Art. IV.—SUN-SPOTS.

THE great sun-spot which made its appearance in the latter part of November last, and which was distinctly visible, even to the naked eye, has had the effect of directing general attention to a subject which some recent discoveries have invested with a peculiar interest.

There is perhaps no branch of astronomy that has made such rapid strides of late years, and that is so full of promise of further revelations in the near future, as that which is concerned with the investigation of the physical constitution of the sun; and it is to observations of the solar spots that we are in large measure indebted for the knowledge which we now possess on that subject.

Though appearances of exceptionally large sun-spots, such as that referred to above, have been recorded from very early times, it was manifestly impossible before the invention of the telescope that those who observed them should form any true idea of the nature of objects which appeared to the eye only as black specks or blotches on the sun's disc. And even after the invention of the telescope a considerable time elapsed before any inkling of their real nature was obtained. The first conjectures were, as might have been expected, exceedingly crude. By some they were considered to be great masses of dense smoke floating above some great centre of conflagration in the sun, like the cloud of smoke which sometimes hangs for days or even weeks together over a terrestrial volcano. By others they were regarded as mountain-peaks or ridges rising above the general surface and showing dark against the luminous background from which they stood out; while by others again they were supposed to be planetary bodies revolving round the sun in such close proximity to its surface as to appear to belong to it. But as improved instruments came into use, and were directed upon the sun's disc, it soon became clear that whatever the so-called spots might be they were certainly none of these things. For a good telescope of even very moderate power shows that they are not projections or protuberances above the solar atmosphere, but rents or cavities in it, bringing into view the lower and presumably less luminous strata of that atmosphere which by contrast with the intensely brilliant surface appear black.

And here, before tracing briefly the successive steps by which our present knowledge on the subject has been arrived at, let me endeavour to convey, so far as mere figures can do so, some idea of the dimensions of these "breaks" or "cavities" in the sun's atmosphere.

The area of the sun-spot is ordinarily divided into the central and darker portion called the "umbra," and the outer and less intensely dark portion of the spot called the "penumbra." A few observers possessed of exceptionally good instruments or exceptionally keen sight, have thought that they have detected within the "umbra" a still more intensely dark or absolutely black portion to which they have given the name of the "nucleus." But for our present purpose it will be sufficient if we adopt the ordinary division into "umbra" and "penumbra."

Now, as to the dimensions of these cavities or depressions, or whatever we may choose to call them, in the solar atmosphere, some measurements may be stated. Sir William Herschell in 1799 measured a spot that was not less than fifty thousand miles in diameter. Captain Davis in 1839 observed an irregularly formed spot, which was not less than one hundred and eighty-six thousand miles in its greatest length, and the surface of which embraced an extent of about twenty-five thousand million miles. Sir John Herschell, after describing a spot which he had himself observed as having an area of three thousand seven hundred and eighty million miles, and another, nearly round, the black space or nucleus in the middle of which "would have allowed the earth to drop through it, leaving a thousand miles clear of contact on every side," says further, "that many instances of much larger spots than these are on record." We may add in reference to the great spot which was visible in November last, as observed by Mr. F. Brodie, of the Fern Hill Observatory, Isle of Wight, on November the 15th, that the "penumbra" measured fifty-six thousand by fifty-one thousand miles, and the "umbra" thirty-nine thousand by twenty-eight thousand. And let it be distinctly understood that these figures are not mere guesses, as seems sometimes to be supposed by those who are not acquainted with the methods employed by astronomers in such calculations, but the result of careful micrometric measurements of the portion of the sun's surface covered by the spots; the extent in miles of any given portion of the sun's surface so measured being, when the sun's distance is known, a simple matter of arithmetical calculation.

As in the course of time the spots came to be observed more systematically and with improved instruments, it soon became apparent that the track pursued by them was always in one general direction, namely, from east to west, so that at whatever point on the sun's surface a spot first appeared, it always moved towards the western edge, or "limb" as astronomers prefer to call it, of the sun, till on reaching the extreme limit of the sun's disc it passed out of sight; an observation which

at first suggested and in the end afforded complete proof of the rotation of the sun on its axis. It was further observed that the spots were not scattered indiscriminately over the surface of the sun, but were always found in two main zones or belts running parallel to the sun's equator and extending on either side from a point a few degrees north or south of it to a point which would correspond to about forty degrees N. or S. latitude on a terrestrial globe, while on the equator itself they were very rarely found, and never near the poles. Nor did it long escape notice that as the spots were very unevenly distributed over the sun's surface, so also their frequency varied greatly at different times, that sometimes for many years very few spots were to be seen, while at other times great numbers of spots, and those of unusual size, presented themselves; though it is only within recent years that the periodicity of these changes has come to be recognised. It has now, however, been established as the result of systematic observations carried on for a period of more than fifty years, that the spots go through a complete series of changes, including a maximum and minimum epoch, in a period of about eleven years and one-tenth, known as the "sun-spot cycle."

Such then are the main *facts* which the telescope has revealed concerning the spots on the sun. Let us now consider the *theories* which scientific men have founded on these facts, in reference, first, to the nature and origin of the sun-spots themselves; and secondly, to their influence on atmospheric and other changes on our earth.

I. Two fundamentally different views have been put forward of the nature and origin of a sun-spot—one ascribing it to causes at work within the sun itself, the other to agencies affecting the sun from without.

The first view is that which was advocated by Sir John Herschell (though apparently only as an alternative hypothesis) in a passage in which he suggests that the spots might be disturbances in the sun's atmosphere analogous to cyclones upon our earth. Referring to the fact, already noticed, that the sun-spots "mainly frequent two zones on the sun's surface nearly corresponding to the regions on our globe in which the trade-winds prevail," he says: "The resemblance is so striking as most strongly to suggest some analogy in the causes of the two phenomena; and it has been held that as our trade-winds originate in a greater *influx* of heat from without on and near the equator than at the poles, combined with the earth's rotation on its axis, so the maculiferous (or spot-bearing) belts of the sun may owe their origin to a greater equatorial *efflux* of heat, combined with the axial rotation of that luminary." And again, after dwelling upon the dimensions of some of the

larger spots referred to above, he says, "What are we to think, then, of the awful scale of hurricane and turmoil and fiery tempest which can in a few days totally change the form of such a region, break it up into distinct parts, open up great abysses in one part and fill up others beside them?" And undoubtedly there is much in the appearance of the spots and of the changes which they undergo, as viewed with high telescopic power, to lend probability to such a view.

The other view is that which supposes the spots to be produced by the impact of meteoric masses, such as are known to follow in the track of comets, on coming into contact with the sun; a theory which has just now a special interest attaching to it, owing to a possible connection which it suggests, between the great sun-spot of November last and the comet which passed so near to the sun in September.

There is an interesting passage in the writings of Mr. R. A. Proctor,[1] in which he ably maintains this view. After referring to certain appearances observed in connection with the great sun-spot of 1859, Mr. Proctor says, "There are indeed reasons for believing not only, as I have already indicated, that the outburst in the sun was caused by the downfall of meteoric masses, but that those masses were following in the train of a known comet, precisely as the November meteors follow in the train of Tempel's Comet. For we know that the November meteoric displays have been witnessed for five or six years after the passage of Tempel's Comet, in its thirty-three years' orbit, while the August meteoric displays have been witnessed fully one hundred and twenty years after the passage of their comet (Comet II., 1862). Now only sixteen years before the solar outburst witnessed by Carrington and Hodgson, a magnificent comet had passed even closer to the sun than either Tempel's Comet or the second comet of 1862 approached the earth's orbit. That was the famous comet of the year 1843. Many of us remember that wonderful object. I was but a child myself when it appeared; but I can well remember its amazing tail, which, in March, 1843, stretched half-way across the sky."

It may well be believed that the two meteors which produced the remarkable outburst of 1859 may have been stragglers from the main body following after that glorious comet. We do not insist upon the connection. We rather incline in fact to the belief that the disturbance in 1859, occurring as it did about the time of maximum sun-spot frequency, was caused by meteors following in the train of some as yet undiscovered comet, circuiting the sun in about

[1] "Pleasant Ways in Science," p. 118.

eleven years, the spots themselves being, I believe, due in the main to meteoric downfalls.

There is greater reason for believing that the great sun-spot which appeared in June, 1843, was caused by the comet which, but three months before, had grazed the sun's surface. As Professor Kirkwood, of Bloomington, Indiana, justly remarks, "Had this comet approached a little nearer, the resistance of the solar atmosphere would probably have brought the comet's entire mass to the solar surface. Even at its actual distance it must have produced considerable atmospheric disturbance. But the recent discovery that a number of comets are associated with meteoric matter, travelling in nearly the same orbits, suggests the inquiry whether an enormous meteorite, following in the comet's train, and having a somewhat less perihelion distance, may not have been precipitated upon the sun, thus producing the great disturbance observed so shortly after the comet's perihelion passage."

In view of the strong grounds which have recently been adduced for believing that the great comet, which is now passing out of sight, is a reappearance of the comet of 1843, my readers will probably agree with me that it is at least a very remarkable coincidence that in each case an enormous sun-spot should have been developed shortly after the comet had passed the sun.

The fields of inquiry opened out by the connection indicated above between comets and sun-spots, are among the most fascinating in the whole range of astronomical research; but we must pass on to consider, in the second place, the effects of these outbursts of solar energy as they concern our earth.

II. Those effects have been supposed to manifest themselves in two ways: first, in variations in the weather corresponding to the variations in the frequency of the solar spots; and secondly, in disturbances of the earth's magnetism, accompanied by displays of the Aurora occurring simultaneously with the appearance of exceptionally large spots.

When the sun-spot period was at first discovered, it was not unnaturally supposed that we had at length found the clue to that for which meteorologists had been so long eagerly seeking—the cycle of the weather. Since the sun's heat is the primal source of all the phenomena which we call the weather, any variation in the amount of that heat, so it was argued, must be accompanied by a corresponding variation in the weather. And in the abstract this reasoning must be admitted to be sound enough. But when the attempt is made to trace the connection between the sun-spot cycle and the weather in sufficient detail to be of practical advantage, the problem is

found to be anything but the simple one which it was at first supposed to be. Indeed the first attempts were made in an altogether wrong direction, it having been assumed, not unnaturally perhaps, but quite erroneously, that the periods of greatest sun-spot frequency would be coincident with periods of diminished solar heat, and the periods of fewest sun-spots with periods when the sun's heat might be expected to be at its greatest. It has now, however, for some time been established that the reverse of this is the fact, and that, whatever else they may be, sun-spots are undoubtedly indications of increased solar energy. Still, when we make the attempt to trace the influence of these periods of increased solar heat upon the weather of our globe, the evidence of any such influence is so doubtful and conflicting as to be of very little practical value; in other words, we are not much, if at all, better able to predict even the general character of a season than we were before the sun-spot cycle was discovered.

The truth seems to be, that though the increase and diminution of the sun's heat which accompanies the increase and diminution in the number of the spots, does, and indeed must affect the weather of the whole globe, yet as regards particular localities the general effect is so overlaid and masked by the various local influences which determine the climate of a place, that it can seldom be traced with any certainty; moreover, in this case the same general cause may produce opposite effects in different parts of our globe, as there is good reason to believe that the very same increase in the sun's temperature which intensifies the heat of a dry and torrid region, may at the same time by raising increased volumes of vapour from the ocean occasion an increase of cloud, with cold and wet weather, in those regions to which the prevailing currents may carry these abnormal masses of vapour.

The connection between the sun-spots and the weather, though a real one, is therefore not of such a kind that we can with our present knowledge found upon it anything in the nature of a weather cycle.

The evidence of the connection between sun-spots and disturbances in the magnetism of the earth is of a very different nature, and is indeed such that it is difficult to understand how it can be questioned by anyone who has that evidence before him.

It may be safely affirmed that whenever the sun-spots are exceptionally numerous or of unusual size, their development is attended by disturbances of the earth's magnetism and brilliant displays of the aurora; and that when the sun-spots are few and small, such disturbances are comparatively rare.

It would be easy to multiply instances in proof of this con-

nection. We shall merely cite one of the most remarkable (already referred to in another connection) as described[1] by Sir John Herschell:—

There occurred, on the 1st September, 1859, an appearance on the sun which may be considered an epoch, if not in the sun's history, at least in our knowledge of it. On that day great spots were exhibited, and two observers, far apart and unknown to each other, were viewing them with powerful telescopes, when suddenly, at the same moment of time, both saw a strikingly brilliant luminous appearance, like a cloud of light, far brighter than the general surface of the sun, break out in the immediate neighbourhood of one of the spots and sweep across and beside it. It occupied about five minutes in its passage, and in that time travelled over a space on the sun's surface which could not be estimated at less than 35,000 miles. A magnetic storm was in progress at the time. From the 28th August to the 4th September, many indications showed the earth to have been in a perfect convulsion of electro-magnetism. When one of the observers I have mentioned had registered his observation, he bethought himself of sending to Kew, where there are self-registering magnetic instruments always at work, recording by photography, at every instant of the twenty-four hours, the positions of three magnetic needles differently arranged. On examining the record for that day, it was found that at that very moment of time (as if the influence had arrived with the light) all three had made a strongly marked jerk from their former positions. By degrees accounts began to pour in of great auroras seen on the nights of those days, not only in these latitudes, but at Rome, in the West Indies, on the Tropics, within eighteen degrees of the equator (where they hardly ever appear); nay, what is still more striking, in South America, and in Australia, where, at Melbourne, on the night of the 2nd September, the greatest aurora ever seen there made its appearance. These auroras were accompanied with unusually great electro-magnetic disturbances in every part of the world. In many places the telegraphic wires struck work. They had too many private messages of their own to convey. At Washington and Philadelphia in America, the telegraph signal men received severe shocks. At a station in Norway, the telegraphic apparatus was set on fire; and at Boston, in North America, a flame of fire followed the pen of Bain's electric telegraph, which, as my readers perhaps know, writes down the message upon chemically prepared paper.

It would be easy, as has been said, to adduce further instances; but those of my readers who witnessed the magnificent displays of aurora on October the 2nd, and November the 17th last, or read the accounts which appeared in the daily papers of the violent magnetic disturbances by which they were accompanied, and will bear in mind the fact that on both occasions a sun-spot of extraordinary size was visible at the time, will hardly doubt that, whatever uncertainty there may be as to the supposed connection between the sun-spot cycle

[1] "Essays on Scientific Subjects."

and the weather, the connection between sun-spots and the magnetism of our earth has at any rate been clearly established.

G. T. RYVES.

ART. V.—THE CHARGE OF THE BISHOP OF MEATH.

Our Country and our Church. A Charge delivered to the Clergy of the Diocese of Meath at his sixth Visitation, October, 1882, by the Most Rev. Lord PLUNKET, D.D., Bishop of Meath. Dublin: Hodges, Figgis, and Co.

IN regard to the Church of Ireland, her position and prospects, no man has a better right to speak than Lord Plunket, the Bishop of Meath. The Charge which he delivered at his recent Visitation deals not only with the concerns of the diocese of Meath, but with the leading social and religious features of the recent agitation in Ireland, considered chiefly, of course, in their relation to the Protestant Church. In bringing before our readers those portions of the Charge which, in a hopeful vein, weigh the evil and the good of disestablishment and disendowment, and give the outlook of the Church as she stands, we pass by the comments which have been made upon the Charge in political or party columns, and we also omit any allusion to statements recently made, both on this side the Channel and on that, about the probable effect of Mr. Gladstone's policy, and of lawless agitation, upon the scattered parishes of the Church, and upon the Church as a whole. It is our purpose, out of the deep interest which we take in the Church of Ireland, that the honoured Bishop should speak for himself. Certainly, as regards ourselves, we have no desire, to point a moral, in any way whatever, at the expense of the Irish Church.

In the diocese of Meath there are, at present, 79 parishes, with a "Church population" of 13,000 souls. According to a Parliamentary Report in the year 1802, of the 92 incumbents then holding livings in the diocese of Meath, 47 (that is a clear majority) did not reside within their parishes; of these, 19 were pluralists, who resided in other parishes, and did their duty in Meath by proxy. Again, in the year 1802, there were 12 benefices without churches, and 54 without glebe-houses. In 1882 all the members are residing in their parishes.[1] There is now no incumbency

[1] "If we include four clergymen temporarily absent from ill-health and two who, from the want of a suitable residence within the parish, are obliged to reside beyond its limits, but within easy reach of their duties."