Although slightly better conditions might be obtained by the occupation of a station somewhat nearer the central line of eclipse, the instruments are being erected on the roof of the Imperial College of Science at South Kensington. The magnitude of the eclipse there at central phase will be 0·96, and the experience of 1912 indicates that this will be ample for the purpose in view. Any advantage likely to be gained by going farther north would, it is thought, not sufficiently compensate for the loss of the facilities afforded by the College laboratories and workshops. Prof. Sampson has also taken this view and will attempt similar work at the Royal Observatory, Edinburgh, where the greatest magnitude of the eclipse will be 0·98.

A large partial eclipse also provides a very favourable opportunity of investigating the spectrum of the sun near the limb. The observations at Mount Wilson have already shown that this spectrum differs very considerably from that given by the centre of the disc, but observations during a large partial eclipse may have the advantage that there will be no scattered light from the central parts of the disc superposed on the light emanating from near the sun's edge.

The spectrograph to be employed at South Kensington has a concave grating of 10 feet radius in an Eagle mounting, and will be adjusted for the second order spectrum so as to avoid undue astigmatism. An image of the sun about 2 inches in diameter will be formed in the plane of the slit by a 6-inch objective, which will receive light from a cœlostat after reflection from a second mirror. Adjustments are provided for maintaining the image of a cusp on the desired part of the slit, and it is expected that the exposures required will not be so long as to cover an undesirable range of solar latitude as the cusp changes its position on the sun. The requisite astronomical data for South Kensington have been specially computed by Dr. L. J. Comrie of the " Nautical Almanac " Office.

The Forms of the Solar Corona and their Origin.

By Dr. William J. S. Lockyer.

It is only during total solar eclipses, when the moon comes exactly between the earth and the sun, and cuts off all the brilliant light of the disc, that an outer solar atmosphere of an exquisite pearly hue known as the 'corona' is revealed. Without such eclipses, this atmosphere, even with the aid of any of the great and ingenious optical means available to-day, would still be unknown. The corona is of very considerable extent, far exceeding, in proportion to the size of the solar disc, that of our own in relation to the size of the earth.

It is well known that the form of the corona varies in shape and brilliancy very considerably. Sometimes the form is very irregular, the coronal matter being extensively distributed all round the solar disc, embracing both the solar poles and the equator. This form is termed 'polar,' 'irregular,' or 'maximum,' as coronal streamers are situated near the solar poles (Fig. 1).

On other occasions the polar regions are conspicuous by the complete absence of streamers, and in their place beautifully curved rifts or plumes are seen, the long streamers being restricted more to the equatorial regions. This type of corona is termed 'equatorial' or 'minimum,' and is sometimes referred to as of a 'wind-vane' form, as it resembles this object (Fig. 2).

Finally, there is a third and also very pronounced shape which is intermediate between the above two forms. This is termed the 'intermediate' type or 'square' corona. In this case the streamers are generally concentrated in mid-solar latitudes, leaving the poles and equator comparatively free from any large coronal extensions.

The use of the terms 'maximum' and 'minimum' with regard to the shape of the solar corona referred to the epochs of sunspot maximum and minimum, and it suggested a connexion with the periodic variation in the spotted area of the sun's surface. Until a few years ago, it was generally concluded that sunspots were therefore the origin of the coronal forms, and their waxing and waning was reflected in the changes of these forms.

Sunspots, however, do not appear at or anywhere near the solar poles; the highest latitude they ever attain is only 45°, and then they are only of very small area. On the other hand, large coronal streamers and prominent rays are sometimes situated in very high latitudes; in fact, at times they are very near or at the poles, and consequently quite outside the regions of spot activity.

Moreover, at the epochs of greatest spotted area, the mean latitude of spots is only about 18°; yet it is precisely at about those epochs that the coronal streamers appear at the poles, and the coronal forms are described as 'maximum' or 'polar.'

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These facts suggested to me in 1903 that the prominences, which are not only very important factors in the mechanism of the solar atmosphere, but also can and do appear in all solar latitudes, might be directly responsible for these changes of form of the corona.

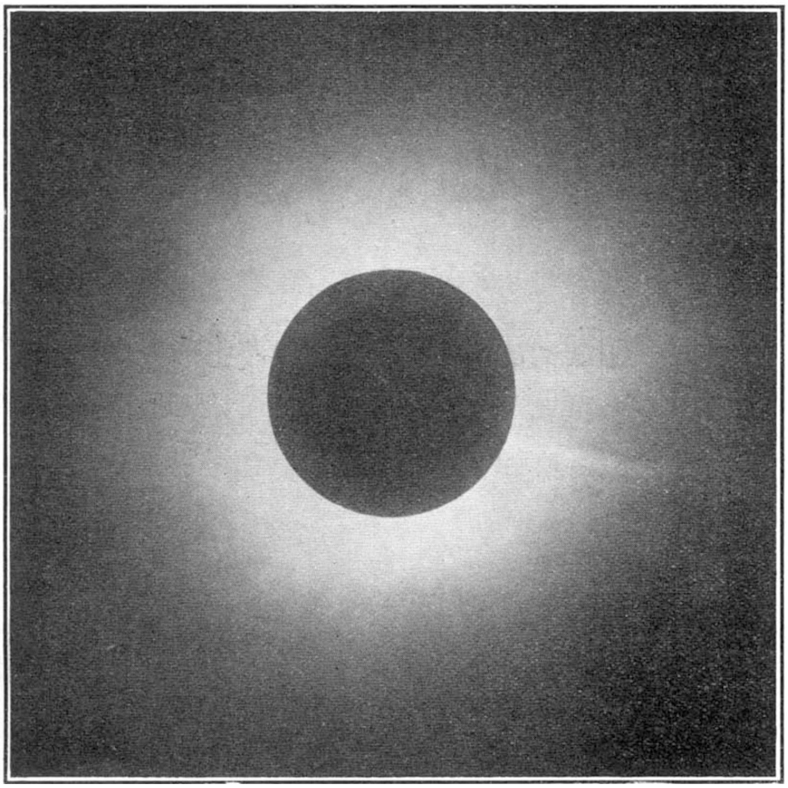

FIG. 1.—Solar corona, Aug. 30, 1905. Maximum type. Exposure 20 sec. By C. R. Davidson. By permission of the Astronomer Royal.

The crucial test resolved itself into demonstrating that the epochs of the occurrence of all those forms of the corona which exhibited streamers at or near the solar poles should be coincident with those epochs when prominences were known to be in very high latitudes. To do this it was necessary to study all the trustworthy data relating to the more modern records of solar activity.

It is well known that the area or number of the spots on the sun varies from year to year, and that about every eleven years or so this number reaches a maximum value. This cyclical change of spotted area is shown at the top of Fig. 3. Sunspots are not formed on all parts of the solar disc, but are strictly confined to a belt which lies approximately between latitudes 45° and 5° on both sides of the equator. Sunspots, therefore, never occur at or near the solar poles. The mean yearly positions of these belts are shown in the third series of curves illustrated in Fig. 3. The latitudes of sunspots are closely associated with sunspot frequency. When there are most spots their mean latitude is about 18° : when there are fewest spots their mean yearly latitudes are about 22° and 8°. The formation of high latitude spots near a sunspot minimum heralds the commencement of a new cycle of spot activity.

In the case of solar prominences, their appearance waxes and wanes very closely with the sunspots, as is indicated in the second curve of Fig. 3. When there are numerous spots there are many prominences, and vice versa. There is, however, a very big difference between their behaviour as regards solar latitude. Prominences can occur in any part of the sun, and they can be as large and conspicuous at the poles as they may be at the equator.

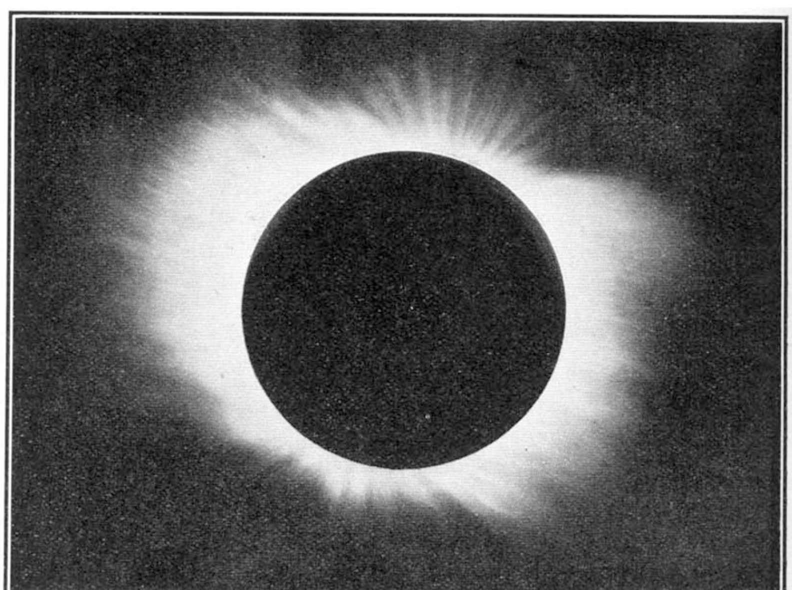

FIG. 2.—Solar corona, May 28, 1900. Minimum type. Exposure 30 sec. By E. E. Barnard.

To illustrate the striking difference between the extent of latitudes covered by spots and promi-

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nences, the accompanying diagram (Fig. 4) has been made showing this distribution for the years 1892, 1893, and 1894, the year 1893 being a year of sunspot maximum.

The central vertical line represents the solar equator or latitude 0°, and the black areas on each side of it indicate the areas of prominences for each of the three years (all drawn to the same scale) plotted for every five-degree zone of latitude on the scale given at the bottom for both north and south solar latitudes. It will be seen that prominences are distributed in all solar latitudes in these years, and in some cases are very pronounced in high solar latitudes in both hemispheres, as indicated by the pronounced peaks in the area curves.

The smaller white areas represent the areas of sunspots for the same years. They are all drawn to the same horizontal scale as regards latitude distribution as the prominences, but the vertical scale for their areas, while the same amongst themselves, is different from that of the prominences.

The diagram clearly shows, in the first place, the insignificant distribution of the spots in latitude compared with that of the prominences, and in the second place, that the zones of maximum spotted area, in these years about sunspot maximum, lie within 20° of latitude on either side of the equator.

A study of the fourth series of curves in Fig. 3 shows that when prominences are at their maximum frequency they occur in two zones, the mean yearly latitudes of which are about 70° and 25°. When they are fewest in number their mean yearly latitude is about 40°. This cyclical change of latitude from year to year is shown in the diagram.

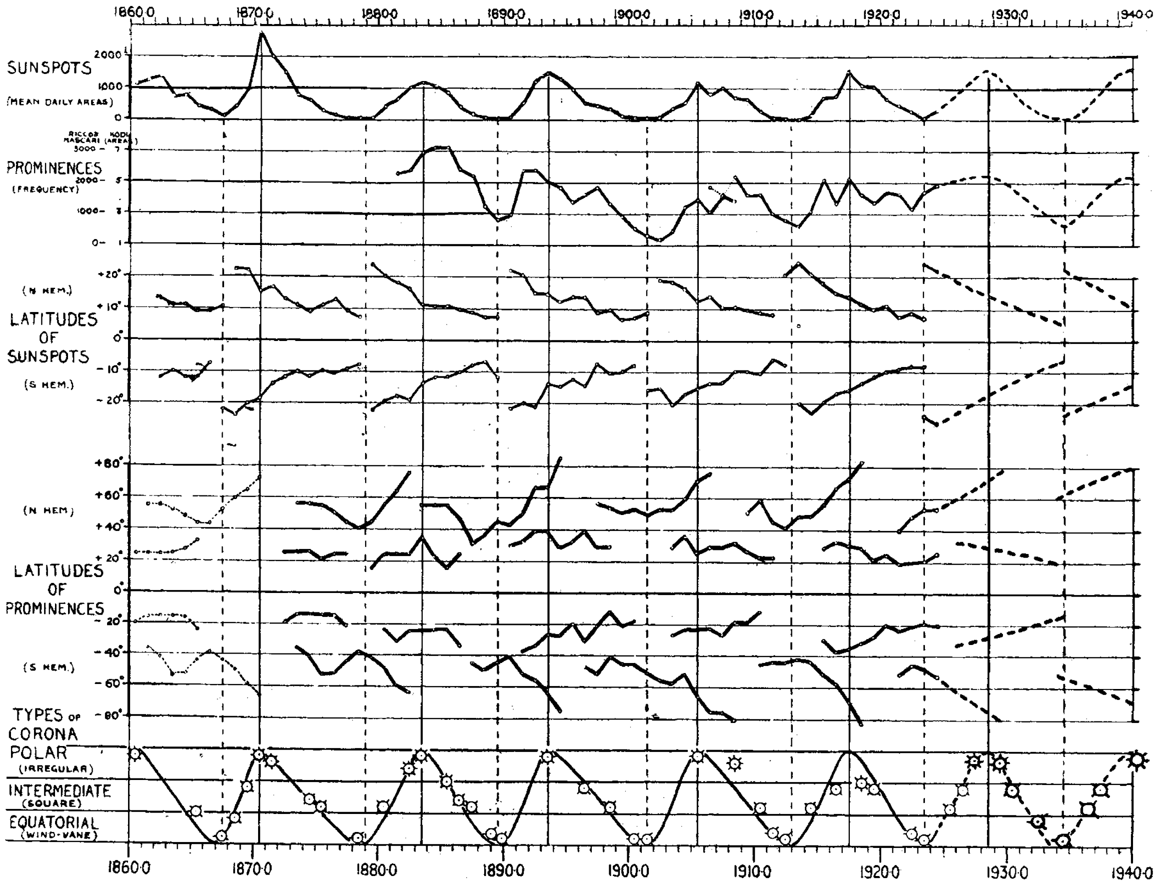

FIG. 3.—Diagram showing the relationship between the different forms of the corona and the latitudes of prominences.

Thus while the epochs of sunspot and prominence maxima are practically coincident, the spots at these times are most active in latitude about 18°, while prominences exhibit their greatest activity in about latitudes 70° and 25°.

Now from the prominence curves for both hemispheres it is quite easy at a glance to distinguish the years when these phenomena attain high latitudes, such as 60° or more. The question is, do these years pick up those cases in which the corona has been observed, and described as of 'polar,' 'irregular,' or 'maximum' type ?

To answer this question easily, the various forms

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of the corona, as recorded by different eclipse observers since the time of routine prominence observations first began, namely, in the year 1872, are brought together at the bottom of Fig. 3. Thus, for example, all the forms termed ' polar ' are placed in the first horizontal strip in their respective years of observation according to the time-scale indicated at the bottom. All those designated ' intermediate ' and ' equatorial ' are also placed in lower strips at their observed years. It is found that a curve can be drawn through them

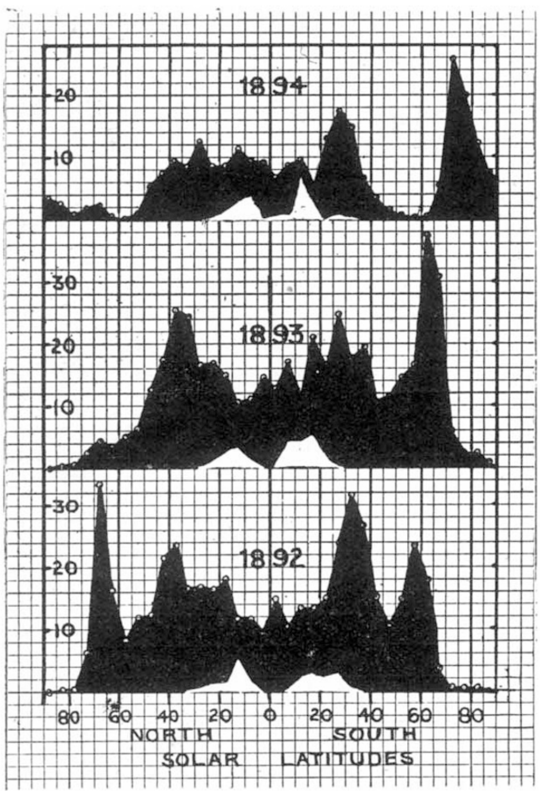

FIG. 4.—Diagram showing the distribution in latitude of prominences (dark areas) and sunspots (light areas) for the years 1892–94 (sunspot maximum 1893).

approximately resembling the sunspot and prominence curves at the top of the figure. Thus it is seen that the forms of the corona follow one another in the following sequence, namely, polar, intermediate, equatorial, intermediate, polar, etc.

Comparing these coronal types with the curves immediately above them, it is fairly obvious that ' polar ' forms are coincident with ' high latitude ' prominences in every case except one, namely, in the year 1883. A re-examination of the prominence data for that year discloses the fact that their presence was recorded up to latitude 65° in the northern and 75° in the southern hemisphere ; the yearly curve did not, however, exhibit distinctive peaks in either hemisphere at those latitudes, but only a gradual reduction in area from the prominent peaks in latitudes 25° north and south. There were therefore high latitude prominences in that year, so that 1883 is no longer an exception as expressed above.

It is important to point out further that there is no case of an ' equatorial ' or ' intermediate ' form of corona being recorded when the prominences were in high latitudes.

The deduction to be made is, therefore, that it is only when prominences are near the solar poles that coronal streamers will be found there. This fact points clearly to the conclusion that prominences are the prime factors in the formation of coronal streamers.

Limitations of space permit one only to mention here the fact that there is a mass of other evidence which can be brought to bear to show the close association of prominences with coronal forms, as, for example, the arch-forms of coronal matter so often recorded as being directly situated over large prominences, in spite of the fact that the material of which prominences are formed is quite distinct from coronal matter.

A more detailed study of the diagram shows that while prominences near the solar poles are responsible for the ' polar ' or ' irregular ' types of the corona, the ' intermediate ' forms owe their origin to the presence of two zones of prominences, and the ' equatorial ' forms to one zone in each hemisphere.

The rhythmic nature of all the curves, as shown by the continuous lines, suggests that they can be continued for a few years without any great error. This has been done in Fig. 3 by means of broken lines[1] up to the year 1940, and below them are forecast the various forms of the corona which may be expected in future eclipses up to that year, based principally on the probable prominence curves. The corona of the present year should therefore be ' polar ' or ' irregular,' corresponding to a very disturbed state of the sun's atmosphere. It should thus be irregular in form, devoid of pronounced polar rifts, and should be very bright. It may exhibit long streamers in any solar latitude. Its brilliancy will probably prevent any but the brightest stars from being seen, but on the other hand it lends itself very favourably to special studies of its composition by means of the spectroscope.

[1] There have just been published the latitudes of the mean areas of prominences for the first half of the year 1926. This shows that the zones of maximum area lie at latitudes 40° and 70° in the northern and 38° and 60° in the southern hemisphere, thus closely endorsing the points forecast in Fig. 3 for that year.

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