the American Association representing certain sciences and a certain region. The original objects of the Society—the organization of scientific work, the teaching of science, the conduct of museums and the like—still need an organization. Our discussion, our public lecture and our dinner with a presidential address should not lightly be abandoned. Within the Royal Society and the British Association there have been clubs, primarily social, but exerting great influence on the policy of the larger organizations. The National Academy performs valuable functions as a select association composed of some of our more eminent scientific men, and the Society of Naturalists, composed of some of our more efficient and public-spirited students of the natural sciences in the eastern states can accomplish much, in the future as in the past, for the advancement of science. J. McKEEN CATTELL.

COLUMBIA UNIVERSITY.

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA.

I.

THE first winter meeting of this Society was held at the Cosmos Club, Washington, D. C., Monday, Tuesday and Wednesday of Convocation Week. Sessions for the reading of papers were held both morning and afternoon, on Monday and Tuesday, and on Wednesday morning. The maximum attendance of about fifty was reached on Tuesday.

Twenty-eight new members were elected, and it was decided to hold the next meeting of the Society at Washington during Convocation Week, 1902–3.

A number of the members lunched together both on Monday and Tuesday at Barton's, and on Monday evening attended a dinner at the same place. The president of the Society presided, and among the most delightful features were the after-dinner speeches of Professor W. W. Campbell, Professor George E. Hale and Professor S. I. Bailey. If a similar function is held at the next meeting it is hoped that the ladies of the Society will more generally follow the example of the two present at this time.

On Tuesday evening President and Mrs. Newcomb received the members of the Society and numerous invited guests at a conversazione held at the Arlington Hotel. During the evening papers illustrated by stereopticon were read by Mr. Percival Lowell on Mars, by Professor S. P. Langley on personal equation and the infra-red spectrum, by Professor George E. Hale on a comparison of the results obtained by photography from the forty-inch refractor and the two-foot reflector of the Yerkes Observatory, and by Professor W. W. Campbell on the work of the Lick Observatory eclipse party in Sumatra and the nebula surrounding Nova Persei.

After the reading of these papers the guests were invited into an adjoining room to partake of still another astronomical treat and refreshments. Here the room was fitted up with numerous transparencies and photographs from the Harvard College Observatory, from the Yerkes Observatory, from the Lick Observatory and from the United States Naval Observatory.

On Tuesday a number of the members visited the Astrophysical Observatory of the Smithsonian Institution upon a special invitation to the Society from Secretary Langley.

At the adjournment of the Wednesday morning session the members formed in line, marched to the White House and paid their respects to President Roosevelt, special arrangements having been made for their reception.

OFFICERS ELECTED.

For 1902: *President,* Simon Newcomb; *1st Vice-President,* George E. Hale; *2d Vice-Presi-*

dent, W. W. Campbell; *Treasurer,* C. L. Doolittle.

For 1902–3: *Councilor,* E. C. Pickering; *Councilor,* R. S. Woodward.

Holdovers: *Secretary,* George C. Comstock; *Councilor,* S. J. Brown; *Councilor,* Ormond Stone.

RESOLUTIONS ADOPTED.

Resolved, That the members of the Astronomical and Astrophysical Society in attendance at this meeting hereby tender their cordial thanks to the Board of Management of and to the members of the Cosmos Club for the use of the Club, Assembly and Council rooms, for the excellent facilities afforded for the illustration and exposition of the papers presented at this meeting, and for the kindly social courtesies extended to all members of our Society.

Resolved, That the thanks of this Society be tendered to Professor S. P. Langley for the special opportunity afforded by him to visit the Astrophysical Observatory of the Smithsonian Institution.

Resolved, That the thanks of the Astronomical and Astrophysical Society be tendered to the Philosophical Society and to its treasurer, Mr. Bernard R. Green, for the use of apparatus and courtesies shown during the present meeting of the Astronomical and Astrophysical Society.

Resolved, That the Secretary of the Society be requested to transmit the substance of these resolutions to the Board of Management of the Cosmos Club, to Professor S. P. Langley and to the officers of the Philosophical Society respectively.

Resolved, That the members of the Society in attendance hereby express their cordial appreciation of the active services of the President in perfecting all arrangements for this meeting and in providing so amply for social as well as for astronomical and astrophysical entertainment.

PAPERS PRESENTED.

1. 'The Flash Spectrum, May 18, 1901': S. A. MITCHELL. [Read by J. K. Rees.]

2. 'Lick Observatory-Crocker Expedition to Sumatra to observe the Total Solar Eclipse of May, 1901': C. D. PERRINE. [Read by W. W. Campbell.]

3. 'U. S. Naval Observatory Eclipse Expedition to Sumatra': A. N. SKINNER.

4. 'Astronomical Photography with the Forty-inch Refractor and the Two-foot Reflector of the Yerkes Observatory': G. W. RITCHEY. [Read by G. E. Hale.]

5. 'On the Phenomenon called Signals from Mars': PERCIVAL LOWELL.

6. 'Preliminary Statement of Results of International Magnetic Observations during the Total Solar Eclipse, May, 1901': L. A. BAUER.

7. 'Meridian Circle Positions of Nova Persei': R. H. TUCKER. [Read by W. W. Campbell.]

8. 'Note on the Parallax of Nova Persei': F. L. CHASE.

9. 'Note on the Parallax of Nova Persei': R. G. AITKIN. [Read by W. W. Campbell.]

10. 'The Energy of Condensation of Stellar Bodies': R. S. WOODWARD.

11. 'Optical Distortion of Photographic Telescopes': HAROLD JACOBY.

12. 'The Constant of Aberration': C. L. DOOLITTLE.

13. 'The Period of Delta Equulei': W. J. HUSSEY. [Read by W. W. Campbell.]

14. 'Duration of Twilight at Different Altitudes within the Tropics': S. I. BAILEY.

15. 'The Determination of Double Star Orbits': GEORGE C. COMSTOCK.

16. 'A Cosmic Cycle': F. W. VERY.

17. 'A Comparison of Printing and Recording Chronographs': C. S. HOWE.

18. 'The Clock Room at Case Observatory': C. S. HOWE.

19. 'The Almucanter as an Instrument for the Determination of Time': C. S. HOWE.

20. 'A Description of the Second (Chile) Mills Spectrograph': W. W. CAMPBELL.

21. 'The Capture of Comets by Jupiter': PERCIVAL LOWELL.

22. 'The Latitude-Variation Observatory of the International Geodetic Association': H. S. DAVIS.

23. 'Some Vices and Devices in Astronomical Computations': H. S. DAVIS.

24. 'On the Pressure of Light and Heat Radiation': E. F. NICHOLS.

25. 'The Mass of Titan and its Perturbations of Hyperion': W. S. EICHELBERGER.

26. 'Observations of November Meteors': C. A. POST and J. K. REES.

27. 'A Kinematic Study of Hansen's Ideal Coordinates': K. LAVES. (Read by title only.)

28. 'The Computation of Laplace's Coefficients by means of Gylden's γ Coefficients': K. LAVES. (Read by title only.)

29. 'A Theorem Concerning the Method of Least Squares': HAROLD JACOBY. (Read by title only.)

30. 'The Nebula about Nova Persei': F. W. VERY.

31. 'A Short and General Method of Determining Orbits from Three Observations': A. O. LEUSCHNER. [Read by O. Stone.]

32. 'Elements of Asteroid 1900 G A and Ephemeris for the Opposition of 1901-1902': A. O. LEUSCHNER and ADELAIDE M. HOBE. [Read by O. Stone.]

33. 'Discovery of Rapid Motion in the Faint Nebula Surrounding Nova Persei': C. D. PERRINE. [Read by W. W. Campbell.]

34. 'A Determination of the Wave Lengths of the More Prominent Nebular Lines': W. H. WRIGHT. [Read by W. W. Campbell.]

35. 'The Bruce Spectrograph of the Yerkes Observatory': E. B. FROST. [Read by G. E. Hale.]

36. 'A Remarkable Solar Disturbance': GEORGE E. HALE.

37. 'A Determination of the Cause of the Discrepancy between Measures of Spectrograms made with Violet to Left and Violet to Right': H. M. REESE. [Read by W. W. Campbell.]

38. 'Four New Spectroscopic Binaries with Notes on the General Subject': W. W. CAMPBELL.

39. 'Discovery of 500 Close Double Stars': W. J. HUSSEY. [Read by W. W. Campbell.]

40. 'Discovery of 300 New Double Stars': R. G. AITKIN. [Read by W. W. Campbell.]

ABSTRACTS OF PAPERS.

The Flash Spectrum, Sumatra Eclipse, May 18, 1901: S. A. MITCHELL.

The writer, through the courtesy of the director of the Naval Observatory, became a member of the expedition to view the Sumatra eclipse on May 18, 1901, and was stationed at Sawah Loento. Two instruments were employed, a camera of 104 inches focus to be used in connection with a cœlostat; and a spectroscope consisting of a Rowland flat grating of 15,000 lines having a ruled space of 3½ x 5 inches, and a quartz lens of 3 23/64 inches aperture and 72 inches focal length. Light from the sun reflected by the cœlostat mirror in a horizontal direction, fell on the grating where it was diffracted, and was brought to a focus on the photographic plate by means of the quartz lens. If grating and photographic plate are each perpendicular to the diffracted beam, the spectrum is 'normal.' It was arranged to photograph the first order spectrum from λ 3,000 to λ 6,000.

The weather on the day of the eclipse was extremely disappointing. First contact was observed in a perfectly clear sky, but clouds soon began to gather and were so dense at second contact that the first flash was not observed at all. Toward the middle of totality conditions became a trifle better, so that it was possible to see, through clouds, the corona extending for about half a diameter from the sun. During no time of the 5 min. 41 sec. of totality was an unclouded view of the corona obtained, but nevertheless, the second flash was seen beautifully. Altogether eight exposures were made, one before and one just after totality for the cusp spectrum, one at first and one at second flash, and four with different lengths of exposure during the total phase. The second flash seemed fully exposed, and it is to a discussion of this photograph that this paper is devoted.

The peculiarities of this photograph are:

1. Normal spectrum.
2. Great dispersion.

On the plate the distance from F to H is 95.4 mm., and as the spectrum is normal, 1 mm., therefore, corresponds to a difference of wave-length of 9.37 tenth-meters, or 1 tenth-meter corresponds to a dispersion of about 0.1 mm. For some reason, the spectra were not in perfect focus, but in spite of this fact, in view of the great dispersion of the spectrum, measures were made and wave-lengths determined with a high degree of accuracy. The spectrum extends from λ 4,924 to λ 3,320, but the focus becomes poor beyond K, and measures were discontinued at λ 3,835. For the purposes of the present comparison, the region from F to H only was regarded. In this part of the spectrum 363 lines were measured in the flash. An arbitrary scale of intensities was assumed whereby 0 represents the faintest line seen with certainty, 10 the strongest line. Wave-lengths were compared with Rowland's measures of the solar spectrum. Of the 363 flash lines, 269 were identified with lines on Rowland's map. Although we cannot directly compare the intensities of the bright lines of the flash (scale 0–10), with those of the dark lines given in Rowland's tables (scale 1–1,000), we can arrive at certain theoretical considerations if we compare the average intensities for the different elements, *i. e.*, $\frac{\text{Flash intensities}}{\text{Solar intensities}}$, and also the ratios of the number of lines of each element identified to the whole number of solar lines for that metal. Forming these ratios and arranging them, we are at once struck with the systematic variations, not only in the ratio of intensities, but also in the per cent. of lines identified. The meaning of these systematic differences will be understood if we consider these ratios in combination with the atomic weights of the various elements, as in the following table, where also is put down the number of the lines in the flash due to each metal.

These lines naturally fall into three groups, as given in the table below.

To these may also be added the following lines:

La, atomic weight, 138.5 ....3 lines
Ba, " " 137 ....1 line
Ln, " " 65 ....1 line

In Group I. would also fall Al if we consider the relative intensities of the two lines λ 3,944.160 and λ 3,961.674; and undoubtedly Na if our plate took in the D lines. The remarkable variation of the relative intensities in the flash and Fraunhofer spectra, as Evershed has pointed out, is undoubtedly due to the *heights* to which the vapors of the different metals ascend in the chromosphere. A gas with an intrinsic brightness 1 and a layer 100 miles in thickness, would give a photographic line in the flash spectrum just as bright as a gas of intrinsic brightness 100 and only 1 mile

Group I.—Lines Strong in Flash and in Solar Spectrum.

Element.	Atomic Weight.	Number of Lines.	Intensity Flash. / Intensity Solar Lines.	Lines Identified. / Total Number of Lines.
Na	23.0			
Mg	24.3	1	0.10	1.00
Al	27.1			
Ca	40.0	8	0.34	0.38

Group II.—Lines Strong in Flash, Weak in Solar Spectrum.

Element.	Atomic Weight.	Number of Lines.	Intensity Flash. / Intensity Solar Lines.	Lines Identified. / Total Number of Lines.
Sc	44.1	6	0.86	0.75
Ti	48.1	62	0.67	0.70
V	51.2	15	0.49	0.68
Cr	52.1	38	0.56	0.64
Mn	55.1	27	0.25	0.48
Sr	87.6	2	1.08	0.67
Y	88.7	2	0.50	0.67
Zr	90.6	8	0.27	0.62

Group III.—Lines Weak in Flash, Strong in Solar Spectrum.

Element.	Atomic Weight.	Number of Lines.	Intensity Flash. / Intensity Solar Lines.	Lines Identified. / Total Number of Lines.
Fe	56.0	125	0.23	0.32
Ni	58.7	9	0.32	0.28
Co	59.0	6	0.19	0.29

thick, if the sun and moon were relatively at rest during the period of the 'flash'; but considering the gradual advance of the moon in covering successive layers of the sun's atmosphere, we see that in the emission spectrum the flash line of the fainter gas would be many times more intense than that of the brighter. The absorption lines of the two gases would be very nearly the same. The extent of the metallic vapors of the sun's surface probably varies inversely proportional to their atomic weights.

In consideration of these facts, it seems altogether likely that the gases of the metals of Group II. extend very high, and are nowhere very much condensed. The flash lines are to be regarded as true reversals of the corresponding solar lines. The metals of Groups I. and III. are somewhat denser near the sun's surface and do not extend so high as those of Group II., but as it is the upper portions that contribute most to the formation of the emission lines, the flash lines are to be regarded as only partial reversals of the Fraunhofer lines, the solar intensities being greater than the flash intensities. Most of the strongest lines in the solar spectrum have been found in the flash; and this, taken in connection with the meaning of the differences of intensities, leads us to further renew our faith in the existence of the 'reversing layer.'

The Total Solar Eclipse of May 18, 1901: C. D. PERRINE.

The expenses of an expedition to Padang, Sumatra, from the Lick Observatory, to secure observations of this eclipse, were defrayed by Mr. William H. Crocker, of San Francisco. Eclipse day dawned with light clouds covering the sky. But little change occurred during the morning. At the time of first contact, the sun shone through a rift in the clouds. At the beginning of totality all parts of the sky near the sun were covered with light cirrus clouds and haze. The inner corona only and Mercury and Venus could be seen during the early part of totality. The clouds became very much heavier towards the end of totality. The time of beginning and ending of totality was 3 or 4 seconds later than the time of these phases computed from data given in the *American Ephemeris,* but the uncertainty of longitudes in Sumatra may account for nearly if not all of this. Twelve photographs of varying exposures were secured with a camera of 40 feet focal length. These show the inner corona and prominences as well, probably, as if the sky had been free from clouds. The longest exposure, one of 150 seconds, shows the streamers to a distance of one and one-third diameters from the limb—more than could be seen with the unaided eye. A number of small prominences are visible on the east limb of the sun. One of these at position-angle 115° is covered with a series of coronal hoods or envelopes. Attention is called to a remarkable disturbance in the corona in the northeast quadrant. At a position-angle of about 65° there is a small compact prominence, over which there is a disturbed area resembling roughly an inverted cone. From the apparent apex of this area a number of irregular streamers and masses of matter radiate as if thrown out by an explosion. I am not aware that a disturbance of this kind has been observed before in the corona proper. Eight photographs were secured with the Floyd telescope of 70 inches focal length. These negatives show the same extensions of corona as those taken with the 40-foot camera. Twelve negatives were secured of six regions on either side of the sun in the direction of his equator for the purpose of detecting any planets existing there. These negatives were obtained with lenses of 3 inches aperture and 11 feet 4 inches focal length.* A preliminary examination of these negatives was made at the station and 92 stars of magnitude 8.6 to 8.8 were found in three of the regions. The plates taken during the latter part of totality show no star images, owing to the increased cloudiness. A negative with long exposure was secured with each of two spectrographs, one having the slit tangential, the other radial. The principal Fraunhofer lines are shown in the outer corona in both, none, however, being observable in the extreme inner corona. Ten negatives were secured with a camera of 21 inches focal length, having a double-image prism placed in front of the objective. The two images given by such a prism and camera furnish a means of detecting by differential methods any considerable polarization in the corona. The axis of the prism was set at several different position angles between the sun's equator and his poles. In this way all parts of the corona were tested. The negatives secured show a large percentage of polarization in the outer corona and a slight amount in the inner corona. The two spectrographs and the polarigraph were designed and prepared for use by Director Campbell and Assistant Astronomer W. H. Wright. The great southern comet was a conspicuous object in the evening sky for several days and was visible without aid for more than a week. Photographs of it with a portrait lens were secured on May 6. The exposures were necessarily short, but show 3° or 4° tail. A faint streamer is also shown to the south, making an angle of about 35° with the principal tail. A number of large copies, on glass, of the eclipse photographs, as well as lantern slides, were shown at the meeting.

* Two of the four lenses used in Sumatra were kindly loaned for the purpose by Professor E. C. Pickering, Director of the Harvard College Observatory.

A Martian Cloud: Percival Lowell.

This paper gave an account of two projections seen upon the terminator of Mars by Mr. A. E. Douglass at the Lowell Observatory on December 7 and 8, 1900; the observations which gave rise to the popular impression last year of signals from Mars. Calculation showed them to belong to different parts of the planet and to have moved during the time they were under observation. Furthermore, the motion in each case was approximately the same—nearly due west in each case. Neither of them reappeared on any succeeding night. They thus showed themselves to be not illuminated mountain tops, but sunset clouds floating in the planet's atmosphere.

Preliminary Statement of Results of International Magnetic Observations made during the Total Solar Eclipse of May 17–18, 1901: L. A. Bauer.

To further test the results obtained by the United States Coast and Geodetic Survey magnetic parties during the total solar eclipse of May 28, 1900, regarding a slight magnetic effect that may be attributable directly to some change produced in the electrification of the upper atmospheric strata by the abstraction of the sun's rays, due to the interposition of the moon between the sun and the earth, an appeal was made for international cooperation in magnetic and allied observations during the recent total solar eclipse. The repetition of the observations was doubly interesting owing to the fact that the present eclipse occurred in the opposite magnetic hemisphere to that of last year, and hence the opportunity was afforded for ascertaining whether the magnetic effect was reversed in its general character to that of last year, as is, for example, the case with the diurnal variation in passing from one magnetic hemisphere to the other. The conditions, however, for obtaining observations at a number of stations distributed along the belt of totality, as was done last year, and thus testing whether the magnetic effect again followed directly in the wake of the shadow cone, were not favorable owing to the present location of the belt of totality. In response to the appeal, simultaneous magnetic observations were made on May 17 from 14 to 21 o'clock, Greenwich mean astronomical time—an interval amply covering the time of the eclipse—at a number of stations encircling the entire globe, three of which were in the belt of totality. The prime purpose of making the observations so as to cover the entire globe was to furnish the possibility of separating a possible eclipse magnetic effect from a contemporaneous magnetic storm of the usual type. The eclipse effect, for instance, doubtless would be confined to a very small belt, whereas a customary magnetic storm, in conformity with the usual experience, would manifest itself at practically the same moment of time over a very large area, and thus be felt at stations far from the totality belt. At none of the outside stations has a disturbance of any appreciable size been thus far reported to me, the general consensus of opinion of observers at these stations being that 'nothing unusual occurred.' At the three stations within the belt of totality the majority of the opinions is that something unusual did occur during the time of the eclipse. Thus at Karang Sago, where was situated the Dutch eclipse party, Dr. W. van Bermelen, assistant director of the Batavia Magnetic Observatory, observed the change in the magnetic declination and horizontal intensity, and he reports the occurrence of 'an extremely interesting magnetic effect.' He has courteously sent me an extract of his observations made during several days before and on the day of the eclipse, and there certainly appears evidence of a magnetic effect in both elements different from that observed on the days prior to the eclipse. At Sawah Loento, the site of the Massachusetts Institute of Technology party, of Boston, the variations in magnetic declination were observed by Mr. G. L. Hosmer on May 17 and 18. Comparing the two days' results for the interval of the eclipse, there is indisputable proof that something different occurred on the day of the eclipse than on the day before. Namely, at this station, situated so close to the magnetic equator the range of the diurnal variation of the magnetic declination is about one minute of arc. The magnetic effect during the time of the eclipse was of about the same amount, so that a steady *decrease* of east declination resulted during the time of day when normally there is a steady *increase.* There was but one magnetic observatory directly within the belt, viz., the one at Mauritius and this was situated not far from the place of beginning of the eclipse. No special magnetic observations were made at this place; however, the regular photographic curves giving the variations in the magnetic elements were obtained. The declination and the vertical intensity curves apparently do not show any disturbance that could easily be picked out and referred to the eclipse. Regarding the horizontal intensity curve—the more sensitive one—Mr. Claxton states 'that the original curve shows slight tremors between 7.15 and 7.50 and occasionally between 8.5 and 9.0 A. M.' I have plotted this intensity curve on a large scale and find that the curve shows no very marked disturbance that might be readily referred to the eclipse, with the exception of one producing an easily perceptible bulge in the curve amounting to about 3–4 units in the fifth decimal c.g.s. units and lasting about 30 minutes. Anyway the effect, if there be one, is very minute, and will not be so readily separated from the usual diurnal variation as in the case of the two previous stations. Whether this is due to the fact that owing to the vicinity of Mauritius to the beginning of the eclipse, the minute eclipse magnetic storm did not have time to develop itself or was just in the embryonic state, cannot be said. The magnetic effect observed at Karang Sago and at Sawah Loento does not appear to have extended very far outside of the belt of totality, it being scarcely appreciable at the Batavia Magnetic Observatory. My grateful and appreciative acknowledgments are due to all who have participated in this interesting investigation—one to my mind of fundamental importance to the theory of the diurnal variation of the earth's magnetism as elaborated by Schuster and von Bezold.

Meridian Circle Positions of Nova Persei: R. H. TUCKER.

Meridian circle positions were obtained on eight evenings in February and March, and on four evenings in November. The difference in the right ascensions resulting from the two series of observations is 0.05 seconds. The star was more than four magnitudes brighter at the time of the first series than at the second. Making allowance for the magnetic equation, the difference between the right ascensions for the two series reduces to 0.01 seconds. The declinations in the two series differ by 0.05″. It is therefore evident that these observations indicate a very small parallax and proper motion. The large proper motion recently reported by a European astronomer is not confirmed.

On the Parallax of Nova Persei: F. L. CHASE.

This paper was based upon observations made with the Yale heliometer, the first set in February and March, the second in July and August and a third in December. The result derived for the parallax confirmed the value found from the first two sets alone, in which the proper motion could not be taken into account, which value was published in a paper presented at the Denver meeting of the A. A. A. S. last August. This value was practically zero relative to the mean parallax of the two comparison stars employed, stars of about the eighth magnitude. In conclusion the author remarked that, considering its probable error, the value found was not incompatible with that required by the hypothesis advanced by Wolf and others, viz., that the apparent displacements in the nebula surrounding the Nova represent a velocity corresponding with that of an electric wave.

Note on the Parallax of Nova Persei: R. G. AITKEN.

An attempt was made to determine the parallax of Nova Persei from the micrometric measures of six faint stars near it. The first set of measures was obtained, under very unfavorable conditions, shortly after the appearance of the Nova, and a second set on two nights in the latter part of July. The resulting values of the relative parallax were all negative, so that no conclusion can be drawn, unless, possibly, that the parallax of Nova Persei is very small. No account was or could be taken of possible proper motion.

The Energy of Condensation of Stellar Bodies: By R. S. WOODWARD.

This paper considers the density, pressure and energy of condensation from a state of infinite diffusion, of a spherical stellar body in which Laplace's law of density holds. Denoting the potential, density, and pressure at a distance r from the center of such a mass by V, ρ and p, respectively, the problem is stated in three equations, namely:

$$\frac{\delta^2(rV)}{\delta r^2} + 4\pi k r \rho = 0,$$

$$dp = c\rho d\rho = \rho dV,$$

wherein k is the gravitation constant and

c is the constant connecting density and pressure in Laplace's celebrated hypothesis. Assuming the density to vanish at a distance r_0 from the center of such a body, it turns out that V, ρ and p are given by the following formulas, in which ρ_c and p_c are the central density and pressure, respectively, and M is the mass of the star:

$$a = \pi / r_0, \qquad q = \sin ar / (ar),$$

$$\rho_c = M\pi / (4r_0^3), \qquad p_c = M^2 k\pi / (8r_0^4),$$

$$V = \frac{Mk}{r_0}(1 + q), \quad \rho = \rho_c q, \quad p = p_c q^2.$$

The energy of condensation of such a mass is found to be

$$\tfrac{3}{4}\frac{m^2 k}{r_0} = \tfrac{3}{4} F r_0,$$

where F is the force of attraction between M and an equal mass of infinitesimal volume situated at a distance r_0 from the center of M. It will be observed that the results here given require no hypothesis as to the temperature of such bodies.

Optical Distortion of Photographic Telescopes: HAROLD JACOBY.

The observations discussed in the present paper form part of a more extended series undertaken in the year 1895, having for its principal object a study of the optical distortion of astronomical photographic objectives. A question had been raised as to the fidelity with which photographic telescopes reproduce upon the negative exact relative positions of the stars as they appear on the sky. This matter is fundamental to the art of astronomical photography throughout the entire range of its more important applications to stellar parallax, interstellar motion within the close clusters, and star charting in general; so that the large amount of labor involved even in its partial elucidation does not appear to be superfluous. Valuable cooperation in the work has been granted with ready kindness by several astronomers; and with their aid the special problem under investigation has been solved in a fairly satisfactory manner.

This special problem may be thus stated: Is the scale-value of an astronomical photograph absolutely independent of the direction of measurement on the negative? In other words, if we determine the coordinates of star-images on the plate in millimeters with reference to a pair of rectangular axes, the question is: Will a distance of one millimeter measured from the center of the plate along the X-axis correspond to precisely the same number of seconds of arc on the sky as a distance of one millimeter measured from the same center along the Y-axis? The matter may be put in still another way. Suppose there were upon the sky a number of stars so situated as to form a small but perfectly exact circle. Would a photograph show these stars situated upon a similar exact circle on the negative, or would defects of the object glass distort their position into an ellipse-like oval, after the manner of atmospheric refraction? If this is the case, equal diameters of the circle on the sky will become unequal diameters of the oval on the plate; and, in general, equal distances upon the sky expressed in seconds of arc will become unequal distances upon the plate expressed in millimeters, even after correction for all known sources of difference, such as refraction, aberration, etc.

Various investigations of optical distortion have been published by Donner, Turner and others; but they were all made by methods necessitating a knowledge of relative star positions based on measures other than photographic. To avoid this inherent difficulty, the writer suggested in 1893 a process in which it is not essential to have a precise previous knowledge of relative star positions. It is thus rendered entirely unnecessary either to make a laborious and time-consuming heliometer triangulation, or resort to comparatively inaccurate star-places, such as those obtained with meridian instruments. Proper motion, also, which necessitates new heliometric triangulations made very near the date of the photographic observations, is altogether eliminated in the use of this method.

It is merely necessary to arrange the telescope so that it can be rotated around its optical axis, or some other axis parallel to its optical axis. Suppose two photographs of a group of stars have been made with such a telescope, rotated 90° between the two exposures. If, then, the object glass possesses the peculiarity of making all the Y-coordinates too large in the first exposure, the same peculiarity will show itself in the second exposure by making all the X-coordinates correspondingly too large. Thus it is sufficient to make a series of negatives of the same star-group, rotating the instrument through various angles between the exposures, when a simple comparison will surely bring to light any form of optical distortion depending on the direction of measurement upon the plate.

The process is a purely differential one, and requires only a roughly approximate knowledge of the absolute star-positions, sufficient for the computation of refraction corrections, etc. It can be applied to an equatorial telescope of the ordinary form if we photograph the region immediately surrounding the pole of the heavens. In that case, the polar axis of the equatorial becomes a suitable axis for rotating the telescope, since the polar axis is parallel to the optical axis, when the tube is pointed at the pole. It is obvious that a trial of this method will furnish not only a determination of optical distortion, but will yield also, as a sort of by-product, a photographic catalogue of the close polar stars. For this reason it seemed desirable to include in the work a set of plates of the south pole as well as the north. In this way we should obtain very precise catalogues of both sets of close polar stars, all reduced and computed according to a uniform method.

In 1895 the writer was visting at the Cape of Good Hope Observatory, and discussed the matter with Sir David Gill. The plan met with his approval, and he consented gladly to make the necessary south polar plates. With equal readiness, Dr. Anders Donner, of the Helsingfors Observatory, offered to make the north polar plates. These latter negatives were measured at Columbia University by Mrs. Herman S. Davis and Mrs. Annie Maclear Jacoby; the measures were reduced at Vassar College by Miss C. E. Furness; and they were published by the Vassar College Observatory. The south polar plates were similarly measured and reduced at Columbia by Misses F. E. Harpham, Mary Tarbox, Eudora Magill and H. L. Davis, and the results will soon be published by the Observatory of Columbia University. The researches for both poles agree in showing that the optical distortion depending on direction of measurement is too small to be detected with certainty even by the delicate differential method here described.

W. S. Eichelberger,
For the Council.

(To be concluded.)

THE U. S. COAST AND GEODETIC SURVEY.

The last annual report* of the Superintendent of the United States Coast and Geodetic Survey to Congress is fully illustrated with maps and diagrams and presents in detail the work accomplished by this bureau for the fiscal year ending June 30, 1901.

Throughout the report there is frequent evidence of the increased scope of the Survey's operations within the last few years, as well as proof of the flexibility of the

* Now in the hands of the printer.