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Concerning the detection of X-ray interferences

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If other Nobel Prize winners express their thanks for this high honour at this juncture by recounting the history of their discovery they are able to report how, at the outset, they envisaged a high, but nevertheless attainable, objective and how they strove toward that objective by many paths, most of which proved initially to be false and how then, after many years of protracted endeavour, they finally achieved their objective. In my eyes the credit to which they are entitled increases in direct proportion to the magnitude of the difficulties which they finally surmounted. By comparison, what I have to say here differs somewhat from those examples. There is no doubt that I, also, had long been aware of the problem, i.e. producing X-ray interferences, before the inherent difficulties had finally been surmounted. But I never believed that it would be my personal good fortune to make a contribution in that direction, and it was for that reason that I did not concern myself unduly in that respect until suddenly I perceived the way which subsequently proved to be the shortest path to success. I am not, therefore, able to recount many details in connection with my personal preparatory work, so I shall confine my comments to explaining the combination of scientific and personal circumstances from which the idea first arose.

In the case of X-rays their discoverer had already made efforts to locate diffraction or interference phenomena in order to solve the question of whether or not they represent a wave phenomenon or the ejection of any small particles. But in this quest his research, which had otherwise been so successful, met with failure. Nevertheless, from the outset there were supporters for the former opinion; for Stokes and Wiechert could point out with complete justification that, according to Maxwell-Lorentz electrodynamics, electromagnetic waves must be produced whenever electricity carriers alter their velocity; one was also aware that cathode rays, which induce X-rays on striking an obstacle, are made up of electrons. W. Wien endeavoured to reconcile this consideration with what was, at that time, the very young quantum theory in order thus to arrive at an estimate of the relevant wavelengths. He arrived

explains the further fact that the direction of the vanishing intensity is parallel to the direction of the primary rays.

Notwithstanding these major arguments the wave theory initially did not meet with complete acceptance. For experts like W. H. Bragg maintained until 1912 the corpuscular view and, in support of that view, they were able to quote a series of phenomena which, in actual fact, have remained inaccessible to explanation by the wave theory. If X-rays do, in fact, fall upon a body, they not only excite the aforementioned secondary X-rays, they also free electrons. The velocities of these electrons do not now depend upon the temperature and other conditions obtaining with the body in question and one might therefore assume that their kinetic energy is derived from the incident X-ray radiation. But this is where the difficulty is encountered. For the velocities which have been observed are not dependent upon the intensity of radiation but, in fact, upon their degree of hardness, and specifically in such a manner that these velocities increase with increasing hardness. If the intensity is weakened this will result in a decrease in the number of electrons released, but it will have no effect upon their velocities. The greatest velocity which occurs is always that which was possessed by the cathode radiation by which the X-rays have been excited; it is almost as if X-ray radiation retains a "memory" of the process of its creation and expresses this fact when, for its part, it releases electrons.

This would be quite easy to comprehend if the energy of the X-ray radiation were to accumulate and remain accumulated at certain points, as would, for example, be the case with the motion of individual corpuscles. But in agreement with the wave theory it expands progressively over increasing areas. This poses us with a complete puzzle, which is merely rendered the more complex by the further observation that the electrons which have been released would appear to prefer the direction taken by the incident X-rays. And it is a source of only qualified comfort if we make clear to ourselves that with the short-wave visible and ultraviolet light rays the same phenomena occur in the photoelectric effect. In this case also, where we most certainly have before us a wave process, they are simply incomprehensible.

We can only understand the reasons why our understanding fails at this juncture. Einstein has provided us with a rule on the dependency of the greatest existing electron velocity upon the frequency of light waves; in this the decisive role is played by the universal constant h , designated by Planck, its discoverer, as the elementary quantum of action. Conversely, more recent measurements - among which particular accuracy was achieved in those

