Short Communications

Ionospheric Absorption on 2.4 MHz at Waltair

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Results of a preliminary investigation on the 2.4 MHz radio wave absorption in ionosphere using the Al technique, are presented. It has been found that the diurnal variation parameter n (cos χ index) has a wide range of values from 0.3 to 1.5 with a mean of 0.62 ± 0.003 (p. e.). The cos χ index n is found to have significant positive correlation with the Zurich sunspot number. The noon-time absorption values show large day-to-day variation and have a positive correlation with sunspot number. The seasonal variation of the monthly mean noon-time absorption indicates an increase in equinoctial months.

THE study of absorption of radio waves reflected from the E-region is of particular value for a clear understanding of the structure of the lower ionosphere. While considerable information based on extensive studies[1–4] at high latitudes is available on the ionospheric absorption, studies on absorption at low latitudes are comparatively few. According to the magnetoionic theory of radio wave propagation in the ionosphere, the absorption index (K) of a wave is given by

$$K = \frac{2\pi e^2}{\mu mc} \frac{N\nu}{\nu^2 + (p \pm p_L)^2} \quad ...(1)$$

where μ is the real part of the complex refractive index, e and m are respectively the charge and mass of the electron, ν the collisional frequency, p the angular frequency of the wave and p_L the longitudinal component of the angular gyrofrequency. The overall absorption that a radio wave experiences is measured in terms of the apparent reflection coefficient given by

$$\rho = \frac{I_1}{I_0} = \exp\left(-\int kds\right) \quad ...(2)$$

where I_0 and I_1 are the amplitudes of the transmitted and the reflected waves respectively. Eq. (2) can be written as

$$-\log_e \rho = \int Kds \quad ...(3)$$

Thus, an evaluation of the apparent reflection coefficient is all that is required for estimating the overall absorption. The experimental technique used is the conventional vertical incidence pulse sounding (Al) technique. The mean of a 10-min amplitude record, recorded after suitable integration, is obtained by numerical integration by Simpson's method[5].

The preliminary results of the absorption measurements on 2.4 MHz for a period of six months (Aug. 1971 — Jan. 1972) are presented in this note. All the computations in the present analysis are done using the IBM 1130 digital computer.

Appleton[6] has shown that for a Chapman type layer, the non-deviative absorption varies with solar zenith angle χ, as

$$\int Kds \propto (\cos \chi)^{3/2} \quad ...(4)$$

But the value of cos χ exponent is found to deviate from the theoretical value of 3/2. So, most workers prefer the relationship

$$\int Kds \propto (\cos \chi)^n \quad ...(5)$$

The variation of the ionospheric absorption with solar zenith angle (χ) has been studied by many workers[7–9] using the relation

$$\log_e \rho = D \cos^n \chi \quad ...(6)$$

where $\log_e \rho$ is the absorption coefficient (ρ being the apparent reflection coefficient), and D and n are constants.

A plot of $[1+\log_{10} \log_e \rho]$ versus $[1+\log_{10} \cos \chi]$ would yield a straight line with a slope whose value is n. Using the absorption and cos χ values corresponding to hourly intervals for each day, the cos χ exponent n for the day is deduced by the method of least squares. Typical plots of diurnal variation of the absorption are shown in Fig. 1.

In Fig. 2 the percentage occurrence of the cos χ index has been shown. Although the value of n varies over a wide range from 0.3 to 1.5, most of the values are found to lie in a narrow range 0.5 - 0.7. The mean of all the observations is 0.62 ± 0.003 probable error. Mitra and Muzumdar[10] at Delhi employing a frequency of 5 MHz and Skinner and Wright[11] at Ibadan using a frequency of 2.4 MHz have reported a value of 0.62 for n and for low sunspot activity.

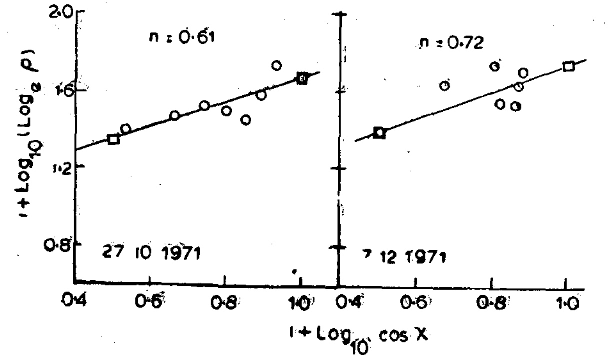

Fig. 1—Typical plots of diurnal variation of absorption at Waltair

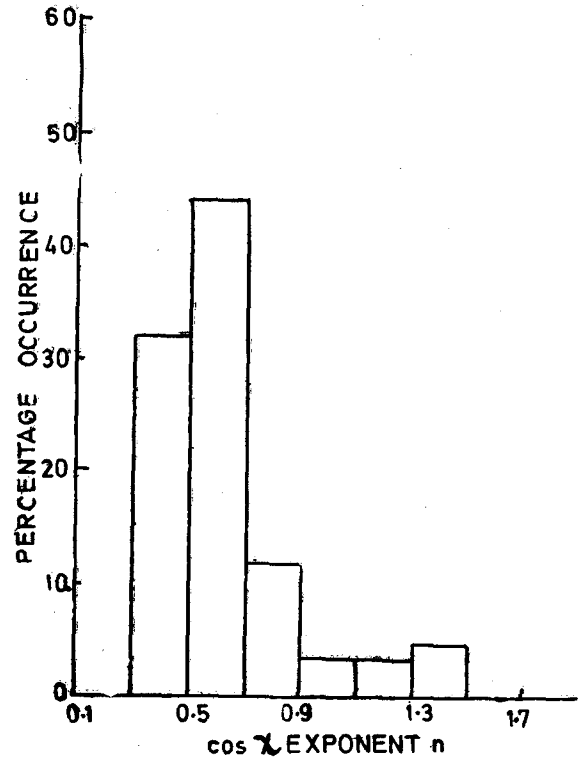

Fig. 2—Percentage occurrences of different values of cos χ index

Murthy and Rao[9] obtained a value of 0.8 for n at Waltair working on a frequency 2.0 MHz. It has been pointed out that the mean value of n decreases with decrease of sunspot activity (Rao and Rao[12]). Table 1 shows how the value of cos χ index (n) varies through the years 1958-1972 at Waltair.

In order to find out whether there is any dependence of the value of n on solar activity, the correlation coefficient is calculated between daily values of n and R_z, the Zurich sunspot number. A positive correlation coefficient of 0.28, significant at $P = 0.05$ level (Fisher[13]), is obtained. Rao[14] obtained a positive correlation for n and R_z at Waltair. The following linear relationship between n and R_z is obtained from the correlation analysis:

$$n = 0.45\,(1+0.0061\,R_z) \qquad \ldots(7)$$

A preliminary study of the noon-time absorption data, taken at local noon, shows a large day-to-day variation. An examination of Fig. 3, which shows the noon-time absorption for the month of December 1971 reveals this fact in a striking manner. A similar day-to-day variation in noon-time absorption was reported by Gnanalingam[15] and Rao *et al*[16]. These variations may probably be due to changes in atmospheric properties[15]. In order to have a preliminary study on the dependence of the noon-time absorption on solar activity, the 2.4 MHz noon-time data are normalized with respect to cos χ, taking $n = 0.62$ and the correlation coefficient with R_z is calculated. A correlation coefficient of + 0.23 (significant at $P = 0.05$ level) is obtained. This positive correlation of absorption with R_z is in conformity with similar earlier work[14].

The monthly mean noon-time absorption data are utilized to study the existence or otherwise of any seasonal variation. The total period of investigation is divided into two seasons for which the calculated values of the average absorption are as follows:

TABLE 1—VARIATION OF n THROUGH THE PERIOD 1958-72 AT WALTAIR

Period of observation	Station	Frequency employed (MHz)	cos χ index n
1958-59 (IGY)	Waltair	5.6	1.30
1962	Waltair	2.0	1.04
1963-64 (IQSY)	Waltair	2.0	1 81
1968-70 *(IGY)	Hyderabad	2.2	0.97
Aug. 1971—Jan. 1972	Waltair	2.4	0.62

*As no data on Al absorption at Waltair are available for the period 1965-71, the absorption values at Hyderabad, (which is almost on the same geographic latitude as that of Waltair (17° 43′ N), are taken as representative values for Waltair for comparison purposes.

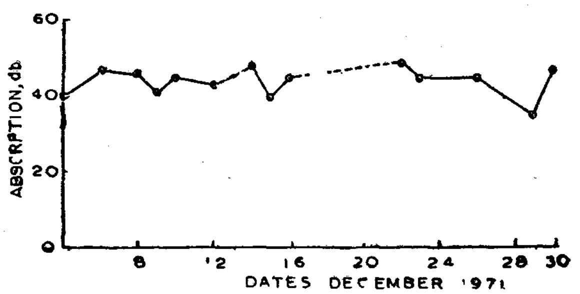

Fig. 3—Day-to-day variation of noon-time absorption at Waltair in December 1971

Season	Absorption (db)
Equinox	47
Winter	45

From an examination of the above data, although it is difficult to conclude with any amount of certainty that the absorption is more in equinoctial months, it is still worthwhile mentioning that the trend of increased absorption in equinoctial months is also evident in similar earlier studies reported by Nakaskul and Nimit[17] and Rao *et al.*[16,18].

The following conclusions are thus obtained from the present preliminary investigation: (i) The diurnal variation parameter n (cos χ index) has a value of 0.62 which is in good agreement with earlier results; (ii) A significant positive correlation is obtained between n and Zurich sunspot number R_z. The mean value n for each year is found to decrease with decrease of sunspot activity; (iii) The noon-time absorption data are found to have a large day-to-day variation. This may be due to the daily changes in atmospheric properties; (iv) The noon-time absorption has a positive correlation with R_z; and (v) A preliminary study of the monthly mean noon-time absorption indicates an increase of absorption in equinoctial months.

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Dependence of Fading Frequency on the Characteristics of Ionospheric Irregularities

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A study has been made of the relationship between fading frequency and the parameters that describe the nature and movement of ionospheric irregularities responsible for fading. It is noticed that the fading frequency is directly correlated with true drift speed and random velocity, and inversely with the structure size.

SEVERAL investigators have studied the relationship between the fading frequency of a radio wave and the horizontal drift speed of ionospheric irregularities which are responsible for the fading[1-3]. However, these studies were made using the similar fades method of analysis for deducing the drift speed from fading records. Further, Rao and Rao[2] and Kaushika[3] consistently reported a finite fading frequency even when the drift speed is zero. This feature was interpreted by Rao and Rao[2] as due to the contribution from random movements and thus suggested a verification using the correlation method of analysis. Recently, Felgate and Golley[4] applied dispersion analysis to ionospheric drift records in which the velocity varies with time, and showed

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