Around 2030 hours the latitude dependence is almost absent.

Figure 3 shows the G contours around this station that can be used to correct the first-order values of electron content for refraction effects. The second-order values of electron content may be determined from the relationship between the first-order and the second-order electron content as given by *Ross* [1965]. The second-order corrections have been found to introduce a maximum of 5% error at 40.010 Mc/s. The direction of such a correction is such as to enhance the latitude dependence of electron content between 20–32° subionospheric dip north. The G contours show a discontinuity around the transverse point (subionospheric position : 36° dip north) and, therefore, the second-order correction becomes ambiguous in this region.

Summary

The total electron content is found to exhibit a latitude dependence analogous to the equatorial anomaly in F_2 ionization. In view of this fact, it is concluded that the latitude dependence is not merely confined to F_2 peak but it is a feature of considerable height range above F_2 peak. In addition, the latitude dependence shows a diurnal variation, being most pronounced in the afternoon between 1200 and 1530 hours and least prominent in the early morning and late evening hours.

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Deduction of Electron Temperature from F-Region Component of Absorption of Cosmic Radio Noise

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In a recent paper by *Abdu et al.* [1967], the total cosmic radio absorption at Ahmedabad was divided into two components (1) a component that depends on f_0F_2 and (2) a component that arises mainly in the D region of the ionosphere. In the present note we describe the results of deduction of electron temperatures from the component of F-region absorption of cosmic radio noise recorded at Ahmedabad at 25 Mhz during 1957–1958 and at 21.3 Mhz during 1964–1965.

The method of computing the absorption due to electron-neutral particle and electron-ion collisions up to N_{max} using true height profiles of electron concentration is explained by *Ramanathan et al.* [1961] and also recently by *Abdu et al.* [1967]. Here we have applied a similar method in the topside of F region also and computed the absorption up to 1000-km altitude. It is necessary to assume a topside electron concentration model for these calculations as there are no direct measurements over Ahmedabad. Therefore we adopted the following model after careful consideration of the available literature and the Aloutte data at similar latitudes:

(1) From h_{max} to $(h_{max} + H/2)$, Chapman distribution given by $N_e = N_{max} \exp [1 - z - \exp(-z)]$ where $z = (h - h_{max})/H$ and H is the scale height of atomic oxygen.

(2) From $(h_{max} + H/2)$ to 1000 km, *Bauer's* [1962] model.

This model depends upon the relative concentrations of O^+, He^+, and H^+ ions in a ternary mixture under diffusive equilibrium. We have given in Table 1 the ratios of $n(He^+)/n(O^+)$ and $n(H^+)/n(O^+)$ assumed at 400 km for our calculations for temperatures 1000 and 1500°K. The first set of ratios was used for temperatures in the range 750–1200°K and the second between 1200–2000°K. These values are consistent with those given by *Hanson* [1964].

Because the scale height H varies directly with temperature, we assumed to start with the diurnal variation of temperature as given in Harris and Priester (HP) model appropriate to the solar activity under consideration. Diurnal curves of electron concentration distributions in the topside up to 1000 km were thus worked out for January, April, July, and September–October, representative of each season, during 1957–1958 and 1964–1965 using monthly median values of N_{max} and h_{max} and the ion density ratios give in Table 1. It may be mentioned here that the median value of h_{max} was about 375 km in 1957–1958 and 300 km in 1964–1965. The total absorption in the region 120–1000 km was then computed. The results are shown in Figure 1 for April, July, and September–October months, excluding January, as we did not have good data for that month in 1964–1965. The full curve 1 shows the F-region absorption of cosmic radio noise at 25 Mhz during 1957–1958 and at 21.3 Mhz during 1964–1965, from 0600 to 1800 hours. The broken curve 2 shows the corresponding computed values of absorption. It can be seen that there is no exact agreement between the calculated and observed absorption, the computed absorption being generally greater except for some hours in October 1958. Though the discrepancy is seen to be much smaller during 1964–1965, we found that the ratio of calculated absorption to that observed was about the same in both

TABLE 1. Ratio of Ion Species Assumed at 400 km

Temperature, °K	H, km	$n(He^+)/n(O^+)$	$n(H^+)/n(O^+)$
1000	53	2×10^{-3}	6×10^{-3}
1500	80	10^{-3}	1.3×10^{-4}

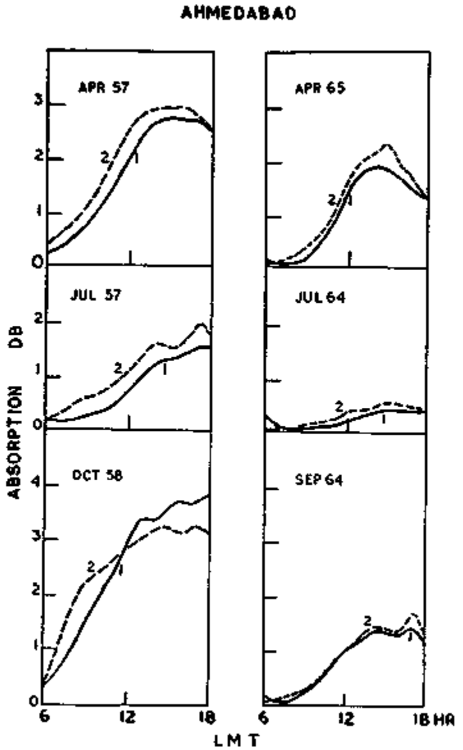

Fig. 1. Nondeviative absorption of cosmic radio noise intensity in the F region deduced from its recording at 25 Mhz during 1957–1958 and at 21.3 Mhz during 1964–1965 (curve 1) and computed as explained in the text (curve 2) for April, July, and September-October.

high and low sunspot years and was higher at 0700–0800 LMT than at any other time during day.

We next examined to see if the discrepancy could be explained by the fact that T_e is greater than T_g, which is the temperature used in our calculations. It is known from rocket and satellite measurements that thermal equilibrium between electrons and neutral gas does not exist in the F region for most of the time [*Bourdeau and Donley*, 1964; *Brace and Spencer*, 1964]. Thus it should be possible to evaluate the electron temperature that will make the observed and computed values of absorption agree within the experimental error of observation. The value of T_e was thus found by iteration with the help of an IBM 1620 computer.

Figure 2 shows the mean diurnal variation of electron temperature T_e for April, July, and September–October during 1957–1958 and 1964–1965. These temperatures represent conditions near F_2 peak since most of the absorption in the F region takes place within 2 or 3 scale heights near h_{max}. However these temperatures can also be assumed to be above h_{max} because of the isothermal nature of the tenuous plasma in the upper levels.

The two curves T_e and T_g shown in Figure 2 show distinct differences. T_e has a diurnal peak around 0800 LMT and is 2 to 3 times greater than T_g at that hour. The departure of T_e from T_g gradually becomes less and less toward noon, though T_e remains at a higher level through evening. There are some instances when T_e and T_g are both equal.

From the seasonal point of view, we notice

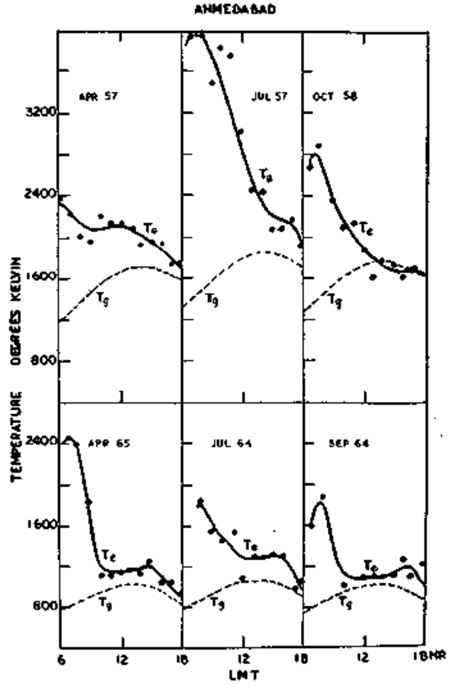

Fig. 2. Monthly mean diurnal variation of electron temperature T_e as obtained from our analysis for April, July, and September-October during 1957–1958 and 1964–1965. The broken curve T_g is the corresponding atmospheric temperature taken from HP model.

that though the morning peak in T_e is higher in July in high sunspot years and in April in low sunspot years, the afternoon T_e seems to be always greater in July than in other months irrespective of solar activity. Further analysis to determine the seasonal and solar cycle variation of T_e is in progress and will be reported elsewhere. Similar seasonal variations of electron-ion temperatures have been reported by *Schmelovsky* [1964], *Roger* [1964], and *Bhonsle et al.* [1965]. These authors also find higher temperatures in summer than in other seasons.

We have compared in Figure 3 our results with those obtained from satellite measurements. It must be remembered that the results are not strictly comparable since the measurements are made at different places and epochs. Nonetheless it is instructive to know the gross features. It can be seen that the diurnal maximum of T_e in the morning obtained from our analysis agrees

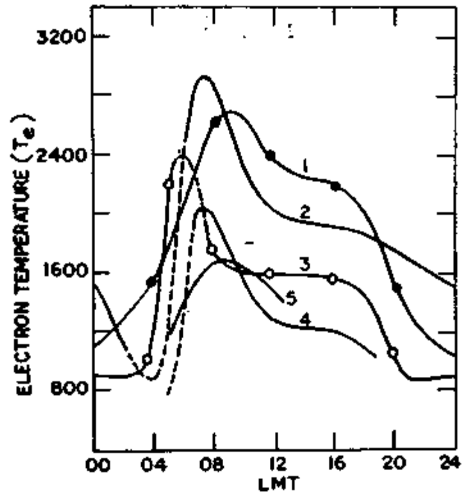

Fig. 3. Comparison of diurnal variation of electron temperature T_e deduced from cosmic radio noise measurements at Ahmedabad and that obtained from (1) Explorer 17 at high latitude during July 1963 between 250 and 400 km [*Brace and Spencer*, 1964]; (2) cosmic radio noise absorption at 25 Mhz at Ahmedabad during 1957–1958; (3) Explorer 8 at midlatitude during November–December 1960 [*Bourdeau and Donley*, 1964]; (4) cosmic radio noise absorption at 21.3 Mhz at Ahmedabad during 1964–1965; (5) Ariel 1 at temperate latitude during 1962 around 400 km [*Bowen et al.*, 1964].

well with the Explorer 8 results of *Bourdeau and Donley* [1964]. Their measurements relate to an altitude of 1000 km over 50–70°S latitude zone during 1960. Their T_e maximum appears a little earlier at 0600–0700 LMT, but such a difference can be expected if there is enough absorption of EUV radiation above 300 km to shift the T_e peak to later hours at lower heights [*Bourdeau*, 1965]. *Brace and Spencer* [1964] have reported from Explorer 17 measurements that T_e was maximum between 0900 and 1000 hours LMT in the height range 250–400 km.

We thus conclude that it is possible to get an estimate of electron temperature near and above h_{max} from the F-region component of absorption of cosmic radio noise intensity. Our results also show good agreement with in situ measurements by satellites.

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The Effect of the Filamentary Interplanetary Magnetic Field Structure on the Solar Flare Event of May 4, 1960

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Studies of solar flare effects conducted by means of the worldwide network of neutron monitors and meson telescopes have verified [see *McCracken*, 1962*a*, *b*] the general Archimedes spiral ('garden-hose') configuration of the solar magnetic field advanced by *Parker* [1958]. The recent deep space probe studies of *Bartley et al.* [1966], *Fan et al.* [1966], and *McCracken and Ness* [1966] have shown that the interplanetary magnetic field may be described in terms of a corotating population of magnetic filaments that adhere to such an Archimedes spiral on a large scale, but which may depart considerably from it on a localized scale. In such a corotating magnetic structure, low-energy (~ few hundred Mev) solar cosmic-ray particles experience very little scattering or lateral diffusion after their injection at the sun.

The extremely short-lived May 4, 1960, solar flare effect was a well-documented event with extensive coverage by neutron monitors and meson telescopes. Table 1 reviews some of this coverage, indicating the percentage enhancements above background recorded by the various detectors. Where possible, either the governing geomagnetic cutoff of the station (M) or the governing atmospheric cutoff for the particular detector system utilized (A) is also shown. The time of maximum counting rates are also indicated for some of the stations.

The May 4 event was also the only occasion for which there was any reported information on the behavior of a ground-based photon detector during a period of solar activity. These data, which were collected at Winnipeg, Manitoba (geographic latitude 49.9°N and geographic longitude 97.2°W) and reported by *Standil et al.* [1961], are listed in Table 1 and depicted in Figure 1. Also shown are the simultaneous Manitoba observations of the ground-level muon fluxes. The muon enhancements may be attributable to primary protons of energy in excess of 4 bev, while primary protons of energy as low as about 350 Mev could produce a significant contribution to the enhancement of the photon counting rates. Figure 1 also illustrates the much more sharply time-resolved 30-second counting rate of the M.I.T. meson telescope [*Palmeira and McCracken*, 1960]. These authors have indicated that the responsible proton energies were above about 6 bev.

Thus Figure 1 indicates that the high-energy protons > ~4 bev arrived at the Manitoba detector very quickly, between 1030 UT and 1045 UT (in good agreement with the M.I.T. determination of 1035 UT for maximum enhancement), while the lower-energy protons > ~350 Mev responsible for the increased photon flux arrived later, between 1045 UT and 1100 UT.

From Table 1 and Figure 1 it is therefore clear that the May 4, 1960, flare effect resulted in the production of a large range of energetic particles. Solar protons of energies > ~350 Mev resulted in the increases noted by the photon spectrometer at Manitoba. The increases in the high-latitude neutron monitors resulted from increased solar proton fluxes above 500 Mev, and the enhancements recorded by the meson telescopes were the consequence of increased proton fluxes above 4 bev. The Deep River neutron monitor data implied a particle flux of 4.5 cm^{-2} $ster^{-1}$ sec^{-1} above 1-bv rigidity. On the basis of a differential rigidity spectrum of the form p^{-4} (for stations lying inside the principal impact zones), this would suggest an integral flux above 10 bev of $\sim 3.4 \times 10^{-3}$ cm^{-2} $ster^{-1}$ sec^{-1}. (On the basis of observations made with high-latitude neutron monitors *McCracken* [1962*a*] has determined that during the time of maximum enhancement the cosmic-ray flux was highly anisotropic, the direction of maximum intensity lying approximately in the plane of the ecliptic and ~55° west of the earth-sun line.