Minor Contributions and Notes

NOTE ON RADIAL MOVEMENT IN SUN-SPOTS

In his very valuable contribution to the study of radial movement in sun-spots, published in the *Astrophysical Journal* for June 1913, Mr. St. John states that the usual course of the displaced lines over spots in a solar image 170 mm in diameter "shows no sharp break and the displacement does not suddenly cease at the periphery of the penumbra, but the line gradually returns to its normal course."

This differs from the statement I have published, viz., that there is "an appreciable break or jolt in the lines at the points where they pass from the penumbrae on to the surrounding photosphere."[1]

The deduction from my plates would appear to be that the motion outward ceases abruptly just at the point where the maximum velocity is obtained, and Mr. St. John's observation "seems to remove one great difficulty in explaining the displacement as due to motion."

The question is of course to some extent one of degree, and it is of importance to determine how far outside the penumbral limits the motion can be traced. It appears to me that the photographic evidence is by no means conclusive, because of the inevitable movements of the solar image on the spectrograph slit while the plate is being exposed; and I am inclined to believe from my own results that the limiting distance within which the velocity apparently changes from its maximum value to zero may be very much smaller than is implied in the sentence I have quoted from Mr. St. John.

I have found that the clearness with which the jolt in the lines is brought out in the photograph depends mainly on the exposure time, but also on the state of the "seeing" during the exposure and on the accuracy of guiding. With very short exposure times the guiding factor does not come in appreciably, and if the seeing is

[1] *Monthly Notices of the Royal Astronomical Society*, January 1910, p. 219.

reasonably good the limits of umbra and penumbra in the photographed spectrum will be very clearly defined. In such plates the displacements are greater and end more abruptly than in plates which have had a long exposure, especially if guiding has been necessary and the seeing has been poor. The reason for this is sufficiently obvious, for with long exposures the unsteadiness of the image on the slit tends to spread the displacements at each point over an appreciable length of the lines, and this has the effect both of reducing the amount of the maximum displacement and of spreading the displacement beyond the point of maximum outside the penumbra.

As I am at the present time on a visit to North India I am unable to refer to my records, but I believe that in my best plates the exposure times did not exceed about 30 seconds; and in those plates especially in which the displacements were first detected the definition is unusually fine, the limits of umbra and penumbra being very clearly marked. In these the displacements certainly seem to end exactly at the dividing line between penumbra and photosphere, and I should say from memory that the movement could not be traced so far outside the penumbra as one-fiftieth of the diameter of the spot.

It is not perhaps fair to judge of the definition of Mr. St. John's plates from the reproductions given in his paper, but it is almost inevitable from the form of spectrograph used that the exposures must have exceeded mine many times over, and Mr. St. John himself states that "with the utmost possible care in guiding the slit cannot be . . . . rigorously held upon the same point with respect to the edge of the penumbra." The Mount Wilson plates have an advantage over mine in the somewhat greater linear dispersion, and the much larger scale of the spot image, but I think this may be more than offset by the longer exposure times. Evidence of the longer exposures seems to be discoverable in the generally smaller values of the maximum radial motion which Mr. St. John's results show when compared with my own.

In the Kodaikanal spectrograph high dispersion is obtained by inclining the camera to a high angle with the collimator, actually 60°, and not by the use of a very high-focus lens. This method

magnifies the spectrum in one dimension only, viz., dispersion, instead of in two dimensions as with increased focal length. The intensity of the spectrum, therefore, is considerably greater than in an autocollimating spectrograph giving the same linear dispersion.

It is of great interest to settle the question of the limits of the radial motion. If it is eventually found that the displacements really end abruptly at the edge of the penumbra, the difficulty of the sudden stoppage of the motion might be explained by supposing the photosphere surrounding the spot to be heaped up, so that the reversing layer is at a higher level outside the spot. The moving gases would then be hidden at the point where they would penetrate the raised photosphere.

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