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Ionospheric Indication of Short-time Solar Activity Variations

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A series of Lyot filtergrams have been photometrically analysed and the variations in the plage intensity determined on a number of days. From simultaneous ionosonde records, correlation has been sought between the electron density variation at fixed heights and that of the H-alpha plage index. The results indicate positive correlation at lower heights, gradually falling off with height in the ionosphere.

THE existence of the ionized layer high up in the earth's atmosphere was inferred long before actual measurements of the ionizing radiation from the sun were possible. There were some doubts about the exact mechanism of the ionization, mainly because the actual nature of the solar outer atmosphere was not known with sufficient accuracy. But the new era which started on 10 October 1946 with the firing of a V_2 rocket carrying a solar spectrograph revealed unexpected features of the radiation from the sun. The role of solar X-rays in the production and control of the earth's ionosphere was realized, and several features of the ionospheric structure and its variation could be understood more clearly.

Some vital information in our understanding of the nature of the chromosphere and the corona can be gained from a knowledge of the processes of generation of these high energy radiations in the solar atmosphere. Close correlation of these variations of the high energy radiation flux with the features observed on the sun by means of optical and radio techniques has been inferred and sometimes observed. Studies on the characteristics of certain types of solar radio bursts have convincingly suggested explosion-type spreading of disturbance in the solar corona. It is logical to assume that the generation of sudden bursts of high energy ionizing radiation should be accompanied by some indications also in the optical domain. Presently, cases of solar flares observed in the light of H-alpha and accompanying X-ray bursts are too well known to need elaboration.

Flares, however, are extreme cases where the level of energy production increases by several orders of magnitude, and no special efforts are needed to detect their effect on the ionosphere. But besides flares, the active zones are known to undergo fluctuations, thereby modulating the output of the ionizing flux. The modulation is expected to be present in the ion-production process in the different layers of the ionosphere, and also, although to a lesser degree, in the electron densities at different ionospheric heights. The changes may be too small to detect directly, but a thorough statistical analysis should bring out the information.

The basic aim of the present investigation was to search for a possible correlation between the fluctuations of the solar optical flux at a selected wavelength and the ionospheric electron densities at a few heights.

Experimental Details and Observations

Lyot filtergrams at regular sequence of the sun were taken at the Kodaikanal Observatory from January 1960. Filtergrams obtained on a few clear days during the IQSY period were chosen for our analysis. Details of the optical arrangement are as follows: The Lyot filter is capable of isolating a band of width 0·75 Å around H-alpha 6563 Å, and a 16 cm aperture lens with a two-mirror coelostat arrangement focuses a 30 mm image through the Lyot filter. The images are recorded on a strip of 35 mm film, which has sensitometric calibrations imprinted on them by means of a standard step wedge. The frames were taken roughly once in 5 min.

The days chosen for our analysis were such that only one prominent plage was visible on the disc. By a simple photoelectric arrangement, the total brightness of the plage was assessed from each frame by comparing the darkening in that area with an equal area at the centre of the disc. The dimensionless index arrived at is thus free from variation due to atmospheric transmission or the photographic development processes, and is plotted against time. Figs. 1 and 2 show plots of the plage index on

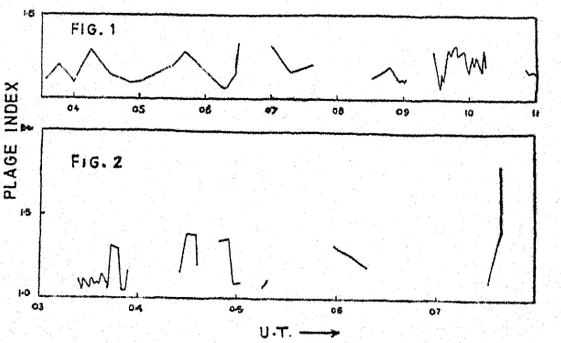

Fig. 1 — Plot of plage index versus time (UT) at Kodaikanal on 21 March 1966

Fig. 2 — Plot of plage index versus time (UT) at Kodaikanal on 13 June 1965

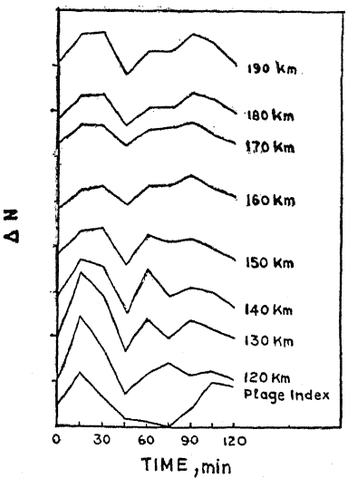

Fig. 3 — N-t curves for different ionospheric heights over Kodaikanal on 2 October 1965

two days satisfying the conditions set for our investigations. The first one (Fig. 1) is for a really quiet day, where the plage brightness hardly shows any variations. The second one is a day when the plage region was active, showing large variations (Fig. 2).

The choice of the dates were further limited by another consideration. To keep the variables affecting the ionosphere to a minimum, care was taken to choose only magnetically quiet days, so that effects of particle ionization do not affect our results. The electron densities of the various heights of the ionosphere were calculated from a series of h'-f records taken at Kodaikanal by a C3 CRPL recorder. The soundings were at regular 15 min intervals. The h'-f records were scaled visually and the N-h profiles calculated by an IBM 1620 computer by the usual matrix inversion method. A series of curves showing the electron densities at constant height during the observation period were obtained and the electron density values at the exact time of the Lyot filtergram frames interpolated from this record. Fig. 3 shows the N-t curves for the corresponding periods during which the H-alpha plage brightness indices are determined for one of the days under investigation.

Interpolated values of electron densities were taken from these curves at the exact moments for

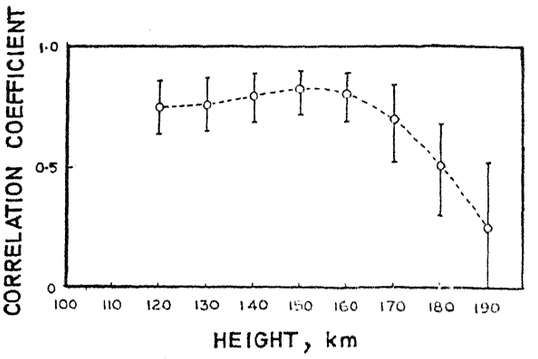

Fig. 4 — Plot of the correlation coefficient between electron density at various heights and the plage index

which the H-alpha plage brightness indices are available. The values of correlation coefficients and their standard errors between the plage indices and the electron densities at different heights were calculated by standard methods. Fig. 4 shows the plot of the correlation coefficient between the two parameters at several heights for one of the days. The vertical bars indicate the confidence limits for the correlation values.

Results

The presence of other factors affecting ionization balance do not show the correlation clearly. To overcome the adverse effects arising from paucity of data, all observations at a fixed height and the corresponding plage indices were grouped together, and the overall correlation calculated. The inclusion of data at different phase points of the daily variation of ionization densities has considerably increased the uncertainties; nevertheless, the results show positive correlation at lower heights, gradually falling off with height in the ionosphere.

Acknowledgement

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