NEW FINDINGS ON LIGHT DIFFRACTION BY A THIN SCREEN WITH A RECTILINEAR EDGE

Yu.I. Terent'ev

Institute of Atmospheric Optics,
Siberian Branch of the Russian Academy of Sciences, Tomsk
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The influence of the screen edge curvature very small in magnitude and the screen absorptivity on the positions of fringers in the diffraction pattern from a thin screen has been revealed in the present paper. It has been proved experimentally that the light reflected from optically denser medium not only loses half a wave, but also undergoes a phase shift by π in the direction of wave propagation. The interference between the edge light propagating to the screen shadow and the incident light has been observed whose diffraction pattern is similar to that observed in the classical scheme. The initial phase delay of the shadow edge light was close to 0.5π and was equal to the phase advance at the edge light propagating to the illuminated side. It is shown that the screen edge projection is not the boundary of the rectilinear light propagation. The realistic scheme of formation of the diffraction pattern from the screen has been proposed. The critical angles of deflection of the edge rays from the incident light direction found earlier and being limiting for the linear dependence of the edge wave amplitude on the diffraction angle are shown to be slightly overestimated. The reason for this has been clarified.

A diffraction pattern from a screen, as shown in Refs. 1 and 2, is due to the interference between edge[3] and incident rays. On this basis, expressions describing well the experimentally observed distances between the diffraction fringes and their intensities were derived.

According to Ref. 1, in the case of a cylindrical incident wave the distances between fringes defined by Eq. (3) have the following form:

$$h = \sqrt{(k_0 + k)\, \lambda L\, [(L + l)/l]}\ ,$$

where $(k_0 + k)$ is the number of $\lambda/2$ in the expression for the geometric path difference between the incident and edge rays; l and L are the distances from a linear light source to a screen and from the screen to the observation diffraction plane, respectively; h is the distance from the shadow boundary (SB) to the diffraction fringe; $k = 0, 2, 4,\ldots$ correspond to the diffraction maxima and $k = 1, 3, 5,\ldots$ – to the diffraction minima. Here, k_0 indicates that the edge wave phase undergoes a phase advance with respect to the incident light phase. Its value could be determined from $h_{\max1}$; however, because of the unknown position of the shadow boundary, it remains unknown. It can be determined from experimentally measured distance h_{21} between the first and the second diffraction maxima.

In this case,

$$h_{\max1} = [2\lambda L\, (L + l)/l - h_{21}^2]/2h_{21}. \tag{1}$$

Then

$$k_0 = (h_{\max1}^2\, l)/[\lambda L\, [(L + l)]. \tag{2}$$

The value of k_0 was found to be 0.69 for h_{21} determined experimentally with $l = 117$ mm and $L = 376.5$ mm.

Since the edge rays propagating to the shadow and outside it are shifted in phase by π (Ref. 1) and the edge ray on the illuminated side runs ahead of the incident ray, the ray diffracted to the shadow at the instant of its deflection in the deflection zone undergoes a phase delay with respect to the incident rays. In the experiments with different values of l and L, the value of k_0 was found to be equal to 0.69, 0.708, 0.626, 0.593, 0.695, and 0.674. Nevertheless, the calculated values of h $(k_0 = 0.69)$ slightly differ from the experimental ones because of the square root dependence of h on k_0 and reduced effect of k_0 oscillations on the position of the diffraction fringe with the increase of k.

According to the data from Table I, when a new blade was used as a screen, the value of k_0 was 0.07 less than for a blunt blade, i.e., for very small curvature radii of the screen edge it affects the position

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and the intensity of the diffraction fringes. That was not noticed by Fresnel.[4]

TABLE I.

λ = 0.53 μm			
l, mm	L, mm	$h_{21\ \mathrm{exp}}$, mm	k_0
New blade			
6	99.5	0.807	0.6
8.63	198.5	1.314	0.634
9	99.5	0.663	0.62
12	99.5	0.58	0.63
35.5	99.5	0.368	0.65
100	99.5	0.266	0.655
Blade with blunt edge			
12	110.5	0.623	0.702

A decrease of the phase shift of the edge wave was also observed for the blade covered in soot. For example, in the case of natural light with λ = 0.53 μm (l = 12 and L = 110.5 mm) soot leads to the decrease of k_0 by a factor of 0.702/0.651 = 1.08. When a He-Ne laser (l = 11.4 and L = 99.5 mm) was used as a source of light, the value of k_0 was decreased by a factor of 0.773/0.016 = 1.255.

The essence of the problem considered above is clearly understood from considerations of the edge light given in Ref. 3 according to which it consists of the Sommerfeld edge component being essentially the light reflected from the screen edge and deflected in the zone of deflection of the incident rays. Since the light loses half a wave due to reflection from a denser medium,[5] Sommerfeld's conclusion that the edge wave coming from the screen edge undergoes a phase shift by π with respect to the incident light wave is true.

When the screen is covered in soot, the reflected component becomes much weaker. Nevertheless, k_0 does not vanish. Thus, the fundamental component at the instant of its appearance also undergoes a phase shift.

Since the rays of the Sommerfeld component come from the screen edge and the rays of the fundamental component deflect in the deflection zone away from the edge, they should have the geometric path difference Δ_k.

From the above reasoning the phase shift of the resultant edge wave described by k_0 is defined by the phase shifts of the fundamental and Sommerfeld components, their amplitudes, and the value of Δ_k. In the case of replacement of the blunt blade with a new one or for blade covered in soot, the reflected component becomes weaker because of reduced reflecting area on the screen edge and the absorption.

The decrease of the resultant edge wave phase shift observed in this case shows that the Sommerfeld component in the diffraction plane undergoes slightly greater phase shift in the direction of wave propagation than the fundamental component, in spite of Δ_k. This allow us to conclude that the light not only loses half a wave due to reflection, but also undergoes a phase shift by π in the direction of wave propagation.

According to the above reasoning, the phase shift of the resultant edge wave approaches the phase shift of the fundamental component when the reflected component becomes weaker.

When the natural light source (λ = 0.53 μm)was replaced by a laser, the value of k_0 increased from 0.702 to 0.773, which can be explained by the increased contribution from the reflected component to the total edge flux.

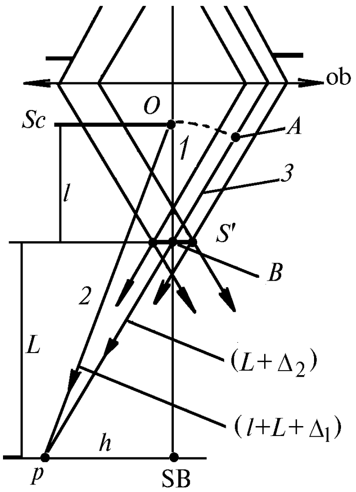

FIG. 1. Scheme of formation of the diffraction pattern from the screen by shadow and incident light.

Figure 1 shows the scheme of the interference of the edge rays *2*, propagating to the shadow of the screen Sc, with the incident light. Such interaction becomes possible because the screen is placed above the image S' of the linear light source S. The edge and incident rays coming from the wave front OA are superposed in the observation plane with different geometric phase differences Δ. Their diffraction pattern is analogous to that observed in the classical scheme (see Fig. 4 of Ref. 1). Here, the position of $\max_1$ is also shifted from the shadow boundary. Contrary to the classical scheme, in this case the incident rays *3* travel greater distance by the time of superposition with the edge rays. Nevertheless, in $\max_1$, shifted to the left of the shadow boundary, there is no path difference between them and the edge rays. Hence, the edge light propagating to the shadow undergoes a phase shift opposite to the direction of propagation. As a result, the edge wave in the shadow is decreased in phase with respect to the incident wave and is not in phase with it.[6,7] An additional path difference Δ_0 corresponds to this phase delay. Since rays *1* and *3* are superposed at the point B on the axis S' without path difference, then

$$\Delta = [OB + BP - (OP + \Delta_0)] =$$
$$= [(\Delta_2 - \Delta_1) - \Delta_0] = (\Delta_g - \Delta_0).$$

Since $\Delta_1 = h^2/2(L + l)$ and $\Delta_2 = h^2/2L$, then

$$h = \sqrt{(k_0 + k)\, \lambda L\, [(L + l)/l]}\ , \qquad (3)$$

where k_0 describes the phase delay of the edge wave by $k_0\pi$ with respect to the incident light phase. This expression is identical to Eq. (3) of Ref. 1; therefore, $h_{\max_1}$ and k_0 are defined by formulae (1) and (2). The values of k_0 obtained in different experiments based on this scheme are presented in Table II. They are approximately equal to the values reported before. This indicates that the phase delay of the edge rays propagating behind the screen is equal to the phase advance of the edge rays propagating from the screen. If the phase shift between these rays is equal to π, the delay and advance of the phase will be equal to $\pi/2$ (see Ref. 1). In this case, k_0 must be equal to 0.5. But then the values of k_0 calculated from Eqs. (1) and (2) are overestimated by 0.1–0.2. The difference between maximum and minimum values of k_0 is not only due to inaccuracy in determination of its maximum value since due to the effect of soot and the decrease of the screen edge curvature, k_0 tends to lower values. The true phase shift between the shadow component of the edge light and the opposite component is likely to be slightly greater than π and the values of k_0 obtained from Eqs. (1) and (2) are slightly overestimated.

TABLE II.

λ = 0.53 μm			
Screen type	l, mm	L, mm	k_0
Blunt blade	12	87.5	0.738
Blade covered in soot	12	98.5	0.705
New blade	83.2	134	0.7

In the considered diffraction scheme soot and a new blade also lead to the decrease of k_0 (Table II) but to a slightly lower degree than in the scheme shown in Fig. 4 of Ref. 1. Therefore, in the edge wave propagating behind the screen the Sommerfeld component is slightly delayed with respect to the fundamental one whereas in the edge wave propagating from the screen it, on the contrary, runs ahead of the fundamental component.

As is known, the boundary of light propagation according to laws of geometric optics is considered as a geometric shadow boundary. By the classical shadow boundary (CSB) is meant the projection of the diffraction screen edge onto the plane of diffraction pattern (Fig. 2). Once the light ray deflection zone was found to be formed above the surface of bodies[5,8,9,10] with its total depth h_{zt} being greater than λ, it becomes clear that the boundary of the rectilinear light propagation differs from the CSB and the projection of light rays passing along the external boundary of the deflection zone should be taken as a true shadow boundary (TSB). A difference between CSB and TSB should be most significant in the case of diffraction of a divergent beam by the screen particularly at small values of l and large values of L. (In the case of diffraction of plane and cylindrical waves, this difference is equal to h_{zt} and $- h_{zt}\,[(l + L)/l]$, respectively.)

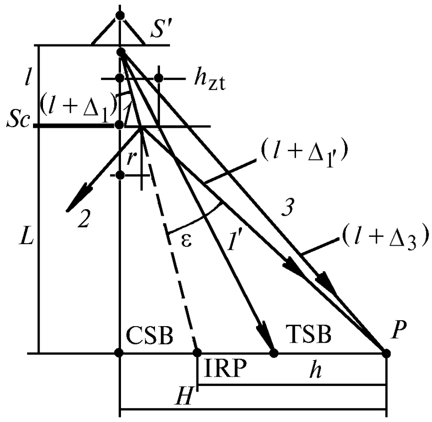

FIG. 2. True scheme of diffraction of a cylindrical wave by the thin screen.

Since the edge rays in the deflection zone of the screen are deflected at a certain distance r from the screen edge rather than at the edge, the formula describing the position of the diffraction fringes with respect to CSB should differ from the above formula. To derive it, lets us use the scheme shown in Fig. 2, where IRP is the projection incident ray *1* prior to its deflection in the zone of the screen Sc, *1'* is the edge ray engendered by deflection of ray *1* in the zone of the screen, h and H are the distances from the point of superposition of edge *1'* and incident *3* rays to IRP and CSB, respectively. According to this scheme, the path difference between the rays interfering at the point P is

$$\Delta = [(\Delta_1 + \Delta_{1'} - \Delta_3) - \Delta_0] = (\Delta_e - \Delta_0).$$

Since $\Delta_1 = \dfrac{r^2}{2l}$, $\Delta_{1'} = \dfrac{(H - r)^2}{2L}$, and $\Delta_3 = \dfrac{H^2}{2(L + l)}$, then

$$H = \frac{r\,(L + l)}{l} + h, \qquad (4)$$

where the second term is specified by the formula given above. Therefore, it specifies the distance from the fringes to IRP, whose position depends on r, rather than to CSB. The unknown values of r, different for fringes of different order, and k_0 do not allow us to find the distances between the fringes of the diffraction pattern from Eq. (4). However, when the distance to the fringes is counted off from the fixed IRP_1 (projection of the incident rays coming after their deflection to $\max_1$), the formula for h and Eqs. (1) and (2) describe adequately the distances between the diffraction fringes as the experimental data presented in Ref. 1 have shown.

This circumstance suggests that k_0 increases with the increase of the edge ray deflection angles. This assumption is reasonable. If $\Delta_0 = k_0\lambda/2$ is caused by the effect of the deflection zone on the rays passing through it, it will increase as the effect intensifies, i.e., as the deflection angle of the edge rays increases. In this case simultaneous shift of the true position of IRP_i towards the beam axis with the increase of the fringe order due to ray deflection in more efficient part of the zone (with smaller r) and the increase of k_0 give approximately the same position of fringes as with k_0 defined from Eq. (2) and h counted off from IRP_1.

In connection with the fact that the position of max_2 is counted off from IRP_1 rather than IRP_2, in the derivation of Eq. (1) the value of $h_{\text{max}1}$ appears to be slightly overestimated, which leads to the above-indicated overestimation of k_0. Table III obtained in the experiments with the diametrically opposed screens gives the values of r_1 from which the incident rays deflect to the first maxima and the distances Δh from IRP_1 to CSB (h_{max_1} was defined from Eq. (1), H_{max_1} was equal to half a distance between max_1 from the left and right screens, and $\varepsilon = h_{\text{max}_1}/L$).

TABLE III.

λ = 0.53 μm					
l, mm	L, mm	$h_{\text{max}1}$, mm	r_1, μm	Δh, mm	ε, min
12	99.5	0.582	7.8	0.073	20
35.5	«	0.381	12.9	0.049	13.2
90	«	0.277	16	0.034	9.6

According to Figs. 1 and 2 of Ref. 2, formula (1) expressing the linear dependence of the edge wave amplitude on the distance h between the point of the edge ray incidence and the shadow boundary (proportional to the diffraction angle ε) incorrectly describes the variations of the intensity J_{e} of edge light when h and ε become less than critical ones h_{cr}, and ε_{cr}. In the case of a cylindrical incident wave (l = 35.5 mm, L = 99.5 mm, and h_{max} = 0.372 mm), h_{cr} = 0.28 mm and $\varepsilon_{\text{cr}} = 0.16°$. This value of ε_{cr} is slightly overestimated. The reason is the following. The dependence $J_{\text{e}} = A/h^2$ was derived on the basis of experiments with a convergent beam (Fig. 1*a* of Ref. 1) in which extentions of the initial ray trajectories entering the deflection zone converged at the point from which h was connected off. Therefore, it is fulfilled when h is a distance from the projections of the initial ray trajectories deflected in the zone to points of their incidence on the investigated plane. In the construction of curve *3* (Fig. 1) describing J_{e} in the shadow, h was taken to be the distance to IRP_1 and matched the above requirement only for the edge rays coming to max_1 of the diffraction pattern and for the rays deflected from the same zone level toward the shadow. The edge rays coming to the maxima of higher orders and those deflected at the same angles into the shadow, deflect in the deflection zone with $r < r_1$. The edge rays propagating to the region between CSB and max_1, as well as to the diametrically opposed shadow zone, deflect with $r > r_1$. The spread of r leads to the spread of distances Δh from the incident ray projections to IRP_1. For $h < h_{\text{cr}}$, h noticeably differs from $h \pm \Delta h$ and the expression $J_{\text{e}} = f(h^2)$ becomes invalid.

When $\varepsilon < \varepsilon_1 = 57.3° h_{\text{max}_1}/L$, IRP is shifted away from the classical shadow boundary with respect to IRP_1 and the distance from it to the point of measurement of the shadow intensity J_{s} becomes equal to $h + \Delta h$. If the quantity $h + \Delta h$ were substituted into the expression for the intensity of the edge wave for $h < h_{\text{cr}}$ this expression would remain valid until a certain minimum value of h, and ε_{cr} becomes smaller.

For a divergent incident beam $\Delta h = \Delta r(L + l)/l$, whereas for a parallel beam $\Delta h = \Delta r$. That is why $\varepsilon_{\text{cr}} = 0.072°$ for the plane wave appears to be smaller than that for the cylindrical incident wave.[2]

From Figs. 1 and 2 and the Cornu spiral, the initial sections of curves *1* and *2* describing J_{s} in the experiment diverge. The main reason of this is that we count h for curve *1* from CSB, whereas for curve *2*, it is counted off from IRP_1 shifted to the right from CSB. However, in the figures IRP_1 is made coincident with CSB.

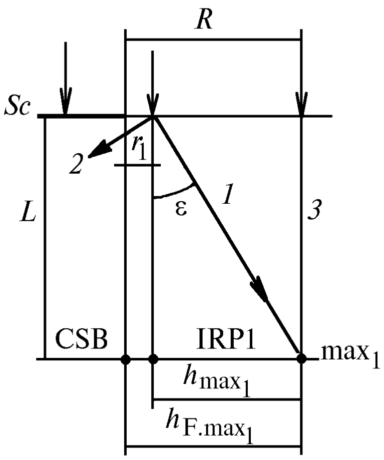

FIG. 3. Scheme of diffraction of the plane wave by the screen.

Figure 3 illustrates the scheme of the plane wave diffraction by the screen for L = 5 mm and λ = 0.53 μm. From Eq. (4) of Ref. 1 the distance h_{max_1} from IRP_1 to max_1 produced due to the interference of the edge ray *1* and the incident ray *3* is equal to 0.135 mm (see Ref. 1). Then $\varepsilon = 9.3'$. According to Table III, this angle corresponds to $r_1 = 16$ μm. For the Cornu spiral,[11] $\max_1$ is formed at $v = 1.2$. Then the distance from $\max_1$ to CSB $h_{F.\max_1} = v\sqrt{\lambda L/2} = 0.138$ mm.

Because the incident wave is plane, the zone, which following Fresnel produces $\max_1$, has the width $R = h_{F.\max_1}$. Then we subtract from it the initial section of width r_1 From the boundary of this section the incident rays deflect in the deflection zone toward $\max_1$. As a consequence, v will decrease down to $v_1 = (h_{F.\max_1} - r_1)\sqrt{2/\lambda L} = 1.06$. In the Cornu spiral, it corresponds to the resultant amplitude of oscillations coming to $\max_1$ being equal to 201.5 mm for the incident wave amplitude being equal to 176.5 mm and the phase of total oscillation differs from the resulting phase for fully open wave front by $\psi = 0.041\pi$.

Due to the decrease in v, the relative light intensity in $\max_1$ will be $J_F = 1.303$. At the same time, the relative intensity of the edge rays in $\max_1$ $J_e = (\sqrt{1.374} - 1)^2 = 0.03$. If the points of the wave front had been sources of light oscillations propagating in different directions and they had been added in the diffraction bands, the light intensity in $\max_1$ would have been determined by the interference of the Fresnel resultant oscillation, having intensity J_F, with the edge light.

Since in $\max_1$ the edge rays are in phase with the incident light and the phase of the resultant wave propagating from the open part of the wave front decreased by r_1 is shifted by ψ with respect to the incident light phase, the relative intensity of $\max_1$ should be no less than

$$J_{\max_1} = (J_F + J_e + 2\sqrt{J_F\, J_e}\cos\psi) =$$

$$= (1.303 + 0.03 + 2\sqrt{1.303 \cdot 0.03}\cos 7.38°) = 1.727.$$

However, it is equal to 1.374, that is, to the value caused by the interference of the edge and incident rays. Therefore, the light perturbations from the points of the open part of the wave front located outside the deflection zone propagate only in the direction of the incident light propagation.

The experiments on the separation of the edge and incident rays when the light was diffracted by a screen (Fig. 3 of Ref. 12) led to the same conclusions. Actually, if the points of the wave front had been sources of light oscillations, every oscillation coming to S_1 would have produced its own diffraction pattern from a slit. Since the points of the wave front are at different angles with respect to the slit axis, the elementary diffraction patterns should be shifted with respect to each other at the same angles and hence should merge to a continuous horizontal band. However, instead of it one can see only $\max_1$ formed by the incident rays coming to the slit in the direction of light propagation and $\max_1'$ formed by the rays coming from the diffraction screen edge.

When the points of the wave front are in the deflection zone of any body, they formally can be considered as sources of light oscillations propagating in different directions. But in so doing it should be remembered that these oscillations propagate at gradually decreasing angles relative to the direction of light propagation as the distance of the point sources from the body edges increases, and propagate in opposite directions when they pass from the deflection zone of optically denser (less dense) medium to the subsequent zone of less dense (denser) medium.[8]

Table IV presents diffraction patterns from the clean blade and blade covered in soot when the intensity J_c of the incident light across the wave front remains constant. Here, if is the light intensity in diffraction fringes; $J_{e.c(e.s)}$ are the edge light intensities with clean blade and blade covered in soot; $J_{e.c(e.s)} = (\sqrt{J_f} - \sqrt{J_c})^2$; $J'_{e.s}$ is $J_{e.s}$ at diffraction angles being equal to those for $J_{e.c}$.

TABLE IV.

$\lambda = 0.53$ μm, $l = 12$ mm, $L = 110.5$ mm, and $J_c = 39.3$ rel units.									
Clean blade, $k_0 = 0.702$					Blade covered in soot, $k_0 = 0.651$				
Fringe	h_{sc}, mm	J_f, rel. units	$J_{e.c}$, rel. units	J_f/J_c	h_{sc}, mm	J_f, rel. units	$J_{e.s}$, rel. units	J_f/J_c	$J_{e.c}/J_{e.s}$
$\max_1$	0.648	52.8	0.998	1.344	0.624	52.2	0.917	1.329	1.174
$\min_1$	1.023	31.8	0.4	0.808	0.994	32.1	0.361	0.817	«
$\max_2$	1.271	45.9	0.259	1.17	1.259	45.5	0.226	1.157	«
$\max_3$	1.682	44.3	0.148	1.127	1.674	43.9	0.127	1.117	«

TABLE V.

λ = 0.6328 μm							
Clean blade, k_0 = 0.773 and J_c = 61.5 rel. units				Blade covered in soot, k_0 = 0.616 and J_c = 65 rel. units			
Fringe	J_f, rel. units	$J_{e.c}$, rel. units	J_f/J_c	J_f, rel. units	$J_{e.s}$, rel. units	J_f/J_c	$J_{e.c}/J'_{e.s}$
max_1	84.55	1.831	1.375	87.4	1.653	1.344	1.467
min_1	48.33	0.791	0.786	53	0.615	0.815	«
max_2	73.22	0.511	1.191	75.4	0.389	1.161	«
max_3	70.26	0.292	1.143	72.84	0.224	1.121	«

TABLE VI.

λ = 0.6328 μm, l = 12 mm, L = 98.5 mm, J_c = 69.24 rel. units, k_0 = 0.746						
Fringe	h_{sc}, mm	h_p, mm	J_{e2}, rel. units	J_f, rel. units	J_f/J_c	J_{e2}/J'_{e2}
max_1	0.654	0.654	2.512	98.1	1.417	1.175
min_1	1.009	1.001	1.055	53.2	0.768	«
max_2	1.255	1.255	0.682	83.7	1.208	«
max_3	1.652	1.650	0.394	80.1	1.157	«

In the case of a clean blade, $F_{bl21}/F_{bl11} = 15/15$ rel. units. For blade covered in soot, $F_{bl21}/F_{bl11} = 20/9.5$ rel. units (F_{bl21} and F_{bl11} are the fluxes of edge rays in the shadow and outside it for the initial parts of the fringes formed by them when S' is in the plane of the screen.[3]

As is seen from Table IV, attenuation of edge light propagating from the screen by a factor of $15/9.5 = 1.58$ due to the absorption of the Sommerfeld component *1′* (Fig. 4) has led to the decrease of the relative intensity in the maxima and its increase in the minima. The reduction of the fringe contrast would be greater if the phase shift of the edge rays were not decreased from $k_0\pi = 0.702\pi$ down to 0.651π for blade covered in soot. This gave rise to the shift of the fringes toward the shadow boundary where the intensity of the edge light was higher.

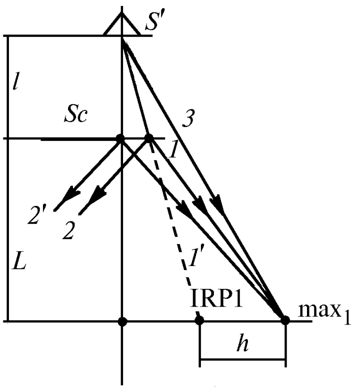

FIG. 4. Scheme of the interference of the fundamental and Sommerfeld components of the edge wave with the incident light in the diffraction pattern from the screen.

The results of experiments with a laser used as a source of light are presented in Table V. In these experiments with a blade covered with soot the ratio F_{bl21}/F_{bl11} was equal to 1.456. These results indicate more clearly the reduction of fringe contrast and the decrease of k_0 on the illuminated side when light is diffracted by the screen covered in soot.

When the incident light interferes with the edge rays propagating to the screen shadow (Fig. 1), the relative intensities of the maxima, on the contrary, increase and those of the minima decrease (see Table VI, where J_{e2} and J'_{e2} are the intensities of the edge wave in the shadow for the blade covered in soot and clean blade, respectively, being equal to $(\sqrt{J_f}-\sqrt{J_c})^2$ due to the increase of the edge ray intensity caused by the absorption of the Sommerfeld component attenuating the fundamental one.

It seems likely that because of relatively small change in the intensities of fringes the above-considered effect of absorbing coverings on the diffraction pattern was not noticed by Fresnel.

With the increase of F_{bl11} by a factor of 1.58, when soot was removed, the edge wave intensity defined as $(\sqrt{J_f} - \sqrt{J_c})^2$ increased only by a factor of 1.174 (Table IV). If it were not the decrease of k_0 for the blade covered in soot, the ratio $J_{e.c}/J_{e.s}$ would be slightly greater but less than 1.56 as before.

The reason for this disagreement is the neglect of the phase shift between the fundamental *1* and Sommerfeld *1′* components of the edge light for the definition of $J_{e.c}$ outlined above. This shift is testified, for example, by the increase of k_0 from 0.651 to 0.702. For the phase of the resultant edge wave to be changed by $(0.702-0.651)\pi$ when the fundamental component and the weaker Sommerfeld component are superposed, the phase shift of the Sommerfeld component with respect to the fundamental one must be much greater. If the phase of the fundamental component propagating from the screen undergoes a phase jump by 0.5π in the direction of light propagation and the Sommerfeld component undergoes a phase shift by π due to the reflection from the screen edge, the Sommerfeld component will run ahead of the fundamental one by $\psi = \left(0.5\pi - \frac{2\Delta_k \pi}{\lambda}\right) \approx 0.5\pi$.

When the blade is covered in soot, the edge light is formed by the fundamental component. Its intensity $J_{e.s}$ in $\max_1$ is equal to 0.917 rel. units (Table IV). Without soot, the edge light intensity should increase up to $J_{e.c} = 1.58\, J_{e.s} = 1.449 = (J_{e.s} + J_S + 2\sqrt{J_{e.s} J_S} \times \times \cos\psi)$, where J_S is the Sommerfeld component of the intensity. For $\cos 0.5\pi = 0$, $J_S = 0.532$ rel. units and makes up 0.58 of the fundamental component.

Because of the effect of the fundamental component with $J_{e.s} = 0.917$ rel. units being in phase with the incident rays in $\max_1$, the light intensity in $\max_1$ increases from $J_c = 39.3$ to 52.2 rel. units (Table IV). In the case of the clean blade the Sommerfeld component with the phase shift $\psi = 90°$ is superposed on $\max_1$. As a result, the intensity of $\max_1$ must increase up to $J'_{\max 1} = = (J_{\max_1} + J_S + 2\sqrt{J_{\max_1} J_S} \cos 90°) = (52.2 + 0.530) = = 52.73$ rel. units. Then the ratio $J'_{\max_1}/J_c = 1.342$, that is, is practically equal to the true value of the relative intensity of $\max_1$.

Actually, $\max_1$ in the diffraction pattern from the clean blade is located between the point with path difference between the incident light and the Sommerfeld component rather than at the point with zero path difference between the incident light and the fundamental edge component, i.e., at great distances from the shadow boundary. Because of this, k_0 increases from 0.65 to 0.7.

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