SCIENCE:

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THE PROGRESS OF ASTRONOMY IN 1893.

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THE year 1893 beheld a most rapid progress in all branches of astronomy. It will be our purpose to call attention to the more important advancements that have been made, and also to items of especial interest, as a complete resumé of the subject would reach far beyond the limits of this article.

In instrumental equipment we have passed beyond our present apparatus, and we are launching out upon a most wonderful improvement in instruments and their accessories. The mounting for the great telescope for the Yerkes Observatory has been completed, and was on exhibition at the World's Fair. The tube will be at least sixty-four feet long. The object glass of forty inches clear aperature is a reality, and Alvan Clark, its makers has said that it will be finished the coming summer.

Brashear has completed the star spectroscope, and is about to commence the solar spectroscope and the spectroheliograph.

Professor Pickering has received from the maker, Clark, a twenty-four inch photographic telescope, the gift of Miss Bruce, of New York. The telescope will be mounted on a high mountain of the Andes, in Peru, and from that elevation its whole energy will be concentrated upon a photographic map of the heavens.

Father Algúe has just departed for Manila, in the Phillippine Islands, at which point he will install an astronomical observatory. The most important instrument that accompanies Father Algúe is an equatorial, with an object glass of nearly twenty inches clear aperature. The mounting is by Saegmuller, of Washington, D. C., the object glass by Mertz, of Munich, and is a companion to that at Strassburg, and the one at Milan, which has been productive of so many interesting observations in the hands of Schiaparelli in his measurement of double stars, and the markings upon the planets, especially Mars. It was the writer's pleasure to recently wish Father Algúe God-speed in his long journey and a rich measure of success from the results of his observations to be made in that far-off land.

The Greenwich Observatory has accepted from the maker, Sir Howard Grubb, an equatorial with an object glass of twenty-eight inches aperature, and the Astronomer Royal reports that it is satisfactory.

The United States Naval Observatory, one of the most magnificent and complete astronomical edifices in the world, both in instrumental equipment and offices for the astronomers, was during the year formally opened.

The Dudley Observatory at Albany, N. Y., has, under the wise administration of its director, Professor Lewis Boss, been moved to a more desirable site, a new twelve-inch object glass by Brashear has been supplied, the other instruments repaired and refitted with all modern conveniences, and a substantial residence built for the director in proximity to the instruments.

Dr. S. C. Chandler, of Cambridge, Mass., has presented to the astronomical world a remarkable series of papers, commenced in 1891, and continued through the past year. The exhaustive investigation undertaken by that gentleman has lead to the proof that the earth's axis of rotation is not invariable, but that a variation of latitude does exist. Dr. Chandler has made a thorough discussion of all astronomical observations, which bear upon the determination of latitude from the time of Bradley down to the present date, and any one who has read his papers must be convinced that he has almost in sight the law that controls the variation in latitude. He has made a thorough discussion of the work of Struve, Peters, Gyldén and Nyrén at Pulkova, with both the prime vertical and vertical circle instruments; observations made at Washington with the prime vertical in 1862–66; Küstner's zenith telescope work; observations made at Cambridge, Leyden, Melbourne and Greenwich; Doolittle's zenith telescope work, and Comstock's and Brown's meridian circle observations at Madison. All these have been discussed in a masterly manner, and from them has been established the fact that the revolution of the earth's pole occupies a period of about 427 days, moving from west to east, the amplitude being a variable and probably entangled with a yearly period.

In connection with what has been said, the reader will find in *Nature*, vol. XLVIII., page 451, a very interesting paper by Professor C. L. Doolittle, given as his address as Vice-President of Section A (Astronomy) at the last meeting of the American Association for the Advancement of Science, held last summer at Madison. Professor Doolittle's paper covers every historical fact connected with the subject of the variation of latitude, besides giving valuable information from the results of his zenith telescope observations carried on so many years at Bethlehem, Pa.

Mr. S. Kostinsky, of the Pulkova Observatory, presented last February to the Imperial Academy of Sciences, St. Petersbourg, a paper containing observations made of close zenith stars with the prime vertical transit instrument at that observatory, for the express purpose of determining the amplitude and period of the variation in latitude, recently dug up by Chandler. From that series an aplitude of $0.60''$, with a period of 412 days, is demonstrated. Mr. Kostinsky's paper will be found in Bulletine de l'Académie Impériale des Sciences de St. Petersbourg, tome VII., page 367.

Upon exhibition at the World's Fair was a new form of pendulum devised by Sigmund Riefler, of Munich. Mr. Leman read a very interesting paper before the Congress of Astronomy held in Chicago, which was a description of the pendulum. His paper appeared in the December number of *Astronomy and Astro-Physics*. Accompanying the article was a table extracted from the records of the Royal Observatory at Munich, giving the daily rate of the clock controlled by one of Mr. Riefler's pendulums. The period covered by the table is from September 1, 1891, to September 2, 1892, or one year. Dr. Seeliger, the Director of the Observatory, states, in forwarding the table, that with a variation of temperature up to 30° centigrade no influence worth mentioning on the rate of the clock could be perceived. The mean daily

observed rate was between +0.01 and +0.03 of a second; when reduced to a constant barometer reading it varied between −0.002 to +0.007 of a second. If all of Mr. Riefler's clocks will keep up such a record as that quoted, then it is to be hoped that a number of them will remain in this country. I have advisedly omitted to describe the mechanical ideas contained, as it would be totally unsatisfactory unless accompanied by a drawing of the escapement, which is not at my command.

Dr. Vogel, of Potsdam, has a highly interesting paper in the *Abhandlungen der Konigl. Preuss*, Akademie der Wessenchaften, Berlin, containing the results of his spectroscopic studies upon the new star in Aurigae, discovered by Anderson in 1892. Dr. Vogel's paper is too extensive to more than mention the most important facts. The spectrum of the new star extended far into the violet and showed many broad and bright bands. It was evident to him that the spectrum was not that of a single body, but was made of the superposed and relatively placed spectra of two bodies, which were moving with great velocity. Dr. Vogel then gives a carefully prepared description of the spectrum as it appeared during each night's observation. Professor Barnard, observing the star with the thirty-six inch at the Lick Observatory, found that it appeared nebulous.

A very interesting series of papers have been printed in the *Astronomical Journal*, containing a discussion by Mr. C. L. Poor, of the orbit of comet 1889, V. A rather faint telescopic comet was discovered by Mr. W. R. Brooks on July 6, 1889. The object would not have attracted much attention from astronomical students were it not for the fact that a short series of observations indicated that another periodic comet had been added to the list. That indefatigable worker, Dr. S. C. Chandler, found that the comet had been greatly perturbed by Jupiter in 1886, so much so as to change the orbit from one of twenty-six years to that of between six and seven. Mr. Poor, however, from a much longer series of observations found that previous to 1886 the comet had a period of over forty years. Recently Dr. Julius Bauschinger in a work entitled "Untersuchungen über deu periodischen kometen, 1889 V (Brooks)" I Theil., has from all the published observations, covering a period of over three quarters of a year, obtained a definitive set of elements, and upon those data Mr. Poor has given the orbit of the comet a most exhaustive investigation. Dr. Chandler had attemped to prove the identity of comet Brooks with that of Lexell's comet, 1770, but Mr. Poor seems to be of the opinion, after weighing carefully all the facts, that comet Brooks is not the same as comet Lexell. Dr. Wilson in *Astronomy and Astro-Physics* for November gave a complete resumé of the subject, accompanied with drawings showing the orbit of the comet before and after its approach within the action of Jupiter.

A new catalogue of colored stars has appeared, prepared by Herr Fredrich Krüger, of Kiel. It contains all the stars north of 23°, south declination, that are of a yellow or reddish color, or those that are remarkable through the existence of absorption spectra. The introduction contains a reference to previous catalogues, the work of different observers, their instruments and methods, etc. The catalogue is indeed a valuable one. In No. 300 of the *Astronomical Journal* will be found a second catalogue of variable stars, prepared by Dr. Chandler. He has used the latest observations and has computed the elements for each.

Judging from the earnestness displayed by Charlois and Wolf, the number of asteroids that will be discovered in the future will only be limited by the amount of patience displayed by those observers in exposing their photographic plates to sky. Up to August 19, the orbits of 372 of those strange little bodies scattered between Mars and Jupiter have been computed. In the present year an even forty have been added to our store-house of knowledge, although some of them may be identified as old ones.

During the year three comets were discovered. The first one was the first return of comet of Finlay. In 1886 Mr. Finlay, an astronomer at the Cape of Good Hope, discovered a small comet, which soon proved to be a short period one, and its return was predicted to occur in the spring of the past year. M. Schulof, of the Bureau des Longitudes, Paris, took the orbit of the comet in hand, and the result of his work will be found in the current numbers of the *Bulletin Astronomique*. Mr. Finlay again found the comet, on May 17, very near its predicted place.

In the first week in last July a bright comet appeared on the eastern side of the sun. Its discovery has been claimed by many. It was seen simultaneously at a number of places in Spain, France, and the United States. It shone as a hazy star of the third magnitude, and as its motion was very rapid, upon coming out from the twilight, a tail of ten or twelve degrees in length was seen. Its orbit does not differ from a parabola.

The last comet of the year was found by Brooks, on October 17. It never became very bright, but in December it was well placed for observing, as it was then subpolar for stations in central northern latitudes.

On April 19 a total eclipse of the sun took place, the line of totality first touching the western shore of South America at Saco, then passing northeastward across the continent, cutting Africa to the south of Cape de Verde Islands. It was observed by two British parties, one at Fundium, west Africa, the other at Para Curu, Brazil. A French expedition was also located at Fundium, another at Joal. Two American parties, one the representative of Harvard College, the other of the Lick Observatory, were stationed in Chili. All observers were fortunate in having good weather. All parties gave their attention to photographing the corona, and many of the negatives show a great deal of detail. The corona as seen in April, 1893, was very different from that seen on Jan. 1 or Dec. 22, 1889. It more nearly resembled that of 1871 in the distribution of the coronal streamers.

During the year appeared a volume which is a monument to the work of any astronomer. It is the Cordoba Durchmusterung, by Dr. John M. Thome, the director of the Cordoba Observatory, in the Argentine Republic. The volume contains the brightness and position of every fixed star down to the tenth magnitude between 22° and 42°, south declination. This valuable work contains the first part of the great undertaking by Dr. Thome, namely, the continuation of Schönfeld's Durchmusterung southward. This has been accomplished for the region between 22°, Schönfeld's lower limit, and that of 42°. These are contained in Vol. XVI. of the Cordoba observations, and give the position of 179,800 stars; the second instalment, forming Vol. XVII., will contain 160,580 stars. The latter volume will appear during the year. The great work carried on by Dr. Thome is truly heroic, and his labors have been since 1885 devoted distinctly to the completion of one grand idea, a durchmusterung from pole to pole.

During the year Mr. Edwin F. Sawyer published a catalogue of the magnitudes of southern stars from 0° to 30°, south declination. The catalogue contains the magnitudes of 3415 stars; the average number of observations for each star was four. The system of magnitudes adopted was that of the Uranometria Argentina. It appears to be the most important and accurate photometrical work which has appeared in a decade.

What has gone before has been the progress of astronomy in the year just past.

In closing we cannot omit to offer our tribute to those that have past from the field, and to mention the honors that have been received by the living.

The death last May of the Rev. Charles Pritchard, D.D., F.R.S., late Savilian Professor of Astronomy and Director of the Observatory at Oxford, removed one who left a deep impression, if not in astronomical investigations, in his students that are taking up the work as he had taught them. Dr. Pritchard was a broad-minded man, honest in his purpose, upright in his character, sensitive to the feelings of his students and active in his investigations. Mr. W. E. Plummer has given in *Observatory* for July, 1893, a sketch of Dr. Pritchard's life, a pure, noble one.

In the death of Dr. Adolp Steinheil the astronomical world has lost one who was an authority upon the construction and grinding of object glasses. His death took place at Munich on Nov. 4 last.

On Dec. 6, death once more entered the flock and took from us that eminent astronomer, mathematician and historian of science, Dr. Rudolf Wolf, of the Zurich Observatory. Since 1855 he had been the Director of that observatory, as well as Professor in the Polytechnicum. Dr. Wolf's pen was well handled, as may be seen in his writings, embracing as they do researches in pure mathematics, astronomy, physics and the history of science. In 1852 appeared the first edition of "Taschenbuch of Mathematics, Physics, Geodesy and Astronomy"; in 1858–61 the four volumes of biographies of Swiss men of science; in 1869–72 his "Handbuch der Mathematik, etc.," in two volumes. Probably his most extensive work, the "Handbuch der Astronomie, ihrer Geschichte und Litteratur," has just been completed. All astronomers have at times turned with interest to his "Astronomische Mittheilaugen," commenced in 1856 and continued to the present time. In 1877 he published his "History of Recent Astronomy, Especially in Germany." Dr. Wolf won his reputation in his important discoveries and researches relative to the solar spots. In *Astronomical Journal* No. 309 will be found a very interesting sketch of his life, and from which we have drawn many of our statements as to his work in astronomy.

The December number of *L'Astronomie* conveys the information that the Academy of Sciences of France had decided to confer the Arogo gold medal upon Professor Asaph Hall for his discovery of the satellites of Mars, and upon Professor E. E. Barnard for his discovery of the fifth satellite of Jupiter. The Arogo medal has been conferred only once before, to the illustrious Leverrier, in recognition of his discussion that lead to the discovery of Neptune.

SUNSPOTS AND METEOROLOGY.

BY H. A. HAZEN, WASHINGTON, D. C.

THE spots on the sun are disturbances or storms largely of electric origin. They have a drift or motion along the surface at the equator of 867′ per day, and at lat. 14°,851′. It is known that these spots have a definite period of about eleven years. They have an intimate relation to the fluctuations of magnetic declination, and to the appearance of auroras. An interesting discussion of the question as to the immediate transmission to the earth of an influence from a solar outburst will be found in recent numbers of *Nature*. From time to time serious efforts have been made to show that there is a close connection between sunspots and terrestrial disturbances. It should be noted that mere coincidences between phenomena, no matter how often they are observed, can have little weight in establishing a relationship, unless it can be shown, *a priori*, how or why there is a connection. On the strength of mere coincidences, the ancients were justified in holding the view that the earth was stationary, and all the universe rolled about it, producing the "music of the spheres."

In studies of coincidences, it is very easy to ignore the cases which disagree with a preconceived relation, and to magnify those that do agree. For example: it is believed by some that sunspots have an influence at the earth only as they first appear by rotation on the eastern limb of the sun, and this, too, in face of the fact that some of our most brilliant auroras have appeared with large spots near the centre of the sun's disc. In Nov., 1882, a spot at the centre of the sun could be seen with the unaided eye, and yet it was assumed that the aurora then seen, one of the finest, was due to a few small faculæ just appearing on the sun. No theory of this kind will hold unless it can be shown why the spot loses its influence after it is a few days old. The present writer is well aware that those who adopt this view, that the sunspot has influence only at the time of its first appearance by solar rotation, will not submit to the following crucial test, which is equally applicable to all discussions of this kind: Decide upon the three days in each rotation when the influence should have been the greatest, and also the three when it was weakest, then determine independently the actual meteorologic conditions over any definite portion of the earth, say, for the lake region, or the Ohio valley, or even the whole United States, as regards storms, cold waves, or any other definite phenomenon. A comparison of the data would at once show the value of this supposed influence and a relationship, if there is one.

Attempt has been made also to determine a periodic effect from these spots, or from the source of energy behind them, at specific solar meridians. At first sight, since, as we have already seen, the spots have a different rotation period at different solar latitudes, it would seem as though such a period could not possibly be established. If, however, there are certain influences at specific solar meridians tending to increase spots independently of their drift, such influences may be felt at the earth and would also show themselves by an increase or diminution in the spots whenever that meridian of the sun was at the centre, though it should be noted that this influence can hardly concentrate itself at any one meridian, but must be felt over many days, unless we consider that the sun's influence has tides or blazes up at certain definite times in each rotation. Spots might drift at any velocity, but when they approached such a meridian they would show it in their appearance all the way from the sun's equator to their limits on either side. Various periods have been set for these meridians of maximum influence; some of these are as follows: 25, 25.5, 26, 27, 27 1/4 days, etc. In order to test this question, it has been customary to arrange spot areas according to the selected or determined period for 100 rotations or so, and then to average each day by itself. There is nothing so easy as to arrange figures in this way, but the procedure is fraught with grave danger, as we are liable to cover up just the most important fluctuations by an indiscriminate mean, and our final result shows such microscopic fluctuations that we are tempted to magnify them by an easy multiplication.

A common argument among advocates of such methods, to account for failures in obtaining a period in the past, is that the exact period has not been discovered. One investigator has developed a period of 27.27778 or 27 d. 6 h. 40 m.; another, in studying shorter periods, has made two, one of 7.26917 days (7d. 6.46 h.), and another of 6.16417 days (6 d. 3.94 h.) and so on. This point is not well taken, however, for a little experience with