SCIENCE

FRIDAY, NOVEMBER 10, 1899.

CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

*SCIENTIFIC WORK OF THE LICK OBSERVATORY.**

INSTRUMENTS AND SCIENTIFIC WORK OF THE OBSERVERS.

THE nature of the scientific work undertaken at the Lick Observatory is determined by such considerations as the unusually fine atmospheric conditions which prevail here, the nature of the instrumental equipment, and the number of observers on the staff. The general policy of the Observatory is to carry on investigations which cannot be pursued to so great advantage elsewhere. Thus, comets which are bright enough to be easily seen at the leading observatories receive only occasional attention, while comets which, by reason of their faintness or unfavorable position, are difficult of observation, are followed as closely as possible. Elaborate investigations dealing with large masses of data, and requiring a large force of computers, can only be undertaken by richly endowed observatories or by those which receive government assistance. The Lick Observatory makes the most of its natural advantages; and extended theoretical researches, which can be made as well in a city as at a fine observing station, do not form a part of our general plan.

As all the principal instruments of the

* Extract from the forthcoming report of the Director of the Lick Observatory to the President of the University of California, for the year ending Sept. 1, 1899.

Observatory are used on practically every clear night, the amount of work accomplished is very considerable, notwithstanding the smallness of the observing force, while the variety of instruments makes the field covered quite a wide one.

THE THIRTY-SIX-INCH REFRACTOR.

This splendid instrument is in perfect order. A small periodic error originally in the driving-gear has been almost wholly corrected by Professor Campbell (who has charge of the instrument), by introducing into the clock-train a periodic error of equal amount but opposite sign, so that the two errors neutralize each other.

About half the time of the 36-inch equatorial is devoted to spectroscopic determinations of the motions of stars in the line of sight, with the aid of the Mills Spectrograph. This department of the scientific work of the Observatory, which is probably as important as any work that can be done at the present time with a large telescope, has been admirably systematized by Professor Campbell, who is assisted in the observations and reductions by Mr. Wright. The probable error of a single determination is only about 0.25 kilometer for the best stars, a degree of accuracy which has never before been reached in such measurements. A correcting lens, which is placed in the cone of rays from the 36-inch objective, and which changes the chromatic aberration of the telescope so as to adapt it to photographic work, has added somewhat to the accuracy and very much to the convenience of the observations.

During the past year 522 spectrograms were obtained. Over 200 spectrograms were definitively, and about 500 approximately, measured and reduced.

In connection with this work, the following stars have been found to have variable velocities in the line of sight, and therefore to be revolving stellar systems:

η Pegasi, χ Draconis, o Leonia, ξ Geminorum, ι Pegasi, θ Draconis, ε Libræ, β Capricorni, h Draconis, λ Andromedæ, ε Ursæ Minoris, ω Draconis, α Ursæ Minoris, α Aurigæ, υ Sagittarii.

From 25 to 30 spectrograms of each of these stars are needed for determining the orbits. The observations of several of them are essentially complete, and the others are being observed as rapidly as circumstances will permit. An investigation of the orbit of η Aquilæ, based on all the available data, has been made by Mr. Wright, who has also partially computed a set of tables for facilitating the reduction of spectroscopic observations.

Two of the stars in the above list are of special interest. In the case of Polaris the velocity in the line of sight has a double period; a short oscillation, having a range of four miles per second and a complete period of 3 days 23 hours, is superposed on a much longer one, the period of which has not yet been determined, though it is probably as much as several years. The star is therefore a part of a triple system, two of the bodies being dark. Capella, or α Aurigæ, has a double spectrum. The two sets of lines undergo a periodic relative displacement.

To aid in the observations and reductions in this important part of the Observatory's work another assistant is greatly needed. It is a severe strain on both the present observers to keep the work in as satisfactory a state as it is at present.

A special study by Professor Campbell of the triple hydrogen lines in the spectrum of o Ceti led to many interesting results.

The 36-inch telescope has also been used for other spectroscopic investigations. The spectra of all sufficiently bright comets have been photographed by Mr. Wright. Observations of nebular spectra have been made by the Director and others. A comparison of the spectrum of hydrogen in a Geissler

tube with the spectrum of hydrogen in the Orion Nebula, by methods devised by Messrs. Campbell and Wright, led to some interesting results, which have been published, with other spectroscopic papers, in the *Astrophysical Journal.*

For the remaining half of the time the telescope has been used for micrometric work by Professor Hussey, Mr. Perrine and Mr. Aitken, and occasionally by other observers. Series of observations of the satellites of Neptune and Mars have been made by Professor Hussey; of the satellites of Neptune and Uranus by Mr. Aitken. One hundred and fifty sets of measures of planetary nebullæ, for parallax, and a set of measures for determining a possible refractive effect on stars by the head of Swift's comet, have been made by Mr. Perrine.

The 36-inch telescope is also used for the observation of comets, and sometimes, particularly in the case of expected comets, for purposes of discovery. Thus Wolf's periodic comet was discovered by Professor Hussey, and Temple's second periodic comet and Holmes' periodic comet were discovered by Mr. Perrine, with this telescope. In the course of his cometary observations Mr. Perrine has found one close double star and about thirty new nebulæ. The formation of a second nucleus in the head of Swift's comet was also discovered by him on May 11th.

Double stars are regularly observed with the 36-inch telescope, but they will be considered in connection with the smaller (12-inch) instrument.

THE CROSSLEY THREE-FOOT REFLECTOR.

After many experiments, changes and minor improvements, this telescope has been brought into excellent working order. It is in the personal charge of the Director, who is assisted by Mr. H. K. Palmer. It will be used for various astrophysical researches, and more particularly for the photography of nebulæ, for which purpose it has proved to be admirably efficient.

Some of the improvements which have been made are as follows: The pier has been cut down two feet, greatly increasing the facility with which the instrument can be handled. A new and powerful driving-clock has been made by the Observatory instrument maker, from designs by Professor Hussey. The double-slide guiding apparatus and the slow motions have been repaired and improved, and electric illumination provided for the former. Wires for electric lighting and for telephone communication have been run to the main Observatory. The study and the photographic room have been fitted up in a convenient manner for work. A very rigid declination clamp has been added to the mounting. The observing slit in the dome has been fitted with an adjustable wind-screen, on the general plan of the one used at the Yerkes Observatory.

The interior walls of the dome have been painted bright red; the inner surface of the dome itself, black. By means of a large red lamp on a movable stand, the interior is sufficiently lighted for the convenience of the observers, without danger of fogging the sensitive plate. These precautions are necessary, because the 'tube' of the Crossley reflector is merely a framework of iron rods, which does not exclude the light like the tube of an ordinary telescope.

Observation with the Crossley reflector is subject to more limitations than observation with the other instruments. Work cannot be pursued on moonlight nights, in slightly foggy, or even in damp weather. Nevertheless, about 70 photographs have been made of 40 different nebulæ and star-clusters, mostly with long exposures of from three to four hours each, and from the most interesting of these, positive enlargements have been made on glass. The definition of these photographs, and the amount of

detail shown by them, are surprising. Many new features are shown, and some general conclusions of the highest interest have already been drawn. From one to sixteen new nebulæ have been found on nearly every plate exposed, and I have estimated that the number of new nebulæ in the sky, within reach of the Crossley reflector, may be something like 120,000. A set of photographs made with the Crossley telescope was exhibited at the conference of astronomers recently held at the Yerkes Observatory, and has since been presented to the Royal Astronomical Society.

An investigation in the distribution of stars in the Great Cluster in Hercules, by means of a photograph taken with the Crossley telescope, has been made by Mr. Palmer.

Following a method which I proposed some years ago, the Crossley telescope has been used to produce photographs of the Great Nebula in Orion, by means of the less refrangible rays of the spectrum, which are directly comparable with drawings. The results are in confirmation of earlier spectroscopic observations made here, and may be regarded as an extension of the spectroscopic method to parts of the nebula which are too faint for visual observation.

THE TWELVE-INCH REFRACTOR.

This instrument is in charge of Professor Hussey, who is assisted by Mr. Coddington. A most important part of its work, as well as that of the 36-inch telescope, is the measurement and discovery of double stars, for which purpose the conditions on Mt. Hamilton are especially suitable. Professor Hussey is at present engaged in the remeasurement of all the Otto Struv stars, or double stars discovered at the Pulkowa Observatory. About 2,000 measures have been made in connection with this work up to the present time.

The number of measures of double stars made during the past year is as follows: By Professor Hussey, 996; by Mr. Aitken, 976. Mr. Aitken's list includes nearly all the rapid binary systems.

A systematic search for new pairs has been made by Professor Hussey, mainly with the 36-inch refractor, within the zone 10° to 14° south declination. Thirty-six new pairs were found during the past year, most of them very close, the distance in two cases being only 0.″15.

The zone between 2° and 10° south declination has been examined in a similar manner, with the the 12-inch equatorial, by Mr. Aitken. About 50 pairs have been found since April 1st of the present year. To guard against errors, each new pair has been examined with the 36-inch telescope on at least one night. Only close stars brighter than the 9th magnitude are included in these lists.

With both equatorials the following complete sets of comet observations have been made during the year ending September 1, 1899:

Comet.	*No. Obs. and Observer.*
1898, I. (Perrine).	21, Perrine.
1898, IV. (Wolf).	8, Hussey.
1898, VII. (Coddington)	9, Coddington.
1898, VIII. (Chase).	1, Aitken, 36 Coddington.
1898, IX. (Perrine).	20, Perrine.
1898, X. (Brooks).	19, Hussey.
1899, a (Swift).	7, Hussey; 17, Perrine.
1899, b (Tuttle).	13, Perrine.
1899, c (Tempel II.).	2, Hussey; 10, Aiken. 31, Perrine.
1899, d (Holmes).	5, Aitken; 9, Perrine.

Total number of comet observations, 208.

At the request of Professor Simon Newcomb, the asteroids discovered by Professor James C. Watson have been observed for the National Academy of Sciences. The work has been done by Mr. Coddington. In general, ephemerides were computed from the data given in the *Berliner Jahrbuch*. The region indicated by the ephemeris was photographed with an exposure of one hour

or more with the Willard 6-inch lens, and the asteroid identified on the negative by the trail caused by its proper motion. It was then observed with the 12-inch telescope. All but two of the Watson asteroids (or three, counting the one that is 'lost') have been rediscovered and observed in this way. From three to five observations have been made of each. In the course of the work Mr. Coddington discovered two new asteroids; (439) Ohio, and (440).

Thirty-seven observations of ten other asteroids have been made by Mr. Coddington, seventy-nine observations of five asteroids by Professor Hussey (including sixty-five observations of the new planet Eros), and ten observations of two asteroids by Mr. Palmer.

THE 6½-INCH MERIDIAN CIRCLE AND THE 4½-INCH TRANSIT INSTRUMENT.

The Meridian instruments are in charge of Professor Tucker, who is assisted by Mr. Crawford. The transit instrument has been little used, as the clock corrections for the time-service have been furnished by the meridian circle.

During the year ending September 1, 1899, 6,000 observations on 106 nights have been made with the meridian circle, mostly of southern stars from the catalogue of Piazzi. In addition to these, observations for a study of the refraction were made during two months by Mr. Crawford, who has also been regularly employed in computation. The reductions have been carried through the early stages for all the observations of the Piazzi stars, and have been completed for about 1,000 observations. A few miscellaneous observations of comparison stars and asteroids have also been made.

The manuscript of the meridian circle results from 1893 to 1896, forming volume IV. of the Publications of the Lick Observatory, has been sent to the State Printing Office.

THE CROCKER PHOTOGRAPHIC TELESCOPE (SIX-INCH WILLARD LENS).

This instrument, in charge of Mr. Coddington, has been employed mainly in the re-discovery of the Watson asteroids. Photographs have also been made of nebulæ, and of comets 1899, a (Swift) and 1898, X. (Brooks).

THE FLOYD TELESCOPE, AND SIX-INCH PORTRAIT LENS.

These two instruments, which are carried by the same equatorial mounting, have been in charge of Mr. Palmer, who has employed them, at such times as could be spared from other duties, in photographing the extended nebulosities of Herschel; also, in photographing other nebulous regions, in connection with the work of the Crossley reflector. Photographs were also made of comet 1899, a (Swift), and 1898, X. (Brooks).

THE BRUCE 6½-INCH COMET SEEKER AND THE 4-INCH COMET SEEKER.

The comet seekers, in charge of Mr. Perrine, have been constantly employed. For two months during the past summer they were used by Mr. Crawford.

The comets discovered at Hamilton during the year ending September, 1, 1899 were

Comet, 1899, IX. (Perrine), September 12, 1898.
Comet, 1899, c (Tempel, II.), Perrine, May 6, 1899.
Comet, 1899, d (Holmes), Perrine, June 10, 1899.

In the year ending September 1, 1898, six comets were discovered at Mt. Hamilton.

THE PHOTOHELIOGRAPH.

Two photographs of the sun are taken with this instrument every clear day, and the negatives are stored for future reference. The work has been done by Mr. Pauli, the Janitor.

THE SEISMOGRAPHS.

The seismographs, in charge of Mr. Perrine, are always kept in adjustment. A

spare seismograph has been loaned to the U. S. Observatory at the Mare Island Navy Yard, on the condition that records and reports of earthquake shocks shall be sent to Mt. Hamilton. Several observers, mostly in the neighborhood of San Francisco, also kindly send reports. The collected results are published yearly by the U. S. Geological Survey.

METEOROLOGICAL INSTRUMENTS.

Meteorological observations are made three times daily. Monthly summaries are furnished to the U. S. Weather Bureau. The daily records of the self-recording instruments are filed for future reference.

The time-service has been conducted as heretofore.

MISCELLANEOUS OBSERVATIONS AND COMPUTATIONS.

The Leonid meteors were observed and chartered by several members of the Observatory staff in November, 1898. The results were sent to Harvard College Observatory for discussion in connection with other data.

The reduction of Professor Schaeberle's meridian observations has been in the hands of Mr. Aitken. During the year the Right Ascension and Mean Place reductions were completed, the separate observations made in each year were collated and the discrepancies removed. The Coast Survey stars were reduced to the epoch 1880, the observations of different years collected, and the final places checked by comparison with other catalogues. The Struve stars are now being reduced to the epoch 1880, and the entire work will be completed during the present year.

Two orbits and ephemerides for comet 1898, IX. (Perrine), were computed by Mr. Perrine.

Elements and ephemerides for comet, 1898, V. (Giacobini), and for comet, 1898, X. (Brooks), and elements for comet, 1899, a (Swift) were computed by Professor Hussey.

The definitive orbit of comet, 1896, III. (Swift), was computed by Mr. Aiken.

An orbit and ephemeris for comet, 1898, VIII. (Chase), were computed by Mr. Coddington and Mr. Palmer.

A computation of the definitive elements of comet, 1897, III. (Perrine), is being made by Mr. Palmer.

Orbits and ephemerides of the new asteroids (439) and (440), and ephemerides for most of the Watson asteroids, were computed by Mr. Coddington.

Two sets of elements for the planet Eros, and circular elements of the asteroids (439) and (440), were computed by Professor Hussey.

Announcements have been telegraphed to Harvard College Observatory, for distribution, at various times.

Measurements of the wave-lengths of lines in the spectre of third type stars, and of the positions of nebulæ on plates taken with the Crossley Reflector, have been made by Mr. Palmer.

A report on the Crocker Eclipse expedition to India is being prepared by Professor Campbell. * * *

James E. Keeler.

Lick Observatory.

THE EARLY PRESIDENTS OF THE AMERICAN ASSOCIATION.

II.

Among our honorary fellows is the name of one who was not only a founder* of the Association of American Geologists in 1840, but also a founder of our own Association,

* The following quotation concerning the formation of the Association of American Geologists is given in a sketch of Professor James Hall, accompanied by an engraved portrait on wood that appeared in the *Popular Science Monthly*, Vol. XXVI., p. 122, November, 1884: "The comparison of observations and interchange of views led to the opening of correspondence,