The Background of Diffraction-Figures

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Abstract

The background of diffraction-figures is examined in dependence of slit-width, distance, divergence of illumination and in Fresnel's and Fraunhofer's manner of observation. The background is higher at large slit-width and do not decrease proportional to distance but more slowly. The difference between maxima and minima of diffraction-fringes is approximately independent of slit-width, which corresponds to Newton's observation that bent light comes only out of small surroundings of edge.

I. Foundations

According to wave calculation and construction of diffraction-figures of slit, the intensity at minima should decrease to zero. Photometer curves show that this is not fulfilled, the minima of lower orders decrease even not approximately to zero.

First it was to secure that not only the dependence on degree of accomplishment of the so called coherence-condition determines the background. The so called coherence-condition was critically considered by Nieke [1] and was formulated new as 'interference angle-condition'. It is to demand that details of the diffraction-figure must appear at a greater angle than the geometric angle to the illumination-slit (or the light-source). The not fulfilled interference angle-condition causes a blur and is interpreted of course as background. Preliminary experiments showed that the angle from the maximum of diffraction-figure to the next one has to be five times greater than the angle to the illumination-slit before the sharpness of fringes does not considerably influence the intensity of minima. Thus the interference angle-condition is to accomplish with 'much larger than' but then the background is practical independent of that. In these experiments were used ten times greater or still greater values.

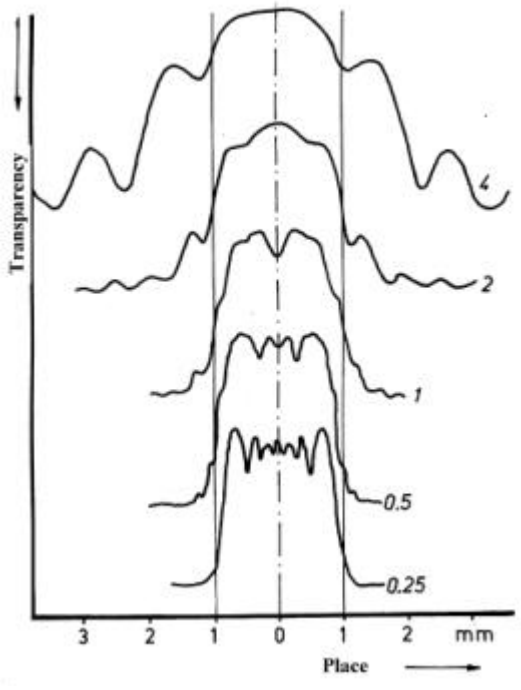

Figure 1. Diffraction-figures of a slit with the slit-width of 2 mm in dependence of distance with parallel incident light. It is drawn up the transparency in dependence of the place in diffraction-figure. The shadow limit of the breadth of 2 mm is marked by vertical lines. The numbers written on the curves declare the distance of the slit to the photofilm in m.

II. Experiments in different distances

A super-pressure mercury lamp with green-filter was projected with a microscope-objective at the illumination-slit. In a distance of 1m stood a lens f' = 1 m so that parallel light fell on the following diffraction-slit. The diffraction-figures were caught in different distances from the diffraction-slit. Figure 1 shows the photometer-curves of negatives. As long as only inner fringes appear the shadow limits are observed, they are called in dependence of their position within shadow-limits. Outer fringes are building up first in larger distances and than outside the shadow-limits over which they spread out in increasing distance.

For the diffraction-figures of figure 2 the lens f' = 1 m is left out and so it is illuminated with divergent light. Here the analogous behaviour appears, a spreading over the shadow limits is to observe if outer fringes appear.

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III. Experiments with equal intervals of fringes

In the diffraction experiments of Newton [2] III observation 5 is shown that bent light only comes out of the small surroundings of edges. Nieke [3] and [4] confirmed this and continued the experiments. So the luminous flux of bent light should be constant at variation of the width of slit. To examine this with the same illumination as in fig 1, that is parallel incident light, and directly behind the variable diffraction-slit stood a lens with

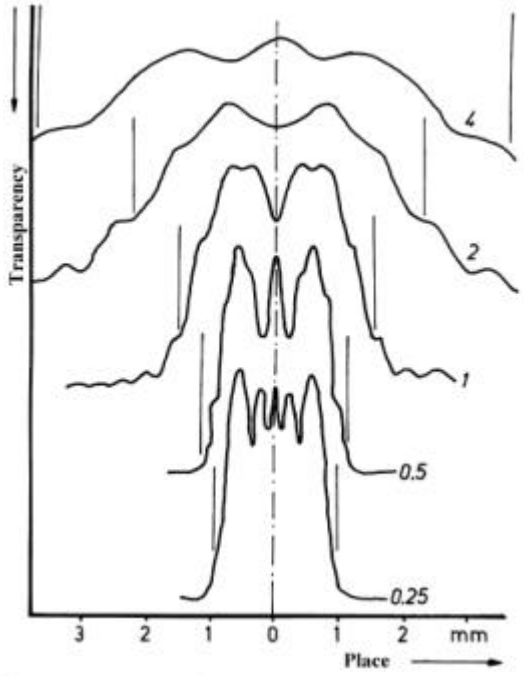

Figure 2. Like figure 1 but without the collecting lens f'= 1 m, therefore in divergent light. Slit-width is put in 1.5 mm. The calculated shadow-limits are drawn by short vertical lines in every diffraction figure

2 m focal length at 2 mm slit-width and 2 m distance or
1 m focal length at 1 mm slit-width and 1 m distance or
0.5 m focal length at 0.5 mm slit-width and 0.5 m distance

to the incident-plane. So Fraunhofer's manner of observation was used at which the intervals of fringes should be equal in the three photos. The measurement of luminous flux is so reduced to the measurement of illuminance. Figure 3 shows the photometer-curves of the negatives. As calculated the diffraction-figures have practically the same intervals of fringes. As known the minima of lower orders out of outer fringes do not decrease to zero, the less so

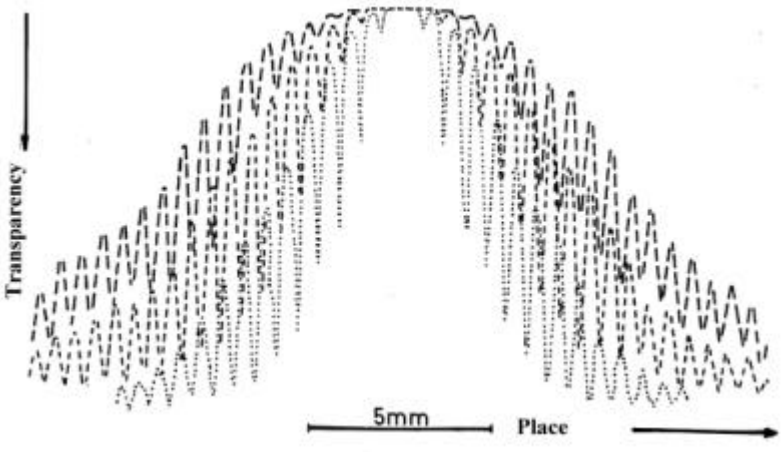

Figure 3. Photometer-curves of different slit-widths in such distances that the intervals of fringes are equal; at equal exposure-times and under equal photometer conditions.
- - slit-width 2 mm,
--- slit-width 1 mm,
... slit-width 0.5 mm.

greater the slit-width. If only the differences of intensities of maxima and minima of bent light are regarded and not the background, so it can be inferred indeed that the luminous flux of bent light is independent of slit-width. In accordance to this it is necessary still to accept a background in dependence on slit-width and distance.

IV. Experiments to determine the dependence of distance

Hitherto the experiments were carried out with mercury light with green-filter. For examination of more accurate dependence of distance in large distances from the slit the small red part, which is transmitted by green-filter, can trifling disturb. A helium-neon laser was used for these experiments. The diffraction-figures of slits were photographic recorded with 0.5 and 1 mm slit-width in different distances and in Fresnel's and Fraunhofer's manner of observation. The negatives are photometered so that the intervals of fringes appear equally. Because diffraction-figures show great density variations, so it is difficult to develop the negatives with a so soft gradation that resulted a linear sensitometric-curve. Therefore the examination took place with a comparison method where no linearity of sensiometric-curve must be presupposed. The density of every minimum was compared with the maximum having the same intensity. For that it was also interpolated. So the value 2.4 means that the density of this minimum lies between the second and third maximum. The results are recorded in tables 1 to 4.

Table 1. Order of that maximum which has the same intensity as the minimum in the same diffraction-figure. Slit-width 0.5 mm at Fresnel's observation-manner.

distance	minimum				
m	1st	2nd	3rd	4th	5th
0.125	1	2.3	7	15	.
0.25	1.3	5.4	12	-	
0.5	2.8	15	-		
1	6.6	-			
2	10	-			

Table 2. As table 1 but 1 mm slit-width

distance	minimum				
m	1st	2nd	3rd	4th	5th
0.25	inner	fringes	3.3	4.6	7.3
0.5	1.4	4.5	9	17	27
1	1.3	4.5	13	19	
2	2.3	8			
4	5	13.5			

Table 3. Order of that maximum which has the same intensity as the minimum in the same diffraction-figure. Slit width 0.5 mm at Fraunhofer's observation-manner.

distance	minimum					
m	1st	2nd	3rd	4th	5th	6th
0.125	1.3	2.6	6.5	11	13	14.6
0.25	1.6	3	3	9	12	13
0.5	9	14	17	18	21	22
1	7.5	15	-			
2	15	30	-			

Table 4. As table 3 but 1 mm slit-width

distance	minimum					
m	1st	2nd	3rd	4th	5th	6th
0.125	1.2	2.6	3.2	5	8	11
0.25	1.5	2.4	3.5	4.2	9	-
0.5	5	11.	17.5	21	22	25
1	7	14	16	30	-	
2	10	25	-			

Generally is to establish that the minima at Fraunhofer's manner of observation have a lower intensity (they correspond to a maximum of higher order) than at Fresnel's manner of observation in the same distance. From the tables it is evident that the background becomes smaller with increasing distance.

V. Discussion

In figures 1 and 2 the influence of inner fringes is dominant, statements on the background can not be made. Figure 3 shows unequivocally that the breadth of background increases with the slit-width but here is simultaneously the distance at which the larger distance at greater slit-width does not compensate this influence. From figure 3 and tables 1 till 4 is evident that background decreases by no means proportionally to the distance but more slowly. Fresnel [5] showed experimentally that the intervals of fringes of a half-plane grow only proportionally to the root of distance if the light strikes parallel. Intervals of inner fringes of the slit have the same dependence. Therefore bent light must not run rectilinear on the farther way. So it is possible to regard background as rest of inner fringes. At sufficient distances the background would then run into the zeroth order.

Insufficient monochromaticity of light forms self-evidently a source of background as also scattering at soilings of edges. For Fraunhofer's manner of observation causes an imagery of the illumination-slit, so diffraction-figures by Fraunhofer's observation-manner show a meaner background. Because here no inner diffraction-fringes appear, so the background is reduced by imagery.

References

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