grafted ovaries from a black guinea pig and bred to a white male. He states that no evidence of foster mother influence was exhibited. Indeed no such evidence was to be expected, for (1) the markings of such hybrids are not uniform, and (2) the mating was not suitable for bringing out such influence. Had the operated pig been bred to a male of the same strain as the pig from which the engrafted ovary was obtained, then in view of my own results on fowls,[5] and Magnus's results on a rabbit,[6] characteristics in the offspring indicative of such influence might have been obtained.

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UNIVERSITY OF PITTSBURGH,
October 9, 1909

ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

THE American Astronomical and Astrophysical Society held its tenth annual meeting at the Yerkes Observatory, Williams Bay, Wis., on August 19, 20 and 21. The meeting was remarkable for the large attendance and for the number and character of the papers presented. Besides a number of guests there were present Miss Calvert, Miss Bigelow, Mrs. Fleming, Miss Furness, Miss Leavitt, Miss Young, Messrs. Adams, Aitken, Barnard, Barrett, Brown, Buchanan, Burnham, Cogshall, Comstock, Curtiss, Eichelberger, Fisher, Fox, Flint, Frost, Gaertner, Hamilton, Hammond, Humphreys, Hussey, Jordan, Laves, Lee, MacMillan, Mellish, Morehouse, Moulton, Parkhurst, Payne, Peters, E. C. Pickering, Petitdidier, Petrajkis, Plaskett, J. Poor, Roe, Schlesinger, Slocum, Stebbins, Stetson, St. John, Stone, Thaw, Updegraff, D. T. Wilson and H. C. Wilson.

President Pickering, after welcoming the society to Williams Bay, referred to the loss during the last year of two of its oldest members. He said in part: "Professor Newcomb, president of our society for six years, always took the greatest interest in its growth and welfare. It rarely happens that a man is really distinguished in more than one department of science. We all know his preeminence in astronomy. He used to say, 'I am not a mathematician,' yet the Mathematical Society in the strongest terms proclaimed him as their most eminent member. Our attitude should not be that of grief at his loss, but rather rejoicing that he enjoyed many years of usefulness after the age when most men's work is done; he lived to see the great works he had undertaken completed, and he is now saved from the suffering which at the end rendered life a burden to him.

"Professor Hough's activity in science extended over many years. We remember, even at our last meeting, his interest in our work and plans. His observations with the Evanston telescope, at one time the largest in the world, were maintained for nearly thirty years."

The president then discussed the present needs of astronomy and expressed the hope that the society might take active part in supplying them. One of the greatest needs is a number of small grants, not exceeding a thousand dollars each, which could be used with the sole object of securing the greatest scientific return. If made to the larger observatories, careful organization and system would permit a large amount of routine work to be secured. If made to a small observatory, or to an amateur, the skill and experience of an expert in his own specialty might be secured, with results far beyond those which could be obtained by another astronomer, however skilful in other lines of work. The only way to supply such needs is to make them known. President Pickering invited the members of the society to send him examples of such researches. For instance: Professor Bailey is now studying the climate of South Africa, perhaps the best in the world for an astronomical observatory, and will return shortly. He is making visual and photometric observations with a ten-inch telescope, and photographing the Milky Way with a Cook anastigmat, using long exposures. A grant of one thousand dollars would permit this work to be continued for another year by his assistant, thus doubling the results obtained, at a small additional expense.

After the address by the president the following papers were read:

Some Results with a Selenium Photometer: JOEL STEBBINS.

This paper is a report of progress in the method of using selenium for the electrical measurement of starlight. It has been found that the best results are obtained by keeping the selenium at a constant low temperature in an ice pack. During the past summer, the accuracy of the method has been so increased that it is now possible to measure first-magnitude stars with a probable error of less than 0.01 magnitude.

[5] *Journal of Experimental Zoology*, Vol. 5, p. 563, June, 1908.

[6] *Loc. cit.*

Precautions Necessary in Photographic Photometry: J. A. Parkhurst.

The results of experiments with stellar and laboratory plates, both focal and extra-focal, were shown by curves thrown on the screen; and the possible errors in stellar magnitude arising from each source were indicated. (1) Comparison of developers, gradation very different. (2) Time of development, possible error exceeding one magnitude. (3) Temperature of development, error nearly one magnitude for range of ten degrees Fahrenheit. (4) Effect of sky fog, possible error of half a magnitude for fog of 0.03 of a density unit. (5) Temperature of exposure, difference of 0.1 magnitude for plates at + 17° and — 2° C. (6) Reduction formulæ for disk diameters of focal images. Error of half a magnitude possible if *log* diameter were used in the formula instead of square root of diameter. (7) Atmospheric absorption. Difference of 0.17 magnitude between the visual and photographic absorptions at 60° zenith distance. (8) Curvature of commercial plates. Error negligible for focal images but might amount to half a magnitude for extra-focal images. (9) Corrections for distance from axis for plates taken 7 mm. from the focus of the Zeiss doublet, amounts to 0.33 magnitude at 3° from the axis. (10) Correction for distance from axis of focal plates might differ by 0.8 magnitude between summer and winter temperatures. (11) Correction for color of stars of solar type is one magnitude. (Details of the work will be published in the *Astrophysical Journal.*)

Standard Photographic Magnitudes: Henrietta S. Leavitt.

Observations for the purpose of determining the absolute photographic magnitudes of a sequence of forty-seven stars near the North Pole have recently been in progress, as described in Harvard College Observatory Circular 150. Sequences of forty stars in the Pleiades and twenty-six stars in *Præsepe* have also been measured, and the results compared with those obtained for the polar stars.

About one hundred and fifty plates were used, taken with eight telescopes. Several methods were employed for determining absolute magnitudes, independent of the visual scale, but all may be grouped in the three following classes:

1. Photographs were taken, diminishing the light by means of screens, or by reducing the aperture of the telescope, and superposing a second exposure of the same length with full light. A similar effect was obtained by attaching an auxiliary prism of very small angle to the object glass; this deflected a part of the light, forming secondary images of the brighter stars.

2. The light was divided by interposing two thin plates of Iceland spar. The positions of the four images of each star furnished the means of determining the relative amount of light in each image.

3. Photographs were taken, having several exposures on the Pole Star, and on the star to be observed, the images being out of focus by varying amounts.

The results obtained by these radically different methods are accordant with each other in the great majority of cases. They also agree closely with the Harvard photometric scale as far as the magnitude 13.2, after allowing for difference of color. We apparently have a satisfactory working basis for determining the magnitudes of stars in all parts of the sky, on an approximately correct scale.

In the discussion that followed Mr. Stebbins's and Miss Leavitt's papers, Messrs. Parkhurst and Humphreys called attention to the large error which might sometimes be incurred by assuming that the absorption of our atmosphere is the same in different azimuths. Professor Pickering remarked that it was the practise to guard against this source of error at Harvard by establishing an arbitrary limit for the residuals obtained with the meridian photometer and similar instruments, and rejecting all observations in which this limit was exceeded.

A Variable Star whose Light Curve Resembles that of R Coronæ Borealis: Annie J. Cannon.

This star, like R *Coronæ Borealis* and RY *Sagittarii*, has long periods of normal brightness followed by sudden fluctuations of large range at irregular intervals. Its position for 1900 is R. A., $5^h\,43^m\,12^s$; Decl., + 19° 02′.0. It follows the Durchmusterung star + 19° 1081 about 3^s and is south 0′.2.

The Pivots of the Nine-inch Transit Circle of the U. S. Naval Observatory: F. B. Littell.

This paper, which was read by Professor Eichelberger in the author's absence, gave the results of several determinations of these errors. The investigation is valuable not only for its application to the work with this instrument, but is of general interest on account of the experience with various methods for determining inequalities of pivots.

The Algol System, Z Draconis: R. S. Dugan.

The material for this paper consists in 18,384 settings made with the Pickering sliding prism

polarizing photometer, attached to the 23-inch equatorial. Considerably more than half the settings were read and recorded by an assistant. Eleven minima were observed in whole or in part. These minima, together with those observed and published in detail by Graff, gave a graphical determination of new elements. The star at its faintest phase was seldom more than just visible. Under these conditions there was no evidence of variability in the depth of minimum. The mean curve shows a nearly symmetrical primary minimum consisting in a drop of 2.55 magnitudes, and also a secondary minimum of 0.065 magnitudes. Each lasts about six hours. After recovering from primary minimum, the curve keeps on rising slowly for some time, and the beginning and ending of secondary minimum are at a higher level than those of primary minimum. This would indicate ellipticity and reflection. The average surface intensity of one star is 18 times that of the other, and the radius of the fainter lies between 0.98 and 1.86 times that of the brighter. The radius of the orbit is from 3.5 to 5 times the radius of the brighter star.

The Problem of Three Bodies from the Standpoint of Spectroscopy: KURT LAVES.

With the present accuracy in the determinations of velocities in the line of sight the problem of three bodies begins to assume importance in this department of astronomy. The paper dealt with that phase of the subject that is analogous to the lunar problem. The perturbation by the "sun" is broken up into three components, P, T, S, along the radius vector, perpendicular to it and perpendicular to the plane of the orbit, respectively. Calling z' the velocity in the line of sight of the disturbed body, we have $dz'/dt = -P \sin\theta + T \cos\theta$ in which θ is the longitude from the ascending node. P and T may be expressed as functions of θ and when t is also expressed in terms of the same quantity we obtain an equation of the form $z' = F(\theta)$. A comparison with the observed velocity curve leads to a determination of the inequalities involved. The approximation has been carried as far as the second power of the parameter involved.

The Determination of the Moon's Theoretical Spectroscopic Velocity: KURT LAVES.

It was shown that the four quantities V_1, V_2, V_3, V_4, in Campbell's notation, can be calculated by means of tables computed on the basis of the elliptic polar coordinates of the earth and the moon.

(1) $$V = K \cdot e \cdot \sin\theta$$

will give both V_1 and V_2. V_1 can not exceed 0.50 km. per second, and V_2 is always less than 0.04 km. As the diurnal change in V_1 and V_2 is at most 0.012 km. we may use approximate values of the longitudes of the sun and the moon.

(2) $$V_3 + V_4 = V_2 \cos E + K_2(1 + e_2 \cos\theta_2) \sin E \cos\beta_2;$$

this formula is easily proved with the aid of the hodographic circle. The index 2 refers to the moon. For $K_2(1 + e_2 \cos\theta_2)$ tables may be constructed with the argument θ_2, the true anomaly of the moon. The angle E, which is nearly the difference between the longitudes of the sun and the moon, is computed thus:

(3) $$\tan p_2 = \tan\beta_2 \operatorname{cosec}(\lambda_2 - \lambda) \text{ and } \sin E = \sin\beta_2 \operatorname{cosec} p_2.$$

Tables based on (3) are being computed for various values of β_2. They will be applicable to the planets as well. As the "Nautical Almanac" is planning to discontinue the computation of E the tables here described should be of considerable value to the astrophysicist.

The Effect of Faulty Collimation of the Correcting Lens on the Star Image: J. S. PLASKETT.

The field of the correcting lens used with visual objectives for photographing star spectra is very limited. A slight displacement from the axis disperses the star image, causes a perceptible difference, transversely, in the position of the images due to light of different wave-lengths. It was shown that even the flexure of the telescope is sufficient to produce this effect. The importance of correct adjustment and of compensating for flexure in the effect on exposure time and on the accuracy of radial velocity measurements was pointed out.

The Width of Slit giving Maximum Accuracy: J. S. PLASKETT.

This paper was a continuation and conclusion of one with a similar title presented at the last meeting. It gave results for other instruments of the relative errors of measurement of early type spectra at various slit widths. It was shown that more accordant and accurate values are obtained at a width of about 0.05 mm. than at either narrower or wider slits. Consequently considerable saving of exposure time over that usually given is possible. The bearing of these results on the proportions of the optical parts in spectrographs was also discussed.

The Photographic Doublet of the Dominion Observatory: R. M. Motherwell.

The images produced by the Brashear 8-inch doublet were surrounded by a halo and a series of tests by the Hartmann method showed this to be due to spherical aberration. On the lens being refigured, by the kindness of the Brashear Company, the halo disappeared and it now gives small and sharply defined images with a widely extended field. Diagrams were shown of the aberration at the normal separation of the front elements, at increased separations, as well as after refiguring.

On the Photographs of Comet c 1908 (Morehouse): E. E. Barnard.

About 350 photographs of this comet were obtained with the three lenses of the Bruce telescope of the Yerkes Observatory. These pictures cover essentially all the more remarkable phenomena of the comet during its visibility in these latitudes, including the extraordinary outbursts or changes that occurred on September 30 and October 15, 1908. The last photograph was obtained here on December 13, 1908, when the comet was close to the horizon. The photograph of December 11 was one of the most remarkable of the entire set. The paper also deals briefly with the possible cause of these extraordinary changes in the tail of the comet.

On Some Experiments in Photographing Enlarged Images of the Planets, direct with the Forty-inch Telescope: E. E. Barnard.

Experiments have recently been made, with improved facilities, in photographing directly enlarged images of the planets with the 40-inch telescope. Some of the photographs of Jupiter which show the belts well, stand a subsequent enlargement of upwards of two or three inches. Better results are hoped for by the use of a new screen by Mr. Wallace. The results so far show that it is now mainly a matter of favorable definition to secure valuable photographs.

On the Proper Motion of some of the Small Stars in the Dense Cluster M 92 Herculis: E. E. Barnard.

The visual and photographic measures of the great star clusters show that but little motion exists in any of the small stars composing them. In M 92 *Herculis* motion is shown in several of the smaller stars, amounting in two cases to as much as 5″ a century. These two stars are of magnitude 13.3 and 14. Motion also seems certain in at least three other stars of between magnitude 14 and 15. The next fifty years ought to give us some idea of the relative motion of many of the stars in this cluster. These motions have been brought to light, in this cluster, perhaps because a closer investigation has been made for that purpose than in the case of other clusters.

Lack of Spectroscopic Evidence of a Dispersion of Light in Space: Edwin B. Frost.

Examination of plates of spectroscopic binaries, taken with the Bruce spectrograph of the Yerkes Observatory, does not give evidence of a difference of radial velocity for different wave-lengths. The star β *Cephei*, having a period of $4^h\,34^m$, would appear especially suitable in this connection. A large range of wave-lengths is obtained for this star only on one-prism plates, and on these any such effect would probably be masked by the accidental errors of measurement. Statistics were read for the star μ *Orionis*, which has a short period, 0.77 day. The spectrum has sharp lines, and many plates have been obtained with three prisms. These show no systematic difference of velocity at different wave-lengths. Mention was made of work successfully commenced with one prism in the red end of the spectrum. While intended for a different purpose, these plates would be available also for a wider range of wave-length in this connection.

Vertical Temperature Gradients in the Atmosphere as Determined by Season and by Types of Weather: W. J. Humphreys.

A large number of sounding-balloon records were grouped according to season and height of the barometer. The results show that while the difference between summer and winter temperatures is most pronounced at the surface of the earth, it is still decided—about half as great—at the hignest elevations thus far reached, and that this difference remains essentially constant above an elevation of about ten kilometers, or in the isothermal region. The seasonal effect therefore extends presumably through the entire atmosphere. On grouping into separate curves the summer gradients obtained during high and low barometric conditions, respectively, it is seen that the high barometer, or clear weather conditions, insure higher temperatures than does the low barometer at the surface of the earth and up to near the isothermal region where the conditions are just the reverse; that is, colder in clear than in cloudy weather. Barometer changes have the same effect on the temperature gradients both winter and summer, except at the surface of the earth. Here the temperature is the lowest in winter during clear weather, or high barometer,

and highest under the same conditions during summer. The low barometer gives exactly opposite results. All these phenomena can be explained as the results of radiation and absorption, especially as modified by condensation and varying amounts of water vapor in the atmosphere.

A Proposed Method of Studying Solar Radiation at Great Altitudes: W. J. HUMPHREYS.

The fact that the solar spectrum is limited to wave-lengths greater than 2,900 Ångström units, makes it desirable to determine whether this limitation is due to atmospheric or to solar absorption. High mountain observations have not definitely settled the question and therefore observations at much greater elevations would be desirable. It is proposed to send small automatic spectrographs to great altitudes with sounding balloons. A suitable spectrograph for this purpose was described with a method for securing proper illumination of the slit and exposure at any predetermined altitude.

Planetary Magnetism of the Sun: W. J. HUMPHREYS.

Assuming an ionization and electric separation in the sun's atmosphere sufficient to account for the magnetic condition that Hale has found in the spots, and assuming unit magnetic permeability, or that which obtains for all known substances at high temperatures, it is easy to compute the magnetic field of the rotating sun as a whole. This would be sufficient to produce a magnetic separation, in the case of the more sensitive lines of only about one one-thousandth of an Ångström unit, an amount too small for certain detection. An absence of measurable polar effects must therefore not be taken to be in conflict with the cyclonic theory of the origin of magnetism in the spots.

New Plans for Tabulating the Moon's Longitude: E. W. BROWN.

These plans having already been put into more or less definite shape, the paper contained an account of those parts of them which presented unusual features. The main difficulty consists in tabulating the very numerous small terms chiefly due to planetary action. The great majority of these can by special devices be put into tables. It is hoped that a machine which has just passed through the experimental stage will enable the computer to obtain the sum of the other small terms with great rapidity for half-daily intervals. An outline was given of the general principles that were used as guides for forming tables, the interests of the ephemeris computer being placed before those of the single place computer whenever they were at variance. A detailed account of the methods will be published within a few months.

A Proposed Design for an Objective Prism Spectrograph for the Determination of Radial Velocities: FRANK SCHLESINGER.

It is proposed to employ two photographic doublets of say six inches aperture and of nearly equal focal lengths. Before each is to be placed a prism of the same aperture, the refracting edge of the one being turned toward the north and of the other toward the south. Plate glass is to be employed for the sensitive plates and one of them is to be turned with the glass side toward the objective. One of the objections to the use of an objective prism in quantitative work is the effect of changes of temperature upon the dispersion of the prisms. It is proposed to obviate this difficulty by surrounding the entire spectrograph with a temperature case supplied with an automatic temperature control, the light from the stars being admitted to the objectives by means of two sheets of plane-parallel glass. The plates are to be measured by superimposing them and obtaining the distance between corresponding lines in the two spectra of each star. These distances will be affected by the radial velocity and will therefore enable us to compute the latter. After an investigation into the various distortions that the spectrograph would involve, and of the sources of error to which the measures would be liable, it was concluded that such a spectrograph would be able to determine the radial velocities of faint stars with a probable error not exceeding ten kilometers for each pair of plates.

Improvements in the Observatory at Ann Arbor: W. J. HUSSEY.

These consist in the overhauling of the director's residence and the installation of instrument shops, a new 37-inch reflector, a single-prism spectrograph and a seismograph.

On Differential Flexure in the Single-prism Spectrograph: R. H. CURTISS.

After calling attention to the serious effect that flexure might exercise in this form of spectrograph, Dr. Curtiss described the device adopted to eliminate it at the Detroit Observatory. As in the case of the Southern Mills three-prism spectrograph and the Mellon single-prism spectrograph of the Allegheny Observatory, the spectrograph box is supported at two points so placed as to make the flexure a minimum. With the Detroit spectrograph Dr. Curtiss has introduced the fur-

ther improvement of making one of these supports adjustable and determining its best position by actual experiment.

The Focal Curves of the Single-material Camera Doublet of the Single-prism Spectrograph of the Detroit Observatory: R. H. Curtiss.

This paper dealt with a recent investigation of the focal curves from λ 3900 to λ 6000 of the new camera lens mentioned in the title. The collimator is an Isokumat of 27.5 inches focus and 1.4 inches aperture. The camera lens has a focus of 16 inches. Nine different combinations of collimator and prism settings were tried covering all cases that might be advantageous. It was found that the deviation from straightness of the focal curves was practically the same in all cases over a distance of 34 mm. But for the portion of the curve corresponding to the interval λ 4000 to λ 5900 the deviations were least for minimum deviation settings in the neighborhood of λ 4400. It was found that the entire region from λ 3900 to λ 6000 could be photographed in sharp focus upon one negative.

The New Spectrograph Measuring Engine of the Detroit Observatory: R. H. Curtiss.

This engine was constructed from designs by Dr. Curtiss based upon his experience with instruments of the Zeiss, Toepfer and Gaertner types as well as with one made by the John A. Brashear Company for the Allegheny Observatory after designs by Professor Schlesinger. The principal features are: a sector for inclining the engine at any desired angle; a long clock spring for taking up the back-lash of the screw; a reversible secondary plate carriage; a motion of rotation of the microscope around an axis parallel to the screw; the use of an interrupted reticle and a removable reticle holder to carry glass reticles of any type. The screw of the engine was made at the observatory shop and seems to possess a remarkable accuracy.

Solar Spectroscopic Observations: Philip Fox.

Results in three lines of work were presented: (1) Spectrograms of a dark calcium flocculus that had a high velocity. (2) A brief report on the work undertaken by Dr. Abetti and the author on the sun-spot spectrum. The photographs were obtained with an 18-foot Littrow spectrograph used with an horizontal telescope of 60 feet focal length. The investigation covers the region from λ 3900 to λ 6800 and includes about 8,000 altered lines. (3) A preliminary report concerning a comparative study of the spectra of the details of the photospheric granulation.

The Use of Quartz Fibers for Micrometer Wires: Philip Fox.

Spider-threads, while excellent in many ways, have two disadvantages: they are affected by humidity and they are too coarse. It is a difficult matter to find spider threads whose diameters do not exceed the resolving power of the telescope. The author has made some experiments with quartz fibers furnished by Professor Nichols. There was no difficulty in finding and mounting fibers that were one third of the usual diameter of spider threads. They are very smooth and do not readily retain dust particles, they are easily illuminated and are not affected by changes in humidity. One fiber has been in use for more than a year.

In the discussion that followed this paper attention was called to the fact that owing to the non-elastic qualities of the fiber there was a tendency for it to work loose from the mounting, under the temperature conditions that usually prevail at a telescope.

Some Dynamical Considerations on Globular Star Clusters: F. R. Moulton.

The assumption on which this paper was based is that the dimensions, masses and relative velocities in the globular star clusters are such that they maintain essentially constant dimensions. Consequently, if this assumption is sound, when two of the three classes of data are furnished by observations, the third, *e. g.*, the masses, is given by the equational relation which is developed.

If π is the parallax of the cluster, D the diameter of the cluster in the same units, N the number of stars in it, then ρ, the average distance between adjacent stars, is

$$\rho = \frac{D}{\sqrt[3]{N\pi}}.$$

If $N = 5{,}000$, $D = 30'$, $\pi = 0''.01$, which is the mean parallax of fifth magnitude stars according to Kapteyn's formula, we have $\rho = 10{,}500$ astronomical units.

An important question in the discussion is whether a star passing through the cluster has many close approaches to other stars, and whether it may be prevented from leaving the cluster by the general gravitative control of the whole group of stars. If R is the radius of the cluster in astronomical units, the probability, P, that a star passing through the cluster will pass within r astronomical units of at least one other star is

$$P = \frac{3}{2}\left(\frac{r}{R}\right)^2 N.$$

With $r = 10$ and the data assumed above, we have $P = 1/43{,}000$. Hence near approaches in such a system are extremely rare.

The period of revolution of a star in a star cluster of approximately homogeneous star distribution, is

$$T = \frac{2\pi R^3}{k\sqrt{M}},$$

where M is the total mass. Supposing $M = 5{,}000$ times the sun's mass and the other data as above, we find $T = 89 \times 10^{12}$ years.

The greatest velocity is

$$V = \frac{k\sqrt{M}}{\sqrt{R}}$$

at the center of the cluster. With the data used above, $V = 1.04$ astronomical units per year; or, in angular measure, as a maximum, 0″.01 per year. The apparent angular velocity varies with the three-halves power of the parallax. Consequently if the large value taken above is actually ten times too great, the greatest apparent angular velocity is only 0″.0003 per year. If these numerical assumptions be regarded as reasonable, then sensible relative motions of permanent members of star clusters are not to be expected until the observations extend over some decades.

Achromatic and Apochromatic Comparative Tests —Second Communication: E. D. ROE, JR.

This paper presented the final results of the testing of two objectives, which was outlined a year ago in a preliminary communication before the society. The two objectives, two-lens type achromatic and apochromatic telescope objectives of approximately the same aperture and focal length, by Mr. Lundin and Steinheil Söhne, respectively, were tested visually on double stars, and in the laboratory the photographic knife edge test was applied to both objectives with satisfactory results, while the color curves of the two lenses were ascertained by measurements on extra- and intra-focal spectrograms. The paper will appear in *Archiv für Optik* (Berlin).

Report of Progress on the Radial Velocity Program of the Lick Observatory: W. W. CAMPBELL.

The programs of observation for the Mills spectrograph attached to the 36-inch equatorial, and for the D. O. Mills expedition to the southern hemisphere (Santiago, Chile) have aimed to secure at least four spectrograms of every star down to the 5.0 visual magnitude, with 3-prism dispersion if possible, and of somewhat fainter stars, especially in the southern hemisphere, with 2-prism dispersion. Up to June 1, 1909, 3-prism spectrograms of 882 stars had been obtained at Mt. Hamilton; 200 of these, whose spectra contain broad and poorly defined lines, have been rejected from the main program for observation later with lower dispersion. Excepting these, the northern observing program is essentially complete for the good summer months; and if next winter, and especially next spring, have average weather conditions, the program should be nearly complete throughout the twenty-four hours of right ascension, by June 1, 1910. The D. O. Mills expeditions, under Astronomers Wright and Curtis, successively, have observed altogether 530 stars brighter than 5.01 visual magnitude and about 150 stars fainter than 5.00 magnitude, or 680 stars in all. Correcting for those stars observed at both Mt. Hamilton and Santiago, the total number of stars whose spectra have been photographed is 1,368. The original Mills spectrograph was succeeded in May, 1903, by a new Mills spectrograph. All the spectrograms obtained with the original spectrograph, and about three fourths of those obtained with the new spectrograph, have been measured and reduced definitively, and are being rapidly prepared for publication. During the first period of the D. O. Mills expedition, in charge of Astronomer Wright, covering two years of observation, spectrograms of about 200 stars were secured. Those containing lines suitable for accurate measurement numbered 148, and four plates, on the average, were obtained for each of these. The results, including all the text, are entirely ready for publication in volume form. Of these 148 stars, 29, or one in five, have been found to have variable velocities. Of the plates secured during the second period of the D. O. Mills expedition, under Astronomer Curtis, about one third have been measured and reduced definitively by Dr. Curtis and his assistant, Mr. Paddock, while carrying on the work of observing. The remainder have been measured approximately —that is, utilizing only a few of the available lines. It should be said that only a small proportion of the spectroscopic binaries discovered at Mount Hamilton and in Chile have been investigated. To do this would require several years of observing, measurement and computation.

The Lick Observatory Double-star Survey—A Report of Progress: R. G. AITKEN.

The program for this survey as originally planned contemplated the examination of every

star to the magnitude 9.0 in the Bonn Durchmusterung from the north pole to declination 22° south, with the object of securing data for a statistical study of double stars. Since 1905, when Professor Hussey left the observatory, the work has been carried on by the author alone. It should be completed in two years' time, provided that the observing conditions between December and June are reasonably good. At present about 85 per cent. of the area has been examined; 3,375 close double stars have been added to those previously known and of these 1,327 are to Professor Hussey's credit. One star in eighteen of those examined has proved to be a double with a separation under 5″. It appears that double stars with a separation under 2″ are far more numerous than those between 2″ and 5″. The discussion of the material thus far collected is under way, but definitive results will not be forthcoming until the survey has been extended to the south pole. It is hoped that an expedition suitably equipped to carry out this program may be sent to South America by the Lick Observatory immediately upon the conclusion of the present survey.

Spectrographic and Photographic Observations of Comet c 1908 (Morehouse): Heber D. Curtis.

Between the dates February 23 and March 23, 1909, one slit spectrogram and seventeen objective-prism spectrograms were secured at the observatory of the D. O. Mills expedition. With the slit spectrograph it was found possible to obtain only the strongest of the pairs of lines of unknown origin which characterized this comet. The wave-lengths of this pair as derived from the slit spectrogram are λ 4254.2 and λ 4275.4.

The following are the wave-lengths as derived from the objective-prism plates: λ 3914.1, λ 4002.1, λ 4021.3, λ 4254.0, (λ 4276.0), λ 4526.0 ±, λ 4545.9, λ 4570.2, λ 4690.7, λ 4716.3. Collecting the differences for the three strongest pairs of lines, λ 4002–21, λ 4254–76, λ 4546–70, together with the corresponding angles at the comet between the radius vector and the line connecting the comet with the earth, we have:

Observer	Date	$\Delta\lambda_1$	$\Delta\lambda_2$	$\Delta\lambda_3$	Angle
Deslandres and Bernard	1908 Oct. 14	20	23	20±	39°9
Deslandres and Bosler	Nov. 1	19.7	21.6	22 0	46 3
Campbell and Albrecht	Nov. 28	19.6	20.7	20.8	37 2
Curtis	1909 Feb. 25	18.5	22.0	24.5	39.7
Curtis	Mar. 21	19.4	22 5	23.8	35.6

The objections to interpreting the doubling of these lines as a Doppler-Fizeau effect have already been stated by Campbell and Albrecht (cf. Lick Observatory Bulletin, No. 147). Assuming the actual velocities along the tail or transverse to the tail to have been the same when Deslandres and Bosler observed on November 1 and when the author observed on March 21, the mean of the intervals for the three principal pairs of lines should have been about four tenth-meters greater, or less, respectively, on March 21 than on November 1, whereas the observed intervals were not quite one tenth-meter greater on the latter date.

The various spectral images are replicas of the tail, as shown by the direct photographs taken at the same dates, as far as can be made out on the small scale of the plates. In this respect the plate of March 20 is of especial interest. The direct photograph on this night shows a marked curve in the tail about half a degree from the head, a curve which is duplicated in each of the spectral images.

Twenty-eight direct photographs of the comet were also made during this period, the majority of them with a 6½ inch portrait lens; many of these plates show interesting evidences of the extraordinary activity which characterized this comet both before and after perihelion.

Three Stars of Great Radial Velocity: Heber D. Curtis.

A number of stars with proper motions of 1″.0 per year or greater have been investigated with the spectrographs of the D. O. Mills expedition to the southern hemisphere, and in the course of this work three stars have been found with radial velocities of unusual magnitude. Of these the most interesting is the star Cordoba Zones 5^h243 ($\alpha = 5^h\ 7^m.4$, $\delta = -44°\ 56'$) whose proper motion of 8.7 seconds of arc per year is the greatest thus far observed. Its magnitude is 9.2, and its photographic magnitude about 10.5, so that a satisfactory plate was secured only by prolonging the exposure time to twenty-nine hours on four consecutive nights. The mean of two plates shows that the star is receding from the sun at a rate of 242 km. per second. Using the Cape value of the parallax of this star, 0″.312, with Kapteyn's values for the proper motion in right ascension and declination, and eliminating the motion of the solar system in accordance with Campbell's value, the resulting space velocity of this star is about 261 km. per second, directed toward a point whose coordinates are $\alpha = 122°$, $\delta = -60°$. This enormous space velocity seems to be exceeded only by the star 1830 Groombridge, which is traveling at a rate of about 278 km. per second toward an apex in $\alpha = 250°$, $\delta = -52°$. From five plates

a velocity of recession of 100 km. per second was found for the star Lacaille 2957, and a velocity of approach of 132 km. per second in the case of the star Lacaille 8362, derived from three plates.

Thirteen Stars having Variable Radial Velocities: HEBER D. CURTIS.

This paper gave a list of thirteen new spectroscopic binaries discovered during the past two years in the course of the work of the D. O. Mills expedition to the southern hemisphere. Eight of the number were discovered by Dr. Curtis, and five by Mr. George F. Paddock. In two cases the spectra of both components of the system are visible.

Note on the Apparent Wave-lengths of Lines in the Different Spectral Types and in Certain Variable Stars: SEBASTIAN ALBRECHT.

In 1906 the author made an investigation of the individual spectrum lines in certain spectrograms, with a view of determining whether there is a shift of any of the lines which is progressive from spectral type to type. A preliminary list of lines which undergo such a change, as indicated by the radial velocities obtained from them, was published in November, 1906. This investigation has been continued intermittently during the last two years, and a number of additional lines have been found whose positions also change progressively.

In the paper referred to, a comparison was made with Mr. Adams's list of sunspot lines (*Aph. Jour.*, 24, 1906). The principal result of the comparison was the strong indication that the physical conditions in the stars as we pass from the F to the Mb type vary roughly in the same direction as from the sun to the sunspots. The results for the additional lines are in harmony with the above conclusion.

In his first paper the author expressed the opinion that for variable stars of large light changes similar changes of apparent wave-lengths of line might be found, corresponding to changes in spectral type from maximum to minimum. Measures of the available spectrograms of the fourth class variables η *Aquilæ* and l *Carinæ* were tabulated according to phase of light variation and some lines in the case of each star were found to show a variation dependent upon the phase of the light curve. In general, the direction of variation is such as to indicate a later spectral type at minimum than at maximum, though the variation does not in each case take place in the same part of the light curve. The change in the spectrum of the variable star is probably such that the spectrum always has some characteristics of more than one spectral type.

Unpublished Work of the Harvard Observatory: EDWARD C. PICKERING.

Discussion of the Revised Harvard Photometry, *H. A.*, 64, 4, pp. 56; ready for distribution.

Observations on J. D. 3182 with the Four-inch Meridian Photometer, *H. A.*, 64, 5, pp. 12; ready for printing.

Magnitudes of Components of Double Stars, *H. A.*, 64, 6, pp. 34; in type.

A Discussion of the Eclipses of Jupiter's Satellites, 1878–1903, by Ralph A. Sampson, *H. A.*, 52, 2, pp. 190; in type.

Durchmusterung Zones Observed with 12-inch Meridian Photometer, 190 pages; in type.

Maxima and Minima of Variable Stars of Long Period, 130 pages; in type.

Photometric Measurements made with the East Equatorial, by Oliver C. Wendell, pp. 56; in type.

Photographic Magnitudes of Seventy-two Bright Stars, Photographic Observations of Occultations, Eclipses of Jupiter's Satellites, Transformation of Prismatic to Normal Spectra, Miscellaneous, by Edward S. King; nearly ready for printing.

Statistical Investigations of Planetary Orbits, by W. H. Pickering; nearly ready for printing.

The Zone of Stars, in declination $-9°\ 50'$ to $-14°\ 10'$, observed by Professor Searle with the eight-inch meridian circle, is now nearly completed. It will occupy three volumes of the *Harvard Annals*. It will be sent to the printer this autumn, unless unforeseen delays arise.

The Photographic Search for Planet O: W. H. PICKERING.

The search for this planet was prosecuted on plates taken by the Rev. Joel H. Metcalf with his 12-inch doublet. Two plates of each region were taken at intervals of a few days apart. A positive was printed from one of these, and the other negative superposed upon it. It was expected to detect the planet by its motion during the interval elapsed. The planet has not as yet been found. This may be due to one or more of three causes: (*a*) The planet may be unexpectedly faint, or reddish in color. Its computed magnitude is 13.5. (*b*) The orbit may be highly eccentric, the computation being based on an approximately circular orbit. (*c*) The orbit may be highly inclined to the ecliptic, and the planet at present situated far from its node. For various reasons the first two causes are not thought sufficiently effective to interfere with the discovery of the planet. We might, by analogy, compare planet *O* on account

of its relative size and position with regard to the other planets, to the sixth or seventh satellite of Jupiter. The inclinations of the orbits of these two bodies are 28° and 26°, respectively. The region already covered in the photographic search extends along the ecliptic for 25°, and reaches to a maximum distance of 10° to the north and south of it. It is expected therefore to make an examination of the higher latitudes next year. The number of stars already examined in the search is estimated at about 300,000.

The Spectrum of a Meteor: Williamina P. Fleming.

On August 14, 1909, while examining a shipment of plates recently received from Arequipa the spectrum of a meteor was found on a photograph taken with the Bruce 24-inch telescope on May 18, 1909. This must have been an unusually bright object, since its trail is very intense, consisting of twenty-three bright lines or bands. As the photograph has so recently been received at Cambridge no study of the spectrum has as yet been attempted.

Graduation Errors of the Circles of the Six-inch Transit Circle of the U. S. Naval Observatory: J. C. Hammond.

This consisted of a description of the methods and results of a thorough examination of the circles that is still in progress. The circles were graduated by the Warner and Swasey Company, of Cleveland, and seem to be quite as accurate as those of the best foreign makers. The examination brought to light a periodic error that repeated itself in every ten minutes of arc. This was traced to a slight eccentricity of a ratchet-wheel and has been corrected for circles subsequently graduated with this engine.

The Clock Vault of the U. S. Naval Observatory: Edgar Tillyer.

In this paper, which was read by Professor Updegraff in the absence of the author, Mr. Tillyer described the devices adopted for maintaining constant temperature in the vault in which are mounted three Riefler clocks.

On the Construction of Astronomical Photographic Objectives at the U. S. Naval Observatory: George H. Peters.

Mr. Peters first described the various attempts that had been made to install a photographic instrument at the observatory with the use of material already at hand, the most noteworthy of these being the reassembling of the parts of the old mounting of the 26-inch equatorial to serve as a mounting for various cameras. Mr. Peters has now undertaken the construction of two 10-inch objectives of about 110-inch focus. These are of the type in which three lenses are employed with large separations. The curves were computed by Mr. Tillyer and the grinding is being done with a machine constructed in the observatory shop.

At the annual meeting of 1908 the society had appointed a committee on luminous meteors. This committee presented a detailed report written by its chairman, Professor Cleveland Abbe, giving a résumé of what had previously been done toward securing photographs of meteor trails. The various methods and instruments that have been employed or proposed were critically examined from the point of view of the astronomer as well as from that of the meteorologist. The report strongly urged the establishment of a network of photographic stations about one hundred miles apart for the purpose of obtaining a tolerably complete record of all the meteors appearing within the network. Automatic instruments of as simple and inexpensive a type as practicable were recommended.

The committee on comets, also appointed at the 1908 meeting, reported orally through its chairman, Professor Comstock. Its attention had been given mainly to the approaching return of Halley's comet. In order that this comet may be adequately observed it will be necessary, on account of its close approach to the sun at the time of maximum brilliancy, to have stations widely distributed in longitude. To secure such stations correspondence has been had with observatories in the eastern hemisphere. The Pacific Ocean presents a wide gap in which no available station exists and the committee has assumed the task of securing funds for the establishment of a temporary station, presumably in the Hawaiian Islands. Such funds are now assured in case the circumstances of the comet's return render it desirable to send out a party. The appearances that the comet will present depend so much upon the exact date of its return to perihelion that no definitive program of observation can be framed before the rediscovery of the comet. It appears, however, advisable to separate the observing program into three classes of observations, viz., photographic, photometric and spectrographic, and the preparation of a detailed program of these divisions has been entrusted, respectively, to Professors Barnard, Pickering and Frost. It is the

purpose of the committee as soon as it has adequate data at its disposal to formulate and publish the proposed program under these several heads.

A proposal to change the name of the society to the American Astronomical Society was discussed at considerable length. It was the feeling of most of the members present that such a change would be desirable from some points of view; as, however, fears were expressed that this change might tend to deprive the society of the great benefits that it now derives from the attendance and contributions of some who engaged altogether in laboratory research, it was voted not to omit the word "Astrophysical" from the name of the society.

A proposal that the society should go on record as deeming any attempt to communicate with Mars as being unpracticable at the present time and as deprecating the use of any funds for such a purpose was also voted down. The members present were unanimous in believing that such attempts are useless, but were of the opinion that it would be wise not to dignify with any formal action the absurd accounts that have recently appeared in the newspapers.

Upon recommendation by the council the society decided to issue a volume giving an account of its activities during the first ten years of its existence. The council announced that thirty-four persons, an unusually large number, had been elected to membership at this meeting; and that the next meeting would be held during August, 1910, at the Harvard College Observatory, the exact date to be determined later.

The last formal action to be taken by the society before its adjournment was the unanimous adoption of the following:

"The Astronomical and Astrophysical Society of America, assembled at its tenth annual session, records its great regret at the death of its first president, Professor Simon Newcomb. Deeply interested in the cooperation and mutual influence of scientific men, Professor Newcomb was conspicuous in the organization and early progress of the society, and was a dominant factor in determining its relation to contemporary astronomy. His enthusiasm for the science and his wide knowledge of its many branches made his presence and participation in the meetings of the society a perennial inspiration to its members.

"Professor Newcomb's own achievements in exact and theoretical astronomy have already become classics in the history of the subject, and will constitute his permanent memorial. The record of a long and active scientific career is closed with the fulfilment of many of his most cherished ideas, and we deeply regret that he was not longer spared for the further development of those subjects to which he had largely contributed.

"The society records its profound respect for the departed member and directs its secretary to transmit a copy of these resolutions to his bereaved family."

FRANK SCHLESINGER,
Editor for the Tenth Annual Meeting

SOCIETIES AND ACADEMIES

THE AMERICAN MATHEMATICAL SOCIETY

THE one hundred and forty-fifth regular meeting of the society was held at Columbia University on Saturday, October 30, 1909, extending through a morning and an afternoon session. About forty persons were in attendance, including twenty-seven members of the society.

Vice-president Edward Kasner occupied the chair, being relieved at the afternoon session by ex-presidents W. F. Osgood and H. S. White. The following persons were elected to membership: Dr. H. T. Burgess, University of Wisconsin; Professor H. H. Dalaker, University of Minnesota; Mr. G. C. Evans, Harvard University; Mr. Louis Gottschall, New York City; Dr. J. V. McKelvey, Cornell University; Miss H. H. MacGregor, Yankton College; Mr. H. H. Mitchell, Princeton University; Mr. U. G. Mitchell, Princeton University; Mr. R. R. Shumway, University of Minnesota; Dr. H. L. Slobin, University of Minnesota; Mr. I. W. Smith, University of North Dakota. Four applications for membership in the society were received. Mr. C. B. Upton, of Teachers College, was appointed assistant librarian of the society.

Resolutions were adopted expressing the sense of loss to the society and to science occasioned by the death of Ex-president Simon Newcomb.

The following papers were read at this meeting:

C. N. Haskins: "On the extremes of functions."

P. A. Lambert: "On the solution of linear differential equations."

Florian Cajori: "Note on the history of the slide rule."

Carl Runge: "A hydrodynamic problem treated graphically."

Edward Kasner: "The motion of particles starting from rest."

G. A. Miller: "Note on the groups generated by two operators whose squares are invariant."

C. N. Moore: "On the uniform convergence of