SCIENCE

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THE HARVARD ASTROPHYSICAL CONFERENCE.

THE first Astrophysical Conference, held on the memorable occasion of the dedication of the Yerkes Observatory, was so marked a success and started a movement so important to American astrophysical science that it was to be expected it would result in the perpetuation of such conferences. Both from the graceful tribute brought on that occasion from Harvard, the oldest observatory devoted to astrophysical research, to the newest seeking similar work, and from the fact that Professor E. C. Pickering's fearless application of modern methods of research to far-reaching astronomical problems had made the Harvard Observatory a center of interest to many astronomers, was it eminently proper that the second Conference, and that first proposing a permanent organization of American astronomers, should be held at the Harvard College Observatory.

Quite apart from the scientific papers read and discussed, the Observatory entertaining the Conference in itself constituted a special contribution. In no other observatory could the methods by which modern astronomy is breaking with traditional types of work be more completely and systematically exhibited. Professor E. C. Pickering's vast organization of work, as concretely represented in the photographic and other results accessible to the members of the Conference, was unquestionably the greatest and most inspiring contribution made to the Conference. There were the organized photometric determinations represented not only in Professor Pickering's own work with the meridian photometer, but in the work of Mr. Wendell in accurate photometric measurements of variable stars, and in the other general photometry systematically carried on by a number of observers. In the photographic enterprises there was the charting of the stars of the entire heavens once every year by means of the eight-inch Bache and Draper photographic doublets and smaller instruments, and the photographic study of the Milky Way on different scales by exposure of four or five hours with the two and one-half inch, eight inch and twenty-four inch Bruce telescopes.

Photographic spectroscopy was represented by a general spectroscopic *Durchmusterung* carried out by an eight-inch telescope provided with an objective prism. For details of the spectra of the brighter stars there were present photographic spectra given by the eleven-inch photographic telescope of the Harvard Observatory and the thirteen-inch at Arequipa, taken with from one to four objective prisms. And for the spectra of very faint objects the twenty-four-inch Bruce, armed with its objective prisms, presented minute details. Among the list of notable discoveries due to these organized methods of research of Professor Pickering there were shown the spectra of the invisible binaries, the spectra of numerous bright line variable stars, the results of study on stars having peculiar spectra, and in the wonderful photographs of clusters, of definition probably surpassing any yet made, were disclosed those hundreds of variable stars in which Professors Pickering and Bailey have just reason to express a proud delight.

Whether the members of the Conference were instructed in shrewd management of stellar photography by Mr. King, or listened to the detailed explanation of the methods of examining photographic spectra by Mrs. Fleming or Miss Maury, with the vast library of plates at their command, or followed Professor Bailey in his most interesting charting of the periods of hundreds of variables in the star clusters, or discussed with Professor Searle the methods by which he is bringing to completion the *Gesellschaft* zone, or reviewed with Professor W. H. Pickering problems in direct telescopic observations, or with Mr. Wendell they followed the highly accurate measurements of stellar magnitude at the equatorial, or whether with any one of the other observers they undertook to follow the work, not omitting the special work with the meridian photometer in which Professor Pickering himself so actively participates, one could not help feeling the presence of a genius for organization and for the determinate solution of vast scientific problems which alike instructed and inspired. It would, therefore, be but just to record the enthusiastic appreciation of the Conference for the contribution which the Director of the Observatory of Harvard College incidentally presented.

Upon organization of the Conference Professor Pickering briefly welcomed the Conference to the hospitality and inspection of the Observatory. The list of papers and their discussion was then immediately begun.

The Conference was presided over alternately by Professor J. R. Eastman, of the United States Naval Observatory, and Professor George E. Hale, Director of the Yerkes Observatory, and the meetings were not only held during the allotted time, August 18th, 19th and 20th, but were carried over to a series of adjourned meetings held during the course of the subsequent week.

Professor Arthur Searle presented his experience on 'Personal Equation in Transit Observations.' He showed that in two observers' work there was a difference in (1) the term $\triangle T + m$, the ordinary personal equation; (2) the collimation micrometrically determined and computed from transits; (3) the apparent position of the instrument, the axis being more inclined to the plane of the equator for one observer than for another; (4) the apparent rate of clock during the evening, due probably to increasing fatigue; (5) that due to magnitude of stars. Professor Searle pointed out a collimation effect on transits due to bad focus of eyepiece, the lines being displaced by reflected light in illumination. This was shown optically and by a series of transits by two observers, Professor Searle and his assistant, Mr. J. A. Dunne, using different foci of eyepiece.

In the discussion Professor W. H. Pickering suggested that the doubling of wires noticed in the transit instrument under false focusing was analagous to the doubling of the lines of Mars, and that the latter phenomenon was probably due to false focus, and hence doubling of the image in the human eye. Professor Comstock stated that there is a law of variation of personal equation with the declination, but that there is also a variation due to physical condition. When the observer is tired, observations are made more quickly. Professor Eastman said that he had found that malarial fever brought down the personal equation as much as half a second earlier and that there was also a diurnal variation in the personal equation. Mr. Hayford stated that the experience of the United States Coast Survey indicated that personal equation was not appreciably affected by using different forms of signal keys.

Professor George C. Comstock presented 'Some Investigations Relating to Zenith Telescope Latitudes.' In the course of a determination of the constant of aberration it was found that two causes of error entered. In the first place, it was noted that any local temperature changes of the atmosphere unsymmetrical with respect to the instrument had a very serious influence on the apparent variation of the latitude. In the second place, general variation in the atmospheric refraction was no t eliminated The atmospheric layers are not normal to the vertical, and the barometric and thermometric gradients vary irregularly. The zenith telescope gave a constant of aberration varying from 20″.38 to 20″.64, with a range of 0″.26, while even the carefully determined values of Preston, 20″.43, and Gill, 20″.58, gave a range of 0″.15. At least a partial explanation of these variations may be found in the local conditions surrounding the various observatories. Comparing the values derived at New York, 20″.46, with that of Naples, 20″.53, the difference is found to be such as may be accounted for by the diurnal temperature changes accompanying the changing land and sea breezes of the respective places. The large value, 20″.58, obtained at the Cape of Good Hope by Gill is capable of similar explanation, and no case has been found that violates this hypothesis. The result is that the local conditions of every place affect the determination of the aberration constant, and in such investigations it becomes advisable to abandon the zenith telescope and all other instruments which depend upon the vertical as a reference line.

Professor Doolittle stated that he had called attention to the outstanding variations in latitude determinations and believed the cause to be a variation in the refraction. The deviation is a good many times as great as the probable error of the observations. The limit of accuracy of the zenith telescope method has been reached.

Doctor Harold Jacoby presented a paper on 'Photographic Researches near the Pole of the Heavens.' The object of the research is to furnish new values of the fundamental constants of stellar astronomy. The plan consists in making exposures for short trails around the pole, like those first made at the Harvard College Observatory. The records on the plates being made apart from either clock or graduated circle furnish an independent method. The particular negatives used were made at Helsingfors by Professor Anders Donner, and the northerly latitude reduces distortion occasioned by refraction to a minimum. Formulæ suitable for the complete reduction of ordinary polar plates star photographs as well as for the special plates described have been deduced and an application made to measures on one plate of six images of each of ten stars, with encouraging results. A discussion was undertaken, assuming first that the instrument remained fixed during the exposure, and second that it was in motion. Making the reductions according to the latter hypothesis the results are in accord with the best north polar distance determinations of Auwers. The line of motion was vertical, by sagging. All the images on two Helsingfors plates, made six months apart, will be measured and the results treated for a general test of the possibilities of the method. The work already accomplished will soon be published in full detail.

Professor Pickering said that aberration and nutation could be thus best determined, and that the 15-inch Draper telescope has for several years been photographing the pole every clear night with automatic exposure, the plate in some cases hanging vertical so as to eliminate one equation of condition. Professor Paul held that lateral and vertical refraction might enter as disturbing factors. Professor Comstook, while agreeing with Professor Paul as to the possibility of refraction variations, held it to be highly desirable that Doctor Jacoby should prosecute his researches. Doctor Jacoby remarked that a new method like this should be received with scepticism and that the test of this plan would be by thorough work extending perhaps over one generation.

Mrs. M. Fleming's paper on the 'Stars of the 5th Type in the Magellanic Clouds' was presented by Professor E. C. Pickering. Stars having spectra consisting mainly of bright lines belong to Type V. In 1891 the number of these stars known was thirty-three. Three of these were discovered by Wolff and Rayet, one by Respighi, six by Copeland, three by Pickering and twenty from the Draper Memorial Photographs of the Harvard College Observatory. In May, 1897, the number known was sixty-seven. All of these stars lie closely along the central line of the Milky Way, and, although the sky had been equally well covered with spectrum plates from pole to pole, a careful examination of the plates failed to show any of these stars outside of this region.

On May 26, 1897, an examination of two photographs taken at Arequipa with the Bruce telescope showed a group of six of these objects in the Large Magellanic Cloud. Two later plates add fifteen more, and these with three other stars in the Milky Way, and one in the Small Magellanic Cloud, make the total number of these stars, so far known, ninety-two. Thirteen of these were found visually; all the others have been found by Mrs. Fleming from Draper Memorial photographs. The great advantages of photography in the study of stellar spectra is thus again demonstrated.

The presence of so many stars of the Fifth Type in the Magellanic Cloud establishes another connection between this object and the Milky Way.

Professor Solon I. Bailey presented a paper on 'Variable Stars in Clusters.' A systematic examination of twenty of the most interesting, dense, globular clusters has been made. In these clusters 18,600 stars were compared, of which 501 were found to be variable. In only a few of these clusters does the percentage of variables amount to more than one per cent., and in many cases it is less. A few clusters, however, give remarkable results. The most striking is Messier 3, where 132 stars out of a total of 900 are variable, or one in seven. Other clusters remarkable for the number of variables are Messier 5, Omega Centauri and Messier 15. These four clusters together have 393 variables. At the present time the periods and light curves of more than one hundred have been determined. These periods are generally less than 24 hours, and are characterized by an abrupt increase in light and a slower decrease. These results have all been obtained by photography. They would have been impossible with instruments of the same size by visual methods. The photographs were made with a 13″ telescope. The faintest variables are quite invisible in the same telescope, and it is doubtful if they can be well studied visually in a telescope of less than 30″ or 40″ aperture. The shortest period of these variables is $6^h\ 11^m$, which makes it the shortest period known.

Professor Bailey's remarkable work was rendered extremely interesting by the exhibition of some of the original photographs and of the numerous charts of the change in brightness of these variables which he had been able to prepare. Professor E. E. Barnard stated that he was surprised that this great discovery had attracted so little attention. He knew the photographic plate could be depended on. The great Yerkes telescope very readily verified the periods. He had verified three of Professor Bailey's periods, but was afraid the visual was inferior to the photographic method. Father Hagen stated that the stars were on the limit of visibility in the 12-inch telescope, and there seemed to be no charts of these clusters. Professor Pickering stated that photographic charts of the clusters would be furnished by the Harvard College Observatory.

Mr. Albert S. Flint, in a contribution on 'Meridian Observations for Stellar Parallax,' presented a summary of the results of the observations for stellar parallax, made at the Washburn Observatory, on a list of nearly one hundred stars. The method employed is that of differences of meridian transits. The value of the method is confirmed by the good agreement with other accurate determinations of stellar parallax and by the absence of any plainly indicated systematic errors. The first comparison gave an average difference of only 0″.03 on the fifty stars elsewhere observed. The probable error of the definitive parallax for any one star varies from 0″.030 to 0″.040, except for great zenith distances. The values depend upon from forty to sixty observations extended through from four to six epochs. A new series of similar observations has been begun, which will include second-magnitude stars and binaries. The new Repsold transit micrometer will be employed, with which the observer maintains bisection with a movable thread, while the chronograph signals are made automatically by the revolving micrometer head.

Professor Comstock said that while the average accuracy of the method is not as great as with the heliometer or by photography more observations can be made and gross error eliminated. The method is useful for a general parallax survey.

Professor Charles Lane Poor, in a paper on 'The Direct Grating Spectroscope and its Applications to Stellar Photography,' stated that already in 1891 and 1892 he had experimented with the direct vision grating in photographing star spectra, and had taken the problem up afresh in the fall of 1897, using both a 2-inch grating and a specially ruled grating of 6.5 inches aperture and 39 inches radius of curvature. Properly mounted on a guiding telescope good photographs of stars to fourth magnitude resulted. Many of these were exhibited by Dr. Poor. Aside from the advantage of securing normal spectra, the method permits the determination of the relative wave-length shift by photographing two stars on same plate. Dr. George E. Hale stated that a machine, intended to rule gratings 9 inches by 15 inches, was now being built at the Yerkes Observatory. The great difficulties attending ruling of surfaces of sharp curvature were described by Dr. Poor.

In discussing the methods of producing normal spectra of stars, Mr. Edward S. King stated that at the Harvard College Observatory two methods of transforming the prismatic into the normal spectrum had been tried with success. In the first, photographs were taken of the original plate through a slit with the plates moving at differential rates. In the second method the plates are inclined to the axis of the lens, so as to make the scale exact for three points of it while maintaining good focus. The first method is applicable for producing any unequal change of scale. The second, though of an approximate character, is the better working method. Mr. King showed admirable photographic comparisons of star spectra with Rowland's map.

Professor E. C. Pickering added that the method just described was thoroughly general and that all scales were thus reproducable. He believed that the Orion lines could be well investigated by a grating, as suggested by Dr. Poor.

Professor G. W. Hough discussed 'The Effect of Atmospheric Disturbance on Telescopic Definition.' The local atmospheric disturbances should be differentiated from the general atmospheric conditions. As the object-glass of the largest telescope is infinitely small compared to the size of the atmospheric waves the disturbance will vary directly with the magnifying power. When a disturbance is just in front of the instrument there is displacement and distortion as well. Capping the object-glass usually produces no improvement.

Professor W. H. Pickering said the local conditions at Arequipa are satisfactory. Caps make little difference with large telescope, but with 6-inch telescope, or less, caps are valuable. Double stars are not the best test of seeing, but rather detail work on planets. Professor Hale said small telescopes are not as good in fair seeing as big ones for any work. There are many false statements on this point. The two faults of seeing are jumping and blurs. At Flagstaff there is a lively jumping. The highest power used at Yerkes is from 2,500 to 3,000.

Miss Agnes M. Clerke's paper 'On the Spectra on Certain Nebulæ,' read in the author's absence by Professor Snyder, called attention to the demand for a special study of the spectra of white nebulæ, by reason of the nature of their structure, their mode of distribution in the heavens, and the quality of their light differentiating them from the gaseous nebulæ. Miss Clerke proposed 30 Doradûs, whose spectrum Professor E. C. Pickering had described as 'partly stellar and partly gaseous;' Messier 1, of which Pierce and Winlock, and later Campbell, had made interesting observations, and N. G. C. 6299 as examples of this anomalous class. Professor E. C. Pickering, exhibited several recent photographs of spectra of the nebulæ indicated by Miss Clerke.

Mr. J. F. Hayford, in speaking of a 'Proposed Publication of the Coast and Geodetic Survey,' said that the Coast and Geodetic Survey proposes to publish in the form of a catalogue of north polar distances the computed data which it now has in its possession. The catalogue will comprise stars which have been observed for latitude in the survey. The number of stars, 6th magnitude and brighter, comprised in the catalogue will be about 3,500. The degree of accuracy pertaining to each polar distance and proper motion will be indicated by attached probable errors. The systematic corrections and weights assigned in the computations to each catalogue are substantially those assigned by Professor Lewis Boss in his report on similar work for the Northwest Boundary Survey in the seventies.

Professor Pickering presented a paper by Mrs. M. Fleming on the 'Classification of the Spectra of Variable Stars of Long Period.' In the classification of the spectra of stars in the Draper Catalogue the letter M was assigned to stars having spectra of the third type. Later these stars were subdivided into four groups, Ma, Mb, Mc and Md, of which α Orionis, α Herculis, $-2°3653$, and o Ceti were given as examples. In the last of these stars the hydrogen lines are bright, and this spectrum has been shown to be characteristic of variable stars of long period; indeed, by this peculiarity in the spectrum about a hundred new variable stars have been found. A further examination of these spectra shows that they can be further subdivided into eleven groups. A classification made from an examination of the continuous spectrum, the comparative brightness of the hydrogen lines being also carefully estimated, always assuming the brightness of $H\gamma$ as 10, the first class, of which R Lyncis is the typical star, showed a spectrum resembling α Tauri, and having $H\beta$ and $H\gamma$ strongly bright, and nearly equal, while $H\delta$ was barely visible. The last group, of which R Leonis is a typical star, shows a continuous spectrum like $-2°3653$ with $H\beta$ invisible, $H\gamma$ barely visible and $H\delta$ strongly marked.

The original photographs were exhibited and examined by the Conference.

Professor G. W. Myers presented 'A Study of the Light Variation of U Pegasi.' The hypotheses assumed were: (1) The light curve given by Pickering in Harvard College Observatory Circular No. 23 represents the true nature of the light change of this star near enough to determine provisional orbital elements, and (2) The light change is capable of explanation on the satellite theory. After the discussion showed the desirability of introducing a flattening, the further assumption was made: (3) The two components are deformed by tidal influence into similar ellipsoids of revolution.

Equations were then derived connecting the light curve with the 'elements' defining the system whereby the latter might be derived from the former, and *vice versa*. From these equations the following results were obtained: The light curve of U Pegasi, given in circular No. 23, is satisfactorily represented by the satellite theory with a circular orbit, whose radius differs but slightly from the sum of the major axes of the components, and whose inclination is very nearly 90 degrees. The smaller component has a brightness of about 0.77, and a radius of 0.78 of the larger, while a slight flattening of the disks probably exists. Accuracy of present observations does not warrant a least square adjustment of the outstanding residuals. There is some reason to believe in the existence in this system of the apioidal form of Poincaré.

Professor E. C. Pickering said it was astonishing how slight were the differences between observed and theoretical values of the brightness, and this agreement was confirmatory both of the observations and the theory. Mr. H. M. Parkhurst could not accept the period assumed, and questioned the accuracy of determinations of minima differing by but .15 of a magnitude. Professor M. B. Snyder held that the relation of Professor Myers' present work to that of Doctor See on the evolution of binaries was quite remarkable, and, seeing that Doctor See's prediction of variation of eccentricity was just what Doctor Myers had required as an hypothesis in treating the similar variable β Lyræ, the results were anything but discouraging to all the hypotheses involved in their interesting work.

Professor George E. Hale, exhibiting a set of remarkable photographs, presented a review of work on 'The Spectra of Stars of Secchi's Fourth Type.' The spectra of 22 stars of this type have been photographed with the 40-inch Yerkes telescope, in most cases with a dispersion of one prism. For the stars Schjellerup 132 and 152, which are the brightest specimens of this type, the three-prism spectrograph was also employed. The photographs all show a large number of lines hitherto unrecorded. Most of these are dark, but there seem to be a certain number of bright lines. These show best with high dispersion, and are not weakened in intensity by widening the slit. The brighter ones have been observed visually, in Schjellerup 132 and 152, using a dispersion of three prisms. At Dr. Hale's request the spectrum of Schjellerup 152 was observed visually with the 36-inch telescope of the Lick Observatory by Professors Keeler and Campbell, who concluded that bright lines were almost certainly present. Further tests of these lines are being made at the Yerkes Observatory. The wave-lengths of two of the brightest of these lines agree very closely with the wave-lengths of two of the brightest lines in the spectra of the Wolf-Rayet stars, as measured by Professor Campbell. It is still too early to conclude, however, that any connection exists between the stars of the fourth type and those of the Wolf-Rayet class. In this connection it should be remarked that the fourth-type stars, as plotted by Mr. J. A. Parkhurst at the Yerkes Observatory, show a much stronger tendency to cluster in and near the Milky Way than any other stars except those of the Wolf-Rayet type. It has been found possible to arrange the spectra of eleven fourth-type stars in a series, having at one end the star DM 59° 2810 and at the other Schjellerup 155b. The investigation, which is being made with the assistance of M. F. Ellerman and Doctor Schlesinger, will be continued during the coming year.

Professor E. E. Barnard exhibited a series of photographs illustrating the work that had been done with the 6-inch aperture lens. These consisted of photographs of various portions of the Milky Way, showing its cloud forms and intricate structure. Many singular peculiarities were shown, such as the great rifts where the Milky Way appears to be rent asunder as if it were breaking up. The impression is that certain portions of the Milky Way consisted of sheets of stars of comparatively little depth, and it is in such regions that the process of disintegration seems to be going on. In some of the great clouds of stars are shown very distinct black holes, in the densest portions, as though tunnels perforated through the cloud masses and permitted one to look into the blackness of space beyond. Another striking feature is the presence of vacant lanes or black channels among the stars of the Milky Way. In these no stars seem to exist. Still another feature is the strange geometrical arrangement of the stars in curves in certain regions, as if some force were at work in this structural arrangement, baffling for the present direct explanation. One of the most extraordinary features is the presence of vast regions of faint diffused nebulosity, mixing up with the stars of the Milky Way. This nebulosity is better dealt with by the photographic plate, because it is too faint to affect the human eye. It is suggested that when this remarkable feature comes to be thoroughly studied, it will doubtless lead to a better understanding of the physical condition of the Milky Way and of its origin.

The photographs of comets, especially of Brooks' of 1893, show most remarkable and rapid changes in the form and structure of the tail. It seemed to suggest that the tail may have encountered some resistance in its flight through space. Comets are perhaps the only objects that would be able to point out such streams of resistance. It is possible that the tail of this comet swept over a meteor stream or some other less resisting medium in space on the 20th, 21st and 22d of October, 1893. Portions of the tail seemed to have been torn off and to be drifting away from the comet as independent masses, and, if our ideas of comets are correct, these might themselves become swarms of meteors.

The series of photographs shown indicated the valuable results attained and the wide field of study opened by this method of research.

Mr. A. Lawrence Rotch gave 'A Brief Account of the Work of the Blue Hill Meteorological Observatory,' in which he described the peculiar instruments used, and adverted to the scientific character of the work carried on. His account was accompanied by photographs of the instruments, and on closing the description he invited the Conference to an inspection of the Observatory, which was cordially accepted and participated in by many of the members. Those who visited the Blue Hill Observatory were greatly impressed with the methods and appliances used in the difficult problems of meteorological research there attempted.

Miss A. C. Maury read a paper on 'The K Lines of β Aurigæ.' She said β Aurigæ is a double star whose components revolve in a period of $3^d 23^h 37^m$ approximately, and with a velocity in the line of sight of 150 miles a second. As the distance between their centers, supposing the plane of the orbit to pass through the sun, is only about eight million miles, the stars are, of course, inseparable by the telescope, but their spectra become separated when, in the course of revolution, one star is approaching the earth and the other receding from it. By the Doppler principle, all the lines of the combined spectrum then appear double, those of the star approaching being shifted toward the violet, those of the star receding, toward the red.

Photographs of the double spectrum, two hundred in number, obtained at the Harvard Observatory during the past nine years, show that the K line (of calcium) varies periodically in intensity. It is stronger in one star in the photographs of one year and in the other star in those of the year following, the relative intensity thus alternating for nine years. This variation, though less perceptible, may extend to other lines of the spectrum. It seems probable that the revolving stars, which are nearly or quite alike in mass and constitution, induce in one another reciprocal variability.

A similar variation has been suspected by Professor S. I. Bailey in the components of the Spectroscopic binary μ' Scorpii, as shown in the Photographs obtained in Peru.

Professor Winslow Upton presented the methods of determining 'The Position or the Arequipa Station of the Harvard College Observatory.' The latitude of the Arequipa station was obtained by observations in the prime vertical made with a special instrument designed by the late Professor William A. Rogers. The observations were made by two Besselian methods, the extreme range for individual observations being 7″. The final value for the latitude is $-16° 22' 28''.0 \pm 0''.19$. The longitude was obtained by telegraphic exchange of time signals between Arequipa and Arica, Chile, the longitude of the latter station having been determined in 1883 by officers in the United States Navy by means of the coast cables. The difficulties or making the exchange directly made it necessary to repeat the signals in passing from the land telegraph line to the cable. The difference of longitude was determined with a probable error of $\pm 0^s.032$, and the resulting longitude is $4^h 46^m 11^s.71$ west of Greenwich.

Mr. Henry M. Parkhurst, in a paper on

'The Rotation of the Asteroids,' discussed his photometric observations, extending over a number of years, on planets Nos. 40 and 42, and from these observations concludes that no hypothesis of rotation need be introduced to account for any changes in brightness.

Dr. Herman S. Davis presented a paper, read by Professor Upton, on 'The Parallaxes of 61 and 62 Cygni and the Probable Physical Connection of these two Stars.' From a review of the observed photographic results of parallax and the apparent difference in parallax of the two stars, the author concludes that 'these two stars are moving through space independently of each other and separated from each other by an interval represented by two and one-quarter light years;' but does not 'regard this difference of parallax as an entirely indisputable fact.' He, however, insists that the two stars of 61 Cygni should be regarded as too remote from each other to form a binary system until more evidence is adduced to disprove this conclusion.

Professor Comstock said he was of the opinion that the stars were at some distance; considering the difference of parallax $0''.08$, Dr. Davis' is not the only hypothesis allowable. A more plausible hypothesis is that one of these stars is accompanied by a dark companion, about which the star revolves so as to counteract the motion of the earth. The *a priori* probability in both hypotheses is perhaps the same. Professor Frisby thought that the parallax determination showed overlapping values not consistent with Dr. Davis' hypothesis. Professor Flint pointed to the large range of variation in the parallax determinations of these two stars and thought Dr. Davis' hypothesis unwarranted.

Professor Charles L. Doolittle reviewed the 'Work of the Flower Observatory.' Double-star observations made by Mr. Eric Doolittle, on a list prepared by Mr. Burnham, have been made with the 18-inch telescope of Mr. Brashear. The difficult pairs observed are a fair test of the performance of the instrument. The theoretical power of separation is $0''.275$ and yet in one case a pair separated by $0''.24$ has been measured. Comparing the work of the Brashear instrument with similar observations made by Mr. Burnham with the Clark instrument of approximately the same aperture at Evanston, it is found that the Brashear instrument will resolve all pairs shown by the Clark. Fourteen pairs of new doubles have been picked up, and this indicates that an ample harvest is yet to be reaped. Four hundred and fifty pairs have been measured on three different evenings, and the results will soon be published. Professor Hough thought the results had certainly shown the Brashear objective to be a good one.

A paper by Professor Arthur Searle on 'Faint Stellar Bands in the Ecliptic' was read by Mr. William Maxwell Reed. If faint stellar bands exist in the ecliptic the observed shape of the *Gegenschein* would certainly be affected. Such bands Professor Searle has observed. The most prominent of these extends from Aquila through Aquarius and Pisces to the neighborhood of η Tauri. Another falls close to the ecliptic. It commences in Gemini and ends in Coma Berenices. These bands seem to be a part of a network, of faint bands that cover nearly the whole sky. The *Gegenschein* is not always perfectly round.

Professor S. I. Bailey, in discussing this paper, said that in his observation of the *Gegenschein* in Chile and Arequipa he had never been able to see the *Gegenschein* perfectly circular. He suggests that the faint bands might be photographed, and thus their character and brightness better determined. He had, however, not been able to photograph the zodiacal light. Drawings of the bands as made independently both by Professor Searle and Mr. Reed were exhibited, and, considering the delicacy of the observations, coincided well.

Professor Frank W. Very, in a paper on 'The Probable Range of Temperature on the Moon,' described his experimental work in determining the radiation from diverse substances at ordinary temperatures. Special attention was called to the compensation involved in radiation from subsurface molecules, which narrows the range of radiant emissivity, as exercised by different materials. Hence, the errors committed in classifying radiators in a very few, or, under certain restrictions, even in a single division, are not large. Measurements of lunar radiation have been carefully made at various phases, and the interpretation of these results in terms of absolute measurement is now possible. The method of reduction was indicated, and the final conclusion was that the moon's surface temperature lags behind the possible temperature which might be given by the sun's rays throughout most of the seven days of the lunar morning. A retention of heat by the surface material of the moon is thus shown, but the retention is so small that almost the whole of the heat received while the sun is above the horizon is lost before sundown on the same day, and thus the proper radiation from the surface, which in the case of the earth goes out to an entire circumscribing sphere, emanates virtually from only half the surface of the moon while it is undergoing insulation. The day temperature of the moon consequently becomes extremely high—above that of boiling water, except in the polar regions—while at night the cold approaches that of space.

Professor William H. Pickering presented a paper (not read) on 'Swift's Comet I., 1892.' This comet, discovered March 6th, was first noticed to have a faint tail, by Finley, on March 26th. As discovered at Arequipa, March 29th, the tail was well developed. Forty-four photographs were taken of this comet and used in a recent investigation of its nature. The tail was plainly two-fold in character, the inner tail continuously issuing from the head, and, being at least 20 degrees in length a month after passing perihelion, consisted of two absolutely straight rays inclined at an angle of 10 degrees. The outer tail was formed by successive eruptions from the head, later diminishing in angle. The whole effect was to produce multiple tails like the comet of 1744. The photographs showed the inner tail to be of a different character on alternate days, now appearing continuous near the head and now bifurcated. The explanation is that the comet rotates about a longitudinal axis directed toward the sun, the rotation period determined being 94.4 hours. This period was determined by the use of the photographs made at Arequipa by the writer, and corrected by those of Professors Barnard and Wolf. Bessel observed in Halley's comet, in 1835, 'a vibration from side to side' with a period of 110 hours; this was probably a similar rotation of the comet with an analogous period. The changing appearance of both comets being explicable by the hypothesis of rotation, the next endeavor was to find a physical explanation of the cause of such rotation. The sun furnishes a strong electro-magnetic field. The comet also by the electrical induction of the sun receives electrical charges, and these charges are, by the gases of the tails, radially projected from the head of the comet, and become in effect so many electrical currents. The result of the motion of these radiating currents, *i. e.*, tails, in the magnetic field of the sun is the production of a spinning of the comet about a longitudinal axis. Theory would thus produce the rotation demanded by observation, and the rotation would be independent of the direction of the motion of the comet, but north of the solar equator the rotational force is in one direction, and south of it in the other.

It is generally impossible to indicate a point in the tail of the comet; the exception occurs on the plates of April 5, 6, 7, 8 and 10, where a bright detailed structure is receding with increasing velocity of from one million to twenty-five million kilometers per day. The velocity of recession is 36 times the acceleration of gravity, and does not agree with any of the velocities required by Bredichin's hypothesis. The spectrum, as given by an objective prism, of the head and tail showed five bands probably due to hydrocarbons. A further test of the theory of axial rotation of comets near the sun would be an observed change of direction or speed of rotation in the solar magnetic field. Another would be the observation of the rotation when the tail is directed approximately toward the observer.

Professor Edward C. Pickering presented to the Conference a letter he had received from Professor H. H. Turner, of the University Observatory, Oxford, England, conveying a provisional statement in reference to measures and comparisons made of plates forwarded him by Professor Pickering. He writes in part: "The optical distortion on the plate is quite small, if existent—up to 3° from the center, and perhaps further. Whatever may be the ultimate definitive result as regards optical distortion, your plates will give (by the allowance for such distortion, which will be quite easy) as good places as we are getting on the plates for the Astrographic Catalogue. The images are perhaps a little larger and more diffused, but are quite easy to measure. This holds for certainly 4°×4°, and probably further. If I am right in believing that fear of optical distortion was the motive for rejecting the photographic doublet the above conclusions show this fear to have been groundless, and the manifest advantages of getting a large field at once prove the doublet to be the right instrument, certainly for charting purposes. If you think this brief note will be of any interest at the Conference, please make use of it."

The subject of 'The November Meteors' was discussed, and Professor Pickering referred to the desirability of obtaining observations in various parts of the sky and in various longitudes, as indicated in a circular issued by the Harvard College Observatory. Professor Barnard recommended the short-focus lantern lens in the photography of the meteors. Professor Pickering referred to the fact that at present there seemed to be no available method of determining the direction of motion of the meteor from its trail on the plate. Professor W. H. Pickering suggested the desirability of pointing the camera in the neighborhood of the radiant. Third-magnitude meteors could thus be photographed. Professor Barnard indicated that meteors seemed to become visible some distance from the radiant. Professor Hale referred to Doctor Elkin's experience as indicating the photographic difficulties. Professor Searle stated that since small meteors appeared near the radiant, and large ones away from the radiant, it was probable that the body of the meteor concealed the light when near the radiant. Professor Eastman said the experience of most observers is that the largest meteors appear at some distance from the radiant. It seems quite likely that Professor Searle's hypothesis gives the true explanation. Professor Barnard thought that, since meteors must penetrate some distance before attaining high illumination, perspective would show them at some distance from the radiant. Professor Eastman suggested the photographing of persisting meteor trails. Professor Barnard had seen the smoke for ten minutes, and in one case thirty minutes, after the flight of the meteor. The trails broke up into knots. Invariably the trails moved eastward among the stars. Mr. E. S. King referred to the accidental photograph of the spectrum of a meteor in the prismatic camera. Professor Hale regarded the photographic spectra of meteors as obtained at the Harvard College Observatory as of the highest value.

Professor Edward C. Pickering, as chairman of the committee appointed at the previous conference to secure the republication of the *Durchmusterung* charts, reported a list of some forty odd subscribers in America, and stated that the charts would shortly be published. Father Hagen stated that Doctor Küstner has written that numerous errors were being corrected, the largest list of these being furnished by Professor Pickering.

General plans for observing the total eclipse of the sun on May 28, 1900, were briefly discussed, and it was agreed by the Conference that unity in the methods of observation could be best attained by appointing a committee to consider the whole question and report on plans at the next conference. The Conference appointed as the committee, Pickering, Comstock and Barnard.

The matter of better organization of the United States Naval Observatory was brought before the Conference, and on motion a committee was appointed to solicit an expression of opinion on this subject from members of the Conference and other astronomers, the committee also to coöperate with similar committees from other scientific bodies in considering the general question of the reorganization of the scientific departments of the government. The Conference, by ballot, selected Professors Pickering, Hale and Comstock as the committee.

One of the most important questions brought before the Conference was the creation of a permanent astronomical and astrophysical society. It was formally resolved that it was desirable to form such a society, and a committee, consisting of Professors Hale, Comstock, Pickering, Newcomb and Morley, was appointed to report to the Conference on the subject. Subsequently the same committee reported a general plan, and was continued as a council further to consider the organization of the society and make arrangements for the time and place of the next meeting of the Conference.

A number of interesting instruments, apart from those developed and used in the complex work of the Harvard Observatory, were exhibited, and among them a zenith sector made by Rittenhouse, and a transit instrument and quadrant, all used by Andrew Ellicott in the last century. The exhibit of chronographs represented: The first Bond chronograph; the last chronograph made by the inventor, Richard F. Bond, and still capable of determining time to within a few thousandths of a second; a new form of electrically controlled chronograph of Professor A. G. Webster; and a Hough's Printing Chronograph, made by Edmund Kandler, of Chicago, for the Philadelphia Observatory. The latter instrument prints the minute, second and hundredth of the second. W. C. Bond & Sons, of Boston, also exhibited a break-circuit chromometer, and Professor Pickering an ingenious instrument for determining periods of periodic variations.

The following ninety-two persons were present at the Conference: C. G. Abbot, W. H. Attwill, S. I. Bailey, E. E. Barnard, N. E. Bennett, H. H. Brackett, Henry S. Carhart, F. L. Chase, H. Helm Clayton, W. H. Collins, H. R. Colson, G. C. Comstock, Charles R. Cross, A. E. Dolbear, Miss H. R. Donaghe, Charles L. Doolittle, H. W. Dubois, John A. Dunne, J. R. Eastman, Mrs. I. W. Eddy, W. S. Eichelberger, W. L. Elkin, S. P. Ferguson, R. A. Fessenden, Edward P. Fleming. Mrs. M. Fleming, Albert S. Flint, Edgar Frisby, R. H. Frost, Miss Caroline E. Furness, Miss E. F. Gill, H. M. Goodwin, Miss Ida Griffiths, J. G. Hagen, George E. Hale, J. F. Hayford, Miss Lillian Hodgdon, G. W. Hough, Harold Jacoby, E. S. King, Laurence La Forge, Miss E. F. Leland, F. H. Loud, C. Lundin, Alex. Macfarlane, Miss A. C. Maury, C. H. McLeod, D. C. Miller, Edward W. Morley, G. W. Myers, S. Newcomb, Henry M. Parkhurst, H. M. Paul, B. O. Peirce, Edward C. Pickering, Mrs. Edward C. Pickering, William H. Pickering, Charles Lane Poor, Miss Mary Proctor, Alden W. Quimby, F. G. Radelfinger, Wm. Maxwell Reed, Charles H. Rockwell, Jonathan T. Rorer, A. Lawrence Rotch, W. C. Sabine, F. E. Seagrave, Arthur Searle, Aaron N. Skinner, Frederick Slocum, M. B. Snyder, Charles E. St. John, John Stein, Miss M. C. Stevens, A. E. Sweetland, Winslow Upton, J. M. Van Vleck, Frank W. Very, Robert DeC. Ward, Charles F. Warner, W. R. Warner, A. G. Webster, Oliver C. Wendell, Miss Sarah F. Whiting, Frank P. Whitman, Miss Mary W. Whitney, Miss A. Winlock, Miss L. Winlock, Miss E. G. Wolffe, Miss I. E. Woods, R. S. Woodward, Paul S. Yendell.

At the close of the Conference Professor Comstock presented a motion recording the thanks of the Conference to Professor and Mrs. Pickering and the members of the Observatory staff for the generous hospitality of the Harvard College Observatory; to the President and Fellows of Harvard College for courtesies and hospitality extended; and to Professor Charles R. Cross for hospitality accorded by the Massachusetts Institute of Technology. With the unanimous adoption of this motion the Conference adjourned.

The undersigned begs to acknowledge his indebtedness to the members of the Conference for generous aid given in the preparation of the foregoing report.

M. B. Snyder.

GEOLOGY AND GEOGRAPHY AT THE AMERICAN ASSOCIATION MEETING.

I.

By the invitation of Section E (Geology and Geography) of the American Association, meetings of the Geological Society of America and of the National Geographic Society were held with this Section, the former in three sessions on Tuesday forenoon, afternoon and evening, August 23d, and the latter on Thursday afternoon, the 25th. These sessions, and those of Section E, were held in the lecture room of the Boston Society of Natural History, excepting the final session, on Friday forenoon, which was held in the geological lecture room of the Museum of Comparative Zoology, in Cambridge.

The address by the Vice-President of Section E, Professor Herman L. Fairchild, of Rochester, N. Y., on 'Glacial Geology in America,' was presented on Monday afternoon. It reviewed the history of the development of this branch of geology in the United States and Canada, concluding with the assertion that the origin of the North American drift through the action of a continental ice-sheet is now, after fifty years of exploration and discussion, as fully proved as any of the principles of geology. It is published in the September *American Geologist* and in the *Scientific American Supplement* for September 3d, 10th and 17th.

In the opening session of Section E, with the Geological Society, on Tuesday forenoon, short memorial addresses on the life and work of the late Professor James Hall were given by Professors Emerson, Fairchild and Niles, and by Dr. Horace C. Hovey, noting Hall's earnestness in boyhood and youth to acquire knowledge of geology and allied sciences, walking twenty