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Effect of Solar Activity on Whistler Dispersion

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Dispersion of the whistler observed at the low latitude station, Nainital, during Mar. 1971 has been compared with the solar radio emission at 245 MHz and the sunspot numbers. It is found that the whistler dispersion has a positive correlation with the solar activity, with a time lag of one day, while it has a negative correlation with the sunspot numbers. Also, the hourly variations of dispersions have been found to be somewhat periodic, with a period corresponding to the life-time of the whistler duct.

1. Introduction

IN ORDER TO study the effect of sun on whistlers it is more purposeful to examine the relationship between solar activity and whistler dispersion than the whistler occurrence, because the latter parameter depends not only on the propagatlon conditions in the ionosphere, but also upon the thunder storm actvity. Iwai and Outsu[1] by comparing whistler dispersion with the solar radio burst at 3750 MHz have observed that the dispersion obtained during the high emission units was large compared to that obtained during the low emission units. This revealed that the solar activity has a positive correlation with the dispersion of whistlers. Kimpara[2] compared the occurrence of whistlers with sunspot numbers and noticed tendency for the frequency of occurrence to increase year by year in accordance with the decrease of sunspot numbers. In the present paper, we report the experimental investigations of the effect of solar activity upon whistler dispersion at the low latitude station, Naini Tal (geomag. lat., 19° 1′ N; geogr. long., 150° 9′ E).

2. Experimental Procedure

The whistler recording equipment consists of a preamplifier, a main amplifier and a magnetic tape-recorder. The signal from a 25 m long vertical receiving antenna is fed to the preamplifier. The preamplifier is used for impedance-matching so that the output signal from the preamplifier can be fed through a low frequency cable to the main amplifier, which is located about 100 m away from the antenna, in the main building. The output signal from the main amplifier is tape-recorded by the magnetic tape-recorder. Both the amplifiers have a flat frequency response range of 500 Hz-15 KHz. A block diagram of the equipments used is shown in Fig. 1.

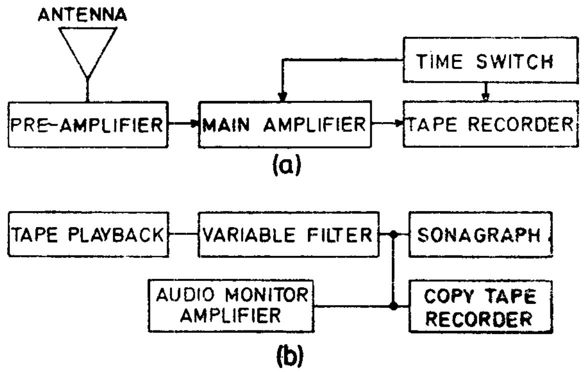

Fig. 1—Block diagram of: (a) whistler receiver, and (b) monitor station

For analysis of the signal, the tape-recorder is played back and the output is fed to the sonograph, which directly supplies a frequency versus time graph. The whistler dispersion is evaluated by measuring the time delay 't' with respect to some arbitrarily chosen atmospherics and then plotting $f^{-1/2}$ as a function of time. This plot is usually a straight line whose intercept with the time axis determines the actual location of the causative atmospherics. The slope of the straight line gives the dispersion in $sec^{1/2}$.

Regular observations of the whistlers at our low latitude station Naini Tal (geomag. lat., 19° 1′ N; geogr. long., 150° 9′ E) is being done since many years. The whistler activity during the month of Mar. 1971 was very high and in the present work we have analyzed the data for the same.

3. Discussion

The daily variation of dispersion of whistlers together with the solar radio emission at 245 MHz is shown in Fig. 2. A positive correlation exists between the dispersion of whistlers and the solar activity with a time lag of one day. During the high solar emission level, the dispersion is large and during the low emission level the dispersion is low. Whistlers of dispersions 14-18 $sec^{1/2}$ were observed, when the intensity of solar radio emission remained over 10

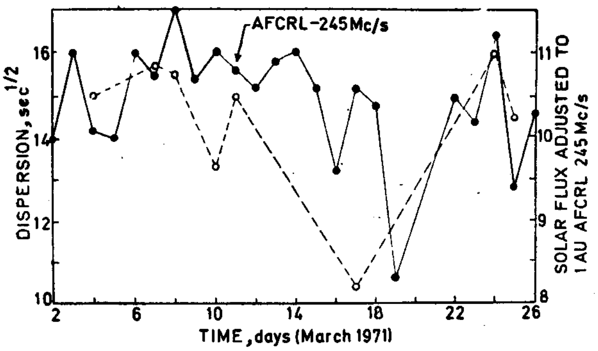

Fig. 2—Variation of whistler dispersion with solar radio emission at 245 MHz (—, dispersion; ..., solar flux)

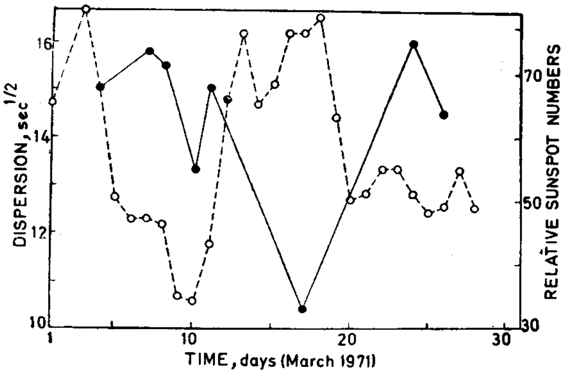

Fig. 3—Variation of whistler dispersion with sunspot numbers (—, dispersion; ..., relative sunspot numbers)

units; on the other hand, the dispersions of 10-14 $sec^{1/2}$ were generally detected on days when the solar emission was lower than 10 units. These results though not sufficient in data may be taken to indicate that solar activity has a positive correlation with dispersion of whistlers. It is seen from Fig. 2 that the dispersion lags behind the solar activity by one day. Such a time lag between the whistler occurrence rate and the solar geomagnetic activity have been reported by many workers. Kimpara[3,4], Outsu and Iwai[5] have showed that the whistler activity lagged behind the magnetic activity by about one to two days.

Fig. 3 shows a plot of the daily variation of whistler dispersion with sunspot numbers. A negative correlation has been found between the two, i. e. during the large sunspot numbers the dispersions are small and vice versa. Kimpara[2] found that the whistler activity is inversly correlated to the sunspot numbers, and further, that the frequency of whistler occurrence tends to increase year by year in accordance with the decrease of sunspot numbers. In general, during the high whistler activity the dispersions are large, and this explains the negative correlation depicted in Fig. 3. Further there is no time lag as that observed in the case of solar activity (Fig. 2). But, when the variation of whistler dispersion with sunspot numbers are considered on yearly basis, a time lag of one to two months occurs[3,4,6].

It is to be noted that while in solar activity and whistler dispersion a positive correlation exists, there is a negative correlation between whistler dispersion and the sunspot numbers. A sunspot appears dark because it is cooler than the normal photosphere, while reverse is the case with solar activity which is due to the thermal agiation of the solar plasma. Hence the above anomaly is to be expected.

Finally, the variation of whistler dispersion with local time for the event of 25 Mar. 1971 is shown in Fig. 4. It is seen that the dispersions are high at the beginning of the appearance of whistlers and then continue to decrease until sun-rise. This decrease in dispersion is interpreted in terms of corresponding decrease in the total electron content of tubes of ionization which has been computed from the whistler dispersion data of 25 Mar. 1971 applying the method as reported by Dikshit[7], and shown in Fig. 5. This shows that the ionization of whistler path (field-aligned column of enhanced ionization known as "duct") has precipitated down continuously, thereby decreasing the dispersion. Outsu and Iwai[5] also observ-

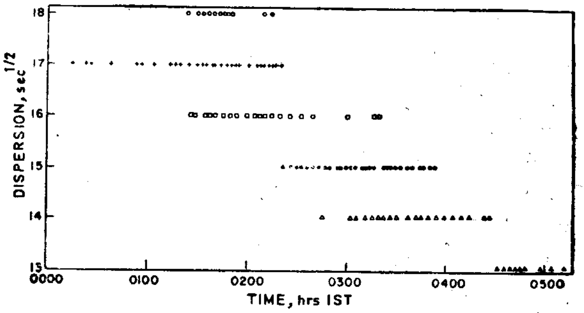

Fig. 4—Variation of dispersion with time

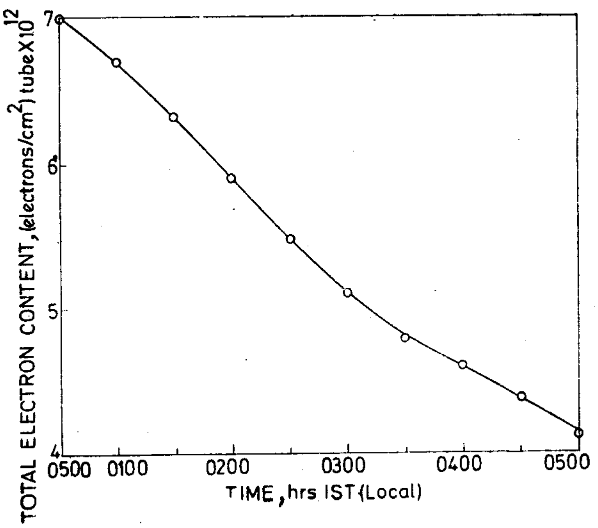

Fig.5—Variation of the total electron content with time

ed that near sun-rise the dispersion starts to decrease. It is known[8] that, in general, the magnetosphere on the dayside is compressed due to the action of solar wind in which the drift causing electric field is generated by the excess of charges due to differential motions between trapped high energy particles and the ambient magnetospheric plasmas. Inspite of this fact, in our observation and that of Outsu and Iwai[5], the ionization in the duct decreases in the morning side. This clearly shows that there are some other processes which cause the decay of ionization. In fact the processes like (i) ambipolar diffusion along the magnetic field (ii) interaction between ionization and neutral winds (iii) $\mathbf{E} \times \mathbf{B}$ drifts are such important factors which cause the decay. Dikshit[7] successfully showed that the downward flux of ionization along the geomagnetic lines of force and $\mathbf{E} \times \mathbf{B}$ drifts causes the decay of ionization in the whistler duct, even though, the ambient plasma around the duct may increase its ionization. In the above study the time variation of the downward flux of ionization could not be studied because the changes in dispersion at a given time were within the error bars of the ionization.

In Fig. (4) though on an average the dispersion decreases continuously yet a particular value of dispersion remains for a definite period only—which shows that the group of dispersions have some kind of periodicity. In fact such periodicities have been found by some workers[9,10] and they correspond[10] to the lifetime of a duct, which roughly is about 1 hr. However, for the full investigation of any hidden periodicity associated with the whistler duct, the standard technique of the power spectrum analysis may de applied.

4. Conclusion

The daily variation of the whistler dispersion shows positive correlation with the solar activity while it shows a negative correlation with the sunspot numbers. The local time variation of whistler dispersion reveals the flow of ionization away from the whistler duct and also some kind or periodicity with the whistler duct.

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