5.0 **IEC VARIATION AND AMPLITUDE SCINTILLATION**

5.1 **Introduction:**

The ionospheric irregularities which give rise to amplitude scintillations are characterized by different ionization density from the surroundings. When these irregularities have large scale sizes and sufficient extension in altitude they may change the ionospheric electron content (IEC) or total electron content (TEC) as seen by a polarimeter (Klobuchar et al., 1978). For a given change in IEC or TEC a corresponding change in Faraday rotation (FR) is introduced in the polarimeter record through,

\[
\delta \alpha = \frac{1.699}{f^2} \overline{M} \delta N
\]

where, \( \delta \alpha \) = change in FR in degrees

- \( f \) = frequency of observation in Hz
- \( \overline{M} \) = mean magnetic field factor in ampere turn per meter
- \( \delta N \) = change in electron content in el. m\(^{-2}\).

Here it is assumed that there is no change in the value of magnetic field factor \( \overline{M} \). A positive \( \delta \alpha \) from ambient value indicates irregularities having higher ionization density while a negative change in FR indicates irregularities having depleted ionization density from the ambient value.

Association of IEC depletion with amplitude scintillations have been reported by many workers particularly from the equatorial region (Hawkins, 1974; Koster, 1976; Fremouw and Lansinger, 1977; Basu and Kelley, 1978). In the equatorial region large TEC depletions associated with amplitude scintillations are believed to be due to drifting ionospheric plasma bubbles coming in to the
raypath. TEC observations (Klobuchar et al., 1978; Yeh et al., 1979) show that scintillation patches in the early evening hours occur in association with depletions in TEC which may be as large as 40 p.c. of the ambient value. Koster (1976) reported that scintillations in the premidnight period are associated with large TEC depletions as observed from Ghana. He observed largest TEC depletions at 21:00 Hrs(LT), a time that is closely associated with the development of 'plumes' (Woodman and La Hoz, 1976) on backscatter radar maps. A more direct evidence of association of plasma bubbles with (equatorial) scintillations came from in-situ measurements by satellite probes (Hanson and Mc Clure, 1980). These measurements showed large biteouts of ion concentrations near Ascension island which is in the equatorial region, at a time when TEC depletions and scintillations were recorded on the ground. Also from topside sounder observations (Dyson and Benson, 1978), all sky imaging photometers at 6300 Å airglow (Weber et al., 1978, 1980) and backscatter radar observations (Tsunoda, 1980a), it has been noted that the topside F-region irregularities that give rise to intense equatorial scintillations, are regions of low ionization density embedded in a high density background. In the Indian sector whether in the equatorial or in low-mid latitude regions, not much work have been reported. However Somayajulu et al. (1977) and more recently Korde and Navaneeth (1983) observed certain features of TEC behaviour during VHF amplitude scintillations. Somayajulu et al. reported TEC (or more precisely IEC) enhancement by as large as 32 p.c. of the background value while observing scintillations at 140 MHz from Delhi (geomag. lat. 18.9°N). Korde and Navaneeth observed a higher decay rate of post sunset TEC in the evenings when scintillations were observed at 136MHz.
over Nagpur, a low latitude station (dip. 11.2°N). Das Gupta et al. (1983) observed Faraday Polarization Fluctuations (PPF) connected with intense amplitude scintillations at 136 MHz from Calcutta, a station near the northern crest of the Appleton anomaly region. From more eastern region (Japan), Sinno and Kan (1978) observed association of TEC depletions with deep amplitude scintillations.

In the present study attempt is made to associate IEC depletions and enhancements with amplitude scintillations at 136 MHz from simultaneous records of amplitude and Faraday rotation to understand the nature of the irregularities in the F-region.

5.2 Results:

Occurrence of scintillations, associated with IEC variations throughout all seasons are shown in Fig. 30. Daytime (0600 Hrs - 1800 Hrs) and nighttime (1800 Hrs - 0600 Hrs) hours are considered separately. A scintillation event is considered to be associated with IEC variation if detrended FR plot shows changes in the polarization phase angle by at least 0.2π radian. This amount of FR generally corresponds to IEC change of about one TEC unit i.e. 10^16 el. m^-2 (Das Gupta et al., 1982). This arbitrary scale is used through all seasons.

From Fig. 30(a), it is observed that daytime scintillation occurrence associated with IEC variation is less frequent in all seasons except in vernal equinox (it is noted that data during equinoctial months March and September are almost nil). In vernal equinox 50 p.c. of daytime scintillations are accompanied by IEC variation. In all other seasons only 25 p.c. daytime events are associated with such IEC variations. Again from Fig. 30(b) it is
Fig. 30: Histograms showing p.c. of scintillation occurrence (of total occurrence) associated (shaded) with IEC variation or without (blank) during nighttime (b) and daytime (a).
noted that majority of scintillations during nighttime occur without much change in IEC except in vernal equinox. Almost 80 p.c. nocturnal scintillation events in vernal equinox are associated with electron content variations. It has to be pointed out that most of the IEC variations are enhancements compared to few depletions.

5.2.1 IEC variation and scintillation index:

From a large number of simultaneous records, it has been observed that scintillation index (S.I.) increases with amplitude of IEC variation. Generally weak scintillations are seldom accompanied by IEC variations while strong scintillations are always associated with excess or depleted electron content. At the time of intense scintillations (S.I. > 60 p.c.) sometimes FPFs, which make it very difficult to retrieve FR data are observed. Scatter diagram Fig. 31 exhibits a somewhat linear relationship between S.I. and amplitude of IEC variation. Of course there are many well scattered data points corresponding mostly to disturbed days. It may be noted that practically no IEC variations are observed below S.I. 20 p.c. level. But even when S.I. approaches 80 p.c. level (9.5 db) IEC varies by about 20 p.c. of the background value. When even stronger scintillations are observed (very rarely) it becomes very difficult to estimate the IEC variation due to FPFs. This difficulty was faced even with less intense (S.I. ≤ 60 p.c.) scintillations on few occasions. Interestingly on few days abnormal IEC variations of significant amplitudes were observed particularly during daytime but no amplitude scintillations occurred.
Fig. 31: Scatter diagram showing p.c. of IEC variation from the background value with S.I.
5.2.2 IEC enhancements and depletions observed on few days:

Scintillation patches particularly in premidnight hours are sometimes associated with IEC depletions and on many more occasions were observed in association with IEC enhancements. Few typical and fewer unique amplitude scintillation events which were observed to be accompanied by IEC variations may be seen in Fig. 32 through 44.

Fig. 32 shows the behaviour of ionospheric electron content variation during the great magnetic storm of 20 December, 1980 during which intense amplitude scintillations were observed. It may be noted from Fig. 28 (in chapter IV) that the storm commenced at about 1100 Hrs on 19 December, 1980 and developed to its peak phase by about 0000 Hrs (LMT) with a \( D_{st} \) peak value \(-248\). The storm continued throughout 20 December before it subsided by next day. Now from Fig. 28 as well as from Fig. 32 it is seen that scintillation started after about one hour from the equatorial \( D_{st} \) peak i.e. at about 0100 Hrs on 20 December and it continued upto about 1300 Hrs. Scintillation index reached very high value (about 80 p.c. at 0300 Hrs, Fig. 28). While amplitude scintillation was observed, IEC exhibited fluctuations or abnormal trends (Fig. 32). The morning IEC build up rate from 0600 Hrs to 0800 Hrs was very high, on that day. On any ordinary day of that month e.g. on 23 December, 1980 as shown in the figure, an average post sunrise build up rate of about 4.5 TEC units per hour which commences at about 0600 Hrs to reach the diurnal peak at about 1400 Hrs is observed. Against this, on 20 December, 1980 the IEC build up rate was about 12 TEC units per hour which was about three times faster than usual. The diurnal IEC peak was lower by about 30 p.c. than
Fig. 32: Faraday rotation plot shows IEC fluctuations on 20 Dec., 1980 (---) associated with scintillations (■■■■) and range spread-F(-----). FR plot (----) on 23 Dec., 80 depicts a normal IEC behaviour.
Fig. 33: Amplitude scintillation patch (-----) observed on 5 Nov. '81 shown along with IEC behaviour(——).
Fig. 34: Faraday rotation plot (---) shows IEC behaviour on 9 Nov., '81 observed with amplitude scintillation (-----).
Fig. 35: Scintillations observed (------) on 14 Oct., 1981 associated with IEC (---) fluctuations.
Fig. 36: Scintillations (-----) associated with postsunset IEC enhancement observed on 15 Oct., 1981.
Fig. 37: FR plot showing association of IEC fluctuations with amplitude scintillations (----) observed on 22-23 Aug., 1981.
Fig. 38: FR plot showing oscillation in IEC during observation of amplitude scintillations (——) on 21-22 Aug., 1981.
Fig. 39: FR plot shows IEC behaviour during observation of scintillation (----) on 16 May, 1981.
Fig. 40: FR plot shows IEC behaviour during observation of scintillation (-----) on 23-24 May, 1981.
Fig. 41: FR plot shows IEC behaviour during observation of scintillation (SSSS) on 23-24 July, 1981.
Fig. 42: FR plot shows IEC behaviour during observation of scintillation (\text{\texttt{ssss}}) on the night of 5 - 6 May, 1981.
Fig. 43: FR plot shows IEC behaviour during the night of 4-5 Feb.,'81 in presence of scintillation patches.
Fig. 44: FR plot shows IEC behaviour during observation of amplitude scintillation (---) on 8 Feb., 1981.
normal, was attained as early as 0800 Hrs. As long as IEC was changing abnormally, moderate to intense amplitude scintillations were observed. After about 1230 Hrs i.e. when scintillations died down, the IEC maintained more or less steady value near the diurnal peak for several hours before it started to decay.

On 5 November, 1981 (Fig. 33), in the evening hours a moderate scintillation patch was observed in association with a large IEC depletion. This depletion indicated the fall in IEC in the satellite raypath by about 6 TEC units against a background of about 30 TEC units i.e. about 20 p.c. of the ambient value. It may further be noted that scintillations continued well past midnight even after IEC recovered to its near normal value at about 2000 Hrs and started decaying immediately thereafter. The diurnal peak is normally attained by about 1400 Hrs, but on 5 November, 1981 and also on few more days of the same month (e.g. 9 November, Fig. 34) IEC continued to build up even upto 1800 Hrs. From the Fig. 33 two small IEC enhancements can be observed in premidnight hours even when the decay process was in full operation. Scintillations were observed from 1800 Hrs to about 0130 Hrs.

Fig. 34 depicts an interesting diurnal IEC plot on yet another winter day, 9 November, 1981. Evening hours showed large amplitude IEC fluctuations with periodicity of about one hour and only after these fluctuations were over, weak to moderate intensity scintillations started developing. These scintillations were observed upto about midnight hour while IEC was decaying at a faster than normal rate.

Fig. 36 represents a scintillation patch associated with a typical premidnight IEC enhancement as observed on many October nights. This must be pointed out that these large IEC
enhancements which are fairly regular in appearance during equino-
xes and winter, are not always associated with amplitude scintil-
tions. From the figure it is seen that comparatively small but fas-
ter IEC changes near the secondary diurnal IEC peak correspond to
the observed scintillation patch. S.I. during that particular eve-
nt remained below 50 p.c. level i.e. below 5 dB peak to peak fade
depth. On 15 October, 1981 as seen from Fig. 36, scintillations
stopped as soon as IEC began to decay from about 2000 Hrs.

As is evident from Fig. 37 on 22 August, 1981 scintillatio-
ns started immediately after sunset and continued even after mid-
night. Almost throughout this period IEC was observed to be und-
ulating in a wave like manner while a general decay process was in
progress. The average periodicity of these IEC undulations were of
the order of two hours.

Intense amplitude scintillations observed during evening
hours of 21 August, 1981 (Fig. 38) were accompanied by relatively
very fast oscillations in IEC. This rare phenomenon continued for
about two hours during which period, scintillations of fade depth
of about 8 dB were observed with high (7-8 fades/min) fade rates.
Even after these FFPs died down gradually, amplitude scintillatio-
ns continued throughout the night with moderate to weak intensity
until it died by sunrise. In this particular event it is noticed
that before the IEC oscillations started there was nearly regular
post sunset IEC build up followed by a relatively small but disti-
nect and abrupt fall by about 2.6 TEC units at 2000 Hrs.

Fig. 39 exhibits a scintillation occurrence which was ob-
served to be associated with a simultaneous depletion in IEC in the
evening hours of 16 May, 1981. It is noticed from the figure that
IEC suddenly dropped by about 25 p.c. at about 2100 Hrs. The onset
of amplitude scintillation was almost simultaneous. Scintillations continued for a short while even after IEC recovered to a normal value at about 2300 Hrs. It is interesting to note that there were two unusual IEC variations around noon but no amplitude scintillations were observed during those periods. On many more occasions such IEC changes were observed in total absence of amplitude scintillations.

The observation of intense amplitude scintillation even during sunrise period of 23 May, 1981 (Fig. 40) was associated with abnormal behaviour of IEC as seen from this station. Magnetic disturbances on that day triggered strong scintillations in association with large amplitude TIDs just after midnight (not shown in the figure) which continued upto 0800 Hrs in the morning. From the figure it is seen that IEC at sunrise period was abnormally high \(28.7 \times 10^{16} \, \text{el m}^{-2}\), compared to a normal value of about \(10^{17} \, \text{el m}^{-2}\). An appreciable depression of IEC may be noted at 0630 Hrs i.e. after sunrise but the normal build up process was immediately resumed thereafter. Scintillations were observed with fade depths about 6 dB during those periods upto about 0800 Hrs. Towards midnight yet another weak patch of scintillation was observed but there was no abnormal change in IEC.

As seen from Fig. 41, two long duration scintillation events were observed on 23 July, 1981. The relatively short duration event that was recorded during daytime was not so intense (S.I. < 30 p.c.) and there was no abnormal change in IEC during that period. But soon after sunset strong scintillations started which continued throughout the night and even upto sunrise hour of the following day. Interestingly in the initial phase of the event unusual IEC enhancements were observed. But as the night progressed beyond
0000 Hrs strong to moderate intensity scintillations continued upto sunrise period but no abnormal change in IEC was observed.

Fig. 42 shows another periodic undulations in IEC during night hours of 5-6 May, 1981 coupled with intense amplitude scintillations. This observation was similar to the activities on 22-23 August, 1981 (Fig. 37) night. The onset time (about 2000 Hrs) and ending time (about 0200 Hrs) of these IEC undulations and scintillations were more or less same in both the cases with similar periodicity (of IEC undulations). It may be pointed out that diurnal peak IEC value on 5 May, 1981 was much higher than the monthly average value. The largest IEC enhancement observed at 2300 Hrs was of the order of 7 TEC units which was little more than 17 p.c. of the ambient value. The last and the least enhancement observed at 0130 Hrs represented excess electron content of about 2 TEC units but it constituted about 12 p.c. of the background value. When this or any other scintillation event was examined for any relationship between fade depth and amplitude of IEC change at any instant, no consistent relationship was observed. However in most cases deepest fade depths were observed only after largest IEC enhancements or depletions were over.

Long duration quasi periodic IEC undulations observed on the night of 4-5 February, 1981 (Fig. 43) reminds one of the similar events observed on 5-6 May and 22-23 August, 1981 (Fig. 42 and 37 respectively). The most visible difference this time is that the related amplitude scintillation patches were isolated showing distinct association with each IEC enhancement. Of the three enhancements in IEC the first one occurring immediately after sunset is to be considered separately since a fairly regular IEC enhancement is observed around that time in equinox as has already been
pointed out. A similar event is shown in Fig. 44 in the same month (8 February, 1981). But in this case no detectable enhancement is seen prior to midnight hour as in Fig. 43. The predawn excess electron content is more pronounced in Fig. 44 compared to Fig. 43. This is further noticed that amplitude scintillation that accompanied the first IEC enhancement in Fig. 44 continued throughout the night from 1930 Hrs to about 0400 Hrs of the following morning. As in most long duration scintillation events, towards the end the scintillation fade depth decreased gradually along with declining fade rates.

5.3 Discussion:

From results presented above some interesting features of the ionospheric irregularities responsible for causing amplitude scintillations at VHF over this region may be assessed.

Majority of scintillation events both during daytime and nighttime occur without significant IEC changes except in vernal equinox. In vernal equinox (with limited data) about 80 p.c. nocturnal scintillation events are associated with IEC variations. In summer about 47 p.c. of the nighttime scintillation events occur with FR fluctuations or abnormal IEC changes. This shows that during vernal equinox and summer, irregularities over this region have sufficient extension in altitude so as to cause appreciable change in height integrated TEC or more precisely ionospheric electron content (IEC) as may be observed by FR measurements. It is also recalled that occurrence as well as intensity of scintillation during these periods are higher compared to rest of the year. As Fig. 30 shows larger amplitude IEC correspond to stronger scintillations but during some magnetically disturbed periods,
strong scintillations were apparently associated with irregularities having marginal excess or depleted electron content from the ambient. But it has been observed, strong magnetic storms generate large amplitude irregularities causing strong scintillations as may be seen from Fig. 32. The stormtime behaviour of IEC and scintillation on 20 December, 1980 is very interesting as it was one of the strongest storm next only to 11-14 April, 1981 event. During winter scintillation is scanty particularly in daytime. But on that December day long duration scintillations were observed with remarkably high intensity even during daytime including sunrise period. The early morning steep rise in FR on 20 December, 1980 (Fig. 32) could have been due to injection of plasma from magnetosphere to ionosphere (Kane, 1976; Barbara et al., 1983) during stormtime, as such a transportation mechanism in the predawn sector of the globe can be expected. The associated intense amplitude scintillations observed from 0100 Hrs to 1300 Hrs were caused by large scale TIDs having periods 30 minutes and more. Obviously these TIDs were generated by magnetic storm related gravity waves (Georges, 1968; Yeh, 1983; Nagpal, 1983) in the auroral region which then propagated towards the equator with an average velocity about 440 m/s. But the velocity must have slowed down to about 100 m/s when these TIDs reached the subionospheric latitude (13°N) as the observed fade rate (about 4 fades/min) and an average irregularity height 350 Km would suggest. From the FR record it is seen that the amplitude of these TIDs varied in between 1-5 TEC units. When the IEC was rapidly increasing, the signature of these TIDs could not be seen in the FR record but strong scintillation patches provided clear evidence of their presence. It may be observed from the figure (Fig. 32) that after attaining the diurnal peak at
about 0800 Hrs, IEC was fluctuating due to the TIDs but also maintaining a more or less steady value which became particularly visible after 1300 Hrs i.e. when scintillations were over. It is also further noticed that this diurnal peak IEC value was about 30 p.c. less than average. Local ionograms at that time registered a large increase in F-region height, $h_pF_2$. Considering this and the significant fall in solar flux as indicated by 10.7 cm emission on that day, it is suggested that noontime ionization density at the increased height of F2 region reached a near saturation state. Obviously the vertical drift (Richmond, 1973) of the F2 layer will result in a reduced value of the magnetic field factor $\overline{M}$ which together with the reduced ionizing flux from the sun decreased the IEC peak value which remained remarkably steady throughout the sunlit hours at the subionospheric point due to near saturation ionization (as loss by recombination will be less at the increased height). Now one can explain the vertical drift of the F2 region either by accommodating a neutral wind system or a downward diffusion of plasma from protonosphere (Spurling and Jones, 1976). In the present case the dumping of charge on F-region from protonosphere cannot be accepted as the sole explanation for the lifting of the F2 layer as it would have increased the FR as seen from ground for increased $\overline{M}$ value. Then again it is difficult to ascertain the neutral wind system as the prime mechanism for the observed increase in $h_pF_2$ if Spurling and Jones model is considered. This model suggests - if increase in $f_0F_2$ and IEC lag in time behind the increase in $h_pF_2$, then neutral wind is responsible for the lifting while for downward diffusion of charges from protonosphere all the parameters vary simultaneously. But in the 20 December, 1980 event, increase in $h_pF_2$ was
found to lag behind the increase in IEC and $f_0F2$ by about 3 and 1½ hours respectively. This leads to a difficult situation if one tries to judge which mechanism was responsible or took the upper hand in lifting the F2 region. The observation of range type spread-F during onset phase of the amplitude scintillation as indicated in Fig.32, shows that spatial resonance mechanism was effective during that period which was associated with magnetic storm related gravity waves (Georges, 1968; Thome, 1968).

From Fig. 29 (Chapter-IV) it may be seen that very intense scintillations were observed almost simultaneously with the onset of the storm at about 1800 Hrs on 11 April, 1981. Thus the observation of scintillation on that day cannot be explained by TIDs generated in the auroral region and southward propagation as in the previous case. In the subsequent days i.e. on 12 and 13 April, intense scintillations were observed in the premidnight hours possibly by TIDs travelling southward (from auroral region) with average velocity 350 m/s which could have originated in the auroral region when the magnetic storm developed to two consecutive peaks at about noon hours on those days. The amplitude of those TIDs could not be measured in terms of excess electron content due to FPFs most of the time. Normally FPFs are peculiar to stations near the Appleton anomaly region (Klobuchar and Aarons, 1980; Lee et al., 1982; Basu and Basu, 1981). Das Gupta et al. (1983) reported observation of FPFs from Calcutta, a station near the northern crest of the Appleton anomaly region. They observed FPFs in association with intense amplitude scintillations when solar activity was very high (1979-1980). In this station also on very few rare occasions FPFs were observed when intense scintillations were also recorded. Lee et al. (1982) have shown that FPFs at VHF are due
to depolarization effect caused by irregularities having a power-law density spectrum with outer scale dimension in the range 50 to 200 m in the presence of high ambient ionization density. This extraordinary range of outer scale dimension indicates a situation when ionospheric irregularities may have a power-law spectrum with multiple spectral indices if one tries to explain the intense amplitude scintillations at VHF (having a Fresnel dimension about one Km at 350 Km mean height) in association with FPFs. Recent multi-technique observations in the equatorial region have shown that in the post-sunset period instabilities in the bottom side F-region lead to convective upwelling of low density plasma region resulting in formation of plasma bubbles (Basu and Kelley, 1979; Basu and Basu, 1981). The steep gradients at bubble boundaries provide a suitable condition for generation of such power-law form of irregularities possibly with multiple spectral indices (Rino, 1982) which can also explain GHz scintillations observed in the equatorial region. But such a situation seems rare over this region as FPFs and IEC depletions (associated with plasma bubbles) were observed on few occasions only over an observation period of about three years. As mentioned already IEC depletions are much less frequently observed than enhancements. But on each occasion of IEC depletions, moderate to strong scintillations were observed. The depletions never exceeded 20 p.c. of the ambient IEC value which are indeed small compared to 40 p.c. depletions introduced by huge plasma bubbles reported from equatorial region (Klobucar et al., 1978; Yeh et al., 1979). Fig. 34 exhibits such depletions in the evening hours (of 9 Nov, 1981). The electron content suddenly dropped by about 13 TEC units at about 2000 Hrs and was followed by another smaller depletion after about one hour. But during these depletions no amplitude scintillations were observed immediately.
weak to moderate scintillations followed only after these IEC variations were over. Such time difference between the two phenomena are also reported by Abdou et al. (1983) and Klobuchar and Aarons (1980) from equatorial observations. This apparent evidence of bubbles or holes at this (i.e. sub. ionospheric geomag. lat. 13°N) latitude further extends the latitudinal extent of the huge equatorial bubble formation as evidenced by Tsunoda (1980b) using steerable backscatter radar. But occasional absence of amplitude scintillations during observation of such bubbles as in the above case is difficult to understand if coexistence of very large scale (∼100 Km) and small scale (∼1 Km) irregularities, as in the equatorial region (Aarons et al., 1980a), is accepted over this region also. In these cases (as in Fig. 34) if coexistence of ∼1 Km irregularities is assumed along with the large scale size irregularities, it would have caused simultaneous amplitude scintillations since corresponding Fresnel dimension is about 1.5 Km. The observation of scintillations afterwards may indicate that the very large scale irregularities of the initial stage may break up into smaller ones which will be sensitive to VHF scintillations. But there is statistically insignificant data to indicate such a process as it has already been pointed out that IEC depletions are much less frequently observed.

Faraday rotation records show that the TIDs responsible for observation of isolated patches of scintillations in the premidnight hours have amplitudes in the range 0.5 to 6.5 TEC units. Their velocity as computed from observed fade rates vary from 80 to 200 m/s transverse to the raypath. Even though their direction of motion has not been found out by spaced receiver or differential two satellite method, it is now well established that they move in
the east-west direction. From these known facts and duration of each scintillation patch, the computed east-west dimension vary from 30 to 450 km. Basu and Aarons (1977) reported from equatorial observations involving simultaneous backscatter radar and scintillation recordings, an east-west velocity range 90 to 140 m sec\(^{-1}\) and a corresponding east-west dimension range 200 km to 400 km or even larger. Now it is noted that even if amplitude of these irregularities corresponds to excess electron content as high as 6.5 TEC units it is only about 20 p.c. of the ambient value. It is small compared to some equatorial observations as well as results obtained by Somayajulu et al. (1977) in a low solar activity period (1975-1976) from Delhi (geomag. lat 19.2°N). Somayajulu et al. reported IEC enhancement up to 32 p.c. of background value in association with strong amplitude scintillation. But it must be noted that during that period due to low solar activity, background ionization itself was much less than what it was during present observations. For example they observed an enhancement corresponding to FR angle 0.42\(\pi\) against a background of only 1.5\(\pi\) i.e. about 32 p.c. excess electron content. While in the present study an increase in IEC corresponding to 2\(\pi\) FR angle against an ambient value 13.5\(\pi\) (Fig. 44) was observed. This enhancement was only about 15 p.c. of the background value. It has been observed very frequently that a faster than average post sunset decay rate of IEC is connected with onset of scintillation particularly during equinoctial and winter months. In summer no such trend can be observed. Recently Korde and Navaneeth (1985) also reported somewhat similar results as observed from Nagpur (dip. 11.2°N), a low latitude station. This suggests that cut off of solar ionizing flux at subionospheric point leads to ionospheric instabilities during periods of high ionization.
density (as observed in winter and equinoxes). In summer, ionization density remains less compared to other seasons as observed through IEC measurements. But it is interesting to take note of the fact that in this station maximum scintillation occurrence is observed in summer as shown in CH-III with a minimum in winter. This is possibly due to different origins of the irregularities responsible for causing amplitude scintillations during summer and other seasons.

In many diurnal plots of FR in equinoctial months show enhancement of IEC at about 2000 Hrs. A similar phenomenon is reported by Koster (1973) but instead of enhancement he reported a nearly regular depletion as observed from equatorial station Legon (dip. 8.47°S). Koster refers this phenomenon as equatorial evening minimum (EEM). He also reported association of amplitude scintillation with EEM. To explain this interesting phenomenon he suggested an elliptical circulation of charges (in a vertical plane in the east-west direction) involving $E \times B$ vertical drift and east-west electric field around the line of sunset. Such a mechanism may be feasible at this latitude also when average ionization density is high and meridional neutral wind is minimum as in equinoxes. It is also recalled that the premidnight scintillation occurrence peak almost coincides (Fig. 5a in Chapter III) with the post sunset IEC peak in the month of February when these phenomena are observed with regularity. One typical association of premidnight amplitude scintillation and the post sunset IEC peak may be seen in Fig. 44 as was observed on 8 February, 1981. It is important to note that not every post sunset IEC peak is associated with amplitude scintillations. If an elliptical circulatory motion around sunset line can be responsible for these two phenomena it is but natural to
expect a similar mechanism around the sunrise line at the sub-ionospheric point. It is remarkable that the predawn occurrence peak of nocturnal scintillation at about 0300 Hrs as seen from Fig. 5a (chapter III) coincides with the presunrise IEC enhancement around the same time as may be observed from a typical plot Fig. 44 (8 February, 1981). From the figures (i.e. Fig. 5a and Fig. 44) it is noted that the two nocturnal scintillation peaks and the post sunset and presunrise IEC enhancements occur about 2½ hours after and before sunset and sunrise respectively. To show the relationship between the two phenomena, in Fig. 45 the average of the filtered out component of the IEC enhancements around 2000 Hrs and 0300 Hrs from the average ambient values for nine days of February, 1981 is plotted along with the p.c. of occurrence of nocturnal scintillation (≥ 1 dB) during the same period. Similar but less pronounced and time shifted plots may be obtained in other equinoctial months. Summer month of May and winter month November also show such occasional anomalous IEC enhancements along with weak scintillations during nighttime. The elliptical circulations operating essentially around the E-region sunset and sunrise lines as conceived by Koster (1973) may transport electrons towards the subionospheric point for this configuration leading to the observed IEC enhancements and amplitude scintillations. It is to be pointed out that scintillations observed during those periods are generally weak having fade rates about 4 fades/min as observed in the month of February when the phenomena are observed most prominently (in absence of data during March and September). A simplified frozen field pictorial representation of the transport mechanism is depicted in Fig. 46. It may be noted that during sunset an electric field in the eastern direction i.e.
Fig. 45: Average excess electron content (----) associated with amplitude scintillations (-----) observed during the month of Feb.
Fig. 46: Elliptical circulation cells assumed around sunset and sunrise lines shown along with field directions in simplest form.
towards the dark hemisphere which will make the electrons to move
towards east there by enhancing the ionization density in the sub-
onospheric point resulting in the observed increase in IEC at
about 2000 Hrs. Similarly during sunrise the electric field will
be in the western direction i.e. from sunlit to dark hemisphere.
This will lead to movement of electrons towards west and when they
arrive at the subionospheric point an enhancement in IEC will be
observed at about 0300 Hrs. It is assumed that the horizontal vel-
cocity of the ionization movement is about 100 m/s so as to have the
observed fade rates of the associated scintillations at those hours.
Due to vertical component of the earth's magnetic field at this lat-
titude, the circulation cells will be inclined instead of being ver-
tical as it would have been at the magnetic equator. This will lead
to movement of ionization from the equatorial region towards higher
latitudes which is possibly why in the equatorial region EEM is
observed while at higher latitude as observed from this station
enhancement in IEC is recorded after sunset. The represented pict-
ure is too simplified when one considers the high velocity (490 m/s)
of the sunset or sunrise line in the E-W direction which makes the
behaviour of the possible circulation cells highly complicated.
Still this mode of transport of ionization looks a feasible expla-
nation for the observed anomalous IEC enhancements and associated
amplitude scintillations even though the exact mechanism for gene-
ration of irregularities responsible is not understood. But if obs-
ervations are made simultaneously with a geostatinary satellite
having subionospheric point towards west of this station the possi-
bility and nature of such a mechanism could be better investigated.