SOME NEW APPLICATIONS OF THE SPECTROHELIOGRAPH

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I. SOLAR PHOTOGRAPHY WITH SUN-SPOT LINES

In several previous papers I have remarked on the importance of photographing the sun with the lines affected in and near spots. In our photographs of spot spectra many lines are strengthened or weakened, not merely in the umbra and penumbra, but in extensive regions surrounding spots. This effect, conspicuous enough to show itself directly in the spectrum, is evidently within easy reach of the spectroheliograph. Furthermore, our experience in the photography of faint hydrogen flocculi warrants the inference that spot phenomena, too delicate in their effect on line intensity to be detected with the spectrograph, will be brought to light by the application of spectroheliographs of sufficiently high dispersion.

The question of dispersion is evidently of crucial importance. If the line employed is sensibly narrower than the camera slit of the spectroheliograph, the admixture of light from the adjoining continuous spectrum will tend to blot out the comparatively feeble impression resulting from the faint light of the dark line. The fact that many of the most interesting cases are represented by extremely fine lines thus points to the use of spectroheliographs of great linear dispersion. This consideration, and the desire to photograph the sun with narrow dark lines other than those affected in spots, led to the provision of four prisms for the 5-foot spectroheliograph and the inclusion, in the original plan of the Snow telescope house, of a spectroheliograph of 30 feet (9.14 m) focal length. The latter instrument has not yet been completed. The delay is due in part to difficulty in securing suitable prisms, and in part to the distortion of the Snow telescope mirrors in sunlight. This distortion, while inappreciable

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1 Contributions from the Solar Observatory of the Carnegie Institution of Washington, No. 18.
2 Contributions from the Solar Observatory, No. 7, p. 6; Astrophysical Journal, 23, 59, 1906. This instrument has been used systematically since October, 1905 for photographic work with some of the wider dark lines.
3 Contributions, No. 2 p. 14; Astrophysical Journal, 21, 64, 1905.

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during the short exposures that suffice with the 5-foot spectroheliograph, would change the focus and seriously affect the definition of the solar image during the long exposures required with much higher dispersion. As explained in a previous paper, it is hoped that such distortion may be overcome in our new vertical telescope, to which the 30-foot spectroheliograph will be transferred.

Meanwhile, a temporary spectroheliograph of 30 feet focal length has been successfully used with the Snow telescope. This instrument was mounted in the telescope house, between the second mirror of the coelostat and the concave mirror of 60 feet focal length. Instead of the latter, a 5-inch (12.7 cm) objective, of 13 feet (3.96 m) focal length, was used to form the solar image on the collimator slit. The spectroheliograph was built in the Littrow form, with camera slit immediately below the collimator slit; an 8-inch (20.3 cm) objective, of 30 feet focal length, serving at once as collimator and camera lens, and a 6-inch plane grating. As the entire spectroheliograph was supported in a fixed position on piers, it was necessary to cause the solar image to move across the collimator slit, and the photographic plate across the camera slit, at a slow and uniform speed. This was accomplished by mounting the 5-inch image-forming objective and the plate holder (13 feet apart) on arms supported at opposite ends of the movable carriage of the 5-foot spectroheliograph. The driving mechanism of this instrument, supplemented by a counter-shaft for slower speeds, served admirably to give the necessary motion.

On account of the small aperture (only a part of which was used) and the short focal length of the image-forming objective, no appreciable change of focus occurred during the exposures. The small diameter of the solar image (1.4 inches = 3.5 cm) prevented the minor details of structure from being recorded, but enough was shown to serve as a good test of the apparatus and its possibilities.

Several photographs of each spot were made by Mr. Adams and myself on each plate, the first exposure with the camera slit set on the dark line, the other exposures with this slit set on the continuous spectrum, a short distance from the line. In order to eliminate the

effect of increased brightness of background, due to the absence of the dark line from the slit in the continuous spectrum photographs, these were repeated, with different speeds of driving.

The first lines tried were those that are strengthened in the umbra and penumbra and on the photosphere, for a considerable distance from spots. The spectroheliograph plates made with such spot lines show the umbra and penumbra much darker than they appear on the plates taken with the light of the continuous spectrum. The apparent diameter of the spot also appears to be considerably increased, doubtless through the inclusion of the dark area surrounding it.

Lines that are weakened in spots, and on the adjoining photosphere, also give definite effects, though the results so far obtained are less satisfactory than in the case of the strengthened lines.

With a large solar image and good conditions of atmosphere, such a spectroheliograph as the one described above is capable of yielding many interesting results, if used systematically with lines affected in spots and with other dark lines. The 30-foot spectroheliograph designed for the "tower telescope" should, however, be much more efficient in many respects than this temporary instrument. The dark areas frequently observed on the sun with the aid of D, usually in the vicinity of sun-spots, indicate that spectroheliographic records, made with the light of this line, will also prove of great value. In fact, the promise of future work with this and numerous other lines is so great that the efforts of many investigators, provided with the most powerful instruments, will be required to derive adequate results in this extensive field.

II. STEREOSCOPIC PICTURES OF THE SUN

The application of stereoscopic methods to solar work dates back to the time of De La Rue, who secured interesting results through the combination in the stereoscope of direct photographs of the sun taken at various time intervals, up to two days. These pictures, according to his descriptions, showed the spots as depressions and the faculae as elevated regions. Since his time but little appears to have been done in this field.

In the summer of 1906 I thought it would be of interest to combine, with the aid of our large stereocomparator, various plates made with
the Snow telescope and 5-foot spectroheliograph. The results were very satisfactory, showing at once the sphericity of the sun and, to most observers, the protuberant character and cloudlike aspect of the flocculi. If the interval is too short, the effect is imperceptible; if too long, the changes in form of the flocculi, and the large displacements due to the solar rotation, trouble the eye when attempting to unite the images.

The photographs reproduced in Plate XXI were taken on August 22, 1906, at 7 h 26 m A. M. and 5 h 21 m P. M. During this interval the changes in the form of the flocculi are very noticeable, but do not prevent a fairly satisfactory combination of the images when a glass positive is viewed with a stereoscope. It is doubtful whether the half-tone print will give satisfactory results, though the sphericity of the sun should be evident.

As for the appearance of the flocculi as elevated regions, this is much better shown with the aid of the original negatives, or with positives reproduced on the same scale. The stereocomparator, provided with all facilities for centering and adjusting plates, permits the observations to be made in a most satisfactory manner. It should be stated, however, that some observers see the flocculi as apparent depressions rather than as elevations. This, however, is uncommon.

It seems probable that further studies of this character will bring useful results. It has already been possible to detect in this way linear markings on the solar surface, of great extent, which do not readily strike the eye when plates are examined singly. For purposes of measurement, and the detection of minute differences of form, the monocular eyepiece, with micrometer attachment, which is furnished by Zeiss as an accessory of the stereocomparator, is of course to be employed. It nevertheless appears probable that the stereoscopic method will prove to have certain advantages of its own, which will recommend it to those who are engaged in the study of spectroheliograph plates.

April, 1907