ANOMALOUS D-REGION DURING X-EMISSION FROM FLARES AND GEOMAGNETIC EFFECT

Dedicated to Univ. Prof. Dr Alois Gregor on his 70th birthday

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1. INTRODUCTION

The course of an extraordinary X-emission of a flare can be traced indirectly through the disturbances of the lower border of the ionospheric D-region, for instance, by recording the SEA-effects (sudden enhancements of atmospherics). According to Appleton [1, 2] and Ellison [3] we are able to determine the value of the multiple of the maximum electron density $N$ and of the recombination coefficient $\alpha$ from the delay of the maximum of the SEA-effect after the maximum of the flare: $(\alpha N)_D = 1/2\Delta t$, where $(\alpha N)_D$ is the value of the multiple for the ionospheric D-region and $\Delta t$ the time-lag between flare maximum and SEA maximum.

We shall be able to determine the reaction of the ionosphere to changes of the ionising emission — "sluggishness" in the D-region — from the effect of the ionising emission of the flare, if we assume that the main outflow, i.e. the maximum of the ionising emission, occurs at the same time as the flare maximum, established by the width of the $H_a$ emission line or the intensity of the $H_a$ emission.

If we know the normal value of $(\alpha N)_D$, computed from the average delay of the maximum absorption after local midday $\Delta t$, or the average value computed by Kamiyama [1] based on the minimum frequencies for reflection, we can calculate the increase of electron density during a flare, assuming, of course, that not only the height of the ionospheric layer will not change considerably during the emission of the flare, but that the recombination coefficient $\alpha$ will also remain constant.

If, therefore, we want to study the effect of flare emission on the ionosphere, it is important to determine $\Delta t$ from the maxima of the flare and SEA, as shown above.

2. RESULTS

Ellison's investigation [3] results in $\Delta t = 7$ min and $(\alpha N)_D = 1.2 \times 10^{-3}$ sec$^{-1}$ corresponding to an increase which surpasses the fourfold normal value $N$ during a flare. In a later paper [4] the receiver time constant is considered and the value is determined as $\Delta t = 6.3$ min.

A new evaluation of the value of $\Delta t$ was based on the measurement of the $H_a$ line-
width observed at the Ondřejov Observatory and the recording of atmospherics on 27 kc/s (Ondřejov 14°47' E, 49°55' N) between July 1, 1957 and June 30, 1960 [5, 6, 7]. We selected 155 flares: 19 of importance 1 -, 57 of imp. 1, 37 of imp. 1 +, 35 of imp. 2, 3 of imp. 2 +, 4 of imp. 3 from those observed during this interval, of which we were certain that the actual maximum of the \( H_a \) line-width was observed and measured and, moreover, there was no other phenomenon in action on the solar disc, which might have been the source of ionising emission. Furthermore, we considered only cases, in which the SEA-effect was perfectly defined, the recording and the time signals were clearly registered and the noise level was quiet and undisturbed by greater thunderstorm activity in the vicinity. The time data were recorded with a precision of 1 min. In order to find the value of \( \Delta t \) we always determined the time of the first large maximum of the SEA-effect; in section 3 we deal with the different methods of determining \( \Delta t \).

The newly established value of \( \Delta t \) is 2.9 and, when considering the receiver time constant, it amounts to 2.4 min. The value of “sluggishness” \( (zN)_D \) is \( 3.47 \times 10^{-3} \) sec\(^{-1} \). If we adopt as the normal value of \( (zN)_D \), the average value derived from Appleton’s, Kamiyama’s and Ellison’s data \([1, 3]\), i.e. \( 3.8 \times 10^{-4} \) sec\(^{-1} \) (if typical value \( \Delta t_a = 22 \) min), then the increase of electron density \( N \) during the flare will, on an average, be 9-fold, i.e. about twice the value given by Ellison. If we adopt for a typical value of \( \Delta t_a \), the mean value \( \Delta t_a = 30 \) min \([2]\), then normal value \( (zN)_D = 2.8 \times 10^{-4} \) sec\(^{-1} \) and the \( N \) during the flare is more than 12 times the normal value.

It is interesting to compare this value with that of Appleton and Piggot from 1949 \([2]\) who found that the ionisation density \( N \) increased during the SID flare effect in the \( D \)-region 6 to 9 times.

The most frequent time-lag \( \Delta t \) is 1 – 2 min (Tab. 1). Adopting \( \Delta t = 1.5 \) min and considering the receiver time constant, the value will be \( \Delta t = 1.0 \) min. If we adopt the value of \( \Delta t = 1.0 \) min for the computation of \( (zN)_D \), we get the value of \( 8.33 \times 10^{-3} \) sec\(^{-1} \) for \( (zN)_D \) and the multiple 22 or 30 for increase of electron density \( N \).

Only five cases were observed in which the maximum of SEA-effect preceded the observation of the flare maximum. The time difference did not exceed 3 min. The small number of these cases is probably due to the fact that the visual spectro-helioscope observation of the \( H_a \) line-width maximum was recorded at the wrong time.

\[\text{Table 1. Frequency } n \text{ of } \Delta t -- \text{values} \]

<table>
<thead>
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*) Details of the methodics of recording the effective value of atmospherics at Ondřejov can be found in [17].