SCIENCE

FRIDAY, DECEMBER 1, 1899.

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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.

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA.

I.

THE third conference of Astronomers and Astrophysicists was held at the Yerkes Observatory, in Williams Bay, Wisconsin, on September 6, 7 and 8, 1899, in accordance with arrangements made by a committee appointed at the second conference, held at Harvard College Observatory in August of last year. This committee, consisting of Professors Newcomb, Pickering, Morley, Comstock and Hale, had also been authorized to prepare a constitution and arrange for the organization of a permanent society. At the second session of the conference the constitution was adopted, substantially as presented by the committee, and at the last session, on September 8th, the organization was completed with the election of the following officers:

President, Simon Newcomb; Vice-Presidents, C. A. Young, G. E. Hale; Secretary, G. C. Comstock; Treasurer, C. L. Doolittle; Councilors, for two years, E. C. Pickering, J. E. Keeler; Councilors, for one year, E. W. Morley, Ormond Stone.

The undersigned will temporarily act as Secretary.

At a subsequent meeting of the Council by-laws were adopted. It was further voted that a report of the proceedings should be furnished for publication in SCIENCE, together with abstracts of the papers, prepared by the authors and edited by the Secretary. It is not intended that the Society shall maintain a library, and an exchange of publications with other societies is not expected. The assessment for the current year was set at two dollars. The Secretary was authorized to arrange for a meeting of the Society in New York City in connection with the meeting of the American Association for the Advancement of Science. The charter members number one hundred and fourteen, consisting of those attending the second or third conference who signed a statement of desire that a society be formed and of those who otherwise expressed to the committee or Council their wish to join when the society should be organized.

The constitution and by-laws follow :

CONSTITUTION.

ARTICLE I.—*Name and Purpose.*

1. This association shall be called The Astronomical and Astrophysical Society of America.

2. The purpose of this Society is the advancement of astronomy, astrophysics, and related branches of physics.

ARTICLE II.—*Membership.*

1. Those persons whose names were signed on or before September 15, 1899, to the annexed statement of desire to form such an association shall constitute the charter members of this Society. Other persons may be elected to membership in the Society by the Council hereinafter provided.

2. The Council shall prepare and publish in the form of a by-law uniform rules for the government of such elections.

ARTICLE III.—*Officers.*

1. The officers of the Society shall consist of a president, two vice-presidents, a secretary, and a treasurer, who, in addition to the duties specifically assigned them by this constitution, shall discharge such other duties as are usually incident to their respective offices. These officers, together with four other members of the Society, shall constitute a Council to which shall be entrusted the management of all affairs of the Society not otherwise provided for. The president and secretary of the Society shall serve respectively as chairman and secretary of the Council, and every officer of the Society shall be responsible to the Council and shall administer his office in accordance with its instructions.

2. The Council shall enact such by-laws as may be found needful and proper for administering the affairs of the Society, and may from time to time modify or repeal such by-laws.

3. The president, the vice-presidents and the treasurer shall be elected annually in a manner to be prescribed by the Council, and shall serve until their successors are duly elected and qualified. Two members of the Council shall be chosen at the first annual meeting of the Society to serve for a period of one year, and two members shall be chosen annually to serve for a period of two years or until their successors are duly elected and qualified. The term of office of the secretary shall be three years or until his successor is duly elected and qualified.

ARTICLE IV.—*Meetings.*

1. The Council shall determine the time and place of each meeting of the Society and shall provide for an annual meeting, at which officers shall be elected.

2. The Council shall have charge of the programme for each meeting.

3. At meetings of the Society, regularly called, twenty members shall constitute a quorum.

ARTICLE V.—*Finance.*

1. The Council shall levy an annual assessment upon the members of the Society sufficient to provide the funds required by the Society for the ensuing year; provided that this assessment shall not exceed the sum of five dollars per member in any year.

2. If at any time there shall be required for the purposes of the Society a larger sum than can be obtained in accordance with Section 1 of this article, the Council shall present at an annual meeting of the Society a statement of such need and of the circumstances attending it, and the Society shall thereupon determine by ballot a policy to be adopted in the matter.

3. No officer of the Society shall receive any compensation for services rendered to it, but the Council may by resolution direct the treasurer to reimburse to any officer expenses necessarily incurred by him in the discharge of his official duty.

ARTICLE VI.—*Amendments.*

1. This constitution may be amended by the affirmative votes of three-fourths of the members present at any annual meeting of the Society, but no amendment shall be voted upon unless a notice setting forth the nature of such proposed amendment shall have

been forwarded to the several members of the Society at least one month before the meeting at which it is proposed to be voted upon.

2. It shall be the duty of the secretary to forward such notices of a proposed amendment to this constitution, when so requested in writing by ten members of the Society.

BY-LAWS.

1.—*Election of Members.*

Any person deemed capable of preparing an acceptable paper upon some subject of astronomy, astrophysics, or related branch of physics, may be elected by the Council to membership in the Society upon nomination by two or more members of the Society. At least once in each year the Council shall consider all such nominations and may request the opinion of persons not members of the Council with reference to the qualifications of the nominees. Blanks for such nominations to membership shall be furnished by the secretary.

2.—*Election of Officers.*

The Council shall provide for holding upon the day preceding the last day of each annual meeting a nominating ballot at which each member of the Society may deposit his ballot for each officer to be elected for the ensuing year. Members not in attendance at such annual meeting may send to the secretary their ballots enclosed in a sealed envelope bearing the signature of the voter. The vice-presidents, or in their absence, tellers appointed by the chair, shall canvass the ballots thus cast, and shall prepare and present to the Society a list showing the three persons who have received the largest number of votes for each office to be filled. In case of a plurality of names receiving the same number of votes in third place, all the names in such plurality shall be included in the list.

Upon the last day of each annual meeting written ballots shall be cast by the individual members of the Society for filling each office about to become vacant, of which only those shall be counted which are cast for persons nominated in the lists prepared as above directed for the office in question or for some higher office.

The nominee receiving the greatest number of votes for any office shall be thereby elected and shall be notified of such election in writing, by the secretary, within ten days thereafter. It shall be the duty of each person thus notified to file with the secretary his written acceptance of such office, and if such acceptance is not filed within sixty days after notification the Council by resolution may declare such office vacant and may elect any member of the Society to fill it until the close of the next annual meeting.

3.—*Treasurer.*

The treasurer of the Society shall keep accounts showing all receipts and expenditures of moneys belonging to the Society, and showing also the indebtedness to the Society of each member thereof, on account of unpaid assessments. These accounts shall be submitted at each annual meeting to an auditing committee, of not less than three members, to be appointed by the Council. The secretary shall be *ex-officio* a member of this committee.

4.—*Secretary.*

The secretary shall be the purchasing officer of the Society and the treasurer shall be the disbursing officer, but the total amount expended by the secretary and treasurer without previous authority from the Council shall not exceed the sum of fifty dollars in any year.

5.—*Unpaid Assessments.*

The treasurer shall report to the Council at each annual meeting a list of all members indebted to the Society on account of unpaid assessments.

6.—*Order of Business.*

The following order of business is prescribed for meetings of the Council:

a. Call to order by the chair.
b. Reading of minutes of last meeting.
c. Announcements by the chair.
d. Announcements by the secretary.
e. Announcements or reports by other officers.
f. Unfinished business.
g. New business.
h. Miscellaneous.
i. Adjournment.

The conference was attended by about fifty representatives of astronomy and physics. Professor Harkness presided over the sessions.

The following are abstracts of the papers presented, prepared as stated above:

S. J. BROWN: *Position of the Polar Axis and the Flattening of Neptune from the changes in orbit of its Satellite.*

The large changes which had been observed in the longitude of the node and the inclination of the orbit plane of Neptune's satellite referred to the earth's equator were explained by Tisserand on the assumption of only a moderate polar compression of the planet. The orbits based upon the measures of Professors Newcomb, Hall, Holden, Hermann Struve and A. Hall, Jr., were best satisfied by a uniform, progressive change of the above elements. From a series of observations by Barnard in 1897–98, and another by himself, the author has been enabled to show that there is a variation in the rate of this change. The result of a least square solution from all the available elements from 1848 to 1898 was given in a table. Although the residuals are but slightly smaller than would result from the assumption of a uniform rate, this is chiefly due to the inaccuracy of the earlier elements. The validity of a variable rate is further confirmed by an apparent increase in the mean motion of the satellite referred to the movable node of the orbit plane on the Earth's equator, which is otherwise difficult to explain. The equatorial protuberance of the planet will cause the pole of the satellite's orbit to describe, with uniform retrograde motion, a small circle around the pole of the planet's equator considered as a fixed point, while the inclination of the two planes will remain constant. The node of the satellite's orbit on the planet's equator will thus move uniformly along the latter, in a direction contrary to the motion of the satellite. The differential equations of this motion were given.

A least square solution of 36 equations of condition gave the following elements of the planet's equator:

$$\left.\begin{array}{ll} \gamma & 17^\circ.84 \\ I_0 & 49^\circ.38 \\ \theta_0 & 119^\circ.16 \\ N_0 & 22^\circ.02 \\ \Delta\theta & 0^\circ.677 \end{array}\right\} \text{Equator of 1850.0}$$

$$\text{The flattening is } \varepsilon = \frac{1}{102.2}.$$

The period of the revolution of the pole of the satellite's orbit is 531.75 years. The flattening is a quantity represented by a difference of only 0''.03 between the polar and equatorial diameters of the planet—a quantity scarcely measurable in the most powerful telescope.

(To be published in the *Astronomical Journal.*)

A. S. FLINT: *The Repsold Transit Micrometer of the Washburn Observatory and Slat Screen Apparatus.*

The transit micrometer is at present employed on the meridian circle, of 12.2 cm. aperture, in a new series of observations for stellar parallaxes by the method of meridian transits. The essential feature of the instrument is an auxiliary screw which is geared with the regular right ascension screw and carries the eye-piece to follow the movable thread. The observer keeps a star image bisected continuously by means of two turning heads on this auxiliary screw, one on each side of the micrometer box, while a series of contact points on the head of the right ascension screw effect the electric signals on the chronograph. The present observer finds the probable error of a single signal to be 0.030s., the same as in the ordinary method with fixed threads.

This micrometer has also a device for obtaining a record of several bisections on a given star in declination without the necessity of reading the micrometer head. A lever clamped to the declination screw travels over a short graduated arc and, being pressed down by the observer, pricks a mark on a strip of paper.

Some suggestions were made for minor improvements, but the performance of the micrometer as a whole has been found very satisfactory.

The slat screen apparatus, designed by Professor Comstock, is intended to furnish the simplest means of diminishing the apparent magnitude of brighter stars. A frame clamped to the objective end of the telescope bears a series of five slats, each 25 mm. wide, in front of the objective. These slats rotate about their longitudinal axes and are so connected as to turn together by means of a wire cord passing over a pulley near the eye end of the telescope. The entire attachment at the objective end is made of aluminium, and the total weight added to the telescope is 27 oz. (0.76 kg.). As viewed with the slats partly turned, a bright star appears as a central stellar image with a line of spectral images extending on either side at right angles to the direction of the slats. Comparisons indicate that this novel appearance has no influence upon the probable error of a single chronographic signal.

E. E. BARNARD: *Triangulation of Star Clusters.*

From the advantages given by the great scale of the 40-inch, it was decided to measure the positions of a number of stars in some of the globular clusters, as a basis for the study of their motions in the future. For this purpose the clusters M 3, M 5, M 13, M 15 and M 92 were selected as representative.

In comparison with Scheiner's photographic measures of M 13 it was found that several of the stars had either diminished very greatly in brightness of late years, or that their light must come mostly from the blue end of the spectrum. The stars, 382 and 393, of his list, are striking examples. Both these stars are given by him as 12.7 magnitude. Visually, the first, which is his normal star, cannot be brighter than the 15th magnitude, while the second is at the limit of the great telescope and has been seen a few times only. Though it is possible that these stars may be variable, the observations do not seem to show it, except possibly in the case of No. 393.

Variable Stars in Clusters.

Some of the small variable stars discovered by Professor Bailey have been regularly observed during the measures of that cluster. Besides the small variables there are three rather bright stars in this cluster which are also variable. Two of these were discovered eight or ten years ago by Mr. C. D. Packer, of London. These three stars vary slowly, requiring upwards of a month for their variations, and one of them has a much longer period. The small stars, however, are very rapid in their changes, with nearly the same periods, averaging, as Professor Bailey has shown, about half a day. Variable No. 33, which rises from the 15th to about the 14th magnitude, and whose period is 12 hours 1 minute, has been specially observed at the request of Professor Bailey. The observations show that this object lies dormant for a large portion of its period as a faint star of the 15th magnitude. It suddenly begins to brighten, and in about 15 minutes has doubled its light; it then slowly declines to a position of rest.

Several new variables were found in this cluster that are not marked on the Harvard photographs.

The Fifth Satellite of Jupiter.

The fifth Satellite of Jupiter was observed with the 40-inch, both in 1898 and 1899, and good measures obtained of it. From the elongation distances obtained at these observations, a new value for the motion of the line of apsides of the orbit was determined. This was found to amount to 900° a year, or a complete revolution of the orbit in 4.9 months. With this value of the motion of the perijove, all the elongation distances observed for the past seven years were accurately represented. A new determination was also made of the periodic time which is 11 h. 57 m. 22.647 s. As this period was derived from nearly five thousand revolutions it is probably very accurate.

The Annular Nebula in Lyra.

A number of the Planetary Nebulæ have been observed and measured. The position of the nucleus of the annular Nebula of Lyra (M 57) was carefully measured in 1898 and 1899. These, compared with Mr. Burnham's measures in 1891 with the 36-inch of the Lick Observatory, seem to show a sensible proper motion for the whole of about 0″.13 annually. This can be verified with certainty by measures four or five years hence.

The small stars near this nebula measured by Professor Hall at Washington in 1877, have been remeasured and the observations show that one of these stars (*f* of Hall's list) of the 15th magnitude seems to have a considerable proper motion.

Difference of Declination of Atlas and Pleione.

The summers and winters of Williams Bay subject the 40-inch to extreme ranges of temperature. Micrometer measures were made in all temperatures between + 80° F. and — 26° F. These observations showed that the focus of the great objective changed to the extent of about 0.7 inch—shortening with the cold weather. To test these changes, a great number of measures of the difference of declination of Atlas and Pleione of the Pleiades, had been made in 1897, 1898 and 1899. These measures besides showing considerable temperature changes, also show some peculiarities not satisfactorily accounted for and which do not show in similar measures of Electra and Caeleno, and which could be explained by a slight oscillation in the position of one of the stars. It is intended to further continue these measures.

ORMOND STONE: *On the Motion of Hyperion.*

If, in the first approximation the motion of the perisaturnium of Hyperion be assumed to be $4n'-3n$, in which n and n' are the instantaneous mean motions in longitude of Titan and Hyperion, the perturbative function will contain an expression of the form

$$C_1 \{e_0 + e' [1 + \cos(4l' - 3l - \pi')]\}, \quad (1)$$

in which C_1 is a function of the mass of Titan and the mean distances from Saturn of Titan and Hyperion, e_0 is the quasi-eccentricity of the orbit of Hyperion introduced by the erroneous assumption in regard to the mean motion of the perisaturnium, e' and π' are the eccentricity and longitude of perisaturnium properly so-called, and l' and l are the longitudes in orbit of Hyperion and Titan, the motions of the two bodies being considered co-planar.

Integration, assuming the values of the coefficients given by Newcomb in his 'Astronomical Papers,' Vol. III., and comparison with Eichelberger's value of the inequality in mean longitude detected by Hermann Struve, result in two solutions, giving rise to two sets of values for m, the mass of Titan, and e':

$$m = \frac{1}{5000}, \qquad e' = 0.0224;$$
$$m = \frac{1}{4370}, \qquad e' = 0.0195.$$

As neither of these values of m differs greatly from the more reliable values found hitherto, it is uncertain which of the solutions is the correct one, and we can only say, at present, that the true value of the eccentricity of the orbit of Hyperion probably does not differ greatly from 0.02.

W. W. CAMPBELL: *The Variable Velocity of Polaris in the Line of Sight.*

Polaris furnishes an interesting case of variable velocity in the line of sight. Six spectrograms were obtained in 1896, as follows:

Gr. M. T. 1896, Sept.	8^d 22.8^h	—20.1 km.
"	15 22.8	—19.1
"	23 21.4	—18.9
Oct.	5 21.0	—19.0
Nov.	11 19.3	—20.1
Dec.	8 16.7	—20.3
	Mean	—19.6

The agreement of these results was satisfactory, and gave no evidence of variable velocity.

In order to test the current results of our work, another photograph of the spectrum of Polaris was obtained on Aug. 8, 1899. This yielded a velocity of —13.1 km., and led to the suspicion that we were dealing with a variable. Two additional plates were secured on August 9th and 14th, which yielded velocities of —11.4 and —9.0 km., respectively. Inasmuch as a range of 4 km. is not permissible in the case of such an excellent spectrum, the star was suspected to be a short period variable, and further observations were obtained, as below :

Gr. M. T. 1899	Velocity	Measured by
August 9^d 0.8^h	—13.1	Campbell
9 20.1	—11.4	Campbell
14 22.8	— 9.0	Campbell
16 0.1	—14.1	Campbell
23 0.3	—10.9	Campbell
24 0.8	—15.2	Campbell
26 0.9	— 9.4	Campbell
*	— 8.6	Wright
27 0.3	—10.6	Campbell
27 16.2	—14.0	Campbell
28 0.8	—14.7	Campbell
*	—14.3	Wright
28 16.3	—13.7	Wright
29 0.4	—12.1	Wright
29 18.8	— 9.6	Wright
30 0.0	— 8.9	Wright
30 16.2	— 9.3	Wright

* Measures of the same plate by Mr. Wright.

On plotting these observations it became evident that Polaris is a spectroscopic binary, having a period a little less than four days. The 1899 observations have been collected and plotted on the assumption that the period is 3^d 23^h. The velocity, at present, seems to be included between —8.6 and —14.6 km., having an extreme range of only 6 km. The velocity of the binary system seems to be about 12 km.

The determinations of velocity made in 1896 lie entirely outside of the present range of values, and leave no doubt that the velocity of the binary system is changing under the influence of an additional disturbing force. I think it is certain, therefore, that Polaris is at least a triple system.

The 1896 observations were made at intervals differing but little from multiples of the period of the binary system, and therefore fell near the same point in the velocity curve. Assuming a period of 3^d 23^h ±, there is no difficulty in selecting the epoch of minimum so that these six observations will fall on the curve satisfying the 1899 observations. The residuals will be negligible if we assume the observations to fall near the lower part of the curve ; and I have no doubt that future determinations of the orbit will definitely place them there. It will be seen that the velocities of the binary system in 1896 and in 1899 differ about 6 km.

The Spectroscopic Binary Capella.

An examination of six spectrum plates of *α Aurigæ*, obtained with the Mills' Spectrograph in 1896–7, leaves no doubt that this star is a spectroscopic binary. The spectrum is composite. The component whose spectrum is of the solar type furnished the following velocities with reference to the solar system :

1896, Aug. 31	+ 34 km.
Sept. 16	+ 54
Oct. 3	+ 49
Oct. 5	+ 44
Nov. 12	+ 4
1897, Feb. 24	+ 3

On the first photograph the spectrum is of essentially normal solar type; on the others it is unmistakably different. There appears to be a second component whose spectrum contains the $H\gamma$ line and the rather prominent iron lines. On the plates of September 16th, October 3d and October 5th, these lines are shifted toward the violet with reference to the solar type spectrum; and in the spectra of November 12th, and February 24th they are shifted toward the red. (Papers published in *Astrophysical Journal.*)

KURT LAVES: *On the Determination of the Constant of Nutation from Heliometer Observations of Eros.*

The opposition of Eros at the end of next year will grant very valuable material for the determination of N, the constant of nutation. In No. 3,156 of the *A. N.*, I have pointed out that this constant could be well determined from heliometer observations of such small planets as come nearer to the earth than the astronomical unit. In the discussion of the heliometer observations of Victoria, made for the purpose of deriving a reliable value of the mean solar parallax, Dr. Gill has carried out this plan. He has found $N = 9''.2068 \pm 0''.0034$ (see Annals of the Cape of Good Hope, Vol. VI., part 6). This result agrees excellently with the value of N derived from direct observations. The reason for this agreement is due to Dr. Gill's new value derived for L, the constant of lunar equation. Indeed, in a former attempt to obtain N by this method, I had employed Leverrier's value $L = 6''.50$, and I was led to a value of $N = 9''.26$. The classical work of Dr. Gill has shown, beyond doubt, that the correct value of L is much smaller; Dr. Gill gives for it $6''.414 \pm 0''.009$. With this value he has obtained the result mentioned above. The quantities on which the final determination of N depends are: the constant of luni-solar precession p^0, the mean solar parallax π^0, the constant of lunar equation L, and the inclination of the moon's orbit to the ecliptic c. We find

$$dN = 0.45\,dL - 0.34\,d\pi^0 + 0.17\,dp^0 + 0.002\,dc.$$

It is thus evident that the small probable error of L in Dr. Gill's value has mainly reduced the formerly large probable error of N. We may regard that the probable errors of L, π^0, p^0, c are as follows:

$$\Delta L = \pm 0''.009\,; \quad \Delta\pi^0 = 0''.005\,; \quad \Delta p^0 = 0''.004\,; \quad \Delta c = 1''.$$

ΔL and $\Delta\pi^0$ are the values obtained from the heliometer observations of Victoria. The smallest geocentric distance of this small planet was 0.82. The greatest geocentric displacement observable for the purpose of determining L was $15''$ (this displacement is due to the semi-monthly translatory motion of the Earth's center about the center of gravity of the System Earth-Moon).

During the next opposition of Eros this planet will be at a mean geocentric distance of 0.34 for about eight weeks, the displacement witnessed will amount to about $37''$. From this it is evident that a systematic series of heliometer observations of this interesting object, will both give us a much more accurate value of π^0 and grant an excellent redetermination of L. It is found that the magnitude of Eros will vary between 8.8 and 9.7 during this time. The most favorable opposition possible for Eros will reduce the geocentric distance to 0.15. Assuming the mean distance for two weeks to be 0.20 we shall have an angle of nearly $64''$ available for heliometric measurements.

Inner Potential Forces in Astronomy.

In No. 445 of the *Astronomical Journal* an investigation was published concerning the ten integrals of the problem of n bodies for forces involving the coördinates and their first and second differential quotients. The conclusion was reached that the new potential function W must be an arbitrary function of the mutual distances and relative velocities of the n bodies and must not contain the time explicitly, in order that the ten integrals should hold. In a communication to the Academy of Sciences of Leipzig on Jan. 9, 1899, Professor A. Mayer, of Leipzig University, has recently taken up the same problem. His investigation deals with the problem in a more general way and has brought to light an oversight of mine in the above definition of W. Following this W should, in addition to the arguments mentioned above, contain the differential quotients of the mutual distances. It is my intention to give a detailed account of Professor Mayer's paper in one of the next issues of the *Astronomical Journal.*

A. HALL, JR. : *The Aberration Constant from Meridian Zenith Distances of Polaris.*

A series of measures was begun by the author with the meridian circle of the Detroit observatory of meridian zenith distances of Polaris, with the idea of determining the aberration constant and the latitude variation.

Measures were made above and below the pole, direct and reflected, but the number of reflected observations has been rather small. A rough reduction of the observations made between May 1898, and July 1899, gives the following values for the aberration constant :

	Direct.	Reflected.
Upper culmination	20″.60	20″.66
Lower culmination	20 .58	20 .40

M. B. SNYDER: *The Phonochronograph, and its Advantages in Certain Astronomical Observations.*

In all kinds of astronomical observations, where phenomena, especially of an unpredicted character, rapidly succeed each other, it has invariably been found extremely difficult to make time records that can subsequently and with certainty be identified with the phenomena. Even with tried assistants as recorders, and with a prearranged code of chronographic signals there is usually a double failure ; first, the proper records are not made by the assistants, and secondly, the time signals can not be satisfactorily identified.

The phonochronograph, as for brevity I designate a high grade phonograph also transformed into an efficient chronograph, seems fully to obviate the difficulties mentioned. The instrument records any vocal expression made by the observer along with a simultaneous sound automatically produced every second or two by the clock or chronometer. The record both for time, and for character of phenomena, is unbiased, absolutely identifiable, and can be read off without introducing any reaction time, excepting that originally entering.

The instrument consists of a phonograph whose cylinder rotates uniformly, and whose sliding carriage, which by turns bears both the recorder and the receiver, also has attached, near a second mouthpiece, a small electromagnet whose armature is attached to a light wooden hammer, which at each closure of the electrical circuit by the clock, strikes a small resonating box placed opposite the second mouthpiece. With properly selected resonating box, it is found that not only can the time signal always be read off by ear as distinct from the vocal record, but be visually distinguished as well. For the purpose of reading off the time record, so as not again to interpolate a reaction time, the sliding carriage also bears a microscope of moderate power, which is placed at an angle of about 90 degrees back of the recording diaphragm and enables one clearly to distinguish the clock from the vocal records. To enable the angular distance between the clock record and any given vocal record to be read off, a graduated circle, with stationary index, is attached to the end of the phonographic cylinder. The instrument is also provided with a rotameter, which rests on the surface of the cylinder and indicates the linear, instead of the angular, distance between records.

With present chronographic appliances it is feasible to construct a phonochronograph that will run for ten minutes, and it seems mechanically possible to treble this at least.

In observations of the meteors, where unexpected features occur, and particularly in solar eclipses, the phonochronograph seems to possess peculiar advantages. It is also suggested that the usual seconds-counting done by an assistant during totality can be done, without any special sacrifice or nervousness, by a phonographic cylinder previously prepared.

G. W. HOUGH: *Actinism of Moonlight in a Total Eclipse.*

Near the middle of the total eclipse of the moon, on December 27, 1898, two negatives were made with the finder telescope, on a Seed 27 plate, with an exposure of five minutes each.

The resulting negatives gave good printing density.

Near the end of totality it clouded, but on the following night a number of negatives were made with the same telescope with reduced apertures.

It was found that an aperture of 0.16 inch, and an exposure of ten seconds gave a negative similar to that made during the eclipse.

From these experiments the actinism or photographic power of the eclipsed moon was found to be $\frac{1}{17000}$ that of the uneclipsed moon. The eclipsed moon was not equally luminous, and the photographic power might range between $\frac{1}{17000}$ and $\frac{1}{300000}$.

Young's General Astronomy gives the photographic power of the eclipsed moon of January 28, 1888, as determined by Professor Pickering, as $\frac{1}{1\,400\,000}$ that of the uneclipsed moon.

I had intended to determine definitely, with my sensitometer, the total actinism of the eclipsed moon, but the exposures which were made for me by a student in astronomy were all too short to be of use.

In 1892 I published a table giving the relative sensitiveness of a considerable number of commercial dry plates for sunlight, candle light, and through red glass. For the rapid plates it was found that the color-sensitized plates were twice as sensitive in the yellow and eight times as sensitive in the red as the ordinary plates.

As the light of the eclipsed moon is always colored, it is obvious that its actinism or photographic power will depend on the kind of plate employed; and possibly on its manipulation previous to development, owing to the effect of preliminary or supplementary exposure.

GEORGE E. HALE: *Carbon in the Chromosphere.*

The level at which carbon vapor exists in the atmosphere of the sun was definitely ascertained in 1897 with the 40-inch Yerkes telescope, when the green carbon (or hydrocarbon) fluting was found in the spectrum of the chromosphere. The layer of carbon vapor to which the fluting is due is not more than a second of arc in thickness, and lies in immediate contact with the photosphere. For this reason it can be observed only with the most powerful telescopes, used under the most perfect atmospheric conditions. The fluting has been repeatedly seen at the Yerkes Observatory during the past summer, and its individual lines identified with the dark lines in the solar spectrum ascribed by Rowland to carbon. On August 17th the yellow carbon fluting, which is more difficult than the green fluting, was also found. These observations reveal an interesting similarity of the sun to red stars of Secchi's fourth type, in which a dense absorbing atmosphere of carbon (which is far more conspicuous than in the sun) has recently been found with the 40-inch telescope to be surmounted by an atmosphere giving a spectrum of bright lines.

Some New Forms of Spectroheliographs.

Of the various forms of spectroheliographs described in my previous papers, the simplest and best is undoubtedly that in which the instrument is moved as a whole at right angles to the axis of the telescope, the solar image and photographic plate remaining stationary. It is not always possible, however, to employ a spectroheliograph of this form. With the forty-inch telescope, for example, the motion of the very heavy spectroheliograph required could not be accomplished without jarring the instrument. For this reason it has been decided to cause the solar image to move across the first slit by means of the slow motion declination motor. The first and second slits are fixed with reference to each other, and the photographic plate is moved across the second slit by means of a screw driven by the same motor, which is mounted on the tube of the forty-inch telescope. A wide range of exposures can be secured by means of a system of change gears. This spectroheliograph, which has an aperture of 6¼ inches, is now nearly ready for trial.

Two other forms of spectroheliographs may occasionally prove useful. The solar image is moved across the first slit in the one case by means of a photographic doublet, of large field, mounted between the slit and the principal focal plane of the image lens, and in the second case by means of a right angle prism, placed immediately in front of the first slit, with hypothenuse face parallel to the optical axis of the collimator. A suitable combination of mirrors may be used instead of the prism. The doublet or prism are connected with a carriage bearing the photographic plate across the second slit, and are moved in a direction at right angles to the optical axis of the collimator. Either device, used in conjunction with a heliostat, affords an easy means of transforming a large fixed laboratory spectroscope, of almost any type, into a spectroheliograph.

Comparison of Stellar Spectra of the Third and Fourth Types.

As previous observations of the faint red stars of Secchi's fourth type have shown none of the lines in their spectra it has been impossible to effect any satisfactory comparison of these stars with the red stars of the third type. So far as their characteristic features go, the spectra are quite dissimilar, the pronounced carbon absorption bands of the fourth type having no counterpart in the banded spectra of the third type stars. The photographs of these spectra recently obtained with the forty-inch telescope, by Mr. Ellerman and the writer, contain hundreds of lines, and render comparisons possible. From these plates it has been found that in certain limited regions third and fourth type spectra are almost identical. It is, therefore, probable that the stars of these two great classes are closely related to each other and to stars like the Sun. The study of fourth type stars is being continued at the Yerkes Observatory.

(*To be continued.*)

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