Citation:

P. Zeeman, On an Asymmetry in the Change of the spectral Lines of Iron, radiating in a Magnetic Field, in:
KNAW, Proceedings, 1, 1898-1899, Amsterdam, 1899, pp. 98-100

molecule in the field, the simple spectral line must be separated into a p-fold line, in such a way, that the position of the different components is symmetrical to the right and left of the original line. *From this it follows, that if p is odd, one component remains at* the place of the original line.

It seems however very difficult to conceive a system, having really, as is necessary for quadruplets, four equivalent degrees of freedom, especially if in addition to this, it is required that the values of α and β must be independent of the direction of the magnetic force, relatively to the molecule. I have not been able to find out a system, really fulfilling these conditions. It is true, it might be argued that the very existence of a quadruplet *proves* the equality of four frequencies, when there is no magnetic field, and hence that the above theory of the quadruplet must be true, even though the mechanism has not yet been found out. However I have some scruples to be satisfied with this view of the case, for I think, it is not yet quite certain, that the vibrations which produce light are really to be described by equations of the form (1).

Physics. — *On an Asymmetry in the Change of the spectral Lines of Iron, radiating in a Magnetic Field.* By Dr. P. ZEEMAN.

1. It is known that in the elementary treatment of the influence of magnetic forces on spectral lines according to LORENTZ's theory it is sufficient, if only one spectral line is considered, to suppose that in every luminous atom is contained one single moveable ion moving under an attraction proportional to the distance from its position of equilibrium. All motions of such an ion can be resolved into linear vibrations parallel to the lines of force and two circular vibrations, righthanded and lefthanded perpendicular to the lines of force. The period of the first mentioned vibration remains unchanged, those of the last are modified, one being accelerated and the other retarded. The doublets seen along the axis of the field, the triplets seen across it are in this manner simply explained and also the observed polarisation-phenomena. Besides we must expect according to the theory that the outer components of the triplet are of equal intensity and likewise the two circularly polarized components of the doublet. Eye observations as well as the negatives taken by myself and others have always confirmed till now this most simple symmetrical distribution of intensities. The question arises cannot the external magnetic forces, sufficient to direct the molecular

currents assumed in the ionic theory of magnetism [1]), favour the circular vibrations more than those along the lines of force [2]). If this be assumed we are also compelled to admit that the revolving of the ions takes place more in a given direction than in the contrary. Hence then there must be a difference of intensity between the two outer components of the triplet and between the two components of the doublet. Although the ordinary magnetism of the highly-magnetic substances has probably disappeared in the spark, it seems rather natural to examine in the first place iron, nickel and cobalt in search of a phenomenon in which the „molecular currents" of Ampère (or that part of these currents, which is produced by the motion of the light-ions) would manifest themselves optically. However it seems to me by no means decided beforehand, that other substances would not exhibit something of this kind. I have however investigated in the first place iron.

The first results obtained were much promising. In the field used several of the iron lines exhibited on the negatives a more intense component at the less refrangible side of the spectrum. Further inquiry has however shown that this seemingly positive result seems to be of no value. I will give the results of my experiments only in extract. Before describing them, it may be remarked, that, if a directing influence, as mentioned, exists, we must expect that the component at the less refrangible side must be intensified and in the case of the triplet as well as in that of the doublet. The sign of the charge of the ions cannot have any influence upon this result.

2. Negatives were taken in the spectra of the third and second orders obtained by means of a Rowland grating (radius 10 ft., 14438 lines to the inch). More accurately was studied the part of the spectrum between 3000 and 4000 A. U., when viewed in the two principal directions across and along the lines of force. The vast majority of the iron lines were, with the field used, resolved into doublets, triplets, quartets etc. perhaps only three or four lines seemed unaffected. Now I found in the case of a few lines inequality between the outer components of a triplet across and of the corresponding

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[1]) cf. Richarz. Wied. Ann. **52**, p. 385, 410. 1894.

[2]) cf. Lorentz. Versl. Ak. Amsterdam, October '97, p. 213. [It was pointed out by Lorentz in the article referred to, that the phenomena observed by Egoroff and Georgiewsky can be explained, without any hypothesis of the kind mentioned by the absorption, which the rays from the posterior part of the flame undergo in the anterior part.]

doublet along the lines of force. On the negative the component at the red side of the spectrum was darker, independently of a commutation of the current. Of course the difference of intensity is dependant upon the time of exposition. Upon some of the negatives the difference was for a special line perhaps 50 or 100 percent.

However it was plain enough, that the outer components of the triplets and also the two components of the doublets were, in the case of the *strong* iron lines, of equal intensity. Now in the case of feebler lines, let *L* be one of them, perturbations will be possible due to the overlapping of one of the components of a „normal" triplet or doublet and a feeble line, say but slightly affected by magnetism. The latter line can 1^0 be present near *L* in the same spectrum; or 2^0 belong to a spectrum of another order as the line *L*; or 3^0 by the very presence of the field a special line may become relatively to other lines more intense or a new line may be originated. By taking negatives with different fields it will of course be possible to evade difficulties from these three causes, at any rate, if the supposed line is thin. We can however by taking also negatives in absence of the field exclude 1, and by taking negatives in spectra of different order or by cutting off any interfering spectrum in using absorbents 2. Having done this, it appeared that also case 3 sometimes occurs; the intensity of the iron lines relatively to the air lines varies considerably and the mutual intensity of the iron lines appreciably. New lines appear, at least lines absent on negatives taken with the field off, became distinctly visible, while yet the intensity of the field was insufficient to resolve the lines in triplets etc.

The last mentioned perturbation is of course most treacherous. Using however fields of varying intensities, I could avoid perturbation 3. Excluding however 1, 2, 3, only triplets, doublets etc. remained, which, I think, can only be called quite symmetrical. Hence till now there is no evidence for a directing influence of the magnetic field on the orbits of the light-ions. ^{1})

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^{1}) cf. PRESTON, Phil. Mag. Vol. 45, p. 333, 1898.

(August 9th 1898).