Some Unusual Forms of Development of Equatorial Spread-F

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Besides the normal development of equatorial spread-F at the base of the F-layer and later its extension at higher heights, it has been shown that the spread-F can, at times, start at the peak of the F-layer and then extend down during clear bifurcation of the main F-layer (kink). The spread-F is generated both at the base as well as the height of discontinuity. The spread-F at a station can also be developed due to the movement of irregularity generated at different location and moving slowly overhead the station. These forms of development of spread-F can easily be identified from a good set of ionograms.

The equatorial spread-F is known to start following the rapid rise of the F-layer in the post sunset hours\textsuperscript{1-4}. Chandra and Rastogi\textsuperscript{5} described the characteristic development of equatorial spread-F. First some diffused echoes are observed near the minimum virtual height, i.e., at the lower end of the ionogram trace with critical frequencies clearly defined. The diffuseness then extends towards higher frequencies and over greater ranges completely obliterating the identification of the critical frequency. Later the diffuseness starts decreasing at lower frequencies and the spread-F transforms completely into frequency type of spread-F. Rastogi\textsuperscript{6} has shown that the spread-F can be generated even much below the base of the F-region if a uniform ionization layer exists at those heights at the time of sunset. Rastogi\textsuperscript{7} has recently shown that spread-F irregularities can be generated even at the region close to the altitude of peak ionization density, provided there is a discontinuity in the plasma density variation with height (a kink or a G-layer). In this communication some unusual developments of equatorial spread-F are described on the basis of examination of the ionograms at Kodaikanal.

In Fig. 1 are reproduced the ionograms at Kodaikanal on 5 Aug. 1958 showing the development of spread-F starting from the peak of F-region and attaining lower heights later. The ionogram at 2015 hrs LT shows a clean trace with no spread at all, while at 2030 hrs LT, some diffused echoes are seen near the critical frequencies. At 2045 hrs LT, the diffused echoes increased in strength generating a discontinuity in the normal trace. At 2100 hrs the spread transforms into range type, the echo height being constant with frequency without any sign of a group retardation effect. Later the spread-F progressed towards lower frequencies and by 2215 hrs LT a fully developed spread-F was seen extending over the entire frequency range from 3 to 8 MHz.

In Fig. 2 are shown the sample developments of spread-F during an intermediate layer in the F-region itself. The ionogram at 1600 hrs indicates the counter electrojet effects due to the complete absence of Esq.
reflection. At 1745 hrs an intermediate layer was seen in the F-region at 5 MHz. At 1830 hrs, the diffused echoes developed at the base of the F-layer, i.e. at the height of 300 km, and at 1845 hrs another layer of irregularities started developing independently at the height of 475 km. At 1900 hrs two very distinct groups of spread-F were observed and by 1915 hrs the whole F-region seems to have developed the spread-F irregularities.

Fig. 3 shows the ionograms at Kodaikanal on 2 Dec. 1961 illustrating the effect of irregularities moving horizontally over the station. At 1845 hrs, both the first and second order traces are clear without any diffused echoes. At 1900 hrs some reflections below the second order traces are seen at a height that remains constant with frequency. These are from a distant irregularity, being propagated obliquely. At 1915 hrs there is a layer at a constant height and in between the first order and the second order reflection traces. The height of spread-F layer gradually decreased with time such that
at 2015 hrs the obliquely transmitted scattering trace and the vertical first order ionogram trace crossed each other. At 2030 hrs, fully developed spread-F irregularity was imbedded in the main F-layer.

It is, therefore, suggested that while considering the theories of the generation of F-region regularities these different forms of the development of the spread-F should be taken into account and a careful study of the excellent sets of ionograms at Huancayo and Kodaikanal would perhaps lead to many new facts about the F-region irregularities and their association with other geophysical parameters.

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References