which these sprang was evolved in Antarctica and spread northward during the Mesozoic after both the African and Austromalaysian connections had been broken. South America was the last of the great land masses to be cut off from Antarctica, hence only in America do we find such nearly related but distinct types as *Ingenhousia* and *Cienfuegosia*. The Australian cottons have been isolated since the southward dispersal of the type which preceded *Gossypium* and which originated in the north. Hence they are found to be farther removed from the Asiatic and American true cottons than are the latter from each other, being properly separated under *Sturtia*. They represent more nearly the immediate type from which *Gossypium* s. str. sprang.

Anthonomus is a type of North American origin, where it was dominant during the Tertiary—Oligocene and Miocene. From some of its first waves of southward dispersal sprang the group to which belongs *Anthonomus vestitus*, which latter has developed on cotton alone in South America. From a later wave of southward dispersal sprang the *A. grandis* group, this species likewise developing on cotton alone, but originating in Central America and Mexico. Almost certainly one of the periodic separations between North and South America took place while the *A. grandis* group dispersal was in progress, thus cutting this species off from South America. During subsequent connections of the two continents no extensive dispersals of these groups occurred. This explains the fact that *A. vestitus* belongs to a group not represented in North America, and indicates the great probability that *A. grandis* does not occur in South America. It also explains the now quite evident fact that both of these weevils have no other food-plant than cotton, having originally developed on that plant.

From these points we may deduce that *A. vestitus* has probably attacked cotton in humid northwestern South America for upward of a million years, if not longer. It is therefore extremely probable that this species is not confined to Peru and Ecuador.

Charles H. T. Townsend

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

The fifteenth meeting of this society was held in Cleveland in connection with the American Association for the Advancement of Science, from December 31, 1912, to January 2, 1913. With the exception of the joint session with the American Mathematical Society and Sections A and B of the American Association for the Advancement of Science on Tuesday afternoon, December 31, the meetings were held in the recitation room of the department of astronomy of the Case School of Applied Science. The secretary of Section A has already reported on the joint meeting (see page 76 of this volume).

The time was so thoroughly filled with the program of papers that little opportunity was afforded for attendance of the meetings of the various sections of the association and the other affiliated societies, or for excursions about the city. Most of the members, however, visited the observatory of the Case School, where are housed an excellent almucantar, a zenith telescope and a transit instrument, and accepted the privilege of visiting the Warner & Swazey shops.

The following members were in attendance: Sebastian Albrecht, S. I. Bailey, L. A. Bauer, J. A. Brashear, E. W. Brown, C. A. Chant, W. A. Cogshall, W. S. Eichelberger, Philip Fox, William Gaertner, James Hartness, G. F. Hull, W. J. Humphreys, F. C. Jordan, N. A. Kent, Kurt Laves, T. A. Lawes, W. I. Milham, D. C. Miller, E. W. Morley, E. F. Nichols, J. A. Parkhurst, E. C. Pickering, J. S. Plaskett, W. F. Rigge, H. N. Russell, Frank Schlesinger, H. T. Stetson, R. M. Stewart, J. N. Stockwell, G. D. Swazey, W. R. Warner, F. P. Whitman, D. T. Wilson, H. C. Wilson, Anne S. Young, E. I. Yowell.

Visitors: G. L. Coyle, S. F. Cusick, Patrick Rafferty, J. I. Shannon.

The following were elected members of the society: W. O. Beal, J. R. Collins, Ralph E. DeLury, R. T. A. Innes, William H. Morton, Earl C. Slipher.

Abstracts of the 36 papers which were read follow in the order of presentation.

The Correction of Actinometer Measurements for Aqueous Depletion: Frank W. Very.

Tables have been prepared for the approximate correction of actinometric observations with air masses and pressures of aqueous vapor as arguments. The first table of multiplying factors is for sea level, and the second is for the conditions and altitude (1,780 meters) of Mount Wilson.

TABLE I

Air Mass	Pressure of Aqueous Vapor				
	$1\frac{1}{2}$ mm.	3 mm.	6 mm.	9 mm.	15 mm.
$\epsilon=\frac{1}{2}$	$F=1.35$	1.40	1.52	1.63	1.86
1	1.65	1.76	2.02	2.28	2.80
2	2.18	2.35	2.66	2.97	3.60
3	2.60	2.80	3.18	3 53	4.22
4	2.99	3.21	3.58	3.96	4.71
5	3.39	3.66	4.05	4.42	5.15
6	3.69	4.09	4.54	4.88	5.56
7	4.03	4.50	4.97	5.29	5.93
8	4.40	4.91	5.43	5.75	6.25
9	4.74	5.35	5.95	6.22	6.60
10	5.10	5.83	6.43	6.73	6.95

TABLE II

Air Mass	Pressure of Aqueous Vapor				
	$1\frac{1}{2}$ mm.	3 mm.	6 mm.	9 mm.	15 mm.
$\epsilon=\frac{1}{2}$	$F=1.70$	1.76	1.78	1.80	1.86
1	2.06	2.16	2.21	2.25	2.30
2	2.34	2.45	2.52	2.58	2.63
3	2.63	2.75	2.84	2.90	2.95
4	2.91	3.05	3.15	3.20	3.25

These tables have been used to get the value ($A=FR$) of the solar radiation outside the atmosphere from observations published in Vol. 2 of the *Annals* of the Smithsonian Astrophysical Observatory. A random selection will illustrate the nature of the results.

TABLE III

Washington, D. C.			
Date	Aqueous Vapor, mm.	A	A at Sun's Mean Dist.
Aug. 24, 03	14.66	3.204	3.255
Dec. 23, 03	3.30	2.878	2.770
May 28, 04	6.50	2.855	2.920
Oct. 21, 04	7.29	3.697	3.639
Jan. 9, 06	1.96	3.227	3.106
Mean......................................			3.185 ± 0.105
Mount Wilson			
Date	Aqueous Vapor, mm.	A	A at Sun's Mean Dist.
Oct. 20, 06	1.59	3.602	3.547
June 7, 05	7.17	3.542	3.634
Aug. 22, 05	13.84	3.526	3.585
Mean......................................			3.589 ± 0.017

The data are very inadequate. The pressure of aqueous vapor is seldom recorded more than once a day, and in the absence of barometer readings I have been obliged to assume values of 760 mm. and 618 mm. for sea level and mountain, respectively. To do full justice to the method, it will be necessary to secure simultaneous observations of the distribution of aqueous vapor in the upper air by means of sounding balloon ascensions or high kite flights. No correction for atmospheric dust has been applied. The depression and the disagreement of the sea-level results are no doubt due principally to the irregular depletion by this ingredient of the lower air. This serious defect very nearly disappears on the mountain.

Astronomy in the Civil Court: W. F. RIGGE.

A short time ago a man was accused in the criminal court (Omaha, Nebraska) of having attempted to wreck a cottage and kill its inmates by means of a suitcase full of dynamite. The state produced only two witnesses, who said they had seen the accused carrying the suitcase near the time and place specified. They had just come from a church a mile away, in front of which they had posed for their photograph. The position of a prominent shadow in this picture enabled an astronomer to compute the exact minute of its exposure. As this was half an hour after the time at which the suitcase had been found the testimony of science eventually freed the prisoner from fifteen years in the penitentiary. It was confirmed by the measurements and computations of a second astronomer, and by a series of three photographs exposed at intervals of one minute on the second anniversary of the taking of the original picture.

A Northern Durchmusterung: E. C. PICKERING.

The Cape Photographic Durchmusterung gives the positions and photographic magnitudes of nearly half a million stars south of declination $-20°$, thus covering about one third of the sky. This great work by Gill and Kapteyn is indispensable to any astronomer studying the southern stars.

One of the greatest needs of astronomy at the present time is the extension of this work to the North Pole. A plan has accordingly been prepared for taking the necessary photographs at Harvard, with the 16-inch Metcalf telescope, with curved plates, using those sensitive to the red, as well as to the blue rays. The photometric and photographic magnitudes, on a uniform scale, will be determined for a number of standard stars on each plate. They will then be sent to Kapteyn, who will supervise their measurement and reduction. If the entire plan can be carried out, the catalogue will contain eight hundred thousand stars, or more, and will fill at least ten volumes of the Harvard *Annals*.

The Scale of the Yerkes Actinometry: J. A. PARKHURST.

A new determination of the absolute scale for the photographic magnitudes of the Actinometry indicates that the published scale may be too extended by an amount not exceeding six per cent. The original scale was obtained from sensitometer images impressed on the plates with exposures of 10 to 20 seconds. The star images had exposures of 5 and 25 minutes. An extended series of new sensitometer exposures ranging from 5 seconds to 34 minutes indicated that the gradation was steeper for the exposures of 5 minutes and longer, than for the exposures in the neighborhood of 10 seconds. No difference was found for exposures of 5 and 25 minutes, and this was confirmed by 422 pairs of images of white stars on the zone plates. The application of the correction of —6 per cent. brings the magnitudes into better agreement with Harvard and leaves the differences with Göttingen the same in amount but with the sign changed.

The Color Scale of the Yerkes Actinometry: J. A. PARKHURST.

A calibration of the color-sensitive plates used in obtaining the "visual" magnitudes of the Actinometry makes it possible to express the varying effect of light of different wave-lengths in difference of stellar magnitude. The spectral intensity curve is nearly symmetrical and has its maximum at wave-length 5350. The absence of selective absorption in the U-V glass of the Zeiss doublet was shown by comparison of spectra taken direct and through the glass.

On R Lyræ with a Three-prism Slit-spectrograph: SEBASTIAN ALBRECHT.

This paper gave the results of a study of two series of three-prism spectrograms, twenty-five plates in all, taken at the Lick Observatory. Following is a summary of the principal results:

1. The radial velocity of the star is —27.22 km. per sec.

2. No periodic variation of radial velocity was found. If such a variation exists, the double amplitude of variation must be less than 1½ km.

3. Wave-lengths were determined for about 600 spectrum lines, between λ 4150 and λ 4700 ±.

4. The individual spectrum lines showed no large periodic shifts.

5. H_λ showed definite variation in intensity, though the data available are insufficient to determine definite connection with phase of light-variation.

6. The wave-lengths of the lines in R Lyræ, a star of irregular light variations, are in good agreement with the wave-lengths of lines in the *M* type stars.

7. A preliminary test of this star for spectral type, according to the method published in the *Astrophysical Journal,* March, 1911, places it at a somewhat "later" type than *Mb,* the type assigned to it in the Draper Catalogue.

A New Form of Printing Chronograph: WILLIAM GAERTNER.

This paper described in detail an instrument for recording time in minutes, seconds and hundredths of seconds, printing the records in figures on a strip of paper. The instrument is used in connection with a clock or chronometer fitted with an electric seconds contact, which operates the minute and second type wheels and controls the speed of the 0.01 seconds wheel.

The minute and second wheels are rotated by two specially designed electro-magnets which operate on pawls and ratchet wheels of 60 teeth. The seconds wheel closes a circuit when it has made a full revolution and operates the magnet which shifts the minute wheel. Both wheels can be turned independently by hand and set to coincide with the clock. The wheel printing the 0.01 seconds is automatically set to zero by the clock circuit and control magnet.

The control of the hundredths of seconds is not made directly on the type wheel, but by means of a ratchet wheel of 100 teeth, and an iron pawl engaging in it. The ratchet wheel is driven by a separate weight driven clock work, regulated by an improved form of conical pendulum friction governor. This regulator is set to run a little fast. When it has gained 0.01 second the control magnet operated by the observing clock will disengage the pawl and drop it in the next tooth of the ratchet wheel, bringing the type wheel again in adjustment. In practise the governor is adjusted so that the regulator gains about 1½ second per hour and therefore the control will take place about every 24 seconds.

The printing of the time records is accomplished by an electro-magnet which operates the printing hammers. A paper strip sufficiently long to take about 1,200 records passes between an ink ribbon and the printing wheels and is fed through two corrugated rollers which give the spacing between records. The same current operates the printing magnet and the electro-magnet which turns the spacing rollers. A mechanism at the same time gives a shift to the ink ribbon.

Samples of the records from the chronograph were exhibited.

Circulation in the Solar Atmosphere as Indicated by Prominences: FREDERICK SLOCUM.

This paper is based upon the study of 4,600 solar prominences of which over one third either by their form or movement indicate a horizontal circulation in the solar atmosphere. The results have been classified according to direction N. or S., heliocentric latitude, and height above the chromosphere. Illustrations were shown of the types of prominences used.

The conclusions from this investigation are given in the following summary: (1) Many prominences, by their shapes or movements, seem to indicate the existence of a horizontal current in the solar atmosphere. (2) This current may have opposite directions at different altitudes in the same locality. (3) It may change its direction just as the wind changes upon the earth. (4) In middle latitudes the average tendency for movement is toward the poles. (5) In high latitudes the average tendency for movement is toward the equator. (6) This tendency is much more marked in the northern than in the southern hemisphere. (7) From latitude 10° north to 10° south the average tendency is from north to south directly across the equator. (8) The prevailing directions mentioned above are the same for prominences of all heights. (9) Upon a rotating sphere the circulation is undoubtedly spiral. The observations used in the present investigation take account only of the north and south components. The east and west components may eventually be added by an extended series of radial velocity measures of prominences. (10) Observations upon prominences within 5° to 10° of the poles are unreliable, as a prominence approaching the pole spirally may project so as apparently to be moving away from the pole.

Cosmical Magnetic Fields: L. A. BAUER.

This paper was read at the joint meeting. For the abstract see page 76 of this volume.

(Opportunity is taken here to correct an error appearing in the abstract of Professor Bauer's paper, "On the Cause of the Earth's Magnetic Field," SCIENCE, January 3, 1913, page 27. The sentence following the equations should read: These characteristic functions, $f_x(u)$ and $f_z(u)$, show an increase, etc.)

Preliminary Note on an Attempt to Detect the General Magnetic Field of the Sun: G. E. HALE.

Read at the joint session (see page 76 of this volume).

Visualizing the Sun's Way: H. C. WILSON.

Two charts were exhibited showing the proper motions and radial velocities of 1,157 stars. The proper motions were taken from Boss's Preliminary General Catalogue and the radial velocities from unpublished records at the Lick Observatory. Chart No. 1 covers the hemisphere having its center at $\alpha = 270°$, $\delta = +30°$, the approximate apex of the solar motion. Chart No. 2 covers the hemisphere having the solar antapex at its center. Stars having radial velocity of approach to the sun are represented by open circles, while those which are receding are indicated by black circles. The amount of the radial velocity is represented, upon an arbitrary scale, by lines parallel to the lines representing the proper motion. Chart No. 1 indicates quite clearly that the solar apex is somewhere in the vicinity of $\alpha = 270°$, $\delta = +30°$, both by the general trend of the proper motions outward and by the prevalence of open circles near the center of the chart. Chart No. 2 shows equally well that the antapex is near $\alpha = 90°$, $\delta = -30°$, by the prevailing blackness of the star images and the general inward trend of the proper motions.

The Spectra of the Gaseous Nebulæ: ANNIE J. CANNON.

Of the 140 nebulæ which have been announced to be gaseous, 50 were detected and 54 others have been confirmed from the examination of the Harvard photographs. An examination of 41 of the brightest has been made for the purpose of general classification. While at least three subdivisions of Class *P* of the Draper notation are indicated, it does not seem advisable at present to assign special designations to them.

The principal class is represented by N.G.C. 7662. The so-called chief nebular lines, λ 4959 and λ 5007, are the strongest lines, λ 3726 and λ 3729 in the violet are extremely faint or invisible, while λ 3869 and λ 4686 are well marked. 28 out of the 41 nebulæ so far studied appear to belong to this general class, although 17 differ from N.G.C. 7662 in having λ 4686 absent, and

2 are peculiar in an increased intensity of λ 4363. A broad bright band approximately at λ 4363 was the strongest band in the spectrum of Nova Geminorum, No. 2, on November 9, 1912, and may be characteristic of the spectra of new stars when they become gaseous, as it is also very bright in the photographs of Nova Aræ and Nova Velorum.

A second class of the spectra of gaseous nebulæ has a line in the violet, which is probably a blend of λ 3726 and λ 3729, for the strongest line, while λ 3869 and λ 4686 are absent, and the chief nebular lines λ 4959 and λ 5007 are barely visible. No. 418 of the Index Catalogue, DM. —12°.1172, is the only object so far found belonging to this class. Since λ 3727 and λ 5007 are both present in the spectrum of the Great Nebula of Orion, it may be intermediate between the two classes represented by N.G.C. 7662 and I.C. 418. A third division of gaseous nebulæ has λ 4686 for its strongest line. N.G.C. 40 is typical of this class, and one other $\alpha = 19^h\ 0^m.5$, $\delta = -6° 8'$ (1900), similar to it, has been found. This class of nebula is of special interest, owing to a possible connection with the spectra of Class O, in which a bright band at the same approximate wave-length is the distinguishing feature. When an object is faint, it may show only the bright band 4686, and it would then be impossible to determine, from its photographic spectrum, whether it belonged to Class O or to the third division of gaseous nebulæ. N.G.C. 40 was observed by Herschel, and a photographic chart plate shows its nebulous character.

For the purpose of comparison a composite photograph was exhibited showing the spectra of Sirius, of I.C. 418, N.G.C. 7662, Nova Geminorum II., on November 9, 1912, the same on March 13, 1912, H.R. 2583 typical of Class *Ob* and N.G.C. 40.

Stellar Spectroscopic Notes: WALTER S. ADAMS.

The following notes contain some of the recent results obtained in the course of the regular radial velocity work with the 60-inch reflector.

The seven stars following are spectroscopic binaries with large range in velocity. *ξ Arietis, Boss 546,* Mag. 5.6, Spectrum B_5. The range shown by the first three plates was 57 km. On a fourth plate two spectra were visible and measures of the separate components gave a relative velocity of 262 km. The spectra of the two stars are nearly identical. *Boss 2484,* Mag. 6.2, Spectrum A_1. The range shown by three plates 88 km. *2 Comæ Berenicis, Boss 3150,* Mag. 6.2, Spectrum A_5. The range shown by three plates 53 km. *Boss 3540,* Mag. 6.8, Spectrum A_0 peculiar. Range shown by three plates 105 km. *16 Sagitarii, Boss 4613,* Mag. 6.2, Spectrum B_1, peculiar. Range shown by three plates 86 km. Traces of a second spectrum are visible. *σ Aquilæ, Boss 5018,* Mag. 5.2, Spectrum B_1. Two spectra are visible on the first plate, one of the type B_5 and the other B_3. The relative velocity of the two components on this plate is 367 km. *Boss 5070,* Mag. 5.8, Spectrum B_5. Range shown by three plates 138 km.

Two photographs of the spectrum of the star *Lalande 15290,* Mag. 8.2, Spectrum G_5, show that its radial velocity is the largest of any star observed to date in the northern sky. The spectrograms which were taken in April and November, 1912, give values of —243 and —241 km., respectively. A photograph of this star taken in December, 1910, with a temporary spectrograph gave an approximate velocity of —250 km. Its proper motion is 1″.97 annually and its parallax is 0″.045 according to the values summarized by Kapteyn in Groningen Publications No. 24. Its velocity in space accordingly as referred to the sun is 318 km., a value only slightly inferior to that of 1830 Groombridge.

Observations of a number of the brighter stars in the *h* and *χ Persei* clusters lead to the interesting conclusion that most of these stars have nearly the same radial velocity and apparently are moving together. The stars observed are as follows:

	Mag.	Spectrum	Mean Velocity
B.D. + 57°.494	6.5	A_1	—44
+ 56°.438	6.5	B_6	—40
+ 56°.470	7.0	B_2	—43
+ 56°.471	6.6	B_1	—43
Boss 519	6.9	B_8	—46
B.D. + 56°.530	6.9	B_6	—45
+ 56°.568	6.7	A_1	—45
+ 55°.612	6.3	B_3	—46

The velocity of *Boss 519* is probably variable. The spectra of most of these stars belong to division *c* of Miss Maury's classification—that is, have relatively sharp lines. The average velocity is exceptionally high for stars of this type and this fact taken in connection with their proper motions and the similarity of their spectra makes it very probable that they form a true group. The star B.D. + 55°.598, Mag. 5.7, has a velocity of —18 km. as determined from one plate and should additional photographs show this velocity to be constant it would seem probable that the star does not belong to the group. The proper motions of most of these stars have been measured recently by Van Maanen and found to be extremely small and their parallaxes are below the limits of error of measurement according to Kapteyn's results.

A comparison of three photographs of the spectrum of Nova Geminorum II. taken in August, September and November leads to the following conclusions: (1) The principal nebular bands are slightly more intense on the last photograph, while the hydrogen and helium lines remain very nearly constant. (2) A very marked change occurs in the line λ 4687 of the principal series of hydrogen. On the August photograph it is very faint, while in November it is fully half as strong as the intensely bright band λ 4640. This line showed evidence of rapid variation on earlier photographs as well, gaining greatly in intensity between May 5 and May 10. Its behavior should prove of great value as bearing on the physical condition of the star. (3) Two other bands, one at λ 4522 and the other at λ 4605 are considerably stronger on the last photograph. (4) The widths of the bright bands have remained remarkably constant throughout the history of the Nova. Measures on the hydrogen, helium and nebular bands show no appreciable change from the photographs of April and May. The positions of the centers of the bands also remain as on earlier photographs, being displaced from one to two Ångstroms toward longer wave-lengths. (5) All of the more prominent bright bands except those at λ 4522, λ 4605 and λ 4640 have broad faint absorption bands nearly symmetrically placed upon them. In several cases the dark bands contain one or more narrow absorption lines. A remarkable case of this sort is the line at λ 4337.5 which has been measured upon all of the photographs taken since March. The bright bands are terminated on either side by bright maxima, the violet member of which is the strongest on the plates of August and November. (6) In addition to the bright bands the spectrum of the star almost certainly shows an extremely faint continuous spectrum probably crossed by dark lines. The *H* line of calcium is seen as a dark line on the November photograph and yields a value of the radial velocity of about + 5 km.

From these considerations it is evident that the spectrum of this Nova and probably of other Novæ as well is by no means so simple in its later history as has sometimes been supposed. The great width of the emission bands, the presence of well-defined selective absorption within them, the persistence of the displacement of their centers toward longer wave-lengths, as well as the marked variation in intensity of some of the important bands such as λ 4687, all go to show that the physical conditions present are the most complex, and must differ greatly from such as produce an ordinary nebular spectrum.

Rate of Light Changes in Various Celestial Objects: S. I. Bailey.

A discussion of the variable stars in Messier 3 shows some examples of extraordinary rates of increase in light. This globular cluster is a faint hazy star of about the sixth magnitude to the naked eye. Its marvelous character is not suggested even in a small telescope. At Arequipa with an exposure of 100 minutes with the 13-inch Boyden Refractor about 1,200 stars were shown. These plates showed stars somewhat fainter than the 16th magnitude. Among these were found 137 variables among 900 stars actually examined for variability, or one in seven. The total number of stars in the cluster is very great. On a plate made by Ritchey on Mt. Wilson with the 60-inch reflector giving an exposure of four hours not less than 30,000 stars are seen, if we include the central mass where an exact count is impossible. Among the variables found in this cluster the maximum rate of increase in four cases appears to be more than six magnitudes an hour. The mean maximum rate of increase of all the variables is about two and a half magnitudes an hour.

It is doubtful whether any other celestial object has so great a known rate of variation as six magnitudes an hour, although it seems probable that this rate may be exceeded in the case of Novæ. Except for Novæ great rates of change appear to be rare. χ *Cygni* has a range of nearly ten magnitudes, but this enormous change takes place during so long a time that the rate per hour is only a fraction of a magnitude. Eros has perhaps the shortest period of a known object. From one maximum to the following is only about two and a half hours. The range may be a magnitude or more at times, and the light curve closely resembles a sine curve. Its maximum rate of change is probably never more than two or three magnitudes per hour. Some of the Algol variables change very rapidly. *U Cephei* and *W Delphini* are good examples. The rate per hour, however, of any known Algol star does not exceed two or three magnitudes per hour.

Relative Intensity of Prismatic and Grating Spectra: J. S. PLASKETT.

The grating spectrograph used was briefly described at the last meeting and is arranged to be used in the Littrow form, giving linear dispersion 17.5 Å per mm. and with incident and diffracted pencils 30° apart giving 33.0 Å per mm. A half prism silvered on the back can be substituted for the grating in the Littrow form, giving the same dispersion at H_γ. Comparisons of intensity were made with the Ottawa three-prism and one-prism spectrographs, giving practically the same dispersions at H_γ. Spectra of the sun and of different stars agree well in showing: (1) The grating does not diffract more than 30 per cent. of the incident light and the spectra are correspondingly weak. (2) The diffraction star spectra are practically uniform in intensity between λ 4800 and λ 3850. (3) Prismatic spectra are relatively stronger in the blue and weaker in the violet than diffraction spectra. (4) Diffraction spectra become equal in intensity to the three-prism spectra at λ 4250, to one and to half-prism spectra at λ 3970. Above these regions prismatic are stronger, below weaker than diffraction spectra. (5) The great loss of light by absorption in prisms is shown by comparison of one- and three-prism spectra. The former are more than twice as strong between H_β and H_γ, three times at λ 4250, seven times at λ 4150, fifteen at H_δ.

A diffraction star spectrograph would be of value in the ultra-violet, when spectra of uniform intensity from H_β down were required, and in the red end where prismatic spectra are unduly compressed.

A New Form of Clock Synchronization: R. MELDRUM STEWART.

The form of synchronization described is adapted to the case where both the synchronized and the synchronizing clocks control electric circuits. In the particular case where it is applied at the Dominion Observatory the synchronizing clock controls a circuit which is closed every alternate second, while that controlled by the synchronized clock is closed for one second every minute, for the purpose of operating electric "minute jumpers." Each of these circuits operates a relay, and it is the coincidence of the opening of the relays which forms the automatic test of synchronism, which takes place every minute. In addition there is used a neutrally adjusted polar relay; the circuit from a local battery is so arranged that, once a minute, while the relay operated by the controlled clock is closed, current flows through the winding of the polar relay, the direction of the current depending on the position of the armature of the relay operated by the synchronizing clock. Thus, at the instant of the opening of the relay operated by the controlled clock, the position of the armature of the polar relay depends on whether the "synchronizing" relay is open or closed (that is, on whether the controlled clock is slow or fast); and since the polar relay is neutrally adjusted, it will remain in the same position until current next flows through it, *i. e.*, until the next even minute. As soon as the relay operated by the controlled clock has opened, its back contact is utilized, in series with the points of the polar relay, to send a current through one or other of two magnets in the clock case, and so to either add to or remove from the pendulum a small weight, so as to accelerate or retard the clock for the following minute. At the end of the minute the automatic comparison is again made, and the clock again accelerated or retarded as required.

The controlled clocks are not particularly good timekeepers, and are exposed to considerable vicissitudes of temperature; to ensure satisfaction the correcting weights are made capable of taking care of a variation in rate of 8 or 10 seconds per day; the synchronization is in this case effective to within about a hundredth of a second. In the case of a high-grade clock very much smaller correcting weights could be used, and the interval between the automatic comparisons could be increased to perhaps an hour.

The principal advantage of this type of synchronization is that there is no possibility of stopping the controlled clock by interference with the synchronizing current, an advantage which, so far as I am aware, is not shared by any other method.

An Investigation of the 9.4-inch Photographic Objective of the Shattuck Observatory: H. T. STETSON.

The original 9.4-inch visual lens by Alvan Clark has been made convertible into a photographic by the substitution of a new flint, giving a focal length of 10 feet 6 inches. Measurements of extra focal plates taken after Hartmann's method for determining aberration errors show extreme variation in the focus to be less than one part in 3,000 for the same wave-length. The greatest irregularities lie in zones of 55 cm. and 85 cm. radii, where there is marked shortening of the focus. Computation of the "criterion" constant gives $T = 0.33$, placing the quality well within the highest class.

The mean diameter of the confusion disk, when expressed in seconds of arc, becomes $0''.69$ as against $0''.45$ for the 40-inch Yerkes. The theoretical resolving power of a 9.4-inch is $0''.52$, whereas for the 40-inch it is $0''.12$. It is suggested that a criterion to best represent the quality of the optical work should involve this constant for any given aperture. This would appear to favor the quality of the smaller lens. This ratio might well be called a "coefficient of resolution."

On the Luminous Efficiency and Color-index of a Black Body at Different Temperatures: HENRY NORRIS RUSSELL.

The curves of spectral sensitiveness given by Parkhurst in his "Yerkes Actinometry" (with the addition of certain data very kindly communicated by Professor Parkhurst) make it possible to compute the luminous efficiency of a body radiating according to Planck's law at any temperature, that is, the ratio of its actual visual or photographic brightness to that of a body radiating the same amount of energy, but all of the wave-length of greatest visual or photographic efficiency. The results here given are provisional, and may be somewhat altered when fuller data regarding the spectral sensitiveness become available.

The visual luminous efficiency is a maximum for a temperature of about 7,500°, its value being 0.11. The visual surface brightness, on the Yerkes scale, varies with the temperature very nearly as the intensity of monochromatic radiation of wave-length $0.541\,\mu$, and the photographic surface brightness like that of wave-length $0.428\,\mu$, the deviations averaging less than $0^m.07$ for temperatures between 2,000° and 25,000°. The color-index can be still more closely represented by the formula

$$\text{Phot.} - \text{Vis.} = \frac{7500^\circ}{T} - 0^m.70,$$

the residuals averaging only $0^m.02$.

For the Harvard visual and photographic observations the mean effective wave-lengths appear to be $0.516\,\mu$ and $0.419\,\mu$, and the color-index is given by the equation

$$\text{Phot.} - \text{Vis.} = \frac{6900^\circ}{T} - 0^m.60.$$

The "black-body" temperatures corresponding to the color indices of stars of the various spectral types may now be determined. The Harvard and Yerkes data give effective temperatures (ranging from 23,000° for Class B_0 to 3,100° for Class M and 2,300° for Class N), which are in excellent agreement with one another and with the previous determinations of Wilsing and Scheiner by visual spectro-photometric methods.

It appears also that the relative visual surface brightness of any two "black bodies" at different temperatures, if expressed in stellar magnitudes, should be 3.8 times the relative color-index on the Yerkes scale, or 4.3 times the color-index on the Harvard scale. The luminous efficiency is almost constant for color-indices between 0.0 (Sp. A) and 0.7 (Sp. G), but falls off rapidly for bodies at lower temperatures.

If these results, which are strictly true only for theoretically perfect radiators, apply approximately to the actual stars, and we could measure the brightness of the latter by means of their whole energy radiation, instead of a narrow spectral region, stars of Class K would seem about twice as bright, those of Class M four times as bright and of Class N more than twenty times as bright as they do now, in comparison with stars of Classes A to G. This would profoundly modify our estimates of the relative abundance of stars of different spectral types.

The Eclipsing Binary ε Aurigæ: HARLOW SHAPLEY.

More than five thousand observations of the variable star *ε Aurigæ,* made by Schmidt throughout the interval from 1843 to 1884, have been studied by Ludendorff, who deduces a period of light variation of 27.1 years and a light curve similar to those of certain eclipsing variables. Only three minima have occurred since the discovery of the light fluctuation by Fritsch in 1821. A study of the light curve by the writer shows that the observations can be satisfactorily represented by the eclipse theory. An accurate orbit is not possible, notwithstanding the large number of observations, but limiting sets of elements have been derived. The eclipse is total—the small bright star being completely hidden for more than a year behind the faint companion, whose volume is one thousand times the greater. The component stars are distantly separated. The mean density of the smaller component, if the masses are approximately equal, is not unusual in comparison to the densities already found for *W Crucis* and *RZ Ophiuchi,* whose periods of 198 and 262 days, respectively, are the longest heretofore known. The density of the big companion, however, is about one millionth that of the atmosphere at the earth's surface. This greatly surpasses the rarity of any other known eclipsing star, but even then must be considered stellar rather than nebular. The sun extended to Jupiter's orbit would not be so dense as this, and seen from a neighboring star would certainly appear as a stellar point. Except near the limb, the larger component will be perfectly opaque. Through the center of the star the extinction must be nearly 40 magnitudes, if the mass is taken equal to the sun's mass. To allow for the translucence near the beginning and end of eclipse, the relative radii of the stars must be reduced still further, which would tend to make the density of the smaller star entirely normal without materially diminishing the density of the large component. The elements of the best orbit, which allowed for darkening to zero at the limb, are as follows: ratio of stellar radii, 0.10; inclination, 77°.0; radius of large star (distance of centers, unity), 0.307; light of each component, 0.50; relative surface brightness, 0.01; hypothetical secondary minimum, $0^m.004$; "equal-mass" densities, 2.4×10^{-9} and 2.4×10^{-6}.

Harvard classes the spectrum as F_8p. Ludendorff finds peculiarities in the radial velocity, and is making a detailed spectroscopic study of the system.

Film Distortions on Small Photographic Plates: F. E. ROSS.

By means of a reseau, tests were made of the film distortions on the small photographic plates used in the photographic zenith tube at Gaithersburg, Md.

The cut Lumiere Sigma plates are 37 mm. long by 27 mm. wide.; in all forty plates were measured, of which 20 were dried in air in the usual way, and 20 were immersed in alcohol before drying. Distortions in only one coordinate, the plates' length, were measured. The air-dried plates showed large, irregular distortions. The probable error of a measured 2 mm. space was $\pm 1.5\,\mu$; of a 22 mm. space, $9.6\,\mu$. For larger distances the probable error was somewhat smaller. The corresponding probable errors of alcohol-dried plates were $0.7\,\mu$ and $2.7\,\mu$, respectively. The probable error of an average distance on air-dried plates was $6.5\,\mu$; on alcohol-dried plates $1.4\,\mu$.

The maximum distortion observed on an air-dried plate was $49\,\mu$; on an alcohol-dried plate $10\,\mu$.

Air-dried plates always showed an expansion over about three fourths its distance from the center. At this point the expansion, which amounted to $19\,\mu$, ceased, but the irregularities became a maximum.

No certain expansion of the alcohol-dried plates could be detected. Air-dried plates which showed unusually large distortions were resoaked in water, dried in air and remeasured. The distortions were found to have been notably changed, in both distribution and amount. They were again well soaked and measured while wet. The distortions were found to have disappeared. Other air-dried plates showing large distortions were resoaked and redried in alcohol. The distortions disappeared in this case also.

Some Effects of Radiation upon Astronomical Instruments: F. E. ROSS.

Read, but no abstract was submitted.

Recent Progress in the Theory of the Galilean Satellites of Jupiter: KURT LAVES.

The paper is a part of a report concerning the Theory of Satellites in the Solar System, which will appear in Vol. VI. of the "Encyclopaedie der Math. Wissenschaften," published by the Academy of Sciences of Göttingen.

The modern investigations of de Sitter, Cookson, Sampson and others were considered, and attention was drawn to the fact that the old Laplace-Souillard theory is inadequate from a modern standpoint.

The Solar Rotation in 1912: J. S. PLASKETT.

Two series of rotation plates were obtained in 1912, though with great difficulty, owing to cloudy and hazy weather. The first of these series, center at λ 5600, the special region allotted to Ottawa, was obtained during June, and the second, center at λ 4250, the general region, during October. The first series, consisting of 25 spectra at each of the latitudes 0°, 15°, 30°, 45°, 60°, 75°, 80°, 85°, was measured and reduced by the writer, and the velocity values obtained are well expressed by a formula of the Faye type.

$$V = (1.431 + 0.563 \cos^2 \phi) \cos \phi,$$

where V is the linear velocity in kilometers per second and ϕ the heliographic latitude. The coefficients of this formula lie between those of the two series obtained in 1911 and the observed values for the two years are in good agreement, the only differences of any magnitude being at latitudes 45° and 75°, where the 1912 value is about 0.04 km. per second lower. The measurement and reduction of the other series will likely give definite information as to the best value of the coefficients of the formula and as to the discrepancy at the two latitudes.

Orbital Planes of Binaries: JOHN M. POOR.

The paper gave a preliminary statement in regard to a statistical method of investigating the parallelism of orbital planes of binary stars to any particular plane in space.

The several attacks upon the problem of determining whether the orbital planes of binary stars are parallel to any particular plane in space have led to no very positive indications that such parallelism exists in the case of the best determined orbits of binary stars.

If such parallelism exists it ought to be indicated in a statistical study of measures of binary stars by the systematic variation in magnitude for different parts of the sky of the correlation coefficient expressing the relation between position angle and distance of the doubles in a limited area of the celestial sphere. As this problem is more easily solved in rectangular than in polar coordinates, it may be put in the form of finding the correlation between $s \cdot \sin P (= x)$ and $s \cdot \cos P (= y)$.

With a view to making a study of this question along these lines the necessary computations have been begun at the Shattuck Observatory, though a sufficient number of correlation surfaces has not yet been computed to allow conclusions to be drawn.

It is hoped that double star observers to whose attention this preliminary statement may come will cooperate by furnishing the writer with lists of their observations published since the appearance of Burnham's General Catalogue in order that the final computations may be based on as large an amount of material as possible.

On Climatic Changes and the Cause of Ice Ages: W. J. HUMPHREYS.

Numerous geological records give evidence of great climatic changes in the past, culminating at times in excessive heat and aridity and at other times in extreme cold and corresponding precipitation. It appears too that the great climatic changes were simultaneous and in the same sense the world over—warmer everywhere or colder everywhere. Hence, whatever the chief cause of these effects, it must have been world-wide.

Certain variations of long duration in the energy output of the sun would meet the above conditions, but the cause of such variations is not apparent nor is there other evidence that they ever actually took place. Hence it seems well to seek for some general terrestrial cause of climatic change—for something in or of the atmosphere.

More or less continuous pyrheliometric records since 1880 show marked deficiencies in the amount of solar radiation received at the surface of the earth during the years 1884, 1885, 1886, 1903 and since June, 1912. The first of these periods followed the explosion of Krakatoa, the second the explosion of Mount Pelée and the third that of Katmai in Alaska. The only other minimum of importance, about half as great as those just mentioned, occurred in 1891 and presumably was also connected with a volcanic explosion.

Now the fine volcanic dust, roughly one micron in diameter, when thrown into the isothermal region of the atmosphere must settle slowly, since it is above the reach of clouds, and spread over all parts of the earth, as we know it did after each of the above-mentioned volcanic explosions. Further, the fine dust *scatters* the short wave-length solar radiation to a much greater extent than it does the relatively long wave-length earth radiation. In other words, earth radiation gets out through this enveloping layer of dust much better than solar radiation can get in. Hence the final equilibrium temperature of the earth as a whole, other things being equal, necessarily is lowered by the presence of a dust veil in the upper atmosphere. In the cases cited above the decrease of insolation seemed sufficient, if long continued, even to bring on an "ice age."

During the geological past there have been several periods of great volcanic activity with intervening ages of volcanic quiescence, just as there have also been ages that were warm and dry alternating with others that were cold and wet.

From the above considerations it is suggested that the alternate presence and absence, each for long periods, of volcanic dust in the high atmosphere may have been an important if not even the controlling factor in bringing about the great climatic changes of which geological records furnish abundant proof.

Photographic Magnitudes of the Brighter Stars of the Polar Sequence: FREDERICK H. SEARES.

The investigation of the magnitude scale of the Polar Sequence previously reported has been extended by photographing the brighter stars with diaphragms and screens producing apparent magnitudes between 10.5 and 15.5. The actual magnitudes were found by comparison with the fainter stars for which the scale had previously been established. The results for any given diaphragm or screen establish a scale for the bright stars which should be homogeneous with the adopted scale for the faint stars, and, as far as the slope is concerned, independent of the reduction constant of the diaphragm. With one exception, the results for all the diaphragms and screens used are in substantial agreement, and show a mean divergence between Mt. Wilson and Harvard expressed by

$$\text{Mt. W.} - \text{H.} = + 0^m.33 + 0^m.075(M - 10.5).$$

The formula holds between magnitudes 2 and 10.5. From 10.5 to 15.5 the scales are parallel, with the constant difference $+ 0^m.33$. The Mt. Wilson results agree closely with those of Parkhurst and Schwarzschild, which extend from magnitude 4.0 to 7.5.

The Photographic and Visual Light-curves of RR Draconis: FREDERICK H. SEARES.

At the fourteenth meeting of the society an announcement was made concerning the photographic variation of the Algol star *RR Draconis.* The eclipse is necessarily that of a bright object by a larger and fainter companion. The relative amounts of light are approximately as 32 to 1, and probably the larger object is the redder of the two. The photographic variation should therefore exceed the visual. This hypothesis was tested by photographing the star upon ordinary and isochromatic plates, the latter being used in connection with a yellow filter. The photographic and photovisual magnitudes of the comparison stars were determined by the use of diaphragms, the zero points of both scales being fixed by comparisons with the Harvard Polar Sequence. The greater photographic range is clearly shown. The results are

	Photographic	Photovisual	Color-Index
Maximum	9.64	9.98	— 0.34
Minimum	13.46	13.23	+ 0.23
Amplitude	3.82	3.25	0.57

The epochs of photographic and photovisual minima are probably the same. The maximum difference permitted by the present series of measures is 0.002 day, the photovisual minimum following the photographic.

Some Recent Changes in the Spectrum of Nova Geminorum No. 2: R. H. CURTISS.

On December 4, 1912, Nova Geminorum No. 2 was found to be passing through a period of marked light recovery. Its brightness, 7.5 magnitude, was identical with its former value seven months previous or about eight weeks after discovery. During two weeks following December 8 the Nova faded rapidly down to magnitude 8.3. Visually the Nova was of a decided greenish-blue color during this period. The spectrum, however, underwent some marked changes.

At the brighter phase of the Nova's recovery the hydrogen lines and λ 4635 had developed greatly in strength and intensity, but with declining light the nebular lines had become the strongest feature of the spectrum. Our observations indicate that the nebular lines actually gained in brightness or at least held their own while the total light of the star waned, but during the same interval the hydrogen lines faded rapidly.

Radial velocities from the dark H line of calcium agree with the value of ten kilometers per sec. positive, obtained shortly after the Nova's discovery.

Do the Declinations of the Accepted Fundamental Catalogues Represent the True Positions of the Stars? W. S. EICHELBERGER.

From two papers presented at the Ottawa meeting by F. B. Littell, on the work of the 6-inch transit circle, and on the work of the altazimuth at the Naval Observatory it appears that the declinations of the stars in Boss's General Catalogue culminating south of the Washington zenith require a correction of about $+ 0''.5$.

This result is confirmed by the results in the volume of the Greenwich Observations for 1908, and the results obtained with the 9-inch transit circle of the Naval Observatory. Further, the 9-inch results show a practically constant correction from declination $- 30°$ to declination $+ 45°$, a rapid but nearly uniform decrease in the size of the correction from declination $+ 45°$ to declination $+ 60°$ and a nearly zero correction from that point to the pole. The rapidly changing correction a few degrees north of the zenith with a constant correction through the same zenith-distances south of the zenith would indicate that the fault can hardly be in the instrument. Can it be in the declinations of the fundamental catalogue?

If there is a discontinuity at the zenith in the determination of declinations at the various European observatories due either to the instrument or to the observer, such an error as supposed may have been introduced into the fundamental catalogues.

The following table, giving the differences between the declinations of three pairs of Pulkowa and Greenwich Catalogues, shows that such a discontinuity exists at least in some of the catalogues.

Decl.	No. Stars	$P_{45}-G_{45}$	Decl.	No. Stars	$P_{65}-G_{72}$	Decl.	No. Stars	$P_{85}-G_{80}$
71° to 65°	10	−0″.03	72° to 65°	15	−0″.08	72° to 63°	16	+0″.15
65° to 61°	8	−0.13	64 to 60	10	−0.10	63 to 60	10	+0.24
Pulk. Zen.								
60° to 55°	13	+0.03	60 to 55	14	−0.63	60 to 56	12	+0.20
55° to 51°.5	6	−0.11	55 to 51.5	11	−0.62	56 to 51.5	13	+0.16
Green. Zen.								
51°.5 to 45°	19	−0.46	51.5 to 46	13	−0.79	50 to 45	18	+0.06
45° to 40°	15	−0.44	46 to 41	14	−0.99	45 to 40	18	−0.07
			41 to 35	14	−0.81			

A discontinuity at the zenith of about 0″.5 is indicated in the Pulkowa Catalogue of 1865, and another of about 0″.4 in the Greenwich Catalogue of 1845.

About half the circumpolars at Pulkowa culminate south of the zenith at their upper transit, and these should give a different latitude from those that culminate north of the zenith at their upper transit, if there is a discontinuity at the zenith. Therefore all the circumpolar observations of the above-mentioned Pulkowa Catalogues were rediscussed to obtain new corrections to the adopted latitude and refraction, introducing into the equations of condition a term (z) to allow for the discontinuity at the zenith.

In the 1845 catalogue all the 110 circumpolars were included in the discussion instead of restricting oneself to the 43 used for a similar purpose in the introduction of that catalogue, and in the 1865 catalogue all of Gyldén's zenith distances were increased 0″.15 to correct for the relative personal equation of Gyldén and Nyrén.

The results of this rediscussion of the Pulkowa observations are as follows:

Z (Decl. south of zenith relatively too small)

1845	+ 0″.09	± 0″.14
1865	+ 0″.37	± 0″.10
1885	+ 0″.12	± 0″.08

	Refraction Constant		Refraction Constant of Catalogue
1845	57″.47	± 0″.064	57″.56
1865	57″.45	± 0″.045	57″.56
1885	57″.38	± 0″.035	57″.37

	Latitude			Latitude of Catalogue
1845	59° 46′	18″.75	± 0″.10	18″.67
1865		18″.67	± 0″.07	18″.54
1885		18″.55	± 0″.06	18″.54

These values of the constants of reduction give the following corrections to the published declinations:

Decl.	1845	1865	1885
50°	+0″.14	+0″.33	+0″.07
25	+0.20	+0.38	+0.07
0	+0.29	+0.50	+0.06
−25	+1.13	+1.54	−0.03

Orbit of the Spectroscopic Binary π^5 Orionis: Oliver J. Lee.

The variable velocity of the star π^5 *Orionis* was announced by Frost and Adams with measures of seven three-prism plates in the *Astrophysical Journal*, 17: 151, 1903.

The following elements have been derived from these measures and from the writer's measures on fifty-seven one-prism plates taken with the Bruce spectrograph in the interval 1907–12:

Period	3.70045 days
Eccentricity	0.051
Longitude of periastron	84°
Semi-amplitude of oscillation .	58.6 km.
Velocity of system	+ 23.7 km.
$a \sin i$	2,978,000 km.
Time of periastron passage ..	1907 Dec. 8.83
	or J.D. 2,417,918.83

The Expression of Pivot Errors by a Formula: R. Meldrum Stewart.

Even the best measurements of pivot errors of a meridian circle or transit instrument are of course affected by accidental errors, and in the case of fairly good pivots these are no doubt larger than the actual deviations of the pivots from a smooth curve. It then becomes a question what pivot corrections should be adopted both for the positions in which the errors have been observed and for intermediate positions. In a recent series of measurements at the Dominion Observatory it was found that a good representation could be obtained by the use of a Fourier series, and it seems probable that the values so adopted are more accurate than the actual observed values.

It is evident that a Fourier series can be made to represent the observed values to any required degree of accuracy; for example, the use of 72 unknowns would reproduce the observed values exactly, in the case where the intervals are 5°. Since, however, these observed values contain errors of measurement, it is probable that a more exact representation of the actual errors will be obtained by omitting the terms with small coefficients; if this be granted, the number of terms to be retained may in any particular case be decided by a computation of the probable error of a single observation. As several independent measurements of the pivot errors are usually made in a series, the probable error of a single observation may be computed directly from the residuals; if now we have a formula which is assumed to represent the actual pivot errors, the differences between the observed values and those computed from the formula may be used to form another probable error; the relative magnitude of these two probable errors will furnish a criterion as to the number of terms required in the formula. The freedom of the residuals from any systematic tendency will of course furnish the final test as to whether or not the formula is suitable.

In the actual determination referred to, which was made by the microscopic method, eight complete measurements were made; the probable error of a pair of microscope pointings (treated as a single observation) was found to be 0.0015 sec.; four terms of the Fourier expansion were found to be sufficient to reduce the computed probable error to the same value, and the resulting formula was adopted as definitive. This formula, expressing the necessary corrections to the observed collimation, was

$$\begin{aligned}\triangle c = {} & 0^s.0010 \cos (2\theta - 188° \, 29') \\ & + 0^s.0117 \cos (3\theta - 3° \, 17') \\ & + 0^s.0021 \cos (4\theta - 59° \, 45') \\ & + 0^s.0008 \cos (5\theta - 121° \, 58'),\end{aligned}$$

θ being the zenith distance. The residuals from the formula were satisfactorily small (in no case exceeding 0.002 sec.) and appeared to be purely accidental.

Values of the formula were computed for different zenith distances, and from these a table was prepared giving the zenith distances at which the value of $\triangle c$ changed from one unit (in terms of 0.001 sec.) to the next; it is this table which is used in the reduction of transits.

The Variable RV Capricorni: S. D. TOWNLEY.

The variability of *RV Capricorni* was discovered by Götz in 1905. From fourteen photographic observations scattered over an interval of five years he deduced a light curve of the Algol type. Seares and Haynes observed the star in 1906 and found a light variation of the antalgol type, with an approximate period of $10^h \, 44^m.6$. The star is classed as an antalgol by Hartwig, and Seares's epoch and period are used in computing the ephemeris.

During the summer and fall just past *RV Capricorni* was one of a list of variables observed by the writer with the 12-inch refractor and Rumford photometer of the Lick Observatory, the use of which was kindly granted by Director Campbell. Three well-determined maxima were obtained and these show that the Seares ephemeris now needs a correction of about $3^h \, 10^m$—the observed maxima coming that much before the computed.

By comparing a well-determined maximum obtained on October 11, 1912, with the first one obtained by Seares, August 13, 1906, a period of $0^d.447573$ has been derived, while the period determined by Seares is $0^d.4476$, which is therefore correct to the number of decimals given.

The observations show conclusively that this star is not of the Algol type, but there is perhaps some question as to whether it belongs to the antalgol or to the cluster type. Additional observations near minimum brightness, which I hope to obtain next summer, will be necessary to decide this point.

Notes on the Real Brightness of Variable Stars: HENRY NORRIS RUSSELL.

The number of variables and of stars having peculiar spectra contained in Boss's Preliminary General Catalogue is large enough to enable an approximate estimate of their mean distance and real brightness to be made by the method of parallactic motion. Assuming that the sun is moving towards 18 h., + 30° at 19 km. per second, the following values have been found, in the usual way, from the data of Boss and Campbell, for the parallactic motion M, the mean proper-motion τ at right angles to the parallactic motion, the mean parallax π, the mean peculiar velocity—r km. at right angles to the line of sight and the solar motion, and ρ in the line of sight, and finally the absolute magnitudes corresponding to the mean observed magnitude and mean parallax. Data for three groups of stars selected at random from Campbell's list of stars of Class B are added to test the value of the method for small groups, and some of the results of Campbell for large numbers of stars are added for comparison.

Objects	No.	Magnitude		M	τ	π	τ km., km.	ρ km.	Abs. Max.	Mag. Min.
		Max.	Min.							
Cepheid variables	13	4.3	5.1	0.″015	0.″007	0.″004	8	9	—2.8	—2.0
Long-period variables	12	4.5	9.4	0.048	0.073	0.012	28		—0.1	+4.8
Irregular variables (Spectrum M)	11	3.7	4.9	0.060	0.042	0.015	13		—0.4	+0.8
Stars of Sp. O to O_{e5}	24	4.95		0.016	0.006	0.004	7		—2.0	
Stars whose spectrum shows bright hydrogen lines	50	4.53		0.028	0.009	0.007	6		—1.3	
Random groups of stars of spectra	12	3.9		0.024	0.009	0.006	7	5	—2.2	
B to B_5.	11	3.7		0.036	0.007	0.009	4	6	—1.5	
	11	3.7		0.043	0.011	0.010	5	6	—1.3	

Campbell's Results

Spectrum B	180	4.07	0.008	0.006	6.2 —2.1
F	180	(4.3)	0.108	0.035	14.4 (+2.0)
G	118	(4.3)	0.075	0.022	15.9 (+1.0)
M	71	(4.3)	0.038	0.011	17.1 (—0.5)

The variable stars of spectrum M appear to be much like the general run of stars of this spectral class in distance, peculiar velocity and (at maximum) in brightness, being then about 100 times as bright as the sun. At minimum, the average long-period variable seems to be comparable with the sun in brightness.

Stars of Class B, showing bright hydrogen lines, do not differ materially in distance, brightness or peculiar velocity from those that do not, and stars of spectrum O are but little farther away or brighter.

The Cepheid variables, on the contrary, are very much farther away, brighter and more slowly moving than most stars of Classes F or G, and closely resemble the Orion stars in all these respects, and also in their strong condensation toward the Milky Way—so much so as to suggest some real relation between them. Even at minimum, these stars average some 400 times as bright as the sun. If they are comparable with it in surface brightness, as seems very probable, their diameters must be at least ten times the sun's—far larger than their spectroscopic orbits. If their average density was less than 1/1200 that of the sun, their companions would collide with them at periastron. It follows that the larger components of these systems must be more massive than the sun, and the invisible companions of the order of one tenth the mass of their primaries—as Campbell has anticipated.

The great brightness of all these variable stars seems a very serious objection to any theory which represents them as stars nearing extinction, but unfortunately, does not itself suggest any theory of their nature.

The Jupiter Perturbations of the Group of Small Planets, $\mu = 2/5$: D. T. Wilson.

Tables have been constructed by the Hansen-Bohlin method for the computation of the perturbations of Jupiter on the group of small planets whose mean daily motions are in the neighborhood of 750″. The perturbations of Pandora 55, of Bellona 28 and of Johanna 127 have been computed and the results compared with those of the same planets computed by Hansen's method by Messrs. Möller, Bohlin and Olsson.

Correcting and Testing Micrometer Screws: Wm. Gaertner.

Read by title.

The Temperature assigned by Langley to the Moon: Frank W. Very.

Langley's opinions in regard to the temperature of the lunar surface in sunshine varied widely at different times, but in the main he favored a low temperature.

The foundation of this opinion is examined and is shown to be invalid. Incidentally, statements by other investigators, which are based to some extent on Langley's opinion, are discussed.

The paper will be published in Science.

At the end of the last session a resolution was adopted expressing the thanks of the society to the authorities of Case School and other friends in Cleveland for the hospitality and privileges extended to the members of the Society.

Philip Fox,
Secretary