DISTRIBUTION OF HEIGHTS OF PROMINENCES

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ABSTRACT

Study of the frequency distribution of heights of nearly 50000 prominences observed on K-spectro-heliograms during a complete solar cycle shows a nearly exponential decrease of frequency with increasing height between 20″ and 220″ of height above the chromosphere.

I. INTRODUCTION

Billings and Kober (1957) have reported in a short note some interesting results based on their study of the heights above the chromosphere of all prominences recorded at Climax and Sacramento Peak for the years 1951–1956. Some time back, as part of a general program of study of the results of prominence observations made at the Kodaikanal Observatory for the period up to 1952 (Ananthakrishnan 1954, 1956, 1957), the present writer made a study of the distribution of heights of prominences according to heliographic latitudes for the solar cycle 1923–1933. At Kodaikanal systematic records have been maintained of the heights of all limb prominences observed on spectrohelio-grams taken in K_{2-3-2}. The heights are measured correct to 5 seconds of arc by super-posing a glass grid on the spectroheliograms; the heliographic latitudes of the promi-nences are also estimated with the help of the same grid. For the purpose of tabulation, the latitude of a limb prominence is taken as the mean of the heliographic latitudes of its two extremities as seen on the spectroheliogram; the height above the limb of the highest part of the prominence is taken as its height. The results of the writer's study which support and amplify the conclusions of Billings and Kober are reported in this paper.

II. METHOD OF ANALYSIS

The original data were first analyzed in the form of monthly frequency tables for $10°$ intervals of heliographic latitude ($0°–10°$, $11°–20°$, ..., $81°–90°$) and for 20-second intervals of prominence heights ($0″–20″$, $21″–40″$, ..., $221″–240″$, and $>240″$). The monthly tables were later combined into annual tables for each of the years 1923–1933. The total number of prominences recorded during the period was nearly 50000.

III. RESULTS

Table 1 gives the percentage frequency distribution of all prominences recorded year by year classified into the 13 height intervals. Table 2 gives the percentage frequency distribution of prominence heights according to heliographic latitude zones for the 11-year period. The main points brought out by the study are the following.

a) Nearly 70 per cent of all prominences that occur during a solar cycle have heights not exceeding 40″ above the chromosphere. About 20 per cent have heights between 40″ and 60″, and nearly 10 per cent have heights between 60″ and 120″. Prominences which are taller than 120″ constitute only about 1 per cent of the total number. About 3 out of 1000 prominences rise to heights exceeding 180″. Less than 1 in 1000 exceed 240″ in height.

b) For the cycle as a whole, the frequency is nearly the same for the height inter-vals 0″–20″ and 21″–40″. However, in the years of rising solar activity more promi-

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TABLE 1

PERCENTAGE FREQUENCIES OF PROMINENCE HEIGHTS FOR ALL HELIOGRAPHIC LATITUDES (1923–1933)

YEAR	HEIGHTS (SECONDS OF ARC)													Total No
	0–20	21–40	41–60	61–80	81–100	101–120	121–140	141–160	161–180	181–200	201–220	221–240	>240	
1923	34 83	37 71	18 00	5 49	2 21	1 08	0 33	0 18	0 15	0 03		. .	0 03	3988
1924	33 49	35 47	18 18	7 14	3 02	1 69	0 35	35	20	07	. .	0 04	. .	4565
1925	28 84	36 96	21.03	7 26	3 20	1 33	0 55	27	12	10	0 06	14	.12	4878
1926	28 88	35 81	18 96	7 27	4 45	2 16	0 95	37	55	14	15	.15	15	5870
1927	32 40	34 93	18 92	6 60	3 35	2 07	0 58	48	32	08	05	08	14	5883
1928	32 83	30 77	19 95	6 79	4.31	2 66	1 13	55	41	21	11	11	16	5593
1929	37 25	29 70	18 80	6 87	3 45	1 99	0 96	45	26	12	05	05	07	4266
1930 .	43 87	29 46	16 19	5 10	2 34	1 72	0 42	42	11	08	08	11	08	3551
1931 .	42 78	33 56	15 77	3 95	2 14	0 93	0 38	17	12	12	02		05	4198
1932.	41 86	32 38	17 54	5 07	1 80	0 82	0 22	06	09	06	03	. .	0 06	3175
1933....	30 20	31 54	25 26	8 21	3 21	1 06	0 21	0.14	0 07	0 04	0 04	0 04	.	2838
Total no.	16891	16449	9228	3128	1549	824	294	164	120	50	29	36	43	48805
Per cent frequency	34.61	33 70	18 91	6 41	3 17	1 69	0 60	0 34	0 25	0 10	0 06	0 07	0 09	100 00

TABLE 2

PERCENTAGE FREQUENCIES OF PROMINENCE HEIGHTS ACCORDING TO HELIOGRAPHIC LATITUDES (1923–1933)

LATITUDE ZONE (DEGREES)	HEIGHTS (SECONDS OF ARC)													Total no
	0–20	21–40	41–60	61–80	81–100	101–120	121–140	141–160	161–180	181–200	201–220	221–240	>240	
0–10	33 94	32 04	19 24	7 25	3 64	1 87	1 00	0 42	0 28	0 12	0.02	0 09	0 08	6481
11–20 .	32 44	32 55	19 45	7 53	4 00	2 19	0 79	.43	31	09	06	.09	06	6670
21–30 . .	31 60	34 71	20 07	6 69	3.35	1 94	0 58	.37	31	10	.13	.06	10	7101
31–40	29 89	35 52	20 64	6 77	3 77	1 87	0 70	32	19	15	.04	04	10	6852
41–50	30.40	35 59	21 31	6 77	2 94	1 64	0 42	37	18	10	.08	.10	10	7080
51–60	33 26	36 58	19 17	6 02	2 52	1 27	0 40	.26	21	.11	.04	12	04	5680
61–70.	42 34	32 27	15 30	4 86	2 55	1 30	0 40	.32	35	05	.08	.05	13	3765
71–80	48 55	28 66	14 00	4 44	2 24	1 18	0 36	09	18	0 12	0 03	0 03	12	3308
81–90..	53 21	28 96	11 13	3 53	1 55	0 80	0 38	0 21	0 11		.		0 11	1868
Total no.	16891	16449	9228	3128	1549	824	294	164	120	50	29	36	43	48805
Per cent frequency	34 61	33 70	18 91	6 41	3 17	1 69	0:60	0 34	0 25	0 10	0 06	0.07	0 09	100.00

nences occur in the height interval 21″–40″, while in the declining years of solar activity the frequency is more in the interval 0″–20″.

c) At heliographic latitudes from 20° to 60° the prominence frequency is highest in the height interval 21″–40″; a higher latitudes the lowest height interval of 0″–20″ has the highest frequency.

d) At sunspot minimum, when prominence activity is feeble in high heliographic latitudes, most of the prominences that occur above latitude 60° are less than 20″ in height. At middle latitudes (30°–60°), where prominence activity is high during the minimum epoch, the frequency maximum occurs in the height interval 21″–40″. At low latitudes, the lowest height interval is again more densely populated.

e) At and close to the epoch of sunspot maximum when prominence activity extends all over the sun, the frequency distribution of prominence heights is roughly uniform at all heliographic latitudes, the maximum frequency occurring in the height interval 21″–40″.

f) To a fair degree of approximation, over the interval of heights from 20″ to 220″ (15000–165000 km), the number of prominences in a specified height range decreases exponentially with increasing height. This is clearly brought out by Figure 1, in which
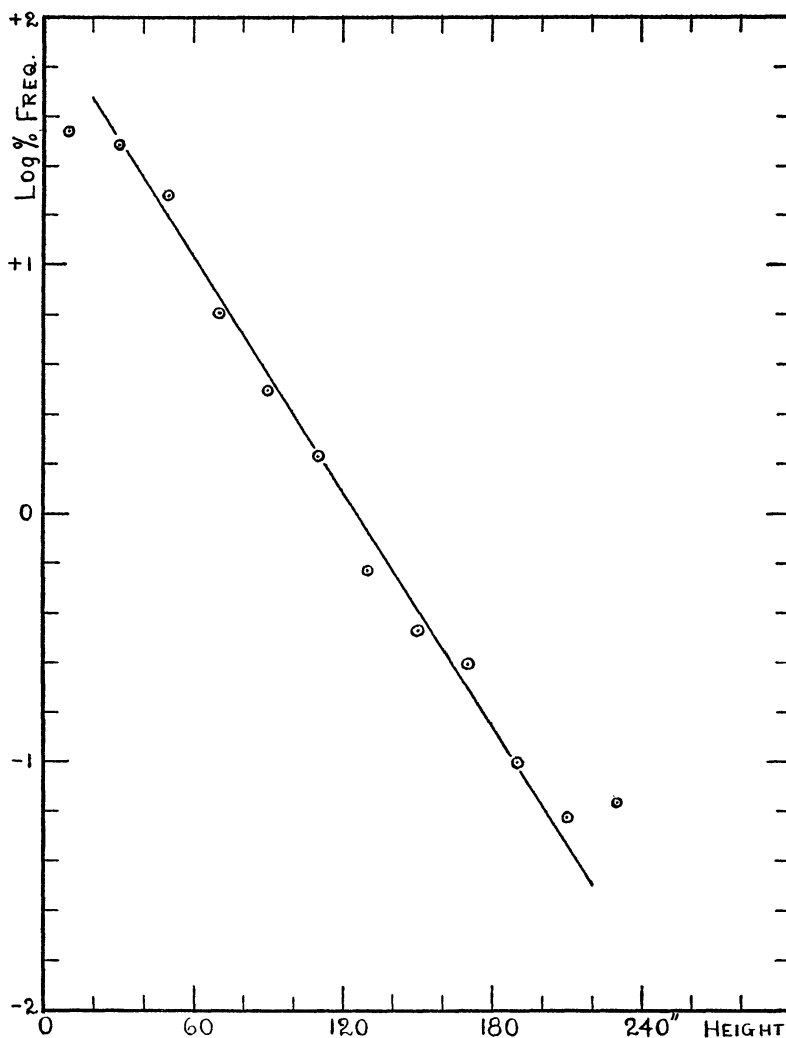

FIG. 1.—Variation of prominence frequency with height above the chromosphere

the logarithms of the percentage frequencies are plotted against heights. In this interval the percentage frequency of prominences in the height range $(h \pm 10)$ seconds of arc is approximately given by

$$N = 10^{(-0\ 016\,h+2)} \ .$$

g) The distribution according to heliographic latitude and according to height of the 43 prominences whose heights exceeded 240″ is given in the accompanying table.

Lat Zone Number	0°–30° 16	31°–60° 16	61°–90° 11	.	
Height Number	241″–300″ 26	301″–360″ 9	361″–420″ 5	421″–480″ 1	>480″ 2

More than two-thirds of these prominences occurred during the years of rising sunspot activity from 1925 to 1928.

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