Diffraction Experiments with Inhomogeneous Illumination

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Abstract

With coloured and one-coloured inhomogeneous illumination is shown its influence on diffraction-figure. In the sphere of inner diffraction-fringes of slit, therefore in short distances, the localization of bent light is easily to demonstrate. In the sphere of outer diffraction-fringes of slit, therefore in large distances, interpretation is limited by the double cover with bent light of the surroundings of both slit-edges.

I . Foundations

Newton [1] III observation 5 had proved that bent light comes only out of the small surroundings of edge. The fine light-line, Grimaldi's luminous edge, becomes so smaller so more sideways he observed. From this Newton [1] III query 1 inferred that light has to be bend most ever narrower it passed the edge.

Nieke [2], [3] and [4] confirmed, completed and extended Newton's diffraction experiments. He found that bent light has to come out of surroundings of the edge smaller than 0.l mm. This fact should be well to investigate and demonstrate with an inhomogeneous illumination.

Besides are to notice some difficulties. As simplest a help-slit could be imaged in the plane of a half-plane or slit. By Nieke [5] the so called coherence-condition could be conceived as interference angle-condition that the aperture-angle to illumination slit remains preserved in the divergence of emerging light. This operates the blur of illumination and the true diffraction as diffraction-figure is added to this blur. With optics of long focal-length the angle of incident bundle can keep small and so the interference angle-condition is to fulfil. It is also to fulfil Abbe's condition for object-like imagery, not only the nought order of diffraction has to contribute for imagery but least yet one order. For this the aperture of imagery must have a minimal size and so a larger angle of illuminated light is necessary. Interference angle-condition and the Abbe-condition set high demands.

Newton [1] III observation 10 observed at diffraction of triangular-slit that in short distances and large slit-width first appear inner diffraction-fringes which correspond to diffraction of half-plane with the edges as half-plane. From this Newton [1] III query 3 concluded that light-particles have to move eel-like. Inner and outer diffraction-fringes have their name according their position within or outside the limits of shadow of the diffraction-object, cf. Nieke [4]. Fresnel [6] found experimentally that with parallel incident light the (unequal) intervals of diffraction-fringes of half-plane grow only

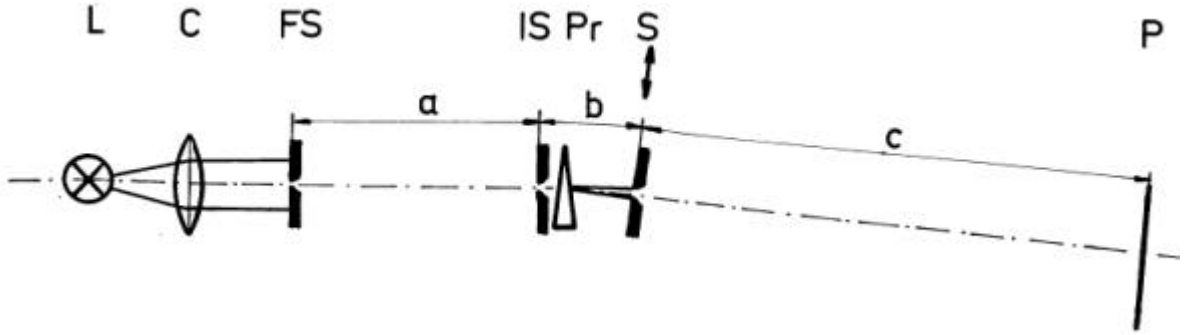

Figure 1. Experimental arrangement for coloured inhomogeneous illumination. L - light-source, a high-pressure mercury lamp; C -condenser; FS -first illumination-slit; IS - second illumination-slit 0.15 ... 0.3 mm; Pr - prism, crown glass 10°...30°; S - diffraction-slit 0.3 mm; F - incident plane, a photo-plate. a = 1 m, b = 120...400 mm, c = 0.25...4 m

with the root of distance behind half-plane. Thereupon is to ensue that photons have not to run always rectilinear. A rectilinear spreading ensued first in larger distances if instead of inner the outer diffraction-fringes of slit are formed, and first then, and not already off slit, photons run rectilinear. Hence by Nieke [2] the extrapolation of the formula for diffraction at the slit in very large distances to the plane of slit was inadmissible and wrong, because the inner diffraction-fringes appear in short

distances. Then bent light does not come from the whole slit as is concluded out of the extrapolation but only out of surroundings of edges.

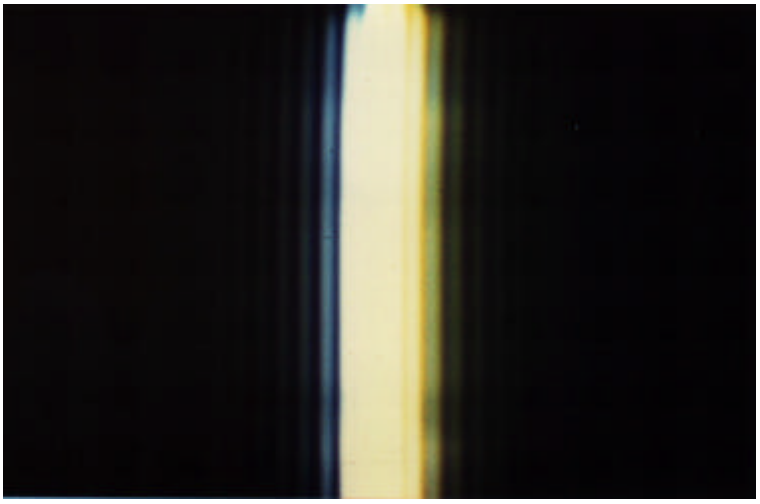

Figure 2. Illumination with mercury-light, blue at one edge and green at the other edge of the diffraction-slit S, with arrangement of figure 1. Distance c even so that outer fringes originated but no mixture disturbed.

Newton [1] observed the bent light only shadow-side. Young [7] observed in addition the light-side luminous edge. Young supposed erroneously that bent light comes only from the edge and developed from this Young's principle. Probably he thought of a stimulation of edges but this can not be with visible light. The knowledgeis important that bent light is also coming light-side as Nieke [2] to [4] confirmed. So in large distances outer diffraction-fringes superposes shadow- and light-side bent light, so the interpretation of inhomogeneous illumination is difficult. However, inner fringes of slit and only the first formed outer fringes consist only of light from one edge.

Figure 3. Illumination of diffraction-slit S with a continuous spectrum, in figure 1. Also distance c even so large that no mixture disturbed.

II. Experiments with coloured inhomogeneous illumination

For coloured inhomogeneous illumination can be used the green and blue line of mercury light. The figure 1 shows this arrangement. In short distances appearing inner diffraction-fringes, it is easy to show that one side of diffraction-figure with inner fringes appears about green and the other blue, if one side of the diffraction-slit is illuminated with green and the other blue. Figure 2 shows a so obtained photo in a distance where the first outer diffraction-fringes just originated. Because of the double illumination with shadow- and light-side bent light, in larger distances appearing only outer diffraction-fringes the only increasingly mixed diffraction-figures are to observe.

With a filament-lamp the prism Pr yielded a continuous spectrum. Figure 3 shows a such obtained photo. In short distances the outermost diffraction-fringes are more and more in this colour which is present at the edge of slit. This appearance is clear to verify in relative short distances, because it is hardly possible to obtain the other slit-edge completely unilluminated.

III. Experiments with one coloured inhomogeneous illumination.

Here the photos ensued with the apparatus according figure 1 but without prism Pr and with putting in a green-filter. Figure 4 a shows the result without diffraction-slit S, this illumination was kept in the following diffraction experiments, it is the diffraction-figure of the illumination-slit IS. Figure 4 b shows that one order (here the zeroth) can be obtained nearly without diffraction if the edges of the diffraction-slit S are placed in the minima of following this order of the illumination-slit IS. In figure 4 c the width of the diffraction-slit S was diminished on the half of figure 4 b. For figure 4 d the diffraction-slit S was so displaced that one edge lay in the minimum and the other in the

maximum of zeroth order of illumination-slit IS. On the side of smaller illumination in the diffraction-figure appear a broad dark strip between zeroth and first order, what is characteristic for this manner of illumination. The intervals of diffraction-fringes are equal in figure 4 c and d. This shows that these intervals are only dependent on the slit-width and the manner of illumination has hereupon no influence.

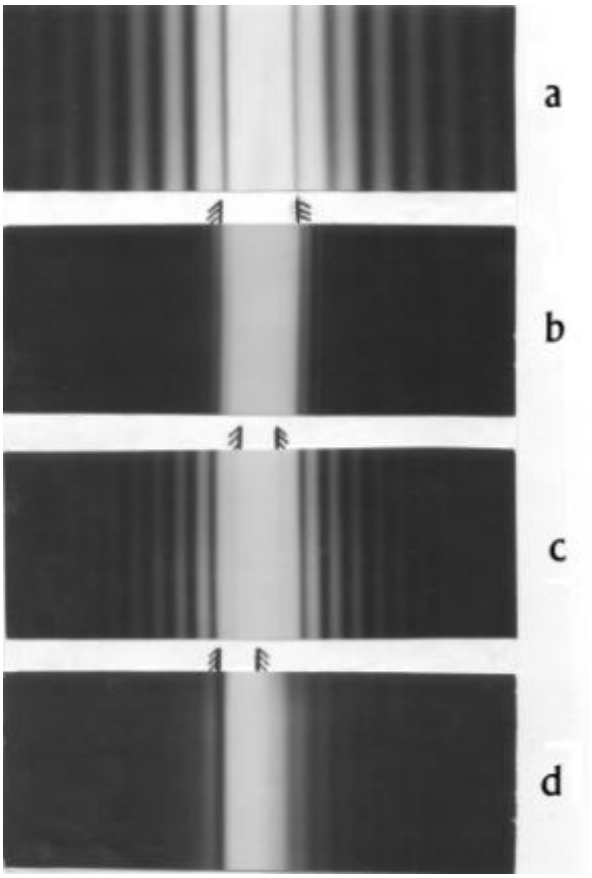

Figure 4. Diffraction-figure at one-coloured inhomogeneous illumination. Experimental arrangement figure 1, but without prism Pr and with green filter. IS = 0.15 mm, b = 100 mm, c = 2 m.
a: diffraction-figure without diffraction-slit S;
b: slit-edges S (0.6 mm) in the first minima of the diffraction-figure of the illumination-slit IS;
c: diffraction-slit S contracted on the half (0.3 mm);
d: diffraction-slit S so displaced that a minimum of the diffraction-figure of IS drops on one edge and the maximum of zeroth order on the other edge.
Above every diffraction-figure the position of the diffraction-slit is indicated.

IV. Discussion

As already Newton [1] had asserted, it is possible to demonstrate the localization of bent light in the sphere of inner diffraction-fringes at the slit. In the sphere of outer diffraction-fringes only in distances after first origin of outer diffraction-fringes locality is demonstrable. In larger distances the double cover of diffraction- figures with shadow- and light-side bent light prevent examinations. In Fraunhofer's manner of observation the illumination-slit is imaged at the observation-plane, and so in the focal-plane no coloured inhomogeneous illumination is demonstrable. Outside this plane a split-up is present and here an observation was possible.

The limits of this method were already directed in section 1. Everyone who has ever tried to produce a real symmetrical diffraction-photo knows what a high adjust-expenditure is necessary obtaining a 'homogenous illumination' . Who never tried this may inspect the sources of figures of diffraction-figures. Also authors, who else produced themselves all figures, often took over diffraction-photos of strange sources. Of course, they have experienced the difficulties but they did not direct on this for in theory of wave-fronts no difficulties should be present. We know at present that light consists out of light-quanta or photons, and therefore deviations are explicable.

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