# PROMINENCES AND THE SUNSPOT CYCLE

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ABSTRACT

The investigations by Lockyer, Evershed, and Bocchino on the relation between prominences and spots are extended to all the prominence observations from 1880 to 1937. A diagram is traced of all the six cycles under consideration, and the behavior of high- and low-latitude prominences and their relationship to the sunspot cycle is examined.

The so-called "metallic prominences" are present only in the low-latitude zone.

The problem concerning the distribution of prominences on the solar disk has interested many astronomers. G. Bocchino in a recent publication[1] has continued the works of Lockyer and Evershed and has extended the search from 1880 to 1931, about five cycles. She has studied the migration of prominences during the sunspot cycle, bringing out new characteristics of the latitude and of the frequency of the prominences.

The material already available from the foregoing five cycles extended up to 1937 now can be discussed in order to contribute to the knowledge of the two zones of prominences (high- and low-latitude) and their behavior in connection with the eleven-year cycle.

Evershed[2] has already shown that prominences can be divided into two different types: low- and high-latitude prominences. The difficulty, however, was to determine the latitude which separates them. In the Evershed diagrams there is a large zone between them, but it is so wide that it is impossible to determine a value for the limiting latitude. Usually, the observers who have worked on this problem have taken the mean width of the above-mentioned zone. We have chosen the value of $\pm 40°$ as the separation between high and low prominences. Then we will call "high-latitude" prominences those which have a latitude greater than 40° and "low-latitude" prominences those under 40°.

We can trace a diagram, as was done by Bocchino,[3] for the years

[1] *Pub. Arcetri*, No. 51, p. 7, 1933.

[2] *Mem. Kodaikanal Obs.*, 1, ii, 1917.

[3] See also G. Abetti, *The Sun*, p. 156, London, 1938.

1880–1937, taking the years as abscissas and the latitudes of the greatest activity as ordinates. These latitudes are determined by bisecting the diagram of mean areas at 40° and taking the weighted mean of each part.

The values of prominence areas are taken from Bocchino's publication and the Arcetri's observations.[4]

For the low-latitude prominences we write

$$\frac{2.5 \times A + 7.5 \times B + \ldots + 37.5 \times Z}{2.5 + 7.5 + \ldots + 37.5},$$

where 2.5, etc., is the mean latitude, and $A$, $B$, etc., are the mean areas of the prominences; these apply also to the high-latitude prominences.

Table 1 gives the mean values for both the northern and the southern hemisphere. The value in the column "Spots" is taken for each year from the *Monthly Notices*. From this table the diagram in Figure 1 has been traced; it confirms Lockyer's and Evershed's deductions.

Let us now analyze the curve of low-latitude prominences in the diagram. It follows the spot development very closely, although it is limited to a zone between ± 18° and ± 28°, while the spots are found, as is well known, in a zone between ± 7° and ± 23°.

Prominences appear at a distance of 10° north and south from the spots and follow them, but with a smaller range of latitude. At the minimum period of the sunspot cycle the latitude of the low-latitude prominences and spots is a maximum. The minimum latitude for prominences and spots is reached one or two years before sunspot minimum. Yet this law is not a rigid one; it is sufficient to observe that, when spots reach their minimum of latitude, the prominences of low latitude, while continuing their motion, are moving toward higher latitudes after attaining the minimum just referred to. During the period when the spots reach their lowest latitudes, we have the greatest distance in latitude between spots and low-latitude prominences.

The determination of the correlation coefficient will confirm what

[4] *Pub. Arcetri*, Nos. 52–56, 1934–1938.

has been said about the analogy which exists between the curves of the low-latitude prominences and of the spots. Mineur's method has been followed in this investigation, and from Figure 2 it is found that the correlation coefficient is about 1 ($\cos \sigma = 0.99$). In Figure 2 the two straight lines start from above 10° on the abscissa for, as is clearly

TABLE 1

| Years | Low Lat. | High Lat. | Spots | Years | Low Lat. | High Lat. | Spots |
|---|---|---|---|---|---|---|---|
| 1880..... | 25°.5 | 54°.1 | 19°.7 | 1909..... | 20°.7 | 49°.0 | 9°.7 |
| 1881..... | 23.8 | 57.9 | 18.2 | 1910..... | 19.0 | 52.7 | 9.9 |
| 1882..... | 22.3 | 64.8 | 17.6 | 1911..... | 23.3 | 52.6 | 6.9 |
| 1883..... | 22.3 | 54.8 | 12.4 | 1912..... | 22.0 | 49.8 | 14.1 |
| 1884..... | 19.8 | 55.7 | 11.2 | 1913..... | 28.4 | 49.4 | 22.4 |
| 1885..... | 21.4 | 50.4 | 11.5 | 1914..... | 26.8 | 49.8 | 22.1 |
| 1886..... | 20.0 | 48.8 | 10.4 | 1915..... | 26.4 | 53.8 | 18.8 |
| 1887..... | 21.5 | 50.8 | 8.5 | 1916..... | 23.9 | 58.7 | 16.0 |
| 1888..... | 23.0 | 51.2 | 7.3 | 1917..... | 21.3 | 61.1 | 14.2 |
| 1889..... | 24.4 | 50.2 | 9.6 | 1918..... | 20.4 | 59.9 | 12.8 |
| 1890..... | 27.8 | 48.5 | 22.0 | 1919..... | 19.7 | 48.3 | 10.3 |
| 1891..... | 25.3 | 52.8 | 20.2 | 1920..... | 19.9 | 46.9 | 10.6 |
| 1892..... | 25.7 | 56.2 | 18.4 | 1921..... | 21.4 | 49.5 | 8.1 |
| 1893..... | 23.1 | 56.4 | 14.6 | 1922..... | 22.6 | 49.3 | 7.7 |
| 1894..... | 22.2 | 59.4 | 13.9 | 1923..... | 23.7 | 53.1 | 15.6 |
| 1895..... | 20.8 | 48.0 | 13.4 | 1924..... | 26.8 | 54.3 | 23.9 |
| 1896..... | 24.5 | 48.6 | 14.2 | 1925..... | 24.9 | 56.6 | 20.0 |
| 1897..... | 18.7 | 52.9 | 8.0 | 1926..... | 23.4 | 62.1 | 18.6 |
| 1898..... | 20.4 | 50.6 | 10.3 | 1927..... | 21.3 | 61.8 | 11.6 |
| 1899..... | 21.8 | 49.9 | 8.3 | 1928..... | 21.5 | 59.0 | 13.6 |
| 1900..... | 20.7 | 52.0 | 7.5 | 1929..... | 20.9 | 53.4 | 10.5 |
| 1901..... | 20.2 | 53.4 | 12.4 | 1930..... | 20.9 | 50.6 | 9.8 |
| 1902..... | 25.6 | 53.3 | 17.0 | 1931..... | 20.2 | 48.6 | 8.6 |
| 1903..... | 26.0 | 53.5 | 12.6 | 1932..... | 22.0 | 50.6 | 8.4 |
| 1904..... | 23.5 | 56.7 | 16.6 | 1933..... | 27.3 | 47.7 | 9.5 |
| 1905..... | 22.1 | 57.0 | 13.6 | 1934..... | 26.7 | 48.6 | 22.3 |
| 1906..... | 22.2 | 63.2 | 14.0 | 1935..... | 25.6 | 50.8 | 23.1 |
| 1907..... | 22.1 | 54.5 | 12.0 | 1936..... | 23.0 | 57.2 | 28.2 |
| 1908..... | 19.8 | 52.1 | 11.9 | 1937..... | 21.4 | 63.1 | ..... |

seen by the dispersion of the points between 6° and 10°, if their mean is taken, there will be two perpendicular lines, i.e., a correlation coefficient of 0, the angle $\sigma$ being 90° ($\cos \sigma = 0$).

Let us now see what the meaning of this result is. A correlation of form undoubtedly exists between the two diagrams under discussion; but it is almost zero for the smallest value of latitude that can be deduced from what has been said, and particularly by considering the years 1888, 1911, 1922, and 1932 in Figure 1.

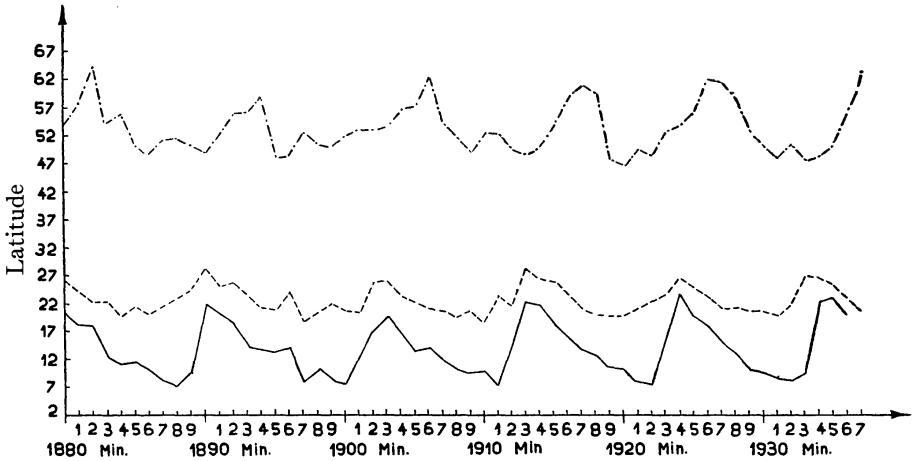


FIG. 1

- - - - low-latitude } prominences
- - - · high-latitude } prominences
——— spots

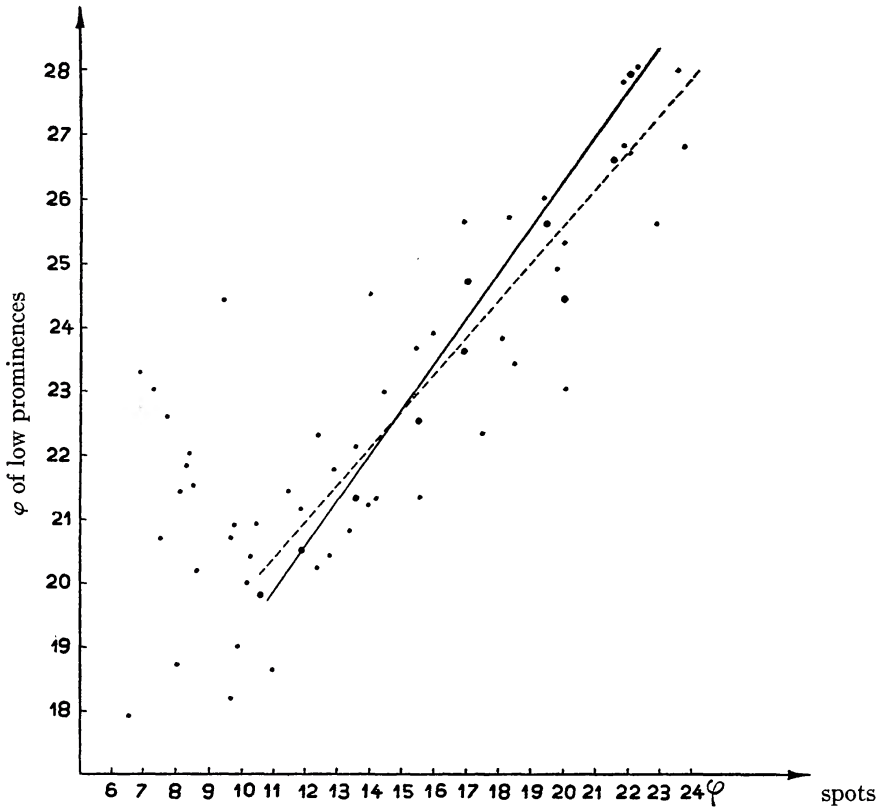


FIG. 2

Turning now to the diagram of the high-latitude prominence, we see that it is more difficult to find an analogy between this curve and that of the spots. Prominences drift toward higher latitudes and reach them about the time of sunspot maximum. Then, while the high-latitude prominences are, in a given year, at their highest latitudes, low-latitude prominences in the same year reach their lowest latitudes. The low-latitude prominences attain the highest latitudes

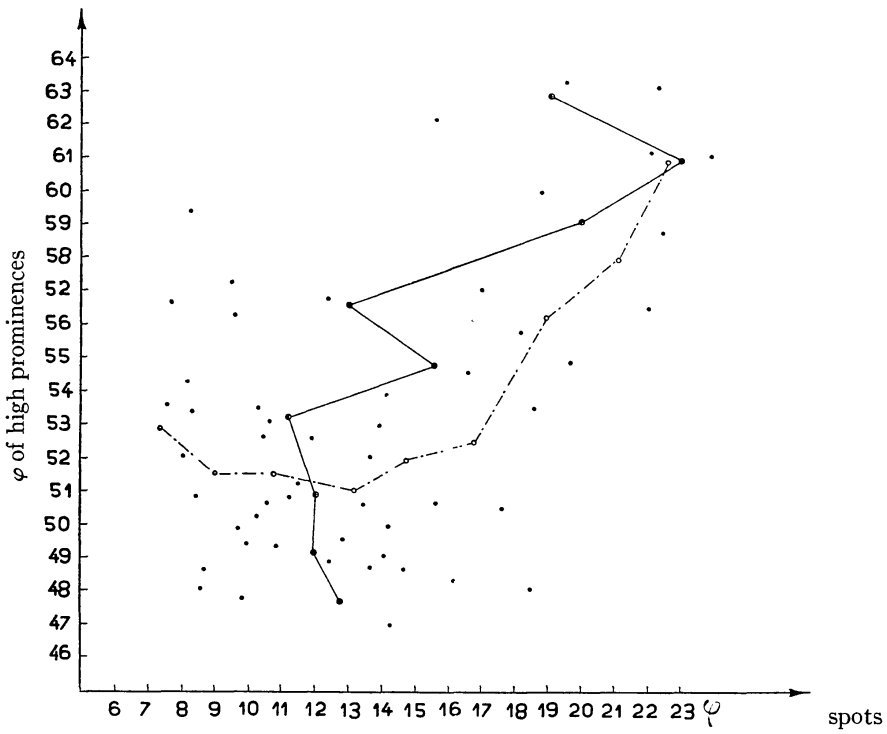


FIG. 3

when the high-latitude prominences are at a minimum. It is rather difficult in this case to find the correlation coefficient, since the two diagrams are not in phase. A remarkable result is obtained by displacing the diagrams of the high-latitude prominence by three years with reference to that of the spots. This gives an almost perfect coincidence between the maxima, but the minima are unaffected by the displacement: the minima of the prominences precede those of the spots. The dispersion of the points in Figure 3 shows that there is no correlation in form between the two curves under considera-

tion. The two lines are almost perpendicular in low latitudes, and they form a small angle in high latitudes; in the first part there is no correlation; in the second one should naturally exist, but it is a forced correlation, for the curve has been displaced in order to obtain the coincidence of maxima. It can therefore be stated that a correlation does not exist between the curve of the high-latitude prominences and that of the spots, or at least only as far as it concerns the duration of the cycle.

In Figure 1 we see that the migration of high-latitude prominences toward the poles is not connected with the phenomena of the low-latitude prominences. Yet they reach a maximum latitude when the spots and the low-latitude prominences drift toward the equator, that is to say, some years after the spots and the low-latitude prominences have reached their maximum latitude. This fact occurs, as is well known, about the period of sunspot maximum. During the maximum of the cycle we have, then, a greatly disturbed zone of low latitude at a mean latitude of about $\pm 20°$, while at the high-latitude zone the prominences are at their maximum latitude of about 60° and are already decreasing in activity.

During the period of sunspot minimum the low-latitude prominences also appear at their highest latitudes; this fact may be attributed to the presence of two zones of activity. By a careful study of these prominences and of dark flocculi a distinction can be made between the prominences of the old and the new cycles; at present, except for the latitude, there is no criterion by which we can make this distinction. In the case of the spots, the sign of the magnetic field provides a definite distinction.

The present investigation may also explain why at the minimum period there are two zones of activity at low latitudes and only one at high latitudes.

To give a general view of the phenomenon, another diagram (Fig. 4) has been drawn in which the abscissas represent years and the ordinates represent the mean areas expressed in prominence units.

The curves representing the motion of the prominences (low- and high-latitude) are the means for the northern and southern hemispheres for the six cycles from 1880 to 1937.[5] The ordinates of the

[5] Values taken from various issues of *Pub. Arcetri.*

curve for the spots are Wolf numbers taken from the Zurich publications. In Table 2, their values are given. The prominences are divided, as before, into low- and high-latitude prominences.

Analyzing Figure 4, it will be noted that in this diagram the low-latitude prominences follow the spots, i.e., they follow the spots not only in the latitude distribution but also in frequency. High-latitude prominences, on the contrary, behave in a different manner: they

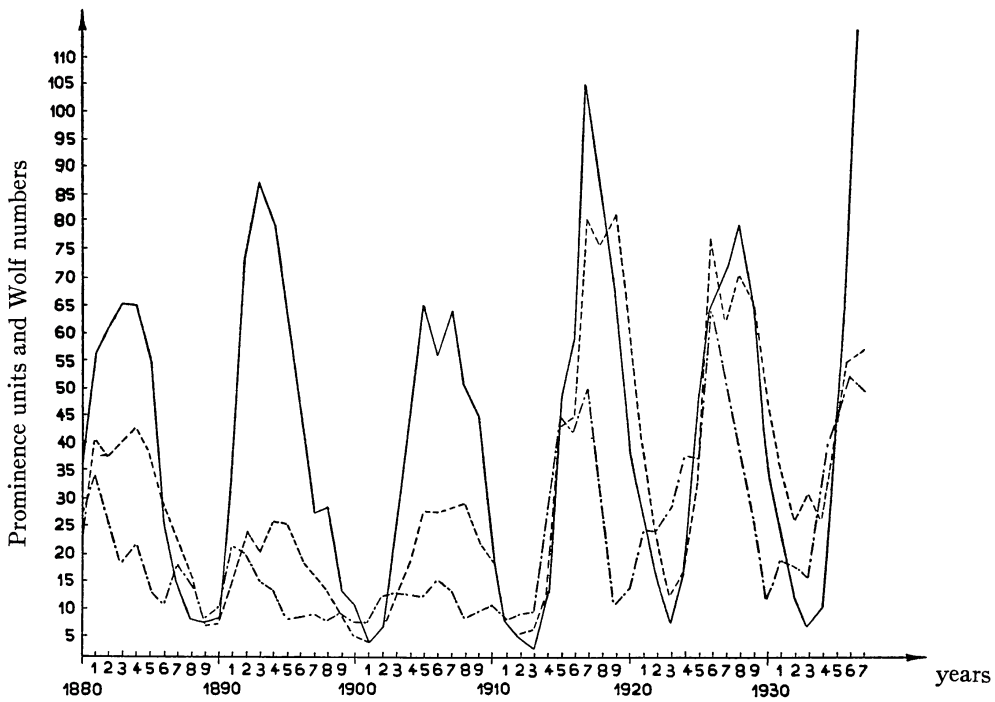


FIG. 4

- - - - low-latitude } prominences
- · - · high-latitude }
——— spots

reach a maximum about two years before the maximum of the sunspot cycle.

To give a clear idea of the phenomenon, the diagram in Figure 5 shows the curves representing the means of the six cycles given in Figure 4 for spots and for high- and low-latitude prominences. In Figure 5 the abscissas represent the years of the cycle and the ordinates represent the mean value given in Table 3, expressed in prominence units.

The first thing to be observed in Figure 5 is that the curve for the spots reaches its maximum in the fifth year.

High-latitude prominences reach a maximum two years before the spots and then decrease to a minimum five years before the spots; they have, therefore, no connection with the spots. But the cycle

TABLE 2

| Years | Low Lat. | High Lat. | Wolf No. | Years | Low Lat. | High Lat. | Wolf No. |
|---|---|---|---|---|---|---|---|
| 1880..... | 201.2 | 262.9 | 32.3 | 1909..... | 217.2 | 82.5 | 43.9 |
| 1881..... | 393.1 | 334.5 | 54.3 | 1910..... | 177.3 | 96.6 | 18.6 |
| 1882..... | 366.5 | 238.8 | 59.7 | 1911..... | 76.1 | 64.3 | 5.7 |
| 1883..... | 387.2 | 174.0 | 63.7 | 1912..... | 42.8 | 77.0 | 3.6 |
| 1884..... | 420.5 | 206.3 | 63.5 | 1913..... | 46.0 | 78.1 | 1.4 |
| 1885..... | 372.2 | 124.0 | 52.2 | 1914..... | 121.5 | 260.0 | 9.6 |
| 1886..... | 275.3 | 91.4 | 25.4 | 1915..... | 415.7 | 431.0 | 47.4 |
| 1887..... | 219.8 | 168.7 | 13.1 | 1916..... | 434.2 | 408.5 | 57.1 |
| 1888..... | 152.3 | 131.7 | 6.8 | 1917..... | 791.8 | 486.9 | 103.9 |
| 1889..... | 54.0 | 69.0 | 6.3 | 1918..... | 743.7 | 275.7 | 80.6 |
| 1890..... | 58.4 | 88.4 | 7.1 | 1919..... | 797.6 | 93.7 | 63.6 |
| 1891..... | 132.3 | 204.7 | 35.6 | 1920..... | 607.0 | 123.8 | 37.6 |
| 1892..... | 229.7 | 189.0 | 73.0 | 1921..... | 378.7 | 233.6 | 26.1 |
| 1893..... | 190.5 | 139.9 | 84.9 | 1922..... | 210.5 | 229.1 | 14.2 |
| 1894..... | 244.1 | 122.4 | 78.0 | 1923..... | 114.9 | 274.9 | 5.8 |
| 1895..... | 239.4 | 67.0 | 64.0 | 1924..... | 157.5 | 364.9 | 16.7 |
| 1896..... | 179.6 | 70.7 | 41.8 | 1925..... | 315.1 | 360.4 | 44.3 |
| 1897..... | 151.9 | 77.1 | 26.2 | 1926..... | 755.6 | 627.1 | 63.9 |
| 1898..... | 120.3 | 67.4 | 26.7 | 1927..... | 599.5 | 517.8 | 69.0 |
| 1899..... | 73.3 | 77.8 | 12.1 | 1928..... | 693.6 | 363.5 | 77.8 |
| 1900..... | 38.5 | 64.0 | 9.5 | 1929..... | 643.0 | 252.2 | 65.0 |
| 1901..... | 29.0 | 63.2 | 2.7 | 1930..... | 470.7 | 100.2 | 35.7 |
| 1902..... | 49.4 | 111.8 | 5.0 | 1931..... | 335.7 | 175.6 | 21.2 |
| 1903..... | 115.5 | 117.1 | 24.4 | 1932..... | 249.0 | 164.5 | 11.1 |
| 1904..... | 164.0 | 113.9 | 42.0 | 1933..... | 294.5 | 142.0 | 5.7 |
| 1905..... | 263.7 | 111.1 | 63.5 | 1934..... | 248.5 | 306.5 | 8.7 |
| 1906..... | 261.5 | 140.9 | 53.8 | 1935..... | 388.0 | 425.5 | 36.1 |
| 1907..... | 270.8 | 124.8 | 62.0 | 1936..... | 531.5 | 506.0 | 80.4 |
| 1908..... | 277.5 | 73.5 | 48.5 | 1937..... | 556.6 | 486.3 | 114.4 |

of the high-latitude prominences also lasts eleven years, although it is not in phase with the spot cycle. Its maximum appears in the eighth year, if we take the minimum of the curve as the beginning of the cycle, as in the case of the spots.

More interesting is the curve of low-latitude prominences, which behave differently. They, too, reach a maximum two years before the spots, but afterward they decrease and reach a secondary minimum one year before sunspot maximum. Then they increase and

attain another maximum, higher than the preceding, at the same time that the spots do. The minimum occurs in the same year as that of the spots. The curve of the low-latitude prominences follows

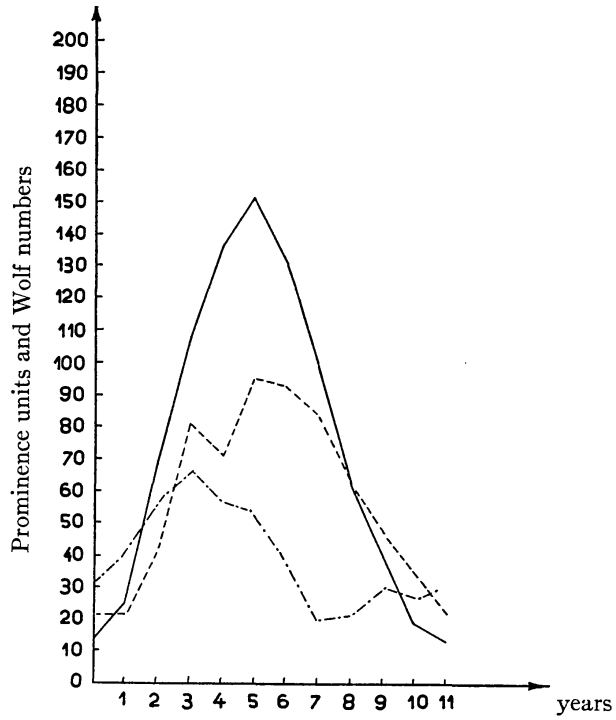


FIG. 5

- - - - low-latitude } prominences
- · - · high-latitude }
——— spots

TABLE 3

| Spots | Low Lat. | High Lat. | Spots | Low Lat. | High Lat. |
|---|---|---|---|---|---|
| 14.2 | 21.2 | 31.2 | 131.8 | 92.0 | 38.0 |
| 25.6 | 21.4 | 41.4 | 99.4 | 83.6 | 19.8 |
| 69.6 | 41.0 | 56.5 | 62.4 | 63.4 | 21.0 |
| 108.4 | 81.0 | 66.8 | 41.2 | 46.8 | 29.6 |
| 136.4 | 71.8 | 56.8 | 19.6 | 34.0 | 26.2 |
| 152.2 | 94.0 | 53.0 | 13.2 | 21.0 | 30.4 |

very nearly that of the spots with respect to its maximum, its minimum, and its amplitude, except for its behavior in the third year before sunspot maximum.

From Figure 5 we see that during the period of sunspot minimum the low-latitude prominences also have a minimum while the high-latitude prominences are already advanced in their cycle. At the beginning of the spot cycle the three curves increase rapidly; and the high- and low-latitude prominences reach a maximum in the same year, exactly two years before the spot-cycle maximum. The high-latitude prominences then begin to decrease and are followed by the low-latitude prominences. One year before the spot-cycle maximum the activity of the spots, which has reached a very high value, begins to make itself felt in the low-latitude prominences, and the latter suddenly increase and reach a maximum at the same time as the spots; then they follow the behavior of the spots, up to their respective minima.

The high-latitude prominences, after the secondary minimum of the low-latitude prominences, slowly decrease; but from the time of maximum activity they hasten toward their minimum.

It has been shown by G. Abetti[6] that the shape of the corona depends upon the development and the frequency of the prominences in high latitudes.

Having distinguished between high- and low-latitude prominences, it is interesting to investigate the difference in their constitution. Several observers have classed them as metallic and hydrogenous prominences according to their spectra, because in the former many metallic lines are present, while in the latter only hydrogen lines appear.

The Kodaikanal Observatory publishes twice a year a list of the metallic prominences, with their positions, their height, and the origin of their lines. The metallic prominences usually differ from the others by the presence of $b_1$, $b_2$, and $b_4$ of *Mg;* $D_1$, and $D_2$ of *Na;* and a group of lines of *Fe* I, *Fe* II, *He*, and *Cr*. I have examined these lists from 1912 to the first half of 1938 and have noticed that the prominences present more or less the same lines, i.e., those given in Table 4. Several prominences show numerous lines of other elements; but if we take their height, we find that they are so low that they may be regarded as more like the chromosphere itself than as

[6] *Ibid.*, No. 56, p. 53, 1938, and *Mem. Soc. Astr. It.*, **9**, 161, 1938.

prominences, and this probably explains the presence of lines that are not usually found in prominences. We define "prominences" as all eruptions that attain a height of 20″ (about 14,000 km—the height in the chromosphere of *Ca* II) or more.

The latitude at which metallic prominences appear is what we

TABLE 4*

| Chromosphere | Elements | $I_d$ | $I_f$ | Height | E.P. |
|---|---|---|---|---|---|
| 4923.9..... | *Fe* II | 5 | 30 | 2000 | 2.88 |
| 5015.6..... | *He* | ..... | 2 | 2500 | 20.52 |
| 5018.4..... | *Fe* II | 4 | 25 | 2000 | 2.88 |
| 5167.3..... | *Mg* | 15 | 18 | 1500 | 2.70 |
| 5167.5..... | *Fe* | 5 | 18 | 1500 | 1.48 |
| 5168.9..... | *Fe* | 7 | 25 | 1500 | 2.88 |
| 5171.6..... | *Fe* | 7 | 25 | 1500 | 2.88 |
| 5172.6..... | *Mg* | 20 | 30 | 2000 | 2.70 |
| 5183.6..... | *Mg* | 30 | 40 | 2500 | 2.70 |
| 5197.7..... | *Fe* II | 2 | 12 | 500 | 3.22 |
| 5204.8..... | *Cr-Fe* | 8 | 7 | 500 | 0.94 |
| 5206.2..... | *Cr* | 5 | 8 | 600 | 0.94 |
| 5208.4..... | *Cr* | 5 | 12 | 600 | 0.94 |
| 5227.0..... | *Fe-Cr* | 8 | 8 | 500 | 1.55 |
| 5234.6..... | *Fe* II | 2 | 15 | 500 | 3.21 |
| 5269.5..... | *Fe* | 8 | 15 | 600 | 0.86 |
| 5270.6..... | *Fe-Ca* | 7 | 7 | 500 | 1.60 |
| 5275.9..... | *Fe* II | 6 | 20 | 500 | 3.19 |
| 5284.1..... | *Fe* II | 1 | 8 | 400 | 2.88 |
| 5316.6..... | *Fe* II | 6 | 30 | 850 | 3.14 |
| 5324.2..... | *Fe* | 7 | 7 | 400 | 3.20 |
| 5362.8..... | *Fe* II | 3 | 15 | 500 | 3.19 |
| 5383.3..... | *Fe* | 6 | 6 | 400 | ..... |
| 5889.9..... | *Na* | 30 | 25 | 1500 | 0.00 |
| 5895.9..... | *Na* | 20 | 20 | 1500 | 0.00 |
| 6678.1..... | *He-Fe* | 5 | 20 | 2200 | 21.13 |
| 7065.2..... | *He* | ..... | 6 | 1000 | 20.87 |

* $I_d$ = intensity on the disk; $I_f$ = intensity in the flash.

have called "low latitude," i.e., less than 40°. Table 5 gives a list of the metallic prominences in high latitudes observed in the period 1912–1938. We find that during a period of 26.5 years, out of 835 metallic prominences observed on the sun, only 28, or 3 per cent, were in high latitudes; and all showed the same lines, namely, $b_1$, $b_2$, $b_4$, $D_1$, and $D_2$.

When we take all prominences, irrespective of whether their spectra show metallic or hydrogen lines, the percentage of high-latitude prominences is 41.

TABLE 5*

| Date | No. of Met. Prom. | Lat. | Height | Elements |
|---|---|---|---|---|
| 1912 | 10 | | | |
| Mar. 19 | | 52°.0 S. | 45″ | *Na–Mg–Fe* |
| Sept. 31 | | 78.5 N. | 20 | *Na–Mg–Fe* |
| 1913 | 4 | | | |
| Mar. 13 | | 46.5 S. | 25 | *Na–Mg–Fe* |
| Mar. 26 | | 44.5 S. | 70 | *Na–Mg–Fe–He* |
| Mar. 26 | | 41.5 S. | 25 | *Na–Mg–Fe–He* |
| 1914 | 12 | | | |
| April 6 | | 45.0 S. | 65 | *Mg–Fe* |
| Oct. 11 | | 49.5 S. | 65 | *Na–Mg–Fe–Fe* II |
| Nov. 4 | | 50.0 N. | 60 | *Na* |
| Nov. 26 | | 52.0 N. | 20 | *Na–Mg–Fe* |
| 1915 | 37 | | | |
| Jan. 15 | | 53.0 N. | 40 | *Na–Mg–Fe* |
| May 20 | | 51.5 S. | 30 | *Na–Mg–Fe* |
| 1916 | 42 | | | |
| Jan. 25 | | 42.0 S. | 60 | *Na–Mg–Fe–Fe* II |
| Dec. 10 | | 43.0 S. | 30 | *Na–Mg–Fe–Fe* II |
| Dec. 25 | | 41.0 S. | 40 | *Na–Mg–Fe–Fe* II |
| 1917 | 46 | ..... | ..... | ..... |
| 1918 | 51 | ..... | ..... | ..... |
| 1919 | 112 | | | |
| Jan. 28 | | 41.0 S. | 70 | *Na–Mg–Fe–Fe* II |
| Feb. 23 | | 43.0 N. | 55 | *Na–Mg–Fe–Fe* II |
| Mar. 2 | | 55.5 S. | 25 | *Na–Mg–Fe–Fe* II–*Cr* |
| Mar. 2 | | 45.5 S. | 50 | *Na–Mg–Fe–Fe* II–*Cr* |
| 1920 | 110 | | | |
| Jan. 12 | | 52.0 N. | 50 | *Na–Mg–Fe* |
| Jan. 17 | | 46.0 N. | 40 | *Na–Mg–Fe* |
| Feb. 5 | | 42.5 N. | 50 | *Na–Mg–Fe* |
| Nov. 30 | | 42.5 N. | 70 | *Na–Mg–Fe* |
| Dec. 3 | | 41.0 N. | 75 | *Na–Mg–Cr–Fe* II |
| Dec. 12 | | 72.0 N. | 110 | *Na–Mg–Fe* |
| 1921 | 42 | ..... | ..... | ..... |
| 1922 | 31 | ..... | ..... | ..... |
| 1923 | 6 | ..... | ..... | ..... |
| 1924 | 6 | ..... | ..... | ..... |
| 1925 | 30 | ..... | ..... | ..... |
| 1926 | 68 | | | |
| Feb. 16 | | 41.0 N. | 50 | *Na–Mg–Fe–He–Fe* II |
| Feb. 17 | | 46.5 N. | 35 | *Na–Mg–Fe* |
| 1927 | 56 | | | |
| Mar. 24 | | 42.5 N. | 20 | *Na–Mg–Fe–He–Fe* II |
| 1928 | 22 | ..... | ..... | ..... |
| 1929 | 46 | ..... | ..... | ..... |
| 1930 | 13 | | | |
| Dec. 26 | | 45.0 N. | 30 | *Na–Mg–Fe* |
| 1931 | 9 | ..... | ..... | ..... |
| 1932 | 1 | ..... | ..... | ..... |
| 1933 | 1 | ..... | ..... | ..... |
| 1934 | 4 | ..... | ..... | ..... |
| 1935 | 11 | ..... | ..... | ..... |
| 1936 | 27 | ..... | ..... | ..... |
| 1937 | 24 | ..... | ..... | ..... |
| 1938 | 14 | ..... | ..... | ..... |

* The second column gives the number of the metallic prominences for the year. Values for 1938 are limited to the first half-year.

The difference between eruptive and quiescent prominences is perhaps only a difference in intensity; Pettit has shown that the spectra of quiescent prominences contain lines with an intensity greater than 30 on Mitchell's scale, while the intensity of the faint lines of the metallic prominences is 15 on the same scale.

The Kodaikanal observations in the region between 4923.9 A and 7065 A show eleven lines in the metallic prominences fainter than 15 in Mitchell's scale (see Table 4); these lines include those of *Cr*, *Fe*, and *Ca*. The three lines of ionized barium which have intensities of 25, 20, and 20 do not appear.

What has been said about the metallic prominences observed between 1912 and the present time agrees with Pettit's examination[7] of the plate of the eclipse of June 8, 1918, with the exception of some lines fainter than 15 observed at Kodaikanal. In Table 4, $I_d$ is the intensity on the disk and $I_f$ in the flash, according to Mitchell.

Whether the differences in the spectra of both types of prominences depend only upon the intensities of the lines could only be decided after a systematic study of the spectra of prominences photographed by Lyot's method. The eruptions are certainly more violent at low latitudes, where the excitation of the elements in the chromosphere and prominences must be greater than in the high-latitude zones.

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November 1938

[7] *Mt. Wilson Contr.*, No. 451, p. 2; *Ap. J.*, **76**, 9, 1932.