Total Solar Eclipses in the British Isles.

By Dr. W. J. S. LOCKYER.

ON June 29 of this year the sun will be totally eclipsed over a belt of northern England. Unfortunately, this event takes place very early in the morning, the total phase beginning at about 5^h 24^m G.M.T. or 6^h 24^m B.S.T., so that the sun will be only about 12° above the north-eastern horizon. Nevertheless, even under these rather unfavourable conditions, every one who has never seen the sun totally covered by the moon should make an effort on June 29 to be somewhere on that belt of country from which to see the striking spectacle of a total solar eclipse.

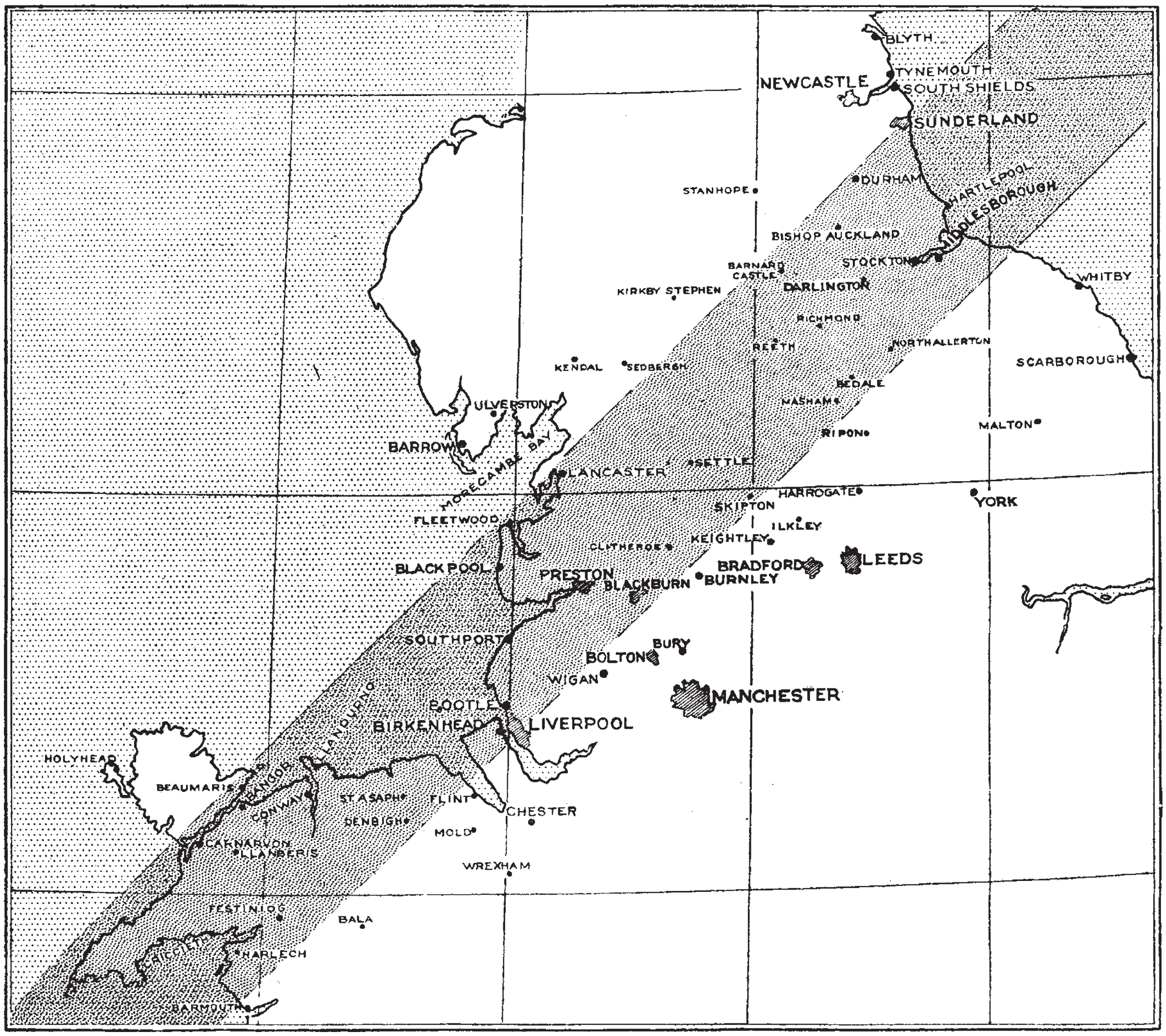

FIG. 1.—Track of the total solar eclipse across England on June 29, 1927.

An approximate position of the path of the moon's shadow is indicated on the portion of a map of England illustrated in Fig. 1. The breadth of the belt is about 30 miles, and the nearer the observer is to the centre of this belt the longer is the duration of totality. The central line of totality strikes the west coast of Britain near Criccieth, in Carnarvon, passes over Southport and nearly over Preston. It then sweeps over the north part of Yorkshire, and passes over Settle and Richmond, finally leaving the coast in the southern portion of the county of Durham, and passing over Darlington and Hartlepool and a little to the north of Stockton. The duration of totality is about 24 seconds, but is a little shorter than this on the west coast and a little longer on the east coast. Large towns just inside the border line of this belt are Carnarvon, Liverpool, Burnley, Skipton, Lancaster, and Durham.

So far, reference has been only made to that part of the track of the moon's shadow which first crosses England after commencing in the eastern Atlantic. Its later course is north-easterly, extending over Norway, Sweden, Lapland, and skirting the west coast of Novaya Zemblya. It then strikes easterly over the Arctic Ocean and north-westerly over north-eastern Siberia, terminating its course in the north-western portion of the Pacific Ocean.

The most satisfactory places for large, well-equipped expeditions will undoubtedly be in Sweden and northern Norway, for there the sun will be well up in the sky and the eclipse of longer duration.

Formerly there were many problems that could be investigated only during a total eclipse of the sun. The rapid advancement of solar physics during the last half-century has so considerably reduced these in number that the importance of observing eclipses from this point of view is much reduced. Thus, it is now known that the corona is a solar and not a lunar appendage; that the prominences can be seen whenever the sun is visible without having to wait for an eclipse to observe them; the study of the spectrum of the chromosphere in the photographic region is not now so important as it was; Einstein's theory of the bending of light by solar influence has been proved and requires no further repetition.

The main problems still to be studied are the exact times of the four contacts for the problem of the moon's motion; the red end of the chromospheric spectrum; the spectrum of the corona, best studied when the sun is in its greatest state of activity; and, finally, the form of the corona. Even the last mentioned is nearing solution, because it is now ascertained that coronal matter is closely associated with prominence matter, and that the positions of the prominences as regards solar latitude are intimately tied up to the positions of the coronal streamers. Thus it is well known that the

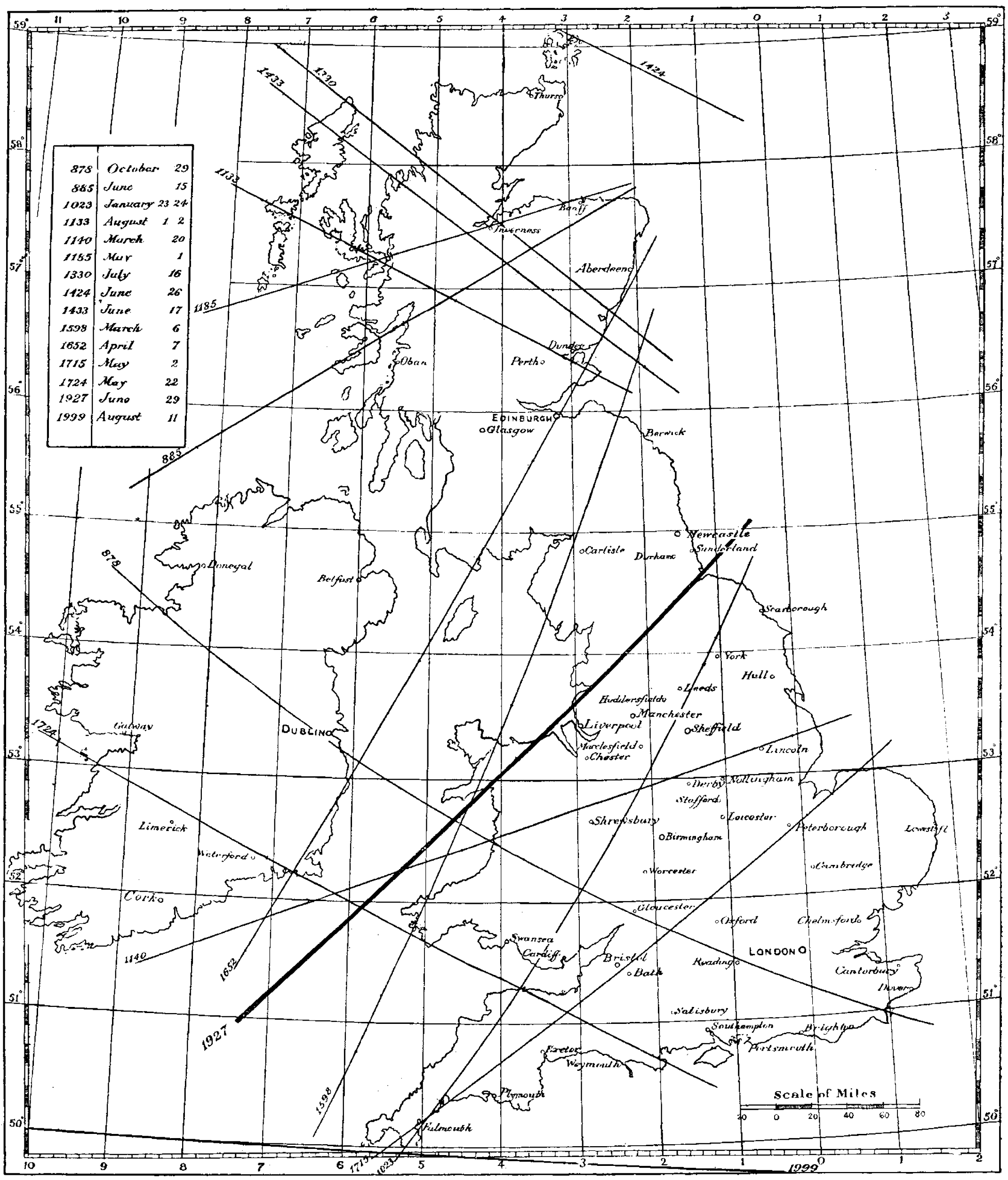

FIG. 2.—Map of total solar eclipses visible in Great Britain and Ireland from 878 to 1999.

form of the corona assumes one of three main types, a polar or maximum form, an intermediate or square form, and a minimum or wind-vane form. The polar form only occurs when the prominences are active near the solar poles. Next year the prominences will be near the poles, so that the type of corona is expected to be of the 'polar' or 'maximum' type.

In connexion with the passing of the moon's shadow over England this year, it is of interest not only to refer to other total eclipses visible in the British Isles, but also to inquire when the next one will take place. A very interesting map was published in the *Monthly Notices of the Royal Astronomical Society* in 1885 in a paper by Mr. J. Maguire, entitled "Total Solar Eclipses Visible in the British Isles, 878–1724." This map is here reproduced (Fig. 2) in a simplified form, to show the centres of the tracks only: those for 1927 and 1999 have also been inserted.

The eclipses here represented commence with the year A.D. 878, and show that thirteen total solar eclipses have occurred in the British Isles since and including that date. The last to take place was that of 1724, so that no total eclipse of the sun has occurred in these islands for the last 203 years.

Accounts of early English eclipses, whether total or partial, are generally alluded to in the "Saxon Chronicle." Thus, the very first record of one occurring in Great Britain, namely, the partial eclipse of A.D. 538, is referred to in the "Chronicle" in the following words: "In this year the sun was eclipsed fourteen days before the Calends of March from early morning till nine."

For the year A.D. 733, the "Chronicle" relates that "in this year Ethelbald captured Somerton; and the Sun was Eclipsed, and all the Sun's disk was like a black shield; and Acca was drawn from his bishopric." According to the Rev. S. J. Johnson, this eclipse was not total but annular, and is the first record of such an eclipse in England.

Omitting references to later eclipses, and coming to that of A.D. 1140, this was total over England, the centre of the track just skirting the south of Ireland, and leaving the east coast of England about the town of Lincoln. About this eclipse the "Chronicle" states: "In the Lent the sun and the day darkened about the noontide of the day, when the men were eating; and they lighted candles to eat by. That was the thirteenth day before the Calends of April. Men were very much struck with the wonder." This eclipse was evidently a very dark one, for William of Malmesbury stated that "while persons were sitting at their meals, the darkness became so great that they feared the ancient chaos was about to return, and upon going out immediately, they perceived several stars about the Sun."

The Scottish eclipse of 1652, when the central line passed near Wicklow in Ireland, and left the east coast of Scotland at Peterhead, is of interest because it was the first eclipse observed in the British Isles after the telescope had first been used in the eclipse of 1612.

The total eclipse of 1715 was of special importance to British observers, because London came well into the shadow belt, the central line passing over Falmouth in Cornwall and leaving the east coast at King's Lynn in Norfolk. Another interesting feature was the fact that the celebrated astronomer Halley received orders from the Royal Society "to provide for the observation to be made at their house in Crane Street," and for this purpose he published a special map showing the whole shadow path over England. With regard to this map he wrote:

"Having found, by comparing what had been formerly observed of Solar Eclipses, that the whole Shadow would fall upon *England*, I thought it a very proper opportunity to get the Dimentions of the Shade ascertained by observation; and accordingly I caused a small Map of *England*, describing the Track and Bounds thereof, to be dispersed all over the Kingdom, with a Request to the Curious to observe what they could about it, but more especially to note the Time of Continuance of Total Darkness, as requiring no other Instrument than a *Pendulum Clock*, and as being determinable with the Utmost Exactness by reason of the momentaneous Occultation and Emersion of the luminous Edge of the Sun, whose least Part makes Day. Nor did this fail of the desired Effect, for the Heavens having proved generally favourable, we have received from so many Places so good Accounts, that they fully answer all our Expectations, and are sufficient to establish several of the Elements of the *Calculus* of Eclipses, so as for the future we may more securely rely on the Predictions: Though it must be granted, that in this our Astronomy has lost no Credit."

Halley seems to have collected quite a large party at Crane Court, for he says that

"There were with us a great many members of the Society: and the Right Honourable the *Earl of Abingdon*, and the Lord Chief Justice *Parker* were of the number: . . . There were also present Gentlemen of other Nations, and among them Monsieur *le Chevalier de Louville* and Mr. *Monmort*, both of them Members of the *Royal Academy of Sciences at Paris*."

Even in 1715 the occurrence of a total eclipse was quite likely to alarm the people, for Halley thought it advisable to warn the public as he states below:

"The like Eclipse having not for many ages been seen in the Southern Parts of Great Britain, I thought it not improper to give the Publick an account thereof, that the sudden darkness, wherein the Stars will be visible about the Sun, may give no surprize to the People, who would, if unadvertized, be apt to look upon it as ominous, and to interpret it as portending evill to our Sovereign Lord King George and his Government, which God preserve."

The observation of this eclipse was favoured with fine weather, and Halley describes how the

"face and colour of the sky began to change from a perfect serene azure blue to a more dusky livid colour, intermixed with a tinge of purple, and grew darker and darker till the total immersion of the Sun."

The well-known phenomena of 'Baily's beads,' first named such after the observation in Scotland of Mr. Baily at the annular eclipse of the sun of May 15, 1836, was distinctly noted by Halley in this eclipse of 1715, for he stated that "about two Minutes before the Total Immersion, the remaining Part of the Sun was reduced to a very fine Horn, whose Extremities seemed to lose their Acuteness and to become round like Stars."

During the total obscuration, which lasted $3^m\ 22^s$, the planets Jupiter, Mercury, and Venus, as well as the stars Capella and Aldebaran, were seen with the naked eye, and "there appeared a luminous ring around the moon as on the occasion of the eclipse of 1706." This luminous ring or corona was regarded at that time as a structureless aureole appertaining to the moon and not, as we know it now, the upper regions of the solar atmosphere, only visible during total eclipses.

Those who have observed total eclipses are familiar with the feelings of weirdness of the occasion, the chilly and damp nature of the air, and the behaviour of animal life, and many who will observe their first total eclipse this year will also be able to corroborate the following account of the 1715 eclipse given by Halley:

"I forbear to mention the *Chill* and *Damp* with which the Darkness of the Eclipse was attended, of which most *Spectators* were sensible and equally *Judges*: or the Concern that appear'd in all Sorts of *Animals, Birds, Beasts,* and *Fishes* upon the Extinction of the Sun, since ourselves could not behold it without some sense of Horror."

The eclipse of 1715 was followed by that of 1724, which took place in the month of May, and was the last to be observed as total in Great Britain. The track of totality passed over the southern portion of Ireland and the south-west portion of England, London being situated just outside the northern boundary. This eclipse was well observed, and Halley again played an important part in connexion with it.

After June 29, 1927, the next total eclipse that will be of special interest to observers in the British Isles is that which will occur in 1999 on August 11 (see Fig. 2). The central portion of the track just skirts the extreme southern coast of Cornwall, so that totality will only be visible to those stationed in the extreme south-west of England. At that remote epoch it is difficult to forecast what the work of the astronomer will be. It is safe to say, however, that the problems now studied during total solar eclipses will all be solved, but it is almost as certain that new problems will have arisen which will necessitate possibly still greater attention being paid to the study of the sun under eclipse conditions. Even if there were no scientific reasons for observing total solar eclipses, they must still attract close attention by reason of the remarkable solar phenomena which then become visible and the weird and awe-inspiring feelings which are aroused by the spectacle.

Spinning Electrons.

By R. H. FOWLER, F.R.S.

THE past fourteen or fifteen months have seen some striking advances and simplifications in theoretical physics. The trench warfare of the preceding three years, which consolidated the ground and marked out slowly the key positions for the new attack, is past. That attack has been launched with almost complete success. The first fury of the advance is perhaps now over. At least it is now possible to survey our older difficulties afresh, to find in many cases that they are no longer formidable. It therefore seems the right moment, and perhaps of general interest, to try to indicate the parts played in this advance by the more striking of the ideas associated with it—in this article the spinning electron. In a later article it may be possible to discuss similarly the other primary conception—the new mechanics, and particularly Schrödinger's equation. Without any assertion of finality in the description of electronic interactions by its means, the importance of the spinning model of the electron can scarcely be over-estimated. Yet the spinning electron has been so lost in the far wider ideas embodied in the new mechanics that it is as yet scarcely appreciated at its full value. It is convenient therefore to devote this article to it alone.

Without prejudice to the difficult prior questions of internal structure, we may regard the electron merely as a singularity in space—the source of the external field by which it is known to us. Until recently this singularity has always been assumed to be the simplest possible, with the external field of an electrostatic point charge acting radially and symmetrically in all directions. The first serious suggestion that the electron should be treated as a more complicated singularity appears to have been made by A. Compton (*Jour. Franklin Inst.*, **192**, 145, 1921). In connexion with a survey of gyromagnetic, diamagnetic and ferromagnetic phenomena he suggested that the singularity might be such as to give rise to the magnetic field of a magnetic doublet besides the usual electrostatic field. Structurally, such an electron must have an axis of symmetry—the doublet axis—and it is natural to think of its magnetism as arising from a spin of its charge about this axis, which will therefore also be its axis of mechanical angular momentum. The fields above mentioned are of course the fields of the electron relative to a set of axes in which its centre is at rest. Relative to other axes they must be derived by the transformation of Lorentz.

We will now show in turn how the use of this more complicated model of the electron resolves the remarkable set of paradoxes in which atomic theory had involved itself by the spring of 1925, owing, as we now see, to the use of an inadequate mechanical model. The most clear-cut of these depends on the statistical conception of weight, so that its appeal is perhaps not so direct as that of some of the others. We know, by a purely enumerative study of atomic spectra and their structure in magnetic fields, the total number of states which must be associated with any one spectral term of an atom or ion. This total is the statistical weight of the term. We know further that spectral terms can be grouped into sets, each characterised by a maximum multiplicity R. If R is one, all the terms are single. If R is two (for example, for sodium), the S terms of the set are single and the rest double, and so on. The weight, as counted above, for an S term of a spectrum of maximum multiplicity R is always R. Now the normal state of any once ionised atom is the core of the atom during the various stages of capture of the next electron. The weight of the core is therefore R, indicating that it can split under perturbation into just R different states. The new electron then comes in, and describes its possible orbits about the core in an approximately central field of force. If the electron is a point charge there seems no escape whatever from the conclusion that the total