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Einstein's aberration experiment

In the *Sitzungsberichte* of the Berlin Academy of December 8 last, which has recently come to hand, Einstein describes an ingenious arrangement which he suggests might serve to decide between the classical theory of light and the theory in which light is regarded as made up of single quanta of energy emitted discontinuously from luminous atoms. Figure 1 (reproduced from the paper)

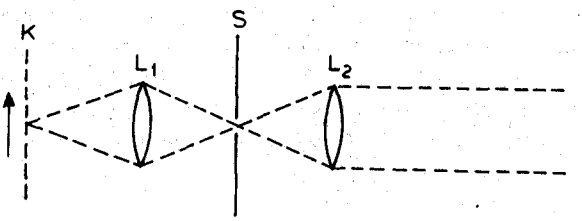

Figure 1

illustrates the proposed experiment. K is a stream of canal rays, L_1 is a focussing lens, S is a screen containing a slit which serves to isolate a definite pencil of light, and the lens L_2 renders the emergent beam parallel. The emergent pencil is observed through a telescope focussed for infinity, so that the image of the slit in the screen S would be seen sharply focussed in the field of view. Since the atoms in the canal rays emitting light are in motion, the Doppler effect comes into evidence, and the rays proceeding at any instant from individual luminous atoms in different directions should, according to the wave-theory of light, be of different frequencies. Einstein suggests that the rays passing through the slit S and incident on the upper and lower parts of the lens L_2 should consequently be of different frequencies. If, therefore, a layer of a dispersing medium such as carbon disulphide be placed between the lens L_2 and the observing telescope, the different rays would travel through it with different velocities. Hence the wave-front should suffer an aberration and the image of the slit seen in the focal plane should shift through an extent proportionate to the thickness of the dispersing layer introduced. Einstein conceives that according to the quantum theory of light, on the other hand, such displacement should not occur, and he believes that the proposed arrangement furnishes an *experimentum crucis* to decide between the rival theories.

I wish here to direct attention to a fallacy which is present in Einstein's reasoning and invalidates it. It is clear that in the proposed experiment what would be observed are not the moving luminous atoms but the fixed edges of the illuminated slit in S, and it is easily shown that even according to the principles of the wave-theory no aberration of the image of the latter could be expected. To make this evident we may conceive the slit to be extremely narrow, or in the alternative, if it be wide, regard it as divided up into a large number of very narrow elements each of which, according to Huyghens's principle, would operate as a secondary source of light. The light from any small portion of the lens L_1 arriving at the slit would spread out by diffraction in all directions in the form of cylindrical waves, so that the waves reaching L_2 would consist everywhere of *superposed* wave-fronts of all the frequencies reaching the slit, and not, as Einstein supposes, of different frequencies at different points of L_2. The waves diverging from S would thus pass through L_2 and the dispersing medium behind it according to the ordinary laws of geometrical optics, and no shift or aberration of the image of the slit would occur. The error in Einstein's reasoning lies in his having ignored the vitally important part which diffraction plays, according to the wave-theory of light, in the theory of the formation of images of illuminated apertures by optical instruments.

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