ON THE EXPERIMENTAL ESTIMATE OF THE DEPTH OF THE EDGE–RAYS DEFLECTION REGION

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An estimation of the depth of a region over different–bodies surfaces in which the incident light diverges from the initial direction, is made from the experiments on diffraction of a parallel light beam on a thick screen.

In Ref. 1 new data on the light edge rays were obtained. Based on these data a quantitative description of the diffraction pattern from a screen[2] and a slit[3] was done as well as of the intensity on the axis of a beam limited by a slit of variable width[4] using interference of the edge rays between each other or with the incident light.

According to Ref. 3, the source of the edge waves is mainly a region at the screen edge. From a comparison of this fact with the experiments showing existence of a zone of light rays[5–8] deflection over the surface of bodies it obviously follows that the appearance of the edge rays is not only due to the incident light scattering at the screen edge but also due to the deflection of incident rays to both sides from the initial direction of propagation in this zone as well.

Understanding of this fact allowed the estimation of the depth of the deflection zone to be made from the experimental observations of light diffraction on a thick screen.

As is shown in Ref. 9, replacement of a thin screen (razor blade) in a diverging light beam from a narrow slit for a thick screen results in more bright diffraction bands. This can be explained as follows: the intensity of the edge rays interfering with the incident light increases because of a superposition of the edge rays initially propagating towards the screen (into the shadow region if the screen was thin) but deflected from it due to reflection and the edge rays from the screen with no difference in their phases. As can be seen from Table I, in this case the resulting intensity of the edge rays is 3.5–4–fold greater than the intensity of edge waves from a thin screen at maxima of different orders.

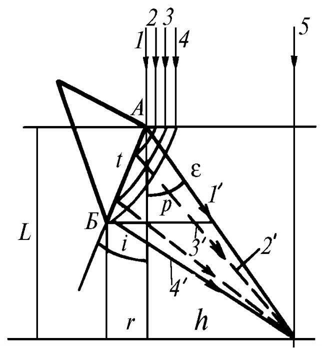

FIG. 1. The scheme of diffraction of a parallel light beam by a thick screen.

Different picture is observed for diffraction of a parallel beam on a thick screen (see the figure). In this case a screen (right–angled glass prism with the legs' length of 10.6 mm) is inclined with respect to an incident beam at the angle $i = 0.075°$ to transform the incident rays *1* and *2* into the edge rays 1′ and 2′ within the front edge A of the prism under the same conditions as it takes place in the experiments with a diverging incident beam.

The results of experiments are shown in Table I, where h_e is the experimental value of the distance from the bands of a diffraction pattern to the shadow boundary; J_{pr} and J_{bl} are the intensities of the bands corresponding to the thick and thin screens, respectively; J_{il} is the intensity of the incident beam *5* in the plane of the diffraction pattern observations; $J_{e.pr}$ and $J_{e.bl}$ are the intensities of the edge rays in diffraction bands for a prism and a blade, respectively; p is the distance from the rear edge B of the prism to the edge rays *1′*; ε is the angle of deflection of the edge rays from the initial direction; $\delta = (i + \varepsilon)$. According to these results, an increase of resulting intensity of the edge rays in this diffraction scheme strongly depends on the order of bands and has the least value in $\max_1$, although the conditions of their formation and, consequently, the amplification of the rays *1′* by the rays *2′* are the same as in the case with the diverging incident beam.

This means that within the prism side the rays *1′* and *2′* are subjected to attenuation. Its source is mainly the region at the rear edge of a prism, since the experiments showed that the deflection zone above a thick screen is most efficient near its edges. The cause of attenuation of the rays *1′* and *2′* apparently is their scattering and change of the phase difference of these rays when deflecting within the region of the prism edge B.

In the case of a diverging beam the bands of the diffraction pattern are located at a distance, from the shadow boundary, $\sqrt{(L + l)/l}$ times longer than in the case of a parallel beam provided L values are equal.[1] In this case because of corresponding increase of the angle $\varepsilon = 57.3°h/L$ resulting in an increase of p, the edge rays *1′* and *2′* propagate within a more weak portion of the prism edge B and are less attenuated.

Reliability of the above stated is confirmed by a growth of the resulting intensity of the edge rays, for example, in the first maximum of the diffraction pattern (Table II) with p increasing due to increase of i up to a certain value occurring in spite of decreasing intensity of the rays *2′* incident on the prism side and reflected from it. This growth is caused by the increase of an angle of their deflection from the direction of incidence and inverse proportional dependence of the edge rays amplitude on the deflection angle.

Dependence of amplification of resulting intensity of the edge rays *1′* and *2′* on the zone of the prism edge B is

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clearly seen from its decrease, for example, at $\max_1$ when p decreases because of increasing L (see Table III).

TABLE I.

Band	λ = 0.53 μm, L = 99.5 mm							
	h_e, mm	J_{il} rel. units	J_{bl}/J_{il}	J_{pr}/J_{il}	$J_{e.pr}/J_{e.bl}$	δ'	p, μm	$K_{4'1'}$
$\max_1$	0.191	38.55	1.42	1.550	1.634	11.1	34	0.51
$\max_2$	0.376	24.51	1.26	1.410	2.430	–	–	0.85
$\max_3$	0.489	15.89	1.24	1.420	2.840	21.4	65	1.14
$\max_4$	0.586	10.15	1.25	1.420	2.655	–	–	1.42
$\max_5$	0.667	6.25	1.26	1.550	2.360	27.3	83	1.68
$\max_6$	0.737	3.79	1.33	1.575	2.700	–	–	2.08
$\max_7$	0.806	2.20	–	1.690	2.670	–	–	–

TABLE II.

Band	λ = 0.53 μm, L = 99.5 mm							
	h_e, mm	J_{il} rel. units	J_{bl}/J_{il}	i'	p, μm	J_{pr}/J_{il}	$J_{e.pr}/J_{e.bl}$ μm	$K_{4'1'}$
$\max_1$	0.191	38.55	1.42	0	19.0	1.53	1.550	– 0.61
$\max_1$	0.191	38.55	1.42	4.5	34.0	1.55	1.634	0.51
$\max_1$	0.191	38.55	1.42	9	47.6	1.58	1.820	0.63
$\max_1$	0.191	38.55	1.42	13.5	61.4	1.59	1.870	0.76

TABLE III.

Band	λ = 0.53 μm, i = 9'						
	L, mm	h_e, mm	J_{il} rel. units	J_{pr}/J_{il}	$J_{e.pr}/J_{e.bl}$	p, μm	$K_{4'1'}$
$\max_1$	99.5	0.191	38.55	1.583	1.821	47.6	0.631
$\max_1$	279.5	0.320	41.40	1.540	1.397	39.5	0.466

In addition to the edge rays *1'* and *2'* the rays *3'* deflected initially on the side near the prism edge A and reflected from this side near the prism edge B as well as the rays *4'* after deflecting at the prism edge A and prism edge B into the illuminated region are superimposed on the incident light. However, they are not the reason of attenuation of the resulting intensity of the edge waves under consideration. This can easily be seen from the following considerations. Since the rays *3'* lose a half–wave at a reflection they attenuate the rays *4'*. The results of experiments with the prism sides blackened with carbon[9] absorbing the rays *3'* show that the residual flux is comparatively small being formed only by the rays *4'*. A path difference existing between them and the rays *1'* and characterized by the number $\lambda/2$ can be written as follows:

$$K_{4'1'} = \frac{(r^2 + 2\,h\,r)L + h^2 t + 0.31\,\lambda\,L(L - t)}{\lambda\,L\,(L - t)},$$

where the coefficient 0.31 takes into account a phase lag by $0.31\lambda/2$ when it is deflected near the prism edge A (see Ref. 1).

Based on the results given in the tables one can conclude that the values of $K_{4'1'}$ do not affect the growth of the resulting intensity of the edge waves. The rays under consideration are also observed in the case of diffraction of a diverging beam but their influence on the amplification of the resulting intensity is negligible.

Based on the data presented in the tables one can conclude also that the most significant amplification of resulting intensity of the edge rays in $\max_1$ is observed at p = 61.4 μm while its strongest amplification with increasing order of bands occurs at p = 83 μm ($\max_5$). Just these values of p are preliminary estimates of the depth of light deflection region which evidently strongly exceeds λ.

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