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Variation of the Effectiveness of the Solar Flare According to its Location

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§ Introduction

Sudden radio fade-out is considered to be caused by the severe absorption in the D region or in the lower region of the E-layer, dueing to the abnormal ionization which is produced by the ultra-violet radiation with which the bright solar eruption is accompanied. It is expected, however, that the effectiveness of the solar eruption upon the ionosphere varies according to its location on the solar disk. The longitudinal effect of the eruption is desired to be analysed on the stand-point of the forecasting for the traffic conditions of the wireless circuits.

A statistical method is adopted for this investigation using the data which have been prepared by Ionosphere Research Committee in Science Council of Japan. This Committee made the nineteen co-operative observations during last four years. In this period, 640 eruptions were observed and 34 eruptions were distinguished from them as the important kind by Tokyo Astronomical Observatory.

§ Sudden Radio Fade-out

In good hours when the solar observations were carried on under the favourable condition of the weather, 95 sudden fade-outs occurred in the wireless circuits from San Fransisco, Manila, and the domestic regions. Therefore, 15 per cent of the whole number of the eruptions were followed by sudden fade-outs. As to the important kind of eruptions, 14 cases were accompanied by fade-outs, and the proportion then was 41 per cent, that was of considerably frequent occurrence.

Dividing the solar disk into nine equi-sectorial regions, the number of eruptions and fade-outs, and the occurrence tendencies, for each of them are shown in Table 1. Fig.1 illustrates the variation of the effectiveness of eruptions upon the traffic conditions, and the ordinates express the percentages against the maximum value. When the fade-out corresponds to two or more eruptions, it is difficult to distinguish the effective one from them; values including those apprehensive cases are shown by circles and the broken-line, while those of the favourable cases are by dots and the full-line in Fig. 1. The maximum value of the occurrence tendency is 10.4 % in the central sector (10°E-10°W) concerning with only the precise cases: and including whole cases, that is 23.7 % in the region 11°E-30°E. The number of the eruptions of the important kind is too small to draw the curve.

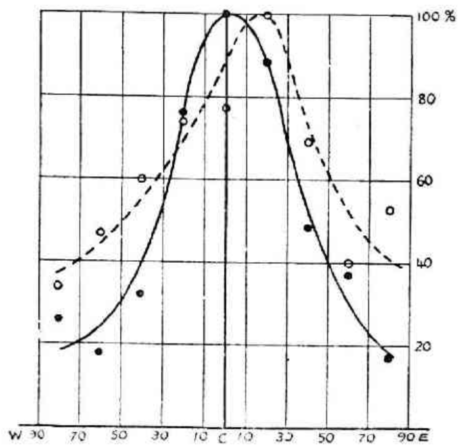

Fig. 1 Variation of the Effectiveness of the Eruption deduced from the Sudden Fade-out.

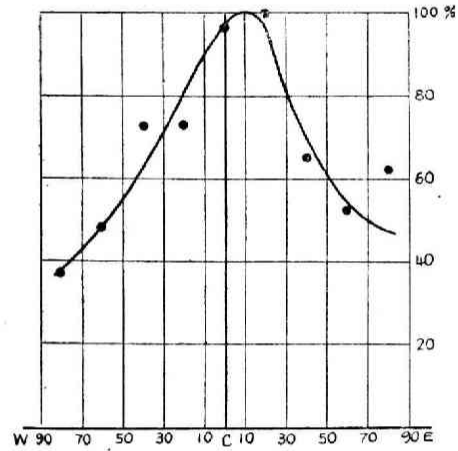

Fig. 2 Variation of the Effectiveness of the Eruption deduced from the Abnormal Absorption.

Table-1 The Effectiveness of Eruptions upon the Traffic Conditions of the Wireless Circuits.

Longitude	West					East			
	90-71	70-51	50-31	30-11	10-10	11-30	31-50	51-70	71-90
No. of Eruptions	37	54	92	63	77	76	80	105	56
No. of the sure Fade-outs	1	1	3	5	8	7	4	4	1
No. of the whole Fade-outs	3	6	13	11	14	18	13	10	7
Occurrence Tendency (%) (sure)	2.7	1.9	3.3	7.9	10.4	9.2	5.0	3.8	1.8
〃 (whole)	8.1	11.1	14.1	17.5	18.2	23.7	16.3	9.5	12.5
Percentage to the Maximum (sure)	26	18	32	76	100	88	48	37	17
〃 (whole)	34	47	60	74	77	100	69	40	53

Table-2 Occurrence Tendencies of the Abnormal Absorption.

Longitude	West					East			
	90-71	70-51	50-31	30-11	10-10	11-30	31-50	51-70	71-90
No. of Eruptions	21	24	47	26	28	31	38	44	28
No. of Abnormal Absorptions	4	6	18	10	14	16	13	12	9
Occurrence Tendency (%)	19	25	38	38	50	52	34	27	32
Percentage to the Maximum	37	48	73	73	96	100	65	52	62

§ Abnormal Absorption

At many occasions accompanying with the eruptions, the echo of the ionospheric sounding is abnormally absorbed dueing to the similar mechanism to that of the sudden fade-out. For each equi-sector, the occurrence tendencies of these phenomena are examined using the data which were obtained during recent two years. The numbers of the eruptions and of these abnormal absorptions are shown in Table 2 and the variation of the effectiveness of the eruption is illustrated in Fig. 2 according to the longitude.

§ Discussion and Conclusion

According to these results, it is concluded that the effectiveness of the solar flares upon the ionosphere, and consequently upon the traffic conditions of the wireless circuits, is most remarkable in the central region (30°E-10°W), and is reduced by half beyond both 50° meridians. It may be also noted that there seems some asymmetries of the effectiveness with regard to the central meridian. The conclusion is also confirmed by examining the data of *fminE*.

Forecasting for the traffic conditions of the wireless, one must be careful for the active regions within 30° meridians on the solar disk.

Since the magnitude of these phenomena is considered to be proportional to the square-root of the intensity of the radiation from the sun, the statistical results mean that the ultraviolet radiation accompanying the solar flare modifies its intensity according to the direction before arriving at the earth's atmosphere. This is perhaps mostly due to the absorption suffered in the sun's atmosphere, and to some extent due to the directional character of the radiation.

For the simplicity of the computations, we may regard the sun's surface as a plane. The error dueing to this simplification is within one per cent when the zenith distance x is inferior to 75°. Assuming the particle density of the sun's atmosphere to be

$$n = n_0 e^{-\theta h},$$

the total number of particles in the column in any direction x is as follows;

$$N = \int_0^\infty n_0 e^{-\theta h}\, dx = \int_0^\infty n_0 e^{-\theta h} \frac{dh}{\cos x} = \frac{n_0}{\theta} \frac{1}{\cos x},$$

where θ is a constant, h is the height above the sun's surface, and n_0 is n when $h = 0$. The initial intensity I_0 of the radiation is then reduced to I_x in the direction of x.

$$I_x = I_0 e^{-kN},$$

where k is the absorption-coefficient. Then,

$$I_x = I_0 \exp\left(-k\frac{n_0}{\theta}\frac{1}{\cos x}\right).$$

Hence, we have

$$\frac{I_x}{I_{x=0}} = \exp\left\{-k\frac{n_0}{\theta}\left(\frac{1}{\cos x} - 1\right)\right\},$$

where $I_{x=0}$ is I_x when $x = 0$. The broken line in Fig. 3 shows the numerical results of $I_x/I_{x=0}$, taking for kn_0/θ to be 2.5. The full-line is drawn by plotting the squares of the averageing percentages in Table 1 and Table 2.

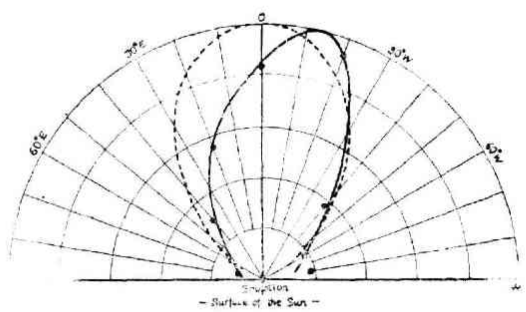

Fig. 3 Variation of the Intensity of the Radiation accompanying the Eruption according to the Direction.

The variation of the effectiveness of the solar flare is partly explained by the absorption in the sun's atmosphere, but the extent of this depends largely on the value of kn_0/θ. Since the observed results show the asymmetry, it is probably a fact that there is the directional character of the radiation from the solar flare. The results may also refer to the studies by J. KLECZEK and F. LINK [1, 2, 3, 4, 5] in Czechoslovakia.

In conclusion, I wish to express my sincere thanks to the members of Ionosphere Research Committee in Japan for their arrangements of many data. It is also noted with thanks that the research was helped by the Scientific Research Expenditure of the Department of Education.

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