A SOUTHERN OBSERVATORY.

ON Tuesday, August 21, 1888, the Union steam-ship, *Mexican*, crossed the Line outward-bound for the Cape, and a certain proportion of her passengers, amongst whom was the present writer, found themselves for the first time in the southern hemisphere. A few nights later, half an hour's darkness before moon-rise gave time for a splendid display of unfamiliar stars. The Southern Cross lay prone towards the west; Alpha and Beta Centauri shone triumphantly above it; Achernar was climbing the sky on the other side of a pole singularly denuded of bright companionship; the lucid streams and knots of the Milky Way were reflected in a pearly shimmer from gently heaving waves, the brilliant effect of the entire sidereal landscape being enhanced by the presence of Jupiter and Mars close together in Scorpio, while the dim cone of the Zodiacal Light, tapering upward from the sun's place, faded out above them on the black background of the sky.

The " four stars,"

> " Non viste mai fuor ch' alla prima gente,"

appealed to mediæval imagination as a symbol and a prophecy of the uplifting of the Cross in the waste places of the earth. Modern travellers regard them from a more prosaic point of view, and are apt to be " disappointed " at their unequal lustre and slightly unsymmetrical arrangement. The firmament they help to adorn, however, is of a splendour at first sight absolutely startling, and at all times peculiarly suggestive. The dullest mind can hardly fail to be roused to wonder by the appearance of the galaxy as it extends past Sirius amidst the grand procession of the stars in Argo, or where the great rift in its structure spans the heavens from the Centaur to the Swan. The intricacy of its branches, the *curdled* texture of its surface, the stupendous collection of distant suns, almost palpably rounded out from the void of space in Sagittarius; the abrupt vacuity of the "Coal-sack," recalling the dark "lanes" tunnelling certain nebulæ and star-clusters, invite, only to baffle, speculations, which the tempting analogues presented by the never-setting Magellanic Clouds, with their mixed contents of stars and nebulæ, help further to stimulate.

"What is the Milky Way?" may be called the question of questions for future astronomers; but it has only of late been brought to some extent within the range of available methods. More feasible aims prompted the foundation of southern observatories. English official astronomy in particular took its rise directly from the requirements of English seamen. Flamsteed was commissioned to determine the places of the stars, not because any speculative interest attached to them, but simply in order that they might serve for divisions (as it were) of the great dial-plate of the heavens, upon which the moon marked Greenwich time, and might hence be got to tell the longitude in every part of the world.

But English astronomy was incomplete, even from a strictly utilitarian point of view, so long as it failed to embrace the whole of the celestial sphere; and in proportion as England's colonial empire became consolidated, the need of a supplementary establishment to that at Greenwich was rendered more and more imperative.

In the choice of its situation, there was scarcely room for a doubt. The Cape of Good Hope was already distinguished as the scene of Lacaille's labours in 1751–3; and these furnished the virtual starting-point of austral astronomy. As their result, ten thousand southern stars and forty-two nebulæ were *known* at the beginning of this century; and an indication of a somewhat anomalous character (yet the only one of any kind at hand) had been procured regarding the figure of our globe south of the equator. It seemed to show that the earth *bulged the wrong way*—in other words, was prolate instead of oblate. Its correction or verification was hence of extreme interest, and the re-measurement of Lacaille's arc of the meridian came to be recognized as a prime necessity of geodetic science. By an Order in Council, dated October 20, 1820, the establishment of a permanent observatory at the Cape was accordingly decreed, and the first Royal Astronomer was immediately afterwards appointed, in the person of the Rev. Fearon Fallows, of St. John's College, Cambridge.

A Cumbrian weaver's son, he had contrived, while still a boy working at the loom, to attain a notable proficiency in mathematics; and, his talents attracting attention, some gentlemen of the neighbourhood subscribed to procure him a suitable education. He graduated in 1813, as third wrangler to Herschel's and Peacock's first and second, and was elected on the earliest opportunity a Fellow of his college. The prosperity and happiness of his life culminated when he found himself as His Majesty's Astronomer at the Cape, in a position to marry the eldest daughter of his first patron, the Rev. Mr. Hervey, of Bridekirk.

This, however, was the last fortunate event of his life. Disappointment and chagrin presided over the entire series of poor Fallows' experiences in South Africa. Suspense through circumlocutory proceedings at home, anxiety due to the misconduct or lawlessness of those employed by him in the colony, vexation indescribable at the defects of the instrument he had chiefly relied upon, personal illness, the deaths of all the children successively born to him, at last exhausted his vital energies, and he died of dropsy supervening upon sunstroke and scarlet fever, July 25, 1831, at the age of forty-two. His grave is in a spot of ground consecrated by himself within a stone's-throw of the broken pier of his transit-instrument; and the syringa-trees he planted now lean their blossom-laden branches towards the upper windows of the dwelling-house where he might have hoped to spend many useful and happy years.

But his work at the Cape was not thrown away. The buildings of the new observatory were well planned and solidly executed; its site was judiciously chosen on a slightly rising ground three miles south-east of Cape Town, almost islanded by the converging sinuosities of the Liesbeck and the Salt River. A desolate spot enough it must indeed have been when Fallows took his first survey of it. Wolves were then still common in the neighbourhood; the cries of jackals mingled at night with the metallic chirping of the Cape frogs; the last Salt River hippopotamus had, not long before, met an untimely death by drowning in its marshes; the mole-burrowed hill-side was bare of almost every form of vegetation save a luxuriant crop of thistles.

Now the smiling culture everywhere apparent indicates the neighbourhood of a refined English home. The slopes are in spring all a-bloom with lilies, asters, and gladioli, delicately striped and shaded with pink and mauve, or flaunting gaudily in purple and orange; Australian willows—the Cape substitute for laburnums—make golden patches against the dark foliage of thick-growing pines planted half a century ago by Lady Maclear on the simple plan of inserting a cone into every molehill; clumps of aloes and eucalyptus recall the vicinity of the tropics; a grove of oaks and cypresses, due to Professor Piazzi Smyth's skill in forestry, brings memories of England; white arums, irrepressible and all-diffusive, nestle round tree-roots, strain upwards to the light through the midst of tall shrubs and hedges, fling themselves in lavish profusion amidst the lush grass, marching processionally (so to speak) or halting in dense clusters, and making milky ways of blossom along every marsh and meadow. Here, indeed, are lilies, enough and to spare, to strew, "with full hands," the graves of a hundred young Marcelluses.

In succession to the weaver's lad from Cockermouth, there was appointed to direct the new South African observatory a solicitor's clerk from Dundee. Thomas Henderson began, at the age of fifteen, to devote his leisure hours to astronomy. His instinct, however, was for the mathematical part of the science; and he had probably never seen a transit-instrument, or handled a telescope, until after he came to reside at Edinburgh in 1819. His twofold life prospered. In his legal capacity he became secretary to Lord Advocate Jeffrey; his astronomical calculations brought him to the notice of Dr. Thomas Young, Sir John Herschel, Captain Basil Hall, and other eminent men. In the summer of 1829, Dr. Young gave in charge to Professor Rigaud a memorandum urging Henderson's superior qualifications for the post of Superintendent of the Nautical Almanac, vacated by his own death a fortnight later; and the recommendation was doubtless influential in procuring for him after three years the offer of the Cape observatory.

Assuming the chief command there in April 1832, he accumulated, in thirteen months, a surprising number of valuable observations, still in part unpublished. One of the results derived from them was, however, of so striking a character as to attract instant and universal attention. It was nothing less than the first authentic determination of the distance of a fixed star.

After Sirius and Canopus, the brightest star in the heavens is Alpha Centauri. This beautiful object is easily resolved into two: one fully three times brighter than the other. And these two circulate round each other, or rather round their common centre of gravity, in a period of about eighty-eight years. The system thus formed was discovered by Henderson to have an "annual parallax" of just one second of arc. That is to say, the apparent places of the component stars as viewed from opposite sides of the earth's orbit, differed, through a familiar effect of perspective, by $\frac{1}{162000}$ of the distance from the horizon to the zenith. The more refined determinations of Drs. Gill and Elkin, while establishing its reality, have since shown that Henderson's parallax was somewhat too large. The actual distance of Alpha Centauri from the earth is, in round numbers, twenty-five and a half billions of miles. Even the ethereal vibrations of light occupy four years and four months in spanning this huge interval; yet Alpha Centauri (so far as is at present known) is the nearest neighbour of our sun in space!

The attractive power of each of these coupled stars appears to be about equal; but while one is nearly twice, the other is only half as luminous, in proportion to the amount of matter it contains, as our own sun. Hence, according to our present notions, the darker, more condensed body must be considerably more advanced on the road towards extinction than its brilliant companion, and an attentive study of its spectrum ought to give interesting results.

Henderson returned to Europe in 1833, unable, in the uncertain state of his health, to support the discomforts—long since banished with the wolves and jackals—of a residence at Observatory Hill. He became Astronomer Royal for Scotland in 1834, and died suddenly of heart disease ten years later.

The third astronomer at the Cape, and the first whose term of activity there was prolonged to a fitting conclusion, was an Irishman. Sir Thomas Maclear was born at Newtown Stewart, in county Tyrone, March 17, 1794. His career, like those of his predecessors, swerved insensibly towards the stars. He was a physician practising at Biggleswade, in Bedfordshire, whose astronomical proclivities had been fostered by the genial influence of Admiral Smyth, when summoned, as one may say, to the celestial charge of the southern hemisphere.

The Royal Observatories at Greenwich and the Cape of Good Hope form together an astronomical establishment such as no other nation besides our own can boast of possessing. It fitly represents the world-wide dominion of which it is the corollary. British empire on the seas led directly to British empire over the skies, the one gaining completeness as the inevitable consequence of the expansion of the other. Southern astronomy seems the proper appanage of the Anglo-Saxon race. Originating with Halley's expedition to St. Helena in 1677, Lacaille's work at the Cape formed the only exception worth mentioning to the rule of its prosecution by our fellow-countrymen on either side of the Atlantic. So far, indeed, as *geometrical* astronomy is concerned, it would survive, without vital injury, the destruction of all results except those obtained at Greenwich and the Cape. Geometrical astronomy is now, however, only one, though the most important, branch of the science.

Sir Thomas Maclear proved an indefatigable and skilful observer. He co-operated energetically with Sir John Herschel, whose memorable stay at Feldhausen, three miles from the Royal Observatory, coincided with the first four years of his tenure of office. He remeasured and extended Lacaille's arc, thereby not only removing all doubt as to the conformity to scientific prediction of the earth's figure, but providing an invaluable groundwork for the survey of the entire colony, now in active course of prosecution by Major Morris, R.E. The long list of comets observed by Maclear includes Halley's, Donati's, Biela's, Encke's at four returns, and the great "southern" one of 1843. He accumulated materials for three star-catalogues, prepared for the press and published by his successors, Mr. Stone, the present Radcliffe Observer, and Dr. Gill. And so completely had his interests become identified with those of his adopted home that he continued, after retiring from the Observatory in 1870, to reside in its vicinity; and on his death, July 14, 1879, was laid to rest within its grounds.

His son, Mr. George Maclear, retains charge of the transit-circle procured by his father in 1855. It is an exact copy of that erected by Sir George Airy at Greenwich.

Mr. Stone was chief assistant at Greenwich when induced to accept the appointment to the Cape by the opportunity it offered for the preparation of an extensive star-catalogue, by the comparison of which with the earlier Madras and Brisbane catalogues something might be learned about the movements of southern stars. This object was most satisfactorily attained by the publication of the "Cape Catalogue for 1880," containing nearly 12,500 accurately determined star-places. By a pure coincidence, Dr. Gould's simultaneous work at Cordoba had the same scope. Its brilliant results are familiar to all astronomers.

Mr. Stone surrendered the direction of the Observatory, in June 1879, to the present Royal Astronomer. Dr. Gill is one of a long line of distinguished Aberdonians. An astronomer by "irresistible impulse," he, like Bessel, exchanged lucrative mercantile pursuits for the comparatively scanty emoluments awaiting the votaries of the stars. The "patines of bright gold," with which Urania's treasure-chests overflow, are not of terrestrial coinage.

The distance of the sun was the first problem upon which Dr. Gill delivered a substantial attack; and his solution of it still remains the best obtained by celestial trigonometry, corresponding so closely with Newcomb's value of the same great unit, derived from direct measurement of the velocity of light, as to reduce within reassuringly narrow limits the uncomfortable margin of uncertainty left by the transits of Venus. In the observations of Mars made for this purpose at Ascension in 1877,* Dr. Gill employed the instrument of his predilection, called —on the *lucus à non lucendo* principle—a "heliometer."

A heliometer is a telescope of which the object-glass has been sawn in two. This does not sound like, nor would it be, an improvement for purposes of simple star-gazing; but the end in view is different. It is that of *precisely* determining the angular distances between adjacent stars, or between a planet and stars near it, though in many cases beyond the range of the ordinary micrometer. The following is the way in which this end is compassed.

The half-lenses of the object-glass are separable by a very fine screw-motion, and they form independent and separable images of any object upon which the telescope is pointed. These images unite into one when the two segments unite to complete one circle; as they are made to slide apart, the images too slip sideways asunder to an extent which can be measured with the minutest accuracy by exquisitely divided scales read with a powerful microscope. In the actual process

* For a popular account of the expedition, see Mrs. Gill's charming "Six Months in Ascension." Murray. Second edition. 1880.

of observation, the telescope is fixed upon a point midway between the stars under scrutiny, so that the field of view is, to begin with, empty. Neither star can be seen. Then the segments of the object-glass are moved oppositely along a line brought beforehand to agree with the line of direction between the stars, until the more westerly (say) of the pair as imaged by one segment, and the more easterly as imaged by the other, begin simultaneously to appear, and are at last carefully made to coincide in the middle of the field. After the scales have been read, the motion is reversed, and a similar coincidence is brought about between the oppositely corresponding stars—that is, between the easterly member of the pair shown by segment No. 1, and the westerly member of the pair shown by segment No. 2. The total distance traversed is, of course, equal to twice the distance between the stars.

The refinements, however (which cannot here be explained), attendant upon these operations are what make their results valuable, and the process of educing them laborious. With the Copernican "triquetrum," the measured apparent intervals between any two of the heavenly bodies could be depended upon to within ten minutes; with the new Repsold heliometer, the error of a single observation is less than one-tenth of a second of arc. So that accuracy has been increased, in the course of three and a half centuries, some six thousand times! At what cost of patience and expenditure of the counted moments of individual human lives, as the fruit of what illuminations of genius, throes of invention, failures and disappointments in some quarters, compensatory triumphs in others, can never rightly be told. The progress achieved was by "leaps and bounds;" it must henceforth be by slow and painful foot-lengths, as the limit of possible accuracy is brought imperceptibly nearer. It is not likely that the astronomical data of three and a half centuries hence will be six thousand times more accurate than those at our disposal.

The heliometer is, of all others, the instrument best adapted for the work (exceedingly simple in principle, yet delicate to an almost inconceivable degree in the details of its execution) of determining stellar parallaxes. The diameter of the earth's orbit affords a base-line 186,000 miles in length, from opposite extremities of which—that is, at opposite seasons of the year—the distances between the object to be examined and two "comparison-stars" are measured. The infinitesimal alternate shift of the star nearest the earth to and from those with which it is compared (assumed, with little risk of error, to be indefinitely remote) is called its "parallax." From its angular amount the distance in miles of the star from the earth can be at once derived.

The minuteness of this little parallactic *see-saw* is difficult to be realized by those unpractised in such matters. A displacement of one second on the sphere is equivalent to a shifting across the width of a human hair placed seventy feet from the eye. But no known star has so large a parallax as one second, which is as much as to say that no known star is so near to us as 200,000 times the distance of the sun. Positive results might, under these circumstances, well have been despaired of; yet they have, in a number of cases, been attained, and form the surest groundwork so far provided for investigations into the mechanism of the skies.

Dr. Gill's observations for stellar parallax were begun at the Cape, July 5, 1881, with the Dunecht heliometer, of which he had become the possessor by private purchase from the Earl of Crawford. He had as a coadjutor Dr. W. L. Elkin, who is now in very effective charge, at Yale College, of the only heliometer yet erected on any part of the American continent. Nine stars in all were measured, of which two gave no indications of possessing *any* sensible parallax. Both, remarkably enough, are brilliant stars of the first magnitude—Canopus and Beta Centauri—which, to shine as they do, from unfathomable depths of space, must be objects of astounding splendour. Canopus, especially, cannot emit less, and may emit a great deal more, than fifteen hundred times the light of our sun—unless, indeed, Dr. Elkin's "comparison-stars" should turn out to be physically connected, consequently at nearly the same distance from ourselves with the giant luminary they attend. This doubt will shortly be set at rest by Dr. Gill's measures, now being carried out with a different pair of stars.

Sirius was shown by the observations of 1881–3 to be at a distance such that its light occupies nearly nine years in reaching us. Its real brightness is that of sixty-three suns, while it attracts the semi-obscure body circulating round it in forty-nine years, with no more than thrice the solar power. This extraordinary lustre relative to mass seems to belong to all stars of the Sirian pattern as to spectrum, and is due most likely in part to their elevated temperatures, in part to the scantiness of their vaporous surroundings.

The success of the Cape investigations in this difficult branch of astronomy invited their continuation on a larger scale, and with more powerful instrumental means. The Government was accordingly induced to sanction the construction, by Messrs. Repsold of Hamburg, of a new heliometer of above seven inches aperture, mounted last year in a building erected for its reception on the summit of the sunny slopes of Observatory Hill. The first view of this great star-measuring machine has, it must be admitted, a somewhat bewildering effect upon the uninitiated onlooker. The eye-end literally bristles with steel rods, handles, and screw-heads, almost as numerous as the stops of an organ, and requiring no less skill and knowledge for their proper use. The revolving "head" is armed with a strange-looking, radiated head-gear, like the sails of a windmill, or a *nimbus* of tin sectors surviving from a barbarous age.

Everything here has, however, a definite purpose. These surprising "flappers" are, in fact, screens of wire-gauze of graduated closeness, used for equalizing the brightness of the stars in the field of view, and so enabling the eye to hold the balance, as it were, even between them. The complex apparatus close to the observer's hand furnishes him with the means of easy control over the whole of the sky-gauging mechanism provided for him. None more perfect has been devised, yet the study of its "errors" is the indispensable preliminary to its use.

Only the sublime end in view could render tolerable the process of arriving at a complete "theory" of such an instrument. The patient laboriousness so readily commended in the heroes of science costs more than the readers of their biographies are apt to imagine. Interminable readings of scale-divisions, interminable castings-up of the columns of decimals expressing the differences of the successive readings, are not in themselves exciting occupations. But they must be pursued during some hours a day for a whole year before the "division-errors" of the new heliometer can be regarded as completely abolished because perfectly known. Nor is this all. Elaborate corrections and interpretations of other kinds have to be added; to say nothing of endless and anxious precautions in the observations themselves—precautions against personal and physiological, as well as against atmospheric and instrumental, causes of error. Accuracy is indeed arduous; and the astronomer who is not what the old Romans used, in their grand way, to look down upon as a *cumini sector*, had better learn another profession.

Twenty-seven stars in the southern hemisphere are now being, or are about to be, measured for parallax with the Cape heliometer. Their selection was governed by the ultimate object of gathering information as to the scale and plan of the marvellous aggregation of suns to which our sun belongs, and amidst which it is moving, in an unknown orbit, to meet unknown destinies. For this purpose, facts of two kinds are urgently needed—facts relative to the real distribution, and facts relative to the real movements of the stars in space. Dr. Gill's operations, when completed, cannot fail to bring important reinforcements to our present small store of each.

Ten stars of the first magnitude lie to the south of the celestial equator, of which nine (Alpha Centauri being already safely disposed of) are in course of measurement at intervals of six months. The upshot will be to give the average distance corresponding to the first order of stellar brightness in the southern hemisphere. An analogous result has lately been published by Dr. Elkin for the ten chief northern luminaries. Their distance, "all round," proves to be thirty-six "light-years." That is to say, light from their photospheres affects our senses only after our planet has revolved, on an average, thirty-six times in its orbit round the sun. So that all our knowledge, even of the stars presumably nearest to the earth, refers, in this year 1889, to the "mean epoch" 1853. We shall learn presently whether the "mean epoch" for the southern bright stars corresponds approximately to this date; or whether a marked disparity may countenance the surmise of our eccentric situation in the group of luminaries to which our sun more especially belongs.

Dr. Gill's list includes five second magnitude stars, the annual perspective displacements of which (if large enough to be measurable) will give something like a definite scale of increasing distance with decreasing lustre. A conclusion will then be feasible as to the rate of movement of the sun in space. The elder Struve made it about five miles a second; but on the supposition of the brightest stars being between two and three times nearer to us than they seem really to be. We can now see that the actual speed of the solar system can scarcely fall short of twelve, or exceed twenty miles, a second. By a moderate estimate, then, our position in space is changing to the extent of five hundred millions of miles annually, and a collision between our sun and the nearest fixed star would be inevitable (were our course directed in a straight line towards it) after the lapse of 50,000 years!

The old problem of "how the heavens move," successfully attacked in the solar system, has retreated to a stronghold among the stars, from which it will be difficult to dislodge it. In the stupendous mechanism of the sidereal universe, the acting forces can only betray themselves to us by the varying time-configurations of its parts. But as yet our knowledge of stellar movements is miserably scanty. They are *apparently* so minute as to become perceptible, in general, only through observations of great precision extending over a number of years. Even the quickest-moving star would spend 257 years in crossing an arc of the heavens equal to the disc of the full moon. Yet all the time (owing to the inconceivable distances of the objects in motion) these almost evanescent displacements represent velocities in many cases so enormous as to baffle every attempt to account for them. "Runaway stars" are no longer of extreme rarity. One in the Great Bear, known as "Groombridge 1830," invisible to the naked eye, but sweeping over *at least* two hundred miles each second, long led the van of stellar speed; Professor Pritchard's photographic determination of the parallax of μ Cassiopeiæ shows, however, that inconspicuous object not only to be a sun about forty times as luminous as our own, but to be travelling at the prodigious rate of three hundred miles—while Dr. Elkin's result for Arcturus gives it a velocity of little less than four hundred miles—a second!

The "express" star of the southern hemisphere, so far, is one of the fourth magnitude situated in Toucan. Its speed of about two hundred miles a second may, however, soon turn out to be surpassed by some of the rapidly moving stars picked out for measurement at the Cape. Among them are some pairs "drifting" together, and presumed therefore to be connected by a special physical bond, and to lie at nearly the same distance from ourselves. This presumption will now be brought to the test.

A remarkable and typical change has affected the aims pursued at our southern national observatory since Dr. Gill assumed its direction. There has been a widening of purpose matching the widened scope of astronomical science due to the development of new methods. The practical usefulness of the establishment was never more conspicuous than at present. The shipping interests, railway service, and surveying operations of South Africa are in immediate dependence upon it. The whole fabric of the "old astronomy"—so far as one hemisphere is concerned—is held together by the re-determinations of "fundamental" and "standard" stars continually in progress at it. But while nothing of what was previously held in view has been relinquished, much of incalculable value has been added. Above all, the ideal, or purely intellectual, side of astronomy has obtained recognition, and in a form likely to be memorable in the history of the science.

The celestial-photographic Paris Congress of April 1887 might be called "epoch-making," for this reason alone—that it marked, officially and for ever, investigations into the structure of the sidereal universe as part of the proper duty of astronomers. These inquiries, the most sublime, of the physical kind, with which the mind of man can be occupied, will not henceforth be abandoned to individual caprice, to be prosecuted by necessarily inadequate means, and neglected when those means (as they could not fail to do) should collapse under the strain put upon them. They will be pursued gravely, systematically, by the concerted efforts of successive generations, through the toil of innumerable unpretending workers guided to effectiveness by the highest intelligence of the times. A measure of success is, under these circumstances, certain; and even a small measure of success in this direction will suffice to broaden and deepen the channels of all future human thought.

Hence the profound significance of the decisions of the Paris Congress, by which an international scheme for photographically charting the heavens, and cataloguing a large proportion of their contents, was set on foot. Fortunately for its own reputation, our Government, after long delay, has adopted what might have seemed the foregone conclusion that a share in this work is England's right and duty, and has authorized the construction of the requisite instruments for Greenwich and the Cape. Before another year has elapsed, they will be mounted in their respective places, and the recording process, to be carried on simultaneously at fourteen or fifteen observatories in every part of the world, will have begun.

Meanwhile, Dr. Gill, to whose initiatory energy the approaching realization of this great plan is due, has almost completed a preliminary task of vital importance to its due accomplishment, as well as to sidereal science in general. One of the most famous achievements of recent astronomy is the "Bonn Durchmusterung," a list of 324,000 stars from the North Pole to two degrees south of the equator, observed by Argelander at Bonn. Until it was compiled, the smaller stars were a nameless crowd with no recognized identity. For the purposes of science, they could scarcely be said to exist. But once

"Set in a note-book, learned and conned by rote,"

their changes could no longer elude notice; and detected change leads commonly to increased knowledge. A solid foundation was, moreover, laid for the study of sidereal statistics, destined, perhaps, to lead to momentous results at no distant future.

An extension of the "Durchmusterung" to the southern hemisphere was contemplated from the first, but was more easy to contemplate than to execute. No southern observatory was in a condition to undertake a task so colossal. Dr. Schönfeld, Argelander's successor at Bonn, carried, however, the enumeration as far as the southern tropic, where it seemed likely to stop, when some surprising photographs of the great comet of 1882, projected on wide fields of stars, taken at the Royal Observatory with the help of Mr. Allis of Mowbray, opened to Dr. Gill the possibility of completing Argelander's stellar review by this relatively unlaborious method. And the possibility is rapidly being converted into an accomplished fact. Two assistants, Mr. C. Ray Woods and Mr. Sawerthal, are employed every fine night in exposing plates with instruments, each consisting virtually of two telescopes, one for concentrating upon the plates the rays of the multitudinous stars within a field of thirty-six square degrees, the other for enabling the operator to keep them steadily there until their self-portraiture is finished. The whole heavens, south of the tropic of Capricorn, will have been covered in duplicate by next April, after which only some supplementary exposures will remain to be made.

Professor Kapteyn, of Leyden, is meanwhile busy measuring the plates successively transmitted to him from the Cape, and the resulting catalogue—the first derived from photographs—will probably be in the hands of astronomers by the year 1891. All stars down to the ninth magnitude, and many fainter, will be included in it, to the number of fully two hundred thousand. This important enterprise is a private and personal one. The entire responsibility for it, financial and other, is borne by Dr. Gill.

There is a prospect that, before another year has elapsed, the vexed question of the sun's distance will have been definitively set at rest. The immediate objects of measurement for the purpose with the Cape heliometer, in combination with some other instruments of the same class in Germany and America, are three of the minor planets—Iris, in October and November 1888; Sappho and Victoria during the summer of 1889. The position of the planet between successive pairs of stars distributed along its path during the favourable period when it culminates near midnight will be determined simultaneously from opposite sides of the equator according to a method devised by Dr. Gill, so stringent and *insistent* for accuracy that the errors admitted by it must be minute indeed. While celestial surveyors have 270 asteroids at their disposal to mark the apexes of their triangles, the long gaps of time between the transits of Venus need be of little concern to them.

To describe the whole of the tasks in progress at the Royal Observatory—the cometary work chiefly in the hands of Mr. Finlay, the first assistant, the lunar and planetary observations, the laborious corrections of star-places and star-motions—would demand more space than is at our command. What has here been aimed at is merely to indicate the directions in which the activity of the establishment tends to expand, and to show that these directions are representative of the present, and must be decisive as to the future, of astronomy. There is room indeed, were the material means at hand, for further expansion. In the spectroscopic department the Cape record is still a blank. Yet the wise outlay of a few hundred pounds would suffice to set on foot, under exceptionally favourable circumstances as to climate and situation, inquiries into the physical condition of southern stars of extreme interest and inevitable necessity.

There is much to be learned, as well as enjoyed, from a visit to the Cape Observatory. Not only the work done there, but the manner in which it is done, is impressive. Lessons of earnestness of purpose, stability of aim, and cheerful self-devotion can scarcely be missed by the itinerant lover of astronomy, in whose mind they will be tempered and illuminated by reminiscences of the beauty of flowers by day, and of the glory of stars at night.

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