On the Work of the Past Year in Astronomy and Celestial Physics.

By J. S. Webb.

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What I am about to say this evening will not fulfil the promise of the title under which it has been announced, but I hope that it will be of none the less interest on that account. Indeed, any attempt properly to sketch the work of a twelvemonth in such a wide range of research, within the limits of a single address, must of necessity end in a barren and uninstructive catalogue of details. I have only selected for remark a few matters of the greatest interest to all, and in regard to those have confined myself almost wholly to the part of a narrator.

Before entering on the proper subject of this address, I cannot refrain from expressing a regret, which I have no doubt you all share with me, at the fact recently made public that the Astronomer Royal has replied in discouraging terms to the communications addressed to him by the Astronomical Society of Christchurch on the subject of the formation of an efficient Observatory at that city. On the last anniversary of the foundation of the sister Province—on the day of its attaining the mature age of twenty-one years—in one of those bursts of genial enthusiasm so often inspired by the celebration of anniversaries, especially where those celebrations take the form of public dinners, and which do occasionally lead to very useful results, it was determined by some of our public-spirited fellow-colonists in Christchurch that a lasting memorial of the day they were celebrating should be enterprised, and their aspirations (determined by what influences I cannot say) took definite shape in the formation of the society I have alluded to, under whose auspices it is proposed to establish such a memorial in the form of an Astronomical Observatory. This society set about its work in right good earnest, and I think we ought most cordially to wish it success. Within a few years from the present time it is almost certain that an Observatory will be founded in New Zealand. Those of you who take a deep interest in those sciences to which we owe our knowledge of what is beyond the little globe on which we live, will join with me in desiring that this Observatory shall be as near to us as may be. It seems, however, to be very probable that if our friends in Christchurch fail in this creditable enterprise, Auckland will be the chosen spot. In every list that I have seen of the places from which it is intended that British astronomers shall observe the transit of Venus over the sun's disc, in 1874, I notice that Auckland is mentioned. How far this is authoritative I do not know, but it is now nearly two years since it was mooted at a meeting of the Auckland Institute that some steps should be taken to secure

the instruments which would be sent thither for the observation of the transit and so to form the beginnings of an observatory. Now, quite independent of all selfish feelings, I think we shall have cause for regret—a regret which will be shared with us by a great many persons in all parts of the world—if the future observatory of New Zealand is fixed at Auckland rather than in the South Island. In latitudes similar to that of Auckland the world is now girt with a chain of observatories. There used to be in former days an observatory—of what pretensions I do not know—at Hobart Town, but it has, I believe, been dismantled for some years. It is to be desired, therefore, that our New Zealand Observatory should be placed in as high a latitude as possible, and the more so now that the work of an observatory includes so much more than the watching of stars and planets. Only here and in South America can any observatory be planted nearer by any considerable approximation to the South Pole of the earth than that chain of southern observatories to which I have just alluded—a chain which may be considered to be now fairly complete, including as it does those of Paramatta, Melbourne, the Cape of Good Hope, Cordoba, and Santiago. The Christchurch Society has not been wholly discouraged by the unfavourable advices lately received. The nature of these has not, so far as I am aware, been made public, but whatever the objections I trust they will be eventually overcome.

The allusion just made to the chain of observatories which encircles the globe in a line nowhere far distant from the thirty-fifth parallel of southern latitude, reminds me that the establishment of one of these forms part of the work of the past year. It was in October, 1871, that the Argentine Observatory at Cordoba was inaugurated. The staff of observers had been on the spot for some time beforehand, but there had been considerable delay in bringing the instruments into position and working order. In the meantime Professor Gould, the director of the observatory, and his assistants, did not forget that there were astronomers before instruments of modern type were thought of. What they continued to do whilst waiting for their instruments offers an example to all lovers of the science to which they have devoted their lives. After computing the tables necessary for their future work, they set themselves to form a catalogue of all the stars of the southern heavens which are visible to the naked eye. Probably when they began this work they were only endeavouring to familiarize themselves with the field of their future researches, but the patient toil has been rewarded by many interesting discoveries. The variability of a great number of our southern stars has been determined by a comparison of these new observations with those of previous observers. Two of the stars, whose variable character has been established by these patient workers, are remarkable for the short periods during which they pass from maximum to minimum of brightness. One of these stars is in the

constellation Musea. It passes through all its changes in the extraordinarily short period of twenty-one hours and fifteen minutes, and during one-fifth of that time is invisible to the unassisted eye. The other is in the Southern Triangle, and has a period of three and a half days, during part of which time it also is invisible. Professor Gould, in his inaugural address, calls attention to the great field that lies before the southern observer of the fixed stars. The number of stars belonging to the Northern Hemisphere whose positions and magnitude have been catalogued is 330,000, whilst less than a sixth of that number have been defined in the regions south of the equator. Of the latter by far the greater number are stars which are visible in Europe. A circle drawn round the South Pole, with a radius of 60° of latitude, will only include 13,000 known stars, whilst a similar tract of the northern sky includes 164,000. Great as is the difference between the two regions in brilliancy, it is certain that much work has to be done before the catalogues of southern stars reach anything like the perfection of those of the north.

The Cordoba observers have been watching the variabilities of stars. Far vaster changes in celestial objects have been subjects of investigation to other astronomers in this hemisphere. It is now some years since Mr. Abbott, of Hobart Town, pointed out the fact that the star *eta* Argus is no longer actually in the nebula where it was seen by Sir John Herschel. The careful observations of the nebula and neighbouring stars which have been incited by this discovery, have led to the knowledge of extraordinary changes now in progress in this distant object. The Melbourne observers have paid great attention to the subject, and Mr. M'George, in a paper read a few months ago before the Royal Society of Victoria, gave a sketch of the results, illustrated by five drawings of the nebula, as observed at different times. The changes which have occurred since the great Melbourne reflector was first turned towards it have been rapid and most extraordinary. It is much to be regretted that the Royal Society of Victoria is not in a position to publish the more important of the papers read at its meetings, some of which are of world-wide interest. Now that the Melbourne Observatory possesses one of the finest telescopes in the world, we may expect that from year to year the indefatigable and able men who have the charge of it will be in a position to add greatly to our knowledge of the phenomena of the southern heavens. The attention they are paying to this and other nebulæ will no doubt lead to an increase of our knowledge of the physical constitution of these wonderful objects. For instance, when *eta* Argus was first observed to have broken loose from the dense nebula in which it was seen by Herschel, the lines of burning hydrogen were distinctly seen by Mr. Le Sueur in its spectrum. He then offered the conjecture that the star had consumed the nebula. In the latest observations of which I have seen any account no trace of the bright hydrogen lines was found, but the star was

found to be nebulous, the nebulosity being most condensed near it. If, as Mr. Le Sueur conjectured, this star had consumed the nebulous matter which formerly surrounded it, it would appear to have found a fresh envelope.

Mankind for ages believed that the celestial orbs ruled the destinies of men in some occult but very direct manner. Science is gradually restoring to us some phases of this faith. The influence which the physical circumstances that surround him have upon the character and actions of the individual man, has been made clear by the comparison and classification of innumerable observations. The statistics of human life, of human action, and human manners, have been brought into conjunction with those of the physical conditions to which our race is subjected, and wonderful and most convincing coincidences have been revealed; and at the same time we have been learning how intimate is the tie which binds together all things that exist in the universe. It is no new thing to acknowledge the rule which the sun has over the physical conditions which prevail upon our planet; but it is only of late years that we have been taught to appreciate at their full intent the influences which are brought to bear upon the sun from without—influences which dictate the character of his dealings with the subordinate members of this system, of which he is the ruling centre. The time has gone by when the sun was accepted as a self-sufficient source of light, and heat, and power. Irreverent investigators inquire into his pedigree, speculate upon the sources of his annual income of force, calculate the probable length of his present existence, and dogmatize on the nature of the "future state" that is provided for him. We have long since satisfied ourselves that there is no certainty about the sun; we suspect him of being influenced by the fair face of any planet that happens to be in aphelion, accuse him of consuming comets behind the scenes, and of devouring myriads of asteroids to keep himself and his subject planets warm. And so we have come to recognize the fact that, as the moral condition of a nation depends upon its harvests, so do these harvests depend upon the physical condition of the sun's surface, whilst this, in its turn, depends upon other things of which we have as yet but little knowledge, but of which we know enough to certify us that they again are not independent phenomena, but are moulded and made what we find them by the flux and reflux of cosmical forces whose origin is far beyond our ken, and of whose mode of action we have but a faint glimmer of knowledge.

Such reflections as these are inevitably excited in the minds of those who address themselves to the study of the current labours and speculations of their fellow men in the departments of science with which we are occupied to-night. The past winter in the Northern Hemisphere, as with ourselves, was remarkable for the occasional intensity of its cold, and general severity of its weather. In November and December the cold was very severe, then

followed a period of eight or ten weeks during which the temperature was above the mean, followed by another period of unusual cold. A careful examination of such records as are available convinces us at once that such a circumstance is no fortuitous accident. There is a weather cycle, not yet perhaps so clearly defined, but certainly as well ascertained as any of those cycles of celestial movements which depend on the unvarying law of gravitation. The temperature of the earth's surface varies from year to year, and shows a maximum every eleven years, or rather in periods of a little more than eleven years. Just before the maximum, and just after it, come the periods of lowest temperature. Very lately, Professor Smyth in Edinburgh, Mr. Stone at the Cape of Good Hope, and Mr. Abbe at Cincinnati, each working upon different materials, have pointed out the close coincidence between the curve of varying terrestrial temperature and that of the sun-spot periods; this is the first generalization. Observations of the sun's surface have not yet extended over a period sufficiently long to admit of a comparison of the phenomena presented with that more extended cycle of about forty-one years which M. Renou long ago deduced from his investigation of the records of great winters. The connection between terrestrial variations of climate and the sun-spot period being established, we at once desire to push our investigation a step further. If the character of our winters depends on the condition of the sun's surface what is it that rules the latter phenomenon? Is the cause within the sun itself, or may we look for it without? Analogy and the cyclic character of the variations lead us to prefer the latter solution. The extraordinary character of the weather of the last and preceding years, the recent extension of our means of examining the surface of the sun, the unusual magnificence of certain auroral displays which have occurred during the period I have under review to-night, have combined to direct the attention of physicists to the inter-connection of various cosmical and terrestrial phenomena. The result has been that every research leads to surer convictions of the inter-dependence of natural phenomena; whilst the further we push our investigations the more we feel that the ultimate cause of those phenomena eludes our grasp.

No natural phenomenon of modern times has evoked at the moment of its occurrence a greater mass of scientific record and speculation than the aurora which, on the night between the 4th and 5th of February last, astonished Europe, and fired the skies over one-half the globe. This aurora was visible in North America and the West Indies, over the whole breadth of Europe, in Western Asia, at the Mauritius, and in Western Australia. There can be very little doubt that, had daylight not interfered to prevent it, the magnificent spectacle which it presented would have been seen from every point on the surface of the globe.

This splendid aurora was coincident with a period of equally notable agitation of the surface of the sun. Signor Tacchini, the Director of the Observatory at Palermo, who devotes himself with great ardour to the spectroscopic observation of the sun, thus describes the condition of things which he found prevailing when the sun rose on the morning of the 5th :—"All the surface of the sun was in abnormal circumstances; the entire rim was covered with splendid flames; towards the North Pole these rose to the height of 20″ (equal to about 9,000 miles), over an arc of 36° to the right and to the left, corresponding to a region of (incandescent) magnesium which on the western border extended to the Equator. In this region, at 50° from the pole, a magnificent protuberance was observed which rose to a height of 2′ 40″ (more than 70,000 miles), and from this point through an arc of 40° the rim presented numerous brilliant flames, and the atmosphere was completely encumbered with luminous threads and shining points up to a height of 2′ (55,000 miles). The chromosphere was throughout more elevated than usual." Along with this agitation of the surface of the sun was to be noted the striking brilliance of the zodiacal light, which some physicists are now maintaining to be in fact a solar aurora. Intimately connected with the auroral display was the appearance of a group of meteors, the radial point of which was in an unusual position. As usual on such occasions a magnetic storm prevailed, and the various telegraph lines including the Atlantic cable were taken possession of by induced currents, which for a considerable period rendered it impossible to work them.

The unusual climatic conditions, and the exceptional prevalence and intensity of auroras (that of 4th February was only the most conspicuous of an extensive series), have filled the transactions of scientific societies and the pages of periodicals devoted to science with statistics, arguments, and theories, all having for their object the elucidation of the cosmical origin of those terrestrial phenomena. I purposed to have given a general account of these to-night, but time will not permit. The intimate connection between both these classes of phenomena and the condition of the surface of the sun is, of course, a fundamental feature with all of them. Signor Tacchini gives it as his opinion that "our polar auroras are nothing else, at least in the majority of cases, than phenomena of electric induction due to the immense auroras produced on the sun." In one form or another this is admitted by almost all theorists on the subject. One theorist has with much ingenuity attempted to connect these phenomena with one another, not as cause and effect, but as both resulting from a common cause. M. Silbermann, after a life-long study of atmospheric currents, forms of clouds, shooting-stars, auroras, and solar phenomena, has reached the conclusion that the innumerable streams of meteors which the earth is continually passing through, are the efficient causes

of all these phenomena. In regard to the auroras of last February he has pointed out that a meteor-stream made its presence known by shooting-stars at the time of the auroral display of the 4th. In the case of auroras in January he traces a stream of meteors from the neighbourhood of Jupiter, where but a short time before phenomena of a very singular character were observed, which he claims to have been the effect of similar auroral displays in the Jovian atmosphere. Jupiter's third satellite passed between us and the disc of the planet in December last. Those who were observing it saw with surprise that instead of appearing bright on the grey background of the planet's atmosphere, it appeared black in contrast with a light of unusual brilliance and of a rosy tint, which seemed to be produced in the atmosphere of the planet, and which some observers conjectured to be a Jovian aurora. A few days afterwards, early in January, 1872, some fine auroras brightened the atmosphere of our own planet, and very shortly afterwards an extraordinary number of protuberances and hydrogen jets made their appearance on the sun. The stream of meteors—to the action of which M. Silbermann attributes the occurrence of all these phenomena—continued to pass the earth for some weeks afterwards, making its presence known by shooting stars radiating from a particular point in the heavens, near the place of Jupiter, and by the auroras of 4th February and 22nd and 23rd of the same month, which accompanied these apparitions.

The central point in the astronomical work of the past year is undoubtedly the observation of the eclipse of December last. The secrets of the chromosphere having been so successfully unravelled, the attention of astronomers was, during the last eclipse, devoted in a great measure to the solution of another grand solar problem—the constitution of the Corona. This question may be said to have been definitely set at rest by the observations then taken. The most successful observations were those of M. Janssen, and I very much regret that his detailed account of them has not yet reached this distant corner of the world, not having been presented to his associates of the French Academy of Sciences up to the end of June. On this account, and because this address is otherwise too long, I propose to remit my remarks on this eclipse to some future occasion. Here I will merely say that the observations of December last definitely prove that the coronal light, which is seen during a total eclipse, is not a simple phenomenon. It is partly derived from reflection of solar light by the particles of a true solar atmosphere, and partly from hydrogen, and probably some other substances, which are at a sufficiently high temperature to be self-luminous.

Setting aside the eclipse observations for the present, the most interesting of the work that has been performed by astronomers during the past year is that which relates to the chromosphere of the sun. Since the method of

spectroscopic observation, by which it is possible to examine this curious region of the sun in broad daylight, was made known, it has been the subject of most ardent investigation in all parts of the world. The Directors of some of the Italian Observatories have, however, taken a decided lead in this interesting field of research. Signor Tacchini, to whom I have already alluded, and Father Secchi, the Director of the Roman Observatory, have been making simultaneous daily observations and drawings of the borders of the sun. Their labours, coupled with those of Lockyer, Huggins, and others in England, have already secured for us a knowledge of what is going on in this particular region of the sun, which may almost be looked upon as complete so far as the phenomena themselves are concerned, although we are yet very far from having anything which we can fairly dignify with the name of knowledge of the proximate causes of what we observe. Father Secchi has contributed to the Proceedings of the French Academy of Sciences what I may call a descriptive catalogue of the phenomena which are to be observed in the chromosphere and protuberances. . . . [Mr. Webb proceeded to give a description of the various appearances presented from time to time by the chromosphere and the "red prominences" which arise from it, which would scarcely be intelligible without the drawings by which it was illustrated. These drawings were coloured copies on a large scale of those which illustrate Father Secchi's paper in the "Comptes Rendus," T. LXXIII., pp. 826, *et seq.*, 2nd October, 1871. After an allusion to the forms of some of these detached masses of flame which have the character of clouds, as "evidently due to the action of fierce atmospheric currents," he proceeded as follows :—] Father Secchi considers that he has established, by a twelvemonth of patient observation, the existence of such currents on the sun having a general set from the equator to the poles, varied by local circumstances in the neighbourhood of important sun-spots. This result has been contested with some spirit, especially by M. Faye, the President (last year) of the French Academy. Those astronomers who are most familiar with the chromosphere appear, however, to accept Father Secchi's theory, satisfied that the observed phenomena coincide with it, and not disposed to make too much of theoretical difficulties. The latter are, indeed, found to be very great when we attempt to explain to ourselves how a circulation can exist on the surface of the sun having any analogy to the trade winds which prevail in certain regions of the earth—or rather to those upper reverse currents which accompany these phenomena. We can account for our own winds by the action of the sun upon our atmosphere, but we are entirely at a loss when we come to inquire how an atmospheric circulation similar to that which the earth enjoys should be engendered on the sun itself. That such currents do exist appears to be established, and when we find a satisfactory theory by which to account for the extraordinary peculiarities

of the solar rotation, which is far more rapid at the equator than near the poles, we shall probably also find the clue to the problem of solar trade winds.

I fear I have exhausted your patience. I have certainly exhausted the time at my disposal either for the preparation or delivery of this address. My subject, however, remains quite inexhaustible; and, with the eclipse of December last, at least one-half of my notes must be remitted as material for a future address.