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XXVII. *On the Magnetic Affection of Light, and on the Distinction between the Ferromagnetic and Diamagnetic Conditions of Matter.* By MICHAEL FARADAY, *F.R.S., Foreign Associate of the Academy of Sciences, &c.**

WHEN a ray of polarized light and lines of magnetic force pass simultaneously and parallel to each other through a transparent solid or liquid medium not possessing forces of double refraction, the ray is rotated according to a simple law of action, which I have expressed in the last part of the Philosophical Transactions†. When such a ray passes through certain specimens of rock crystal, oil of turpentine, &c., it is also rotated according to a natural law well-known, without any reference to magnetic force. A very striking distinction exists between these two cases of rotation, though they at first appear to be the same; for the former rotation is dependent in its direction upon the lines of magnetic force, and not upon the position of the observer or the course of the ray of light, whereas the latter is dependent upon the position of the observer or the course of the ray.

Upon consideration it appeared that the peculiar character of the magnetic rotation might be made available in exalting the final effect of the magnetic force upon the ray, and also in demonstrating many important points in a more marked manner and higher degree than had yet been possible; and upon referring the idea to experiment, it was found to be true. The following pages contain some of the results.

A parallelopiped of heavy glass 0·7 of an inch square and 2·5 inches long, had the two ends polished and silvered. The silvering was then removed from a space about 0·1 of an inch wide along one of the edges of one end, and also from a corre-

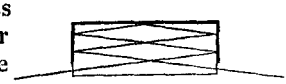
* Communicated by the Author.

† 1846, part i. pp. 4, 5. [Phil. Mag. vol. xxviii. pp. 298, 299.]

sponding space on the other end, except that the parts cleared were on the contrary sides of the parallelopiped; so that each end was furnished with a good plane reflector, but these overlapped each other (fig. 2). In consequence of this arrangement, a ray of light could be transmitted diagonally across the length of the piece of glass; or the ray, after entering at one end, could be reflected two or more times within the glass and then passed out.

A similar piece of heavy glass was silvered at the two ends and one side of the prism; and the silvering was then removed at the ends for the space of 0·1 of an inch from those edges which were the furthest from the silvered side (fig. 1). A ray of light passing in at the unsilvered part of one end with a certain degree of obliquity, could be reflected at the other end, then at the side, and again at the first end, passing thus three times along the glass and finally out at the second end. At other inclinations the ray would pass five, seven, nine, eleven, or a greater number of times along the glass before it issued forth on its course through the air to the eye of the observer.

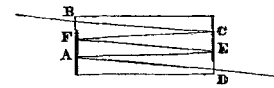
Fig. 1.



Either of these pieces of glass could produce the desired result of repeated reflexions within, but the first form was found most convenient in use. When a strong light was employed, it was not difficult to follow the series of images produced by successive reflexion up to the ninth or tenth image, these corresponding of course to a transit of the ray seventeen or nineteen times along the substance of the glass. A little change of position of the silvered glass between the Nichol's prisms used as the polarising and analysing apparatus, was sufficient to bring any one of these images into view, the glass being at the same time under the full influence of the electro-magnet, or the helix, employed to generate lines of magnetic force. A further advantage is gained if the ends of the piece of glass are not quite parallel to each other, the sides proceeding from the edges where the ray enters and issues forth being in a very slight degree different in length. This arrangement causes the series of reflected images to open out if seen at one end and to close up if seen at the other, and thus the observation of a particular image or the simultaneous comparison of two or more images, is favoured.

On considering the effect of this arrangement, it is evident that if ABCD represent a trough of solution of sugar, or any other body having the ordinary rotating influence over a polarized ray, then a ray sent in at D and passing out at A

Fig. 2.



would be rotated to a certain amount. But if, instead of proceeding onwards at A, it were reflected by the surface A F to E, and were there observed, it would be found to have received no rotation, for the effect produced in going from D to A would be exactly compensated by its return from A to E. Or if the reflexions were made more numerous and recurred at E F and C, so that the ray should traverse the body five times, still an amount of rotation equal only to that which its passage once along the substance could effect would be finally produced.

Such would not be the case if A B C D were a diamagnetic, rotating the ray by means of magnetic force; for then, whichever way the ray was passing, it would still be rotated in the *same* direction in relation to the lines of force. So if observed issuing forth at A, it would have an amount of rotation (which we may call right-handed) equal to what one transit across the diamagnetic could produce; if observed at E, it would have an amount of left-handed rotation double the amount of the first or unit quantity; if observed at F, it would have three times the first amount of right-handed rotation; if observed at C, four times the amount of left-handed rotation; and at B would possess five times the original amount of right-handed rotation.

This was confirmed by the result of an experiment. The great magnet described in the Philosophical Transactions* was employed, and the parallelopiped of glass (fig. 2) submitted to its powers; the direct ray, or that producing the first image of the luminous object, acquired a right-handed rotation equal to 12°. Moving the glass a little the second image was brought into view, or that produced by the ray which had traversed the glass three times, and its rotation was 36°. The third image was then observed, and the rotation of the ray producing it was 60°, as nearly as my rough apparatus could measure angular quantities. The same general results were obtained with the second piece of glass described.

The experiment proves in a very striking manner, that whichever way the ray of light is passing through the diamagnetic, the direction of its rotation depends essentially and alone upon the direction of the lines of magnetic force.

It also proves and manifests in a manner not to be mistaken, the difference in this respect between the magnetic rotation of

* 1846, p. 22, par. 2247. Phil. Mag. vol. xxviii. p. 398.

the ray and that produced by quartz, sugar, oil of turpentine, and such bodies.

Either by independent or by conjoint observations of the different images, it proves that the effect is proportionate to the length of ray submitted to the magnetic force (Experimental Researches, 2163); for the unit length and multiples of the unit length may be observed at once, the intensity of the magnetic force and other circumstances remaining unchanged.

It permits the attainment of a far greater degree of accuracy in the measurement of the amount of rotation of a given ray, or in the estimation of the comparative degrees of rotation of the different coloured rays.

The form of the arrangement makes a short piece of any given diamagnetic, as a crystal, &c., sufficient for an experiment, which would not suffice if the ray were passed but once through it.

It allows of the concentration of the magnetic force by an approximation of the poles, when a magnet is used, so as to exalt the effect; or to render a weak magnet equivalent to a stronger one, so that even good ordinary magnets may now be made available. Or if a helix be used, a much shorter and weaker one than that which before was necessary, may now be employed.

[*Note.*—A heavy domestic affliction having suddenly taken the author's attention away from this paper, the remaining part must be deferred to the next number of the Phil. Mag.]

XXVIII. *On the Blue Compounds of Cyanogen and Iron.* *By* Alexander W. Williamson, *Ph.D.**

IT is a well-known fact that the different substances which pass by the general name of prussian blue, when prepared in the usual way, are not pure combinations of iron, but invariably contain potassium, of which the quantity varies according to the circumstances under which they are formed. It has been the subject of frequent experiment to decide whether this potassium should be considered as an admixture or as an essential constituent, and in the latter case to discover what part it plays in the constitution of the compound. Among those various researches we may confine ourselves to the consideration of those of Berzelius† and Gay-Lussac ‡.

Gay-Lussac found that prussian blue retains potassium so

* Communicated by the Chemical Society; having been read March 16, 1846.

† Poggendorff's *Annalen*, vol. xxi. p. 490. ‡ Ibid. vol. xxv. p. 385.