuperscript{11} analysed the diurnal variation of cosmic noise of 18 Mc/s at Colorado. Their absorption data did not allow them to separate the D-region absorption from the absorption produced by other layers of the ionosphere.
Therefore they used the absorption recordings to study the electron-density of the D-layer as a function of local time and height of the D-region and derived the vertical distribution of the ionizable constituent, which is supposed to be nitric oxide. From these studies, Warwick and Zirin came to the conclusion that the recombination coefficient within the D-region was either constant or increased with height.

In high latitudes, Little and Leinbach\textsuperscript{12} have been working on 65 and 30 Mc/s in Alaska. This work is still in progress and is mainly concerned with polar blackouts associated with geomagnetic storms and visible aurorae. Little and Leinbach\textsuperscript{13} have devised an instrument called a riometer (relative ionospheric opacity meter). They have discovered the interesting phenomenon of "Pre-SC polar cap blackout", which is caused by low-level ionospheric ionization produced by low energy cosmic rays emitted by the sun at the time of some flares. These particles are of intermediate energy between primary cosmic rays and the particles responsible for geomagnetic storms and arrive at the earth within a few hours after the onset of the solar flare.

In tropical latitudes, the study of ionospheric absorption of radio waves has not received much attention. There are only a few observations made with conventional pulse-techniques at Singapore, Ibadan and Delhi. Until quite recently, no observations on the measurement of ionospheric absorption using extra-terrestrial radio noise were made in low latitudes.
SCOPE OF THE THESIS

Using the opportunity of the IGY, the Department of Atmospheric Physics of the Physical Research Laboratory, Ahmedabad (lat. 23°02'N, long. 72°38'E), India, which had been maintaining an ionospheric research station at Ahmedabad, started ionospheric absorption measurements using cosmic radio noise on 25 Mc/s as the extra-terrestrial source of radio waves.

The cosmic radio noise recording equipment on 25 Mc/s was designed and constructed by the author in 1956 under the guidance of Professor K.R. Ramanathan and has been maintained to date without any serious gaps. The records have proved very valuable for studying various aspects of ionospheric physics. Among the problems studied are:

a) the diurnal and seasonal variations of total ionospheric attenuation; and its analysis into a daytime component and a component associated with the F-layer,

b) sudden ionospheric disturbances (SID's) associated with solar flares. These show up as sudden cosmic noise absorptions on the cosmic noise recordings (SCNA's), and

c) changes in the ionospheric attenuation during geomagnetically disturbed periods.
The thesis embodies the results of the study of the above-mentioned features obtained from cosmic noise records of Ahmedabad collected during the years 1956 to 1959, a period of high solar activity. Some of the points that have emerged from these studies have been published. The second chapter contains a brief background discussion of ionospheric absorption and an outline of the methods of measuring absorption and summary of the results of measurements of ionospheric absorption obtained with different techniques. In the third chapter, the experimental setup at Ahmedabad is described. The subsequent three chapters are devoted to the presentation and discussion of the experiment results.