

On the Photographic Method of Registering Absorption-Spectra, and its Application to Solar Physics

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1879 Proc. Phys. Soc. London 3 43

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VI. *On the Photographic Method of Registering Absorption-Spectra, and its Application to Solar Physics.* By Capt. W. DE W. ABNEY, R.E., F.R.S.

THERE are certain difficulties in registering the visible absorption-spectra as observed, dependent on the eye of the observer, and on his power of representing correctly what he sees; and it is owing to these deficiencies that curious mistakes have been made in endeavouring to draw absorption-phenomena. Up to the present time it has been, comparatively speaking, useless to attempt such registration by means of photography, owing to the fact that merely one part of the spectrum was impressionable by the silver salts employed as a sensitive medium. Since my discovery that silver bromide could be prepared in such a molecular state as to be sensitive to the whole spectrum (visible, ultra violet, and ultra red*), the difficulty in the employment of photography is done away with; and it should be taken into use as much as possible, so as to eliminate the errors of eye-observations. A natural objection would arise at first sight, viz. that for the different parts of the spectrum the sensitiveness of the silver compound is materially different, and that consequently the absorption at different parts cannot be well compared. The objection vanishes, however, at once, if ordinary precautions are taken; and as an illustration I will take a case.

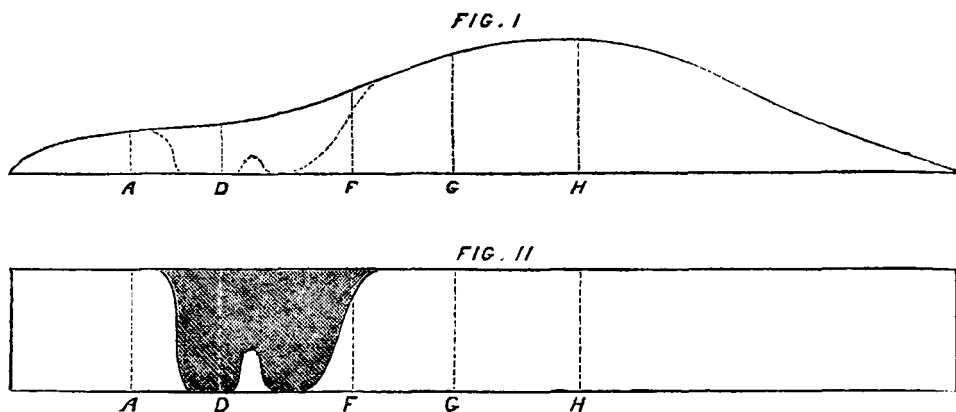
The absorption of a violet (cobalt) glass was required to be registered photographically. A spectroscope having two prisms of 62° was judged to give sufficient dispersion; and a lens was used in the camera of a focal length of about 2 feet. This gave a spectrum about 4 inches long, including the visible and invisible radiations. The plate having been placed in the camera, the top half of the slit was shielded, and sunlight was reflected onto the bottom half for two minutes; the sunlight was diverted, and the absorbing medium (in this case violet glass) was placed in front of the slit†, the lower half

* Except those radiations of low amplitude and large wave-length which are emitted by bodies at ordinary temperatures.

† When this paper was communicated to the Physical Society, Prof. Macleod suggested that the absorption of a liquid might be better demonstrated if a wedge-shaped vessel containing it were placed in front of a

covered up, and sunlight again reflected onto the top half of the slit for two minutes more. The plate was then developed, and a print taken from the negative. A scale of shade having been prepared, the following diagram was drawn from the measurements made with it.

The top continuous curve of fig. I. shows the intensity pro-



duced on the plate by unscreened sunlight. The dotted line in the same figure shows the curve obtained when the cobalt glass is interposed.

I would here remark that care is necessary not to introduce an error, as it must be remembered that the shades produced photographically have not the same gradations as the intensity of light, as Bunsen and Roscoe first showed.

Fig. II. shows the absorption of the violet glass, on the presumption that the intensity of the radiations is equal throughout the spectrum, an assumption which is very generally made.

I have found that it is convenient in taking these spectra to modify this method. The absorption produced by potassium chromate takes somewhat of a wedge-form, shading off from darkness in the violet to total transmission at the least-refrangible end of the spectrum. If a dilute solution of this

longer slit, of which a small image might be produced at the focus of the collimating lens. This is quite practicable, as Professor Macleod and myself have found by actual experiment; and if the image of coloured liquid be corrected by a similar wedge of colourless liquid of nearly the same specific gravity, there is no inconvenience attaching to it.

substance be interposed in each case between the source of light and the slit for half the time of exposure, we have an impression of the spectrum the varying intensity of which is less marked than if such an artifice be not employed.

I may here remark incidentally that the passage of light through an aqueous solution seems to interfere very little with the intensity of the photograph at the least-refrangible end. I had looked for a marked diminution, but have scarcely noticed it.

In photographing these absorption-spectra the source of light should be brilliant: sunlight, the image of the incandescent points of the electric light, or the oxyhydrogen light, may all be used; but I prefer sunlight, as we are enabled by the Fraunhofer lines to fix the locale of the absorption-bands more readily than with the other two.

Another application of this method is to the solar spectrum itself. Researches have shown that the bright-line spectra of incandescent compound bodies should lie in the least-refrangible end of the spectrum, and that to discover these a search must be made in these regions. As far as the visible spectrum is concerned such a search has been made; but we have yet to examine those regions which are invisible. At a low temperature it is quite possible that the compound bodies should give off vapours of the compound, whilst at high temperatures, such as that of the electric arc, they are probably dissociated. If, then, we wish to ascertain the existence of such compounds in the photosphere, we are driven to compare the solar spectrum with the bright-line spectra of the various compounds when heated at such low temperatures as those of the ordinary colourless gas- or spirit-flame. To photograph portions of such spectra (even the most "actinic" region of the spectrum) is a feat of uncommon difficulty; and it would require hours, I might say days, of exposure to impress lines in the red-region. Such an attempt would be practically useless, as we can accomplish the same end in as many minutes by an indirect method as it would require hours by the direct method.

The following illustration will show how it can be accomplished. The top half of the slit is covered as before, and sunlight reflected onto it, and the spectrum is impressed

on the photographic plate. The bottom half is next covered up, and a flame, in which the compound to be examined, is placed in front of the slit; the sunlight is then caused to traverse the flame, and a second spectrum is impressed on the plate through the top half of the slit.

New absorption-lines are thus formed in the solar spectrum, or *those already existent are intensified*, as is already well known. As an example, lithium chloride was heated in the flame, and the known line of lithium was found reversed between B and C, though absent in the spectrum of sunlight, and a faint line lying in the spectrum below the red was found intensified. By following out this plan we perhaps may eventually establish the existence of compounds in the solar photosphere. By using the light emanating from the white-hot carbon points of the magnetoelectric light to produce a continuous spectrum, and by burning the metallic compounds as before for one spectrum, and then by using sunlight to give the other spectrum, confirmatory evidence would be obtained. I may remark that I have photographed bright-line spectra of lithium, and got the same line in the ultra red as that obtained reversed. This method seems to promise to be a new weapon of attack in solar physics, more especially in this ultra-red portion.

VII. *On Spectra of Lightning.*

By ARTHUR SCHUSTER, *Ph.D., F.R.A.S.**

ALL observers of lightning-spectra agree in having seen the line-spectrum of nitrogen; but most of them have seen, in addition to this, sometimes a continuous spectrum, sometimes a band spectrum, the chemical origin of which is unknown.

The following historical summary may give an idea of our knowledge on that point.

Prof. Kundt (*Pogg. Ann.* cxxxv. p. 315) observed a line spectrum consisting of one or two lines in the red, some very bright ones in the green, and some less bright ones in the blue. He mentions that the lines are not always seen together.

* Read February 22nd.