

Correction on Previous Reports Concerning the Hyperfine Structure of Y II Lines

In a recent letter to the editor and at the Washington meeting of the American Physical Society the writers¹ reported some structure appearing in the spectrum of yttrium II. At that time, the structure was considered to be hyperfine structure. A more detailed examination has shown that this is not true, and it is the purpose of this letter to correct the error. Since the original report was submitted, the same lines have been photographed when using a different sample of yttrium. This new sample was obtained from A. D. Mackay in New York. With the new sample the same results were obtained for the line $\lambda 4900$, but the intensity ratio of the components to the line $\lambda 4786$ was found to vary with the samples. The consistent behavior of the line $\lambda 4900$ may be explained by assuming that the component is a heretofore unidentified fine structure line in the spectrum of yttrium I. The wave number of this component is found to check the wave number of the yttrium I transition ${}^4F_{23}^0 - {}^4F_{31}$ calculated from the data given by Meggers and Russell.²

Because of the small dispersion of the spectrograph used, and the numerous Y lines in the neighborhood of $\lambda 4854$, it was impossible to get photographs on which the interference fringes of the lines did not overlap. This situation prevented an accurate check of the intensity ratio for the components of $\lambda 4854$.

Both samples were examined for impurities and faint traces of erbium and gadolinium were found. These impurities are estimated to be less than one percent and the observed structure cannot be explained by their presence. Furthermore, the structure of the lines $\lambda 4786$ and $\lambda 4854$, which certainly exists, is not explainable as radiation from known terms in yttrium I or yttrium II. At present, the writers are unable to explain this structure, a brief resumé of which is given in Table I. Apparently it is not hyperfine

TABLE I. Structure of yttrium lines.

λ obs.	ν obs.	ν calc.	Int. ratio (Chem. Dept.)	Int. ratio (Mackay)	Identification
4900.130	20401.94		3.9	3.9	Y II ${}^3F_2 - {}^3D^0_2$
.098	20402.07	20402.0	1	1	Y I ${}^4F^0_{23} - {}^4F^0_{33}$
4786.580	20885.92		3.7	1.6	Y II ${}^3F_3 - {}^3D^0_3$
.529	20886.14	?	1	1	?
4854.962	20591.75			1	?
.870	20592.14	?		1.8	Y II ${}^3F_2 - {}^3D^0_1$

structure; a conclusion which agrees with the results of Schüller and Schmidt.³

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June 5, 1935.

¹ Kruger and Challacombe, Phys. Rev. **47**, 509 (1935); **47**, 798 (1935).

² Meggers and Russell, Bur. Standards J. Research **2**, 733 (1929).

³ Schüller and Schmidt, Naturwiss. **22**, 838 (1934).

On Bitter's Patterns

F. Bitter,¹ by the sedimentation method, has obtained regular striations on ferromagnetic single crystals. His results suggest that the line-up of the magnetic moments in

these crystals is not homogeneous. There is hardly any doubt that Bitter's patterns are characteristic for the thermodynamically stable state of solid iron, nickel, etc. His experiments therefore constitute a direct proof for the contention, that a *perfect* (thermally stable) crystal cannot completely be described by an ideal atomic lattice, but that there exist *secondary structures*, whose characteristic lengths D are large compared with the ordinary lattice constants $d \sim 10^{-8}$ cm.

I here advance in a preliminary way a suggestion concerning the characteristic lengths D of magnetic secondary structures.

The energy of a magnetic moment μ in an effective field H is proportional to $H\mu$. Associated with it is a Larmor frequency, roughly given by

$$\nu = H\mu/h, \quad (1)$$

where h is Planck's constant. All of the magnetic moments μ throughout the crystal are in a state of *cooperative* interaction,² the theory of which necessitates the consideration of *retardation* effects, caused by the finiteness of the velocity of light c . Because of these retardation effects the magnetization will form a system of *standing waves*, with the wavelength prototype

$$D = c/n\nu = ch/nH\mu = (ch/nH_s\mu)H_s/H, \quad (2)$$

where H_s is the field at saturation and n a pure number of the nature of a refractive index. It is approximately $\mu H_s = k\theta$, where θ is the temperature of the Curie point. Finally

$$D = (ch/nk\theta)H_s/H. \quad (3)$$

As H increases, D decreases, in accordance with Bitter's experiments. D is minimum for $H = H_s$. Let $\theta = 1000^\circ \text{Abs.}$ and $k = 1.37 \times 10^{-16}$ ergs, then

$$D_{\min} = 1.4 \times 10^{-3}/n \text{ cm}, \quad (4)$$

which is of the same order as the smallest observational values.

The stabilization of the standing waves in a fixed position is probably due to the presence of imperfections and to surface actions. In a perfect real crystal imperfections would be absent, and the surface should hardly be capable of fixing the standing waves in a definite position, so that in this case the striations will probably be washed out.

A more complete theory must take into account the crystalline structure. Also it is clear, that crystals possess a multitude of normal modes, which may account for the complexity of the observed patterns.

Similar considerations can be advanced concerning the ordinary secondary structure in all crystals. In this case the standing waves are associated with the *optical* normal modes.³ In passing we remark that the present quantum theory of the metallic state must, in some important instances, be at fault, because of the neglect of electromagnetic retardation effects.

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California Institute of Technology,
June 6, 1935.

¹ F. Bitter, Phys. Rev. **38**, 1903 (1931).

² F. Zwicky, Phys. Rev. **43**, 270 (1933).

³ For the characteristic lengths involved see F. Zwicky, Proc. Nat. Acad. Sci. **19**, 822 (1933).