Some Theoretical Considerations on Anomalous Diffraction Gratings

I wish to publish some theoretical considerations about the phenomena shown by certain gratings in the experiments of Wood[1] and Strong.[2] Both consider as a "typical case" the following phenomenon exhibited by their grating *C*. Let us consider the intensity of a continuous spectrum as a function of the increasing wave-length. Then: (a) at certain characteristic wave-lengths (Rayleigh's wave-lengths) the intensity falls nearly to zero and shows a sharp edge; (b) after having been nearly zero for an interval of the order of 100A (dark band), the intensity rises to abnormally high values and shows a bright band without sharp edges.

Part (a) may be explained by Rayleigh-Voigt's theory.[3] I wish to point out that the derivative of that second-order term, which carries the irregularity in the distribution of intensity, becomes infinite for Rayleigh's wave-lengths. Hence a sharp edge in the intensity must be present in every grating, but only the geometrical characteristics determine whether the irregular term is the important one for the intensity, or not.

In connection with part (b) of the phenomenon the following should be noted. (I) A suggestion of Langer related by Wood: Since the position of the bright bands depends upon the optical constants of the metal of the grating, these bands would be connected with that part of the diffracted waves which travels with different velocity along the surface of the grating. (II) Rayleigh's condition for the phenomenon (a) means that the wavelets with velocity c diffracted by a groove must reach the neighboring grooves in resonance with the incident wave; similarly when slower waves were diffracted by the grooves, one would expect effects of resonance for larger wave-lengths. (III) Applying the principle of Huygens to the diffraction, we must remember that an oscillator on a metallic surface sends also Sommerfeld's superficial waves,[4] which, to be noted, are polarized with their magnetic vector parallel to the surface, as the anomalously diffracted light.

Starting from these considerations I made an attempt to extend Rayleigh-Voigt's theory, including superficial waves on the grating. This extension is not quite formally satisfactory, but it seems to me to be sufficiently justified. It explains the essential features of the phenomenon (b); the width of the bright bands is due to the absorption of the superficial waves, and their distance from Rayleigh's wave-length depends upon the strong variation of the optical constants with wave-length. Wood's result that a negative image of the bands is found in the spectrum of the regularly refracted light, is easily understood from the point of view of the approximation method.

The theory was checked by a rough numerical evaluation starting from suitable data. In carrying out the calculations it appears clearly that the whole phenomenon of the bands is extremely sensitive to changes of the form of the grating. Hence one has to think that every anomalous grating will show its own type of bands. It follows also that the study of grating *C* was very useful in distinguishing phenomena (a) and (b) which seem to be due to quite different physical mechanisms. I do not think, however, that it will be easy to define the characteristics of a grating showing the same bands as grating *C*. The presence of strong bands seems to be due to accidental relations between the coefficients of Fourier's development of the profile of the grating; one can only say that the presence of narrow grooves or ridges in the profile, that is, a prevalence of high harmonics, is a necessary condition. A detailed account will be published in the *Nuovo Cimento*.

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[1] Wood, Phys. Rev. **48**, 928 (1935).
[2] Strong, Phys. Rev. **49**, 291 (1936).
[3] Lord Rayleigh, Proc. Roy. Soc. **79**, 399 (1907); Voigt, Gött. Nachr. p. 41 (1910).
[4] Sommerfeld, Ann. d. Physik **28**, 665 (1909).

The Paschen-Back Effect—$^2S\ ^2P$ Multiplets in Strong Fields

In an article published in the *Physical Review* on the Paschen-Back effect of $^2S\ ^2P$ multiplets Green and Loring[1] have stated that the fine structure of magnetic triplets in "strong fields" had never been experimentally established, the theory, however, having been expounded long before. The authors then explain how they have studied the phenomena for the 6708 line of Li "in reversal" and managed to resolve the s components.

Presumably the authors had not had information about my experimental work on the same subject carried out at the Laboratoire du Grand Electro-aimant de l'Académie des Sciences at Bellevue, under the direction of Professor A. Cotton. Nevertheless the results had been published as early as January 1935 in the *Comptes Rendus Acad. Sci.* and republished in the *Jubilee Book* of Peter Zeeman ('S Gravenhage, Martinus Nijhoff, 1935) in an article by F. Croze and P. Jacquinot.

In this work the 6708 line has been studied up to 44,000 gauss and I stated explicitly that the s components are resolved into two sub-components and that, moreover, the components on the short wave side give a larger separation than those on the other. The values of the separation I found are in satisfactory agreement with the values calculated after K. Darwin. The results had been obtained for the Li emission line given by a high frequency tube as described in the two notes previously quoted, and are quite the same as those obtained by Green and Loring in a 38,000-gauss field with the line "in reversal."

It was with great pleasure that I had the opportunity of reading the confirmation of my own experiments in the article by Green and Loring whom I am always personally happy to quote.

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[1] Green and Loring, Phys. Rev. **49**, 630 (1936).