

function is determined to suit the boundary conditions, by the image-method; and it is shown that one of the stream lines breaks up into the median line of the channel and a symmetrical oval. The strength of the doublet can be so adjusted that this oval does not differ appreciably from a given circle when the latter does not occupy more than half the breadth of the channel.

Preliminary Wave-lengths of Flash Spectra taken in Spain, August 30, 1905: Dr. S. A. MITCHELL, Columbia University, New York City.

The wave-lengths were obtained from photographs taken by the writer while a member of the United States Eclipse Expedition. The spectrograph was a four-inch grating of 14,438 lines per inch ruled on a parabolic surface, which was used without slit. Weather conditions were splendid. The photographs are remarkable for their splendid detail throughout their whole length from D_3 to 3,300. There are about five thousand measurable lines in this region. The dispersion of the grating is about the same as for the 'Bruce three' spectrograph of the Yerkes Observatory and the Mills spectrograph of the Lick Observatory, the distance from D_3 to H being seven inches.

On the Minimum Number of Operators whose Orders exceed Two in any Finite Group: Dr. G. A. MILLER, University of Illinois, Urbana, Ill.

When just half of the operators of a group are of order 2 the order of the group is twice an odd number, and all the operators of odd order together with the identity constitute an abelian subgroup whose order is half the order of the group. Professor Miller's paper has for its main object the proof of the following theorems: If the order (g) of a group is written in the form

$$2^{\alpha_0} p_1^{\alpha_1} p_2^{\alpha_2} \cdots p_{\lambda}^{\alpha_{\lambda}},$$

$p_1, p_2, \dots, p_{\lambda}$ being distinct odd prime numbers and $\alpha_0 > 0$, the number of the operators whose orders exceed 2 can not be less than

$$\frac{(p_1^{\alpha_1} p_2^{\alpha_2} \cdots p_{\lambda}^{\alpha_{\lambda}} - 1)g}{2p_1^{\alpha_1} p_2^{\alpha_2} \cdots p_{\lambda}^{\alpha_{\lambda}}}.$$

Moreover, it is possible to construct a group in which the number of operators whose orders exceed 2 is exactly equal to this number. If a group of order g contains the smallest possible number of operators whose orders exceed 2, the sub-group which is composed of all its operators which are commutative with one of the non-invariant operators of order 2 contains no operator whose order exceeds 2. This sub-group is a Sylow sub-group and just half of the remaining operators are of order 2.

Results of Physical Observations on the Saturnian System with the 18-inch Clark Refractor: Professor DAVID TODD, Amherst College, Amherst, Mass. (Presented by title.)

With the exception of those papers which appear upon the joint program of Friday morning, as given above, the papers of Section A were presented in connection with the program either of the Mathematical or of the Astronomical Society, according to the subject matter treated in each case. This arrangement was made in accordance with a resolution adopted at the Ithaca meeting to the effect that 'the sectional committee be empowered to turn over technical papers to the technical societies.'

LAENAS GIFFORD WELD,
Secretary

THE ASTRONOMICAL AND ASTROPHYSICAL
SOCIETY OF AMERICA

II

A New Form of Meridian Mark: G. W. HOUGH.

Two years ago I established a meridian mark in order to study the change of azi-

mouth for the 6 $\frac{3}{4}$ -inch Repsold meridian circle. Collimator marks, according to published statistics, as well as from theory, do not seem to be sufficiently stable for the study of azimuth changes unless supplemented by frequent observations of circumpolar stars. The method I have employed for bringing a mark in focus is simple, direct and vastly preferable to the use of a long focus lens; since the marks may be located at such distance that any probable change in the place of the pin will not sensibly change the direction.

In photographic work, when it is desired to bring objects lying in different planes to a common focus the aperture of the lens is reduced. Accordingly, I made some experiments and found when the aperture of the object-glass of the Repsold meridian circle, of 6-foot focus, was reduced to one inch, all objects at about 1,000 feet and beyond were brought in good focus.

A concrete pier 2 feet square and rising 2 $\frac{1}{2}$ feet above the surface of the ground was erected at a distance of 1,140 feet. On the top of the pier was bolted a cast-iron box, 15 inches wide, 10 inches high and 10 inches deep. Inside the box is an adjustable brass plate with a hole 0.15 in diameter, behind which is placed a 50-volt 16-candle lamp. Electricity is supplied from a storage battery, at the observatory, which had been installed for rotating the dome and illuminating the instruments. During daylight, when the sun is not shining, the mark appears like a sixth-magnitude star; at night brighter.

In order that an object at a finite distance may suffer no change of direction, the hole in the cap which covers the object-glass must be in the optical axis. Any deviation will cause a displacement proportional to the focal length of the telescope divided by the distance of the object. At 1,000 feet one inch subtends an angle of 17".1.

Hence very great precision in the fit of the brass cap is unnecessary. In order to know whether the hole in the cap is in the optical axis, the cap may be revolved 180 degrees, or the mark may be observed with the *full* aperture of the object-glass. In the latter case there is seen a well-defined disk of light about 90" in diameter.

In 1861 and for a number of years following, at the Dudley Observatory, I had a mark at the distance of six miles. After a rain the mark could be observed with great precision. The unsteadiness of a terrestrial mark does not depend directly on the distance.

The Significance of the Star Ratio: GEORGE C. COMSTOCK.

The number of visible stars increases very rapidly as we extend the count to fainter and fainter magnitudes, and any rational attempt at their enumeration must involve a limit, or limits, of brightness at which that enumeration shall cease. The rate of increase in the number of stars as this limit is made to move down the scale of magnitudes is called the star ratio, and the numerical value of this ratio in different parts of the sky and at different points in the scale of stellar magnitudes has been made the subject of research by many astronomers. From these investigations it appears that in general the number of stars is increased more than threefold and considerably less than fourfold for each increase of one magnitude in the limit to which the enumeration is extended. The ratio appears to be a little greater in the Milky Way than in extra-galactic regions and possibly a little greater for the brighter magnitudes than for the fainter ones, although it seems probable that the last relation is confined to the region outside the galaxy.

The point of major interest in the discussion is, however, that in general the rate

of increase is decidedly less than fourfold, while a very simple analysis shows that if the stars are strewn with some rough uniformity of distribution throughout a region of indefinite extent, the average star ratio should be very approximately a fourfold increase per magnitude. The disparity between this theoretical ratio and that found actually to obtain, throws discredit upon the hypothesis above made with respect to the distribution of the stars, and there has been reared upon it the current concept which represents the stellar system as of finite and measurable extent, broader in the galaxy because here the star ratio is relatively large, smaller at right angles to the Milky Way because here the star ratio diminishes. The idea is that the faint stars are faint because of their greater distance and are more numerous because the volume of space in which they may be distributed increases with the cube of the distance. But if the stellar system reaches out only to a certain limit and the space beyond is void, it can contribute nothing to the number of stars and the star ratio, while everywhere below the value that would obtain for an infinite system ought to diminish very rapidly as we approach the confines and deal with stars fainter than any that have been hitherto enumerated, although Professor Pickering holds that even within the range of magnitudes covered by his investigations, such a diminution in the value of the ratio is distinctly shown.

The present paper controverts the views above outlined and shows that the supposed fourfold ratio that constitutes their theoretical basis has been erroneously derived through ignoring an essential factor of the problem. The faint stars appear faint not only because of their greater distance, but because they actually emit less light than do the brighter ones, and because of this inferior luminosity they are

nearer than has been assumed. This diminished distance is shown by observation of their proper motions and because of it we have a diminished space available for the faint stars, they are less numerous and the star ratio smaller than is required by the erroneous theory above considered. When the diminishing intrinsic brightness of the fainter stars is properly taken into account the author finds from a discussion of the star ratio for galactic stars down to the faintest yet enumerated (the Herschel gauges), that there is here no indication of a limit to the stellar system.

Outside the galaxy the conditions are different, the values of the star ratio are progressively smaller and suggest some one of the following alternative conditions or possibly a combination of them:

(a) At right angles to the galaxy the limits of the stellar system fall within the range of vision, as indicated above.

(b) The stars remote from the plane of the galaxy are on the average progressively less luminous than those in the galaxy.

(c) The transmission of light through the extra-galactic spaces is impeded by some absorbing medium which serves to diminish the brilliancy of the stars in larger measure than is the case in the galaxy.

Any of these alternatives will serve in explanation of the observed facts and it is not now feasible to make definitive choice among them.

Preliminary Wave-lengths from Flash Spectra taken in Spain, 1905: S. A. MITCHELL.

The flash spectra were photographed by means of a Rowland four-inch grating ruled on a parabolic surface. The grating was used without a slit, so that the spectrograph consisted merely of grating and photographic plate. The spectra, which show wonderfully fine definition, extend

from the *D* lines to λ 3,300 in the violet, a distance of 9.5 inches.

Measurements are now being made on the three or four thousand lines of the flash spectra. These photographs show a dispersion about the same as the Bruce three-prism spectrograph of the Yerkes Observatory and the Mills spectrograph of the Lick Observatory, or a dispersion one fifth that of a twenty-one-foot grating of ordinary Rowland mounting in the first order spectrum, or one tenth of the second order. The eclipse spectra were practically normal. Wave-lengths thus far deduced show a probable error less than five-hundredths of an Ångström-unit.

Comparison of Results of Observations with the Reflex Zenith Tube and Zenith Telescope at the Flower Observatory during 1905 and 1906: C. L. DOOLITTLE.

The Temperature of Mars: PERCIVAL LOWELL.

On the Absence of Long Heat Waves in the Sun's Spectrum: E. F. NICHOLS.

Formulas for the Comparison of Astronomical Photographs: HAROLD JACOBY.

This paper contains formulas suitable for the direct comparison of rectangular coordinates measured on different astronomical negatives. The problem here involved supplements what may be called the fundamental transformations in the reduction of celestial photographs; viz., the calculation of right-ascensions and declinations from rectangular coordinates, and rectangular coordinates from right-ascensions and declinations.

Light Curves of New Variable Stars of the Algol Type, and of Short Period: HENRIETTA S. LEAVITT.

In a recent circular of the Harvard Observatory thirty-six new variable stars were announced, mostly brighter than 9.5 at

maximum. All are within fifteen degrees of R. A. 12^h, Dec. — 60°, the region including both the Southern Cross and the Nebula in Carina. About sixty new variables in this area, mostly fainter than the tenth magnitude at maximum, had been announced in previous circulars. A large proportion of the new objects appear to have short periods, and several are of the Algol type. These are now being studied with a view to determining their periods and light curves. The periods of four have already been announced, those of three others are now made public for the first time. All but one of the seven variables are of the Algol type. The periods vary from nine tenths of a day, to five and one third days, while the smallest and the largest ranges observed are four tenths of a magnitude, and two and one half magnitudes, respectively.

The variable C. P. D.—50° 3,809 is of special interest, as the period is equally divided by a secondary minimum. The principal minimum is nine tenths of a magnitude fainter than the normal brightness, 9.3, while the secondary minimum is four tenths of a magnitude fainter than the normal. The average deviation from the light curve of a single observation is very large, being no less than ± 0.14 magn., while the average deviation for all the other Algol variables here described, is only ± 0.07 magn. This large deviation does not appear to be due to accidental errors of observation, though the variable was difficult to measure on many of the plates. It has not been found possible to improve the period on the supposition that it is constant, and it is probably to be corrected by a third term, not yet determined.

C. P. D.—49° 6,972 has a large range. The faintest magnitude observed is 11.5, which is two and a half magnitudes fainter than the normal brightness; but no observation at minimum has as yet been secured,

and the form of the light curve at that point is not determined.

C. P. D.—63° 2,485 was at first supposed to be of the Algol type, but has been found instead to be a short-period variable of unusual interest. As has already been announced in a recent circular, the light curve resembles that of an Algol variable with a minimum covering about half the period, but the light appears to be changing continuously, though very slightly, even when near maximum. As the range is only four tenths of a magnitude, four independent observations were made on each plate. By taking means, the accidental errors were reduced one half. The mean magnitudes were then arranged in the order of phase, and the mean phase and magnitude was taken for each successive group of five plates. The average deviation from the light curve of the points thus obtained is only ± 0.02 magn., and may be compared with the deviations found with the best photometric measures.

The large proportion of Algol variables among those discovered in this region is interesting. Of thirty-six variables announced last month, four have already been shown to be of the Algol type, and others, of which the observations have not yet been discussed, are supposed to belong to the same class. On the other hand, of more than seventy variables in Scorpius and Ophiuchus, announced two years ago, few, if any, appear to vary in this manner. The same is true of the Magellanic Clouds. The present study of the distribution of variable stars is in a very early stage and much generalization from the results as yet obtained is rash. Yet it has already become evident that certain kinds of variables are apt to be found in groups. It is desirable that the number of persons engaged in this research should be increased, so that the systematic survey of the heavens may be completed with a reason-

able degree of thoroughness during the next few years. Evidently it is of the highest importance to ascertain the types to which new variables belong, even if their number is too large to permit the computation of all the periods.

A Peculiar Binary System: ERIC DOOLITTLE.

Latitude Terms of Long Period, from the Flower Observations: C. L. DOOLITTLE.

This series embraces a period of seven years and nearly two months, and is practically homogeneous in all respects. As a term having a period of about six years has been supposed to be indicated by similar series elsewhere, it seems desirable to examine my results for evidence on this point.

Without making any assumption as to the law of latitude variation, the intervals from minimum to minimum were found graphically. The maxima were not employed for this purpose, as they were less clearly indicated. Six periods were found as follows:

1st	459 days
2d	410
3d	470
4th	439
5th	446
6th	416
Mean	$\overline{440}$ days
5 periods = 2,200 days	
6 Julian years = 2,191.5 days	

The difference 8.5 days is of no importance for present purposes.

This close agreement seems to fall in line with the possible existence of a term having a period of about six years.

The method of procedure was as follows: For each interval from minimum to minimum, terms of the form $x \sin \theta + y \cos \theta$ were removed from the given values of the latitude. A series of 103 equations was then obtained of the following form:

$$\Delta + a\alpha + \sin \theta \cdot y + \cos \theta \cdot z + \sin 2\theta \cdot u + \cos 2\theta \cdot v = n.$$

Δ is a constant correction to the latitude assumed.

α a uniformly progressive change.

The period of θ is six years.

The solution results in the following expression for $\Delta\phi$ in units of the second decimal place:

$$-1.96 \sin \theta + 0.35 \cos \theta + 1.25 \sin 2\theta + 0.94 \cos 2\theta,$$

α is quite inappreciable.

The maximum and minimum values of this expression are as follows:

Maximum 1898, February 1, $+0''.024$

Minimum 1902, April 9, $-0''.035$

The range, $0''.059$, seems too great to be altogether fictitious when the amount and character of the data employed are considered.

Period of the Solar Rotation: PHILIP FOX.

An investigation of the solar-rotation period based upon measurements of positions of 1,600 calcium flocculi on one hundred of the Rumford spectroheliograms taken at the Yerkes Observatory in the year 1904, gives the following results:

ϕ	ξ	P
0° to 5°	14.50°	24.82 ^d
5 10	14.44	24.93
10 15	14.18	25.38
15 20	13.92	25.86
20 25	13.68	26.32
25 30	13.95	25.80
30 35	13.68	26.31
35 40	13.25	27.18

The investigation will be continued, using the plates for the years 1905 and 1906.

Opportunities for Solar Research: GEORGE E. HALE.

It is safe to say that every astronomer would prize an opportunity to observe any of the fixed stars from a position where its disk would appear as large as the sun. It does not seem probable, however, that such observations of stellar phenomena can ever

be made, except in the case of the sun itself. For it should ever be borne in mind, when considering the importance of solar research, that our most intimate knowledge of stellar phenomena must be derived from solar observations. In the case of the other stars, we may determine their positions, measure their radial velocities, observe their brightness and analyze their light, but we have no means of studying the details of their structure, which must be understood before we can advance far in the solution of the great problem of stellar development. Thus we are driven back to the sun and forced to the conclusion that this typical star well deserves our most serious attention, and the application of every available means of research.

One can not but be impressed, when considering the sun from this standpoint, with the comparative neglect of the numerous opportunities awaiting the student of solar physics. It is possible, by the application of easily available instruments, for any careful student, wherever situated, to solve solar problems of great importance. If time permitted, it could be shown that almost all the apparatus required in such work can be constructed at very small expense. For our present purpose, however, let us assume that the observer has at his disposal one of the *coelostats* so commonly employed in eclipse work. If this *coelostat* has a rather thick mirror, which is frequently resilvered, it may be depended upon to serve well for solar work, provided that the mirror is shielded from sunlight during the intervals between the exposures of photographs, and that these exposures are made as short as possible. We may assume that the sunlight is reflected from the *coelostat* mirror to a second plane mirror (which should also be as thick as possible) and from this mirror to an objective, which should have an aperture of at least

6 inches and a focal length of from 40 to 60 feet. In place of this objective, a concave mirror, of similar aperture and focal length, may be employed. This apparatus will furnish the necessary means of forming a fixed solar image, of large diameter, within a laboratory, where accessory apparatus can be mounted. Let us now consider briefly some of the investigations that can be undertaken.

Direct Photography.—The routine photographic work, done under the direction of the Greenwich Observatory, provides ample material for the study of the positions and motions of sun-spots, but special investigations may well be undertaken with the aid of direct photographs. The important thing in all solar work is not merely to make observations of some single phenomenon, but to carry on two or three series of carefully correlated observations, so designed as to throw light on one another. For example, Mr. Maunder has recently found that the rotation periods of sun-spots in nearly the same latitude show differences as great as those encountered in passing from the equator to the highest latitude in which the spots are found. The cause of such differences may well be a subject of most careful investigation. The proper motions of spots, which are associated with their period of development, must be fully taken into account. We might also make the hypothesis, merely for the purpose of testing the question, that the rotation period of a sun-spot depends upon its level with respect to the photosphere. For this reason it would be desirable to investigate, in connection with the study of the rotation, the question of the level of sun-spots. A simple means of doing this will be mentioned later. But it may be added here that the question of level raises other considerations, which should not be left out of account. It is

probably worth while to investigate photographically the old Wilsonian hypothesis, since visual observations have proved so discordant in attempts to determine the relative widths of the preceding and following penumbra of spots at various distances from the center of the sun. As a sun-spot is depressed below the level of the surrounding faculæ, the vexed question of the visibility of the umbra near the limb may depend upon whether faculæ are present or missing on the sides lying in the line of sight. It is quite possible that the temperature of the umbra may vary with its distance above the photosphere. Thus correlation between observations bearing on spot level and observations of spot spectra is desirable.

Spectroscopy.—The spectroscopic study of solar phenomena has been greatly retarded, through delay in adopting suitable instruments. The short-focus spectroscopes attached to equatorial telescopes are admirably adapted for visual observations, but in photography their linear dispersion is much too small to realize the full resolving power of the grating employed. In laboratory work, on the contrary, while the spectroscopes have been sufficiently powerful, they have usually been of the concave grating type, where astigmatism interferes seriously with the study of solar details, and the solar image on the slit of the spectroscope has been so small that the individual phenomena, in any event, could not be separately distinguished.

The construction of a powerful spectrograph of the Littrow type is an extremely simple matter. A small slit, mounted on a short metallic tube, is supported immediately above a long narrow photographic plate. The wooden support for plate-holder and slit rests on a pier and forms the end of a long light tube of rectangular section, which is closed at its other end by

the wooden support for the lens, which serves at once for collimator and camera. The angular aperture of this lens is, of course, defined by that of the objective which forms the solar image on the slit, but if possible its focal length should be from ten to twenty feet. The rays, after being rendered parallel by the lens, fall upon a grating, which need not be larger than a four-inch (a much smaller one would do very useful work). The spectra should be photographed in the second, third or fourth order, so as to give sufficient scale.

With such an instrument, new work of great value may be done. Even with a very small solar image, a photographic study of the solar rotation should yield results of great precision. Halm believes, from his spectroscopic work, that the rotation period varies with the solar activity. This is yet to be confirmed, but the question well deserves investigation. There is some reason to think that the rotation period is not the same for different substances in the reversing layer. The iron lines, for example, may give values different from those obtained with the carbon lines. It is also interesting to inquire whether the enhanced lines of an element give the same period as the other lines in its spectrum.

Another interesting investigation, which does not require a large solar image, is the study of the radial velocity of the calcium vapor in the flocculi. It is only necessary to measure, with great precision, the wavelengths of the H_2 and H_3 lines, corresponding to various points on the solar image. In this way the rise and fall of the calcium vapor in the flocculi can be ascertained. To be of the most service, this investigation should be carried on in conjunction with some other study of the flocculi.

The photographic study of sun-spot

spectra offers a most promising opportunity. It is a very easy matter to photograph spot spectra in such a way as to record for study thousands of lines which are beyond the reach of visual observation. Nevertheless, this has been accomplished only recently, simply because spectrographs of suitable design have not previously been applied in this work. At the Solar Observatory on Mt. Wilson it has been found that, in general, the lines strengthened in spot spectra are strengthened in the laboratory when the temperature of the vapor is reduced, while the lines that are weakened in sun-spots are weakened in the laboratory under the same conditions. Thus it appears probable that the temperature of the spot vapors is below that of the reversing layer. This conclusion has been confirmed by the discovery in the spot spectrum of the flutings of titanium oxide. This compound thus exists at the lower temperature of the sun-spot, but is broken up into titanium and oxygen at the higher temperature of the reversing layer. The bearing of this result upon stellar spectroscopy will be seen when it is remembered that the flutings of titanium oxide form the principal feature of the spectrum of the third-type stars. It has also been found that Arcturus gives a spectrum resembling very closely the spectrum of a sun-spot. A further study of this question will require a large number of observations of spot spectra, with special reference to the question of variations in temperature, as indicated by variations in the relative intensity of the spot lines. As already remarked, the temperature of spots may also depend upon their level, and this possibility must be borne in mind.

Work with the Spectroheliograph.—It is perhaps commonly supposed that the spectroheliograph is necessarily an expensive instrument, out of reach of the average

observer. As a matter of fact, however, a spectroheliograph capable of giving the best results can easily be constructed of materials ordinarily available in any observatory or physical laboratory. It is sufficient, for many purposes, to photograph only a narrow zone of the solar image. In this case small lenses will suffice for the collimator and camera, and small prisms for the optical train. The lenses and prisms may be mounted in wooden supports, on a wooden platform, rolling on four steel balls in V-shaped tracks. The motion of the instrument across the solar image may easily be produced by a simple screw, driven by a small electric motor. Such a spectroheliograph was used to good purpose at the Solar Observatory before the permanent instrument was completed.

Brief mention may be made of some of the numerous investigations possible with such an instrument. It has recently been found at the Solar Observatory that the dark hydrogen flocculi, photographed near the sun's limb, are slightly displaced with reference to the corresponding calcium flocculi. In general, they lie nearer the limb. This probably indicates that the absorbing hydrogen clouds are, on the average, at a higher level than the brilliant calcium clouds. This subject deserves careful investigation, extending over a considerable portion of time. The type of spectroheliograph just referred to is as suitable for the purpose as any instrument that can be constructed. Another question, which seems to be somewhat more difficult to solve, is the actual difference in elevation of the calcium flocculi, as photographed in the H_1 and H_2 lines. Indeed, it is still a question as to how important a part the dense calcium vapor plays in determining the form of the H_1 flocculi. These objects resemble the faculae so closely that they appear practically identical with them,

though slight differences, which are apparently genuine, are occasionally found.

Another method of investigating this whole question of levels is afforded by the spectroheliograph. It will be remembered that when the level of sun-spots was last under discussion, reference was made to the relative radiation of the umbra and neighboring photosphere, corresponding to different distances from the center of the sun. It was pointed out that when a spot approaches the limb, its radiation decreases less rapidly than that of the photosphere. The natural conclusion was that the spot lies at a higher level than the photosphere and thereby escapes much of the absorption produced by a comparatively thin layer of absorbing matter. Recent observations at Mt. Wilson have shown, however, that the proportion of violet light in sun-spots is much smaller than in the case of the photosphere. As it is known that the violet rays undergo much more absorption near the sun's limb than those of greater wavelength, it is obvious that the light of the spot would suffer less absorption, even if it were at the same level as the photosphere. Thus the only proper method of investigating this question will be through the use of monochromatic light.

The spectroheliograph affords a simple means of accomplishing this. It is only necessary to make photographs of the spot and adjoining photosphere, corresponding to various distances from the sun's center. The camera slit should be set on the continuous spectrum (not on a line), preferably in the violet or ultra-violet, since the change of absorption would be most felt in this region. In order to make photographic comparisons easily possible, the intensity of the photosphere should be reduced to approximately the intensity of the umbra, by means of a dark glass, mounted over the collimator slit, but not

covering that part of the slit through which the light of the umbra passes. It is obvious that a large image of the sun will be required in this work.

The spectroheliograph can be applied to other studies of absorption. The H_1 flocculi, for example, are reduced in brightness near the sun's limb much more than the H_2 flocculi, presumably because the latter lie at a higher level. These differences can be studied photometrically on spectroheliograph plates made for the purpose. Since it is a question just what level is represented by the background (between the flocculi) in calcium, hydrogen or iron photographs, the instrument should be arranged so as to permit photometric comparisons with the light of the photosphere, of practically the same wave-length as the calcium, hydrogen or iron line employed.

These new applications of the spectroheliograph have only recently occurred to me, and are mentioned because of their suitability for use with instruments containing prisms of ordinary height, capable of photographing only narrow zones of the solar image. Numerous other problems might be mentioned, such as the comparative study of H_1 , H_2 and H_3 photographs, and of calcium, hydrogen, and iron images; the distribution of the flocculi in latitude and longitude, their varying area, as bearing on the solar activity and on terrestrial phenomena, and their motion in longitude, as measuring the solar rotation. But limitations of time forbid more than a mere reference to work and methods, the details of which are discussed elsewhere. My purpose has been accomplished if I have shown that with comparatively simple instrumental means any careful observer may secure important results. In much of this work it is desirable that investigators occupied with similar problems should co-operate with one another. The International Union for Cooperation in Solar

Research was organized with this end in view. It has already inaugurated solar studies, on a common plan, in several different fields, and is preparing to extend the range of its activities in the near future.

HAROLD JACOBY,
For the Council

SCIENTIFIC BOOKS

Rock Minerals, their Chemical and Physical Characters and their Determination in Thin Sections: JOSEPH P. IDDINGS. Wiley and Sons, New York. Pp. xii + 548, with numerous figures in text.

In presenting this work the author and publishers have won the gratitude of every American student in petrography, and of every teacher as well. Heretofore, the only systematic and comprehensive treatises available have been the 'Mikroskopische Physiographie' of Professor Rosenbusch or Professor Iddings's condensed translation of the same, and the works of Fouque and Levy. While no one would for a moment wish to disparage the work of one who has fairly earned the title of father of modern petrography, yet, as may readily be comprehended, the manner of presentation in the first-named publication, as well as the language in which it is presented, is German, and not always easy of comprehension to the average American student.

There have been, it is true, other works on the subject, in English, as Professor Luquers's 'Minerals in Thin Sections' and Harker's 'Petrology for Students,' but such make no pretense at completeness, and it has remained for Professor Iddings to give us a book as comprehensive and systematic as those of the German and French writers noted.

Within the limits of some 550 pages Professor Iddings includes not merely a description of the optical properties and methods of determination of all the ordinary rock-forming minerals, but also chapters on their chemical and physical characters. The critical chapter of the book is undoubtedly that relating to the optical properties of minerals, and it is apparently in recognition of this that the author has devoted upwards of 100 pages