Dr. P. ZEEMAN. *On the influence of magnetism on the nature of light emitted by a substance. Appendix to No. 33.* (Phil. Mag. March 1897).

Since the publication of my original paper in the Proceedings of the Academy at Amsterdam, and while the present paper was in the press, I have become acquainted with two attempts, till now unknown to me, in the same direction, and also with the original account of FARADAY's experiment referred to in § 1 [1]). The last is to be found in FARADAY's 'Life' by Dr. BENCE JONES, vol. II. p. 449 (1870), and as it is extremely remarkable I will reprint it here:—

»1862 was the last year of experimental research. STEINHEIL's apparatus for producing the spectrum of different substances gave a new method by which the action of magnetic poles upon light could be tried. In January he made himself familiar with the apparatus, and then he tried the action of the great magnet on the spectrum of chloride of sodium, chloride of barium, chloride of strontium, and chloride of lithium."

On March 12 he writes:—"Apparatus as on last day (January 28), but only ten pairs of voltaic battery for the electromagnet.

»The colourless gas-flame ascended between the poles

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of the magnet, and the salts of sodium, lithium, &c. were used to give colour. A NICOL's polarizer was placed just before the intense magnetic field, and an analyser at the other extreme of the apparatus. Then the electromagnet was made, and unmade, but not the slightest trace of effect on or change in the lines in the spectrum was observed in any position of polarizer or analyser.

»Two other pierced poles were adjusted at the magnet, the coloured flame established between them, and only that ray taken up by the optic apparatus which came to it along the axis of the poles, *i. e.* in the magnetic axis, or line of magnetic force. Then the electromagnet was excited and rendered neutral, but not the slightest effect on the polarized or unpolarized ray was observed."

»This was the last experimental research that FARADAY made."

In 1875 we have a paper by Prof. TAIT, who has kindly sent me a copy. »On a Possible Influence of Magnetism on the Absorption of Light, and some correlated subjects" (Proc. Roy. Soc. of Edinburgh, Session 1875—76, p. 118). Prof. TAIT remarks that a paper by Professor FORBES, read at the Society, and some remarks upon it by MAXWELL, have recalled to him an experiment tried by him several times, but which hitherto has led to no result. Then the paper proceeds:—

»The idea is briefly this.—The explanation of FARADAY's rotation of the plane of polarization of light by a transparent diamagnetic requires, as shown by THOMSON, molecular rotation of the luminiferous medium. The



plane-polarized ray is broken up, while in the medium, into its circularly-polarized components, one of which rotates with the aether so as to have its period accelerated, the other against it in a retarded period. Now, suppose the medium to absorb one definite wavelength only, then—if the absorption is not interfered with by the magnetic action—the portion absorbed in one ray will be of a shorter, in the other of a longer, period than if there had been no magnetic force; and thus, what was originally a single dark absorption line might become a double line, the components being less dark than the single one."

Hence here the idea is perfectly clearly expressed of the experiment, tried in vain; an idea closely akin to that of § 15 above [1]), both being in fact founded on KELVIN's theory of the molecular rotation of the luminiferous medium, though not directly applicable to the experiment of § 9, in which case the lines of magnetic force are perpendicular to the axis of the tube.

In the second place I have to mention two papers by the late M. FIEVEZ, to which attention has been drawn by M. VAN AUBEL, in a letter to Prof. ONNES and intended for communication to the Academy of Sciences, Amsterdam. Prof. ONNES read the letter at the January meeting, and made at the same time some explanatory remarks of which in the following I make free and extensive use [2]). The papers referred to are:—

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[1]) Comm. N°. 33.

[2]) As the remarks of Mr. ZEEMAN resume the paper of mine, it seems superfluous to give a translation of it. H. KAMERLINGH ONNES.

M. FIEVEZ, »De l'Influence du Magnétisme sur les caractères des Raies spectrales" (*Bulletin de l'Acad. des Sciences de Belgique,* 3e série, tome IX. p. 381, 1885); and FIEVEZ, »Essai sur l'Origine des Raies de FRAUNHOFER, en rapport avec la Constitution du Soleil" (*l. c.* 3e série, tome XII. p. 30, 1886). Here experiments are described as in §§ 4 and 13 of the present paper. Nothing, however, is observed about the widening of the absorption-lines, nor about the polarization of the emitted light. The results obtained by M. FIEVEZ merit careful attention and consideration. He has observed with a flame in a magnetic field not only widening but reversal and double reversal of the lines of the spectrum, the lines at the same time becoming more brilliant. Unfortunately quantitative details are not given. The facts observed in some cases by FIEVEZ are qualitatively not in accordance with my observations or what is to be deduced from my results. Hence even in the cases where the results are qualitatively in accordance, the question remains whether FIEVEZ has observed *the same phenomenon.* The field used by FIEVEZ seems to have been more intense than the one I had at my disposal. Is it possible perhaps to account in this manner for the »double renversement (c'est-à-dire l'apparition d'une raie brillante au milieu de la raie noire élargie)"? I think the answer must be in the negative. For, arguing from § 19, a line must widen, or else, the field being very intense, become a triplet. We cannot but understand from FIEVEZ's description of the experiment that the light was emitted perpendicular to the lines of force. Now the double reversed line of FIEVEZ is not



the triplet to be expected from theory, for it is expressly stated by FIEVEZ that the line experimented upon is not the simple line of the spectrum, but one previously widened and reversed (by some agency independent of magnetism). By the action of magnetism a brilliant line in the centre of the black line appears. Hence perhaps one may interpret the case of double reversal as a direct action of magnetism, but then only as a doubling of the absorption-line and not as a division of the original line into three parts. As the application of LORENTZ's theory given in § 18 is confessedly only a very first sketch, further theoretical and experimental evidence is wanted before we are able to decide whether in the experiment of FIEVEZ a specific action of magnetism on light or perturbing circumstances have been prevalent. Indeed one may make the same objection to M. FIEVEZ's experiment as I myself have made to my own analogous experiment in § 6.

The whole of the phenomena observed by FIEVEZ can readily be attributed to a change of temperature by the well-known actions of the field upon the flame (change in its direction or outline, magnetic convection, &c.); and the last sentence of his paper states that »les phénomènes qui se manifestent sous l'action du magnétisme sont identiquement les mêmes que ceux produits par une élévation de température." The negative result obtained by FIEVEZ with absorption-spectra would without further consideration (as in § 12 [1])) point

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in the same direction. The inference to be drawn from FIEVEZ's experiments alone would rather be, I think, that the temperature of the flame is changed in his experiments than that a specific action of magnetism on the emission and absorption of light exists. By experiments already in progress I hope to settle the dubious points.

Summarizing we may say:—Had the experiments of FIEVEZ come to my knowledge they would have been a motive for me to further investigation, FIEVEZ not having prosecuted his inquiry up to a decisive result. At least at present it remains even doubtful whether the phenomenon observed by FIEVEZ with a magnetized flame is really to be attributed to *the specific action of the magnetic field on the period of the vibrations of light*, which I have found and undoubtedly proved by the experimental confirmation of LORENTZ's predictions.