CORRESPONDENCE.

To the Editors of 'The Observatory.'

Anomalous Dispersion in the Sun.

GENTLEMEN,—

In your note with the above title (*Observatory*, October 1915, p. 405) you refer at some length to Dr. Sebastian Albrecht's study of Rowland's solar wave-lengths, the results of which appear to afford strong confirmation of Julius's theory. According to this theory, the shifts of the solar lines towards the red are largely, if not wholly, due to anomalous dispersion, which is an effective agent, together with anomalous scattering, in displacing both solar and stellar lines.

In view of the painstaking and intricate research of Dr. Albrecht, I feel regret at the necessity of showing that these important results may probably turn out to be illusory.

When direct measures of Sun and arc spectra photographed together are made, little or no evidence is found to support Dr. Albrecht's results. Dr. Royds has made a careful comparison of our Kodaikanal measures of Sun and arc, and he is publishing the results of his enquiry in a Bulletin of the Kodaikanal Observatory. I will not repeat here what he has to say, but will confine my remarks to certain subsidiary results which I have been able to obtain.

It is obvious that if lines with companions towards red are displaced by anomalous dispersion towards blue, and lines with companions towards blue are displaced towards red, all close double lines should show a wider separation in the Sun than in the emission-lines of an arc spectrum, where anomalous dispersion can play no part. The difference of separation between Sun and arc will be the sum of the red and violet shifts of each component of a double line, and these shifts, according to the mean results of Albrecht, for separations lying between 0·0 A and 0·2 A, are about 0·0103 A to the red and 0·0073 A to the violet, or a total difference of 0·0176 A. Now any difference of this order of magnitude would, of course, be easily detected in high dispersion spectra. The difference will, however, depend not only on the separation, but also on the intensity of the lines.

To test the matter, I select at random two pairs of iron lines which happen to be well shown on some plates of Sun and arc spectra which I have at hand here. There are three plates of the same region, all taken in the fourth order of our new Anderson grating of 75,000 lines. The solar absorption spectra are from the centre of the Sun's disc, and the emission spectra are from the central part of an iron arc about 5 mm. in length, and with current strength of about 7 ampères. The dispersion is over 2 mm. to the ångström, and the definition excellent. I give the results in the following table:—

λ Rowland.	Origin and Intensity.	Separation (mean of 3 plates). Sun.	Arc.
3918·464	Fe 4	0·101	0·100
3918·563	Fe 4		
3928·075	Fe 8	0·156	0·174
3928·231	Fe 2		

The three plates gave very accordant values, and the mean results are not likely to be in error by an amount exceeding one unit in the last place, although the separation of the first pair in the Sun exceeds Rowland's value (0·099) by two units. In the second pair my measure of the solar separation agrees precisely with Rowland.

It is seen that for the first pair the evidence for an anomalous dispersion-effect is negligible, and if the mean of Rowland's and my measures be taken it is nil.

For the second pair there is the large difference of 18 units, but it is the wrong way for anomalous dispersion, the solar lines being nearer to one another than the arc lines. The difference represents, of course, the difference of shift of the two lines towards the red. Thus the stronger, more refrangible line has a large shift, and the faint companion a very small shift, or possibly no shift at all, since 18 units is exactly equal to the mean of all my measures of the redward shift of the stronger line. If anomalous dispersion were an effective agent in displacing these lines, the red component should have a large shift towards red, whilst the stronger violet component would be much less shifted, the separations being greater instead of less than the arc-line separation*.

It may be noted that Rowland gives a line of intensity 1 on the violet side of the strong line and slightly nearer than the red companion; also there are two more lines on the red side, each given as of intensity 2. These lines, it might be argued, would so

* Possible differences of shift due to a difference of pressure between arc and Sun need not be considered in these comparisons, since the arc was photographed at a pressure of ⅔ atmosphere only.

complicate matters that little residual effect could be expected. Rowland's intensities for this group are, however, very misleading: the line on the violet side is so faint and involved in the shading of the strong line that its existence even is questionable in my plates; also the two lines on the red side are of considerably less intensity than the red companion to the strong line.

In my research on the displacements of the solar lines, I find that measures have been made of five other pairs of lines in less refrangible regions of the spectrum*. Of these, only one gives an appreciably larger separation in the Sun than in the arc, viz., the well-known pair b_3, which gives seven units in favour of anomalous dispersion. The mean separation of all the pairs is 0·237 A, and is identical for Sun and arc, thus giving no support to the new theory.

In *Kodaikanal Observatory Bulletin*, No. 36, I have shown that the stronger solar lines are, in general, much more shifted than the weak lines, and the measures given above for the lines at 3928 are an instance of this rule. Dr. Albrecht, by his method of treating the data, eliminates the general shift of the lines towards the red, and deals only with the residual shifts; but he has ignored this most important factor depending on intensity, which might modify his results materially, and in a direction tending to neutralise his residuals—for it so happens that his list of lines with companions towards violet contains lines of higher intensity than the list with companions towards red, the mean intensities being 5·1 and 2·9 respectively. This alone, however, will not account entirely for the plus and minus residuals found by Albrecht, which certainly cannot readily be explained away; but it is well known to those who have had occasion to use Rowland's wave-lengths in reducing spectrum measurements that, in addition to the systematic errors allowed for by Albrecht, there are considerable accidental errors affecting even the well-defined lines, and any conclusions based on residuals in the third decimal place are, in my opinion, untrustworthy.

Apart altogether from the question of shifts in the solar lines, I may refer to the fact that the existence of bands due to anomalous dispersion, or anomalous scattering, has never been demonstrated in the solar spectrum. If these bands are present in sufficient intensity to affect materially the positions of the Fraunhofer lines, then there must be a clearly marked difference between the width and character of the absorption-lines and the emission-lines of the chromosphere. Is there any such difference? Certainly not in the case of the hydrogen line a, for, no matter what dispersion may be employed, the emission line at the base of the chromosphere exactly matches the absorption-line; even the remarkable projections and other irregularities at the edges of the

* *Kodaikanal Observatory Bulletin*, No. 39.

line, due probably to turbulent movements of the gas, are reproduced in the emission-line. As regards the finer chromosphere-lines, I have been unable to detect any difference in the character of the bright lines of the flash spectrum and the corresponding dark lines shown in contiguous strips of the photosphere spectrum in eclipse photographs.

The vast majority of the Fraunhofer lines appear exceedingly narrow and sharply defined with ordinary dispersive power, and this in itself seems to tell against the presence of any underlying bands, which might be expected to show diffuse edges. It is true, however, that with high dispersive power many of the finer lines are found to be distinctly wider than the corresponding arc lines when these are observed at the centre of a long arc.

I now challenge the advocates of anomalous dispersion to produce evidence of these bands, in which the true absorption-lines are supposed to be immersed. I am, Gentlemen,

Yours faithfully,

Srinagar, Kashmir,
1915, November 22.

J. Evershed.