# THE AXIAL INTENSITY OF A LIGHT BEAM AS A FUNCTION OF THE SLIT WIDTH DERIVED ON THE BASIS OF YOUNG'S DESCRIPTION

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*The dependence of the axial light beam intensity on the width of a slit limiting a beam starting from the interference of the edge rays with the axial rays is explained.*

*Expressions are derived for the half-width of a limiting slit and the intensities of the maxima and minima of the illumination that agree fairly well with the experimental data.*

*The conditions are considered under which the significant amplification of the axial intensity oscillations is observed on the beam axis caused by the change of the width of a limiting slit with the intensity of the incident light and other experimental parameters being constant.*

The quantitative description of a light diffraction pattern by a slit observed in the geometric shadow was given in Ref. 1. This description was based on the interference of the rays diffracted from the diametrically opposed edges of screens forming a slit. It came into use owing to the fact that new data on the edge wave were established in Ref. 2.

Here, in the contrast to the above-mentioned conditions, the direct rays propagate simultaneously with the edge rays to the region of the projection of a slit. Hence, the light intensity at the arbitrary points lying on the beam axis must be determined by the interference of the edge rays with the direct rays.

Figure 1 shows a diagram of the interference of the rays, where *1* and *2* are the edge rays and *3* is the direct ray which converge on the beam axis in the plane of the slit $S_3$ of 30 mm width; $S_2$ is the slit of variable width positioned symmetrically about axis of a beam which comes from the slit $S_1$ of 30 mm width; $l$ and $L$ are the distances from $S_2$ to the light sources $S_1$ and $S_3$, respectively; $h$ is the distance from the geometric shadow boundary (GSB) to the beam axis in the plane $S_3$; $\varepsilon$ is the angle of deflection of the edge rays from the initial direction; and, $t_h$ is the half-width of $S_2$.

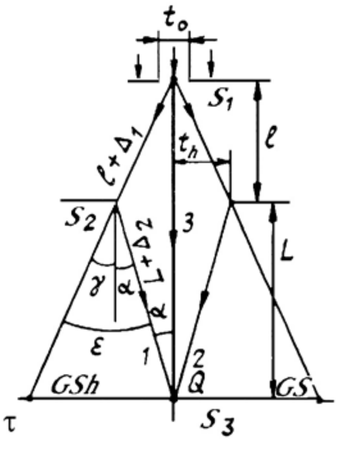


*FIG. 1. The diagram of interference of the rays diffracted by the edges of a slit of the variable width with the axial rays.*

Based on this diagram, we derive the formula which describes the appearance of the maxima and the minima of the light intensity in the plane $S_3$ at the point $Q$ as a function of the width $S_2$. The total difference of the path lengths between the rays *1*, *2*, and *3* is equal to $\Delta = (\Delta_g - \Delta_a)$, where $\Delta_g$ is the geometric path difference between the above-mentioned rays and $\Delta_a$ is the additional path difference which is equal to $0.69\,\lambda/2$ and is caused by an initial phase jump of $0.69\,\pi$ which the edge rays experience propagating to the illuminated side along the ray paths.[2] Obviously, $\Delta_g = (\Delta_1 + \Delta_2)$. Since $\Delta_1 = t_h^2/2l$ and $\Delta_2 = t_h^2/2L$, then $\Delta_g = t_h^2(L + l)/(2lL)$. In what follows

$$\Delta = \left[\frac{t_h^2(L + l)}{2Ll} - \frac{0.69\lambda}{2}\right] = k\lambda/2\ .$$

From which

$$t_h = \sqrt{(0.69 + k)\lambda Ll/(L + l)}\ , \tag{1}$$

where $k$ is the number of $\lambda/2$ in the total path difference between the rays; $k = 0, 2, 4, \ldots$ corresponds to the maxima while $k = 1, 3, 5, \ldots$ corresponds to the minima of the illumination at the point $Q$. The validity of Eq. (1) can be easily confirmed by the data from Tables I and II in which the half-width of the slit $t_{hcal}$ calculated from this formula is compared with its actual value $t_{ha}$, where $\Delta t = (t_{ha} - t_{hcal})$.

As the next step, we find the expressions describing the light intensity on the beam axis when it attains its maximum and minimum. According to Ref. 2, the intensity of the edge rays is $I_e = A/h^2$, where $I_e = I_{e1} = I_{e2}$. As can be seen from Fig. 1, $h = t_h(L + l)/l$. In this case $I_e$ and the amplitude of the edge $a_e$ are equal to

$$I_e = \frac{Al^2}{t_h^2(L + l)^2}\ , \quad \text{and} \quad a_e = \frac{\sqrt{A}\ l}{t_h(L + l)}\ .$$

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*TABLE I*

| $l$ = 51.5 mm; | | $L$ = 408.5 mm; | $\lambda$ = 0.53 μm | |
|---|---|---|---|---|
| Band | $k$ | $t_{ha}$, mm | $t_{hcal}$, mm | $\Delta t$, μm |
| $\max_1$ | 0 | 0.1335 | 0.1293 | 4.2 |
| $\min_1$ | 1 | 0.201 | 0.2024 | −1.4 |
| $\max_2$ | 2 | 0.256 | 0.2554 | 0.6 |
| $\min_2$ | 3 | 0.3005 | 0.299 | 1.5 |
| $\max_3$ | 4 | 0.3385 | 0.3372 | 1.3 |
| $\min_3$ | 5 | 0.373 | 0.3714 | 1.6 |
| $\max_4$ | 6 | 0.4035 | 0.4027 | 0.8 |
| $\min_4$ | 7 | 0.4335 | 0.4318 | 1.7 |
| $\max_5$ | 8 | 0.461 | 0.459 | 2 |

*TABLE II*

| $l$ = 100 mm; | | $L$ = 191.5 mm; | $\lambda$ = 0.53 μm | |
|---|---|---|---|---|
| Band | $k$ | $t_{ha}$, mm | $t_{hcal}$, mm | $\Delta t$, μm |
| $\max_1$ | 0 | 0.1583 | 0.155 | 3.3 |
| $\min_1$ | 1 | 0.2473 | 0.2426 | 4.7 |
| $\max_2$ | 2 | 0.3083 | 0.306 | 2.3 |
| $\min_2$ | 3 | 0.3603 | 0.3585 | 1.8 |
| $\max_3$ | 4 | 0.4073 | 0.4040 | 3.3 |
| $\min_3$ | 5 | 0.4473 | 0.445 | 2.3 |
| $\max_4$ | 6 | 0.4843 | 0.4826 | 1.8 |
| $\min_4$ | 7 | 0.5183 | 0.5175 | 0.8 |

Owing to the summation of the amplitudes of the interfering rays, the resultant amplitude of the maxima of the illumination is $a_{max} = (2a_e + a_a)$, where $a_a$ is the amplitude of the direct rays on the beam axis. Then,

$$I_{max} = a^2_{max} = (4I_e + 4\sqrt{I_e I_a} + I_a),$$

where $I_a$ is the intensity of the axial rays. According to Ref. 3, in the case of the cylindrical incident wave we have $A = 0.02046\lambda L(L + l)I_{dr}/l$, where $I_{dr}$ is the intensity of the direct rays coming from the screens of $S_2$ in the plane of $S_3$ the presumed shadow boundary provided that the slit $S_2$ is removed from the beam. On account of this, we derive

$$I_e = \frac{0.02046\lambda L l I_{dr}}{t_h^2(L + l)}, \tag{2}$$

$$I_{max} = \left[\frac{0.08184\ \lambda L l I_{dr}}{t_h^2(L + l)} + \frac{4}{t_h}\sqrt{\frac{0.02046\lambda L l I_{dr}}{L + l}} + I_a\right], \tag{3}$$

where $t_h$ is the calculated half-width of $S_2$ for the conditions of the maxima of the illumination on the beam axis. If $t_n$ is replaced by its value from Eq. (1), then we derive

$$I_{max} = \left[\frac{0.08184\lambda\ I_{dr}}{0.69 + k} + 4\sqrt{\frac{0.02046 I_a I_{dr}}{0.69 + k}} + I_a\right]. \tag{4}$$

In the minima of the illumination we have $a_{\min} = (a_a - 2a_e)$, hence,

$$I_{\min} = \left(I_a + 4I_e - 4(I_a I_e)^{1/2}\right).$$

Substituting for $I_e$ its value from Eq. (2) we have

$$I_{min} = \left[\frac{0.08184\ \lambda L l I_{dr}}{t_h^2(L + l)} - \frac{4}{t_h}\sqrt{\frac{0.02046\lambda L l I_{dr}}{L + l}} + I_a\right], \tag{5}$$

By solving Eqs. (5) and (1) simultaneously we express $I_{min}$ in terms of $k$

$$I_{min} = \left[\frac{0.08184\ I_{dr}}{0.69 + k} - 4\sqrt{\frac{0.02046 I_{dr} I_a}{0.69 + k}} + I_a\right], \tag{6}$$

*TABLE III*

| $l$ = 100 mm; $L$ = 191.5 mm; $\lambda$ = 0.53 μm | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Band | $t_{hcal}$ μm | $I_{\exp}$ | $I_a$ | $I_{\exp}/I_a$ | $I_{dr}/I_a$ | $I_{cal}$ | $a_{\exp}$ | $a_a$ | $a_e$ | $I_e$ | $h_{cal}$ | $A$ | ε° | $I'_a$ |
| $\max_1$ | 0.155 | 26.4 | 15.1 | 1.748 | 0.989 | 27.16 | 5.138 | 3.886 | 0.626 | 0.392 | 0.452 | 0.08 | 0.136 | 0.396 |
| $\min_1$ | 0.2426 | 9.5 | – | 0.629 | 0.966 | 9.28 | 3.082 | – | 0.4019 | 0.1615 | 0.707 | 0.081 | – | 0.167 |
| $\max_2$ | 0.306 | 20.4 | – | 1.351 | 0.949 | 20.66 | 4.517 | – | 0.3153 | 0.0994 | 0.892 | 0.079 | – | 0.105 |
| $\min_2$ | 0.3585 | 11.16 | – | 0.74 | 0.934 | 11.07 | 3.3406 | – | 0.273 | 0.0745 | 1.045 | 0.0814 | – | 0.08 |
| $\max_3$ | 0.404 | 19.8 | – | 1.263 | 0.908 | 19.14 | 4.368 | – | 0.2409 | 0.058 | 1.178 | 0.0796 | – | 0.064 |
| $\min_3$ | 0.445 | 11.89 | – | 0.788 | 0.886 | 11.89 | 3.449 | – | 0.2186 | 0.0478 | 1.298 | 0.0805 | – | 0..054 |
| $\max_4$ | 0.4826 | 18.37 | – | 1.217 | 0.859 | 18.35 | 4.286 | – | 0.200 | 0.040 | 1.407 | 0.0792 | – | 0.047 |
| $\min_4$ | 0.5175 | 12.35 | – | 0.818 | 0.833 | 12.4 | 3.5145 | – | 0.1857 | 0.0345 | 1.509 | 0.0785 | – | 0.042 |

The correspondence of formulas (3) and (5) and, hence, (4) and (6) with the results of the experiment is confirmed by the data from Table III, where $I_{\exp}$ are the experimental values of the intensity; $I_{cal}$ are the calculated values of the intensity determined from formulas (3) and (5). Here the constancy of A for all the recorded maxima and minima has been demonstrated which is the additional confirmation of the previously established character of the change in $I_e$. To this end, we found $a_{\exp} = (I_{\exp})^{1/2}$ and $a_a = ((I_a)^{1/2})$, $a_e = (a_{\exp} - a_a)/2$, $I_e = a_e^2$, $h_{cal} = f(t_{hcal})$, and, finally, $A = I_e h_{cal}^2$. The last column of the table contains the values of the intensity of the edge wave for $I_{dr} = I_a$, which are equal to $I_e' = I_e I_a / I_{dr}$.

If we consider the interference of the axial rays with the rays coming from one edge of $S_2$ for max when $I_{dr} = I_a$, we obtain $a_e' = (I_e)^{1/2} = 0.63$; $a_{\max 1} = (a_a + a_e') = 4.516$; $I_{\max 1} = a_{\max 1}^2 = 20.394$; $I_{\max 1}/I_a = 1.351$. On account of the measurement error we have this ratio equal to its value in the case of diffraction by the screen[3] that testifies once more the correctness of the explanation of the phenomena which determine the light intensity in both cases.

In order to find the light intensity on the beam axis for any arbitrary width of $S_2$, we will take advantage of the summation rule for the coherent oscillations. According to this rule we have

$$I_{hcal} = a_a^2 + (2a_e)^2 + 2a_a a_e \cos\psi = \left(I_a + 4I_e + 4(I_a I_e)^{1/2}\cos\psi\right), \quad (7)$$

where $\psi$ is the phase difference between the axial and edge rays. It is obvious that

$$\psi = \frac{2\pi}{\lambda}\Delta = \left[\frac{t_h^2(L + l) - 0.69\lambda Ll}{\lambda Ll}\right]180°.$$

When $\psi$ and $I_e$ are replaced by their values, we obtain

$$I_{hcal} = \left\{ I_a + \frac{0.08184\lambda Ll I_a I_{dr}}{t_h^2(L + l)} + \frac{4}{t_h}\sqrt{\frac{0.02046\lambda L l I_a I_{dr}}{L + l}} \times \right.$$

$$\left. \times \cos\left[\frac{t_h^2(L + l) - 0.69\lambda Ll}{\lambda Ll}\right]180° \right\}. \quad (8)$$

Table IV gives the values of $I_{hcal}$ and $I_{\exp}$ for $t_h = t_h' = (t_{he} - 2\ \mu m)$ (see Ref. 1). These values indicate that $I_{hcal}$ are slightly higher than $I_{\exp}$ on these sides of the maxima which correspond to the smaller width of $S_2$ while on the opposite sides, conversely, they are slightly lower. When $\varepsilon = 57.3°$ $t_h'(L + l)/(lL)$ decreases starting from approximately $\varepsilon = 0.123°$, the new factor comes into force and results in a considerable delay in $I_{\exp}$ which increases relative to $I_{hcal}$ (taking into account a certain excess of $I_{hcal}$ relative to $I_{\exp}$ on the sides adjacent to the maxima). As was pointed out in Ref. 2, this factor is due to the violation of the inverse proportionality of the amplitude of the edge wave to the deflection angle of the diffracted rays when $\varepsilon$ is less than its critical value $\varepsilon_c$.

To clarify the behavior of the edge waves at the angles less than $\varepsilon_c$, we plot $I_e' = f(h)$ by the points corresponding to $I_e'$ at the established maxima and minima of the intensity (Table III) and on the shadow boundary (Fig. 2). In the case of diffraction by the screen the ratio of the light intensity on the shadow boundary and the intensity of light incident on the shadow boundary without the screen is constant and according to the large quantity of experimental data is, on the average, equal to 0.306. The direct rays propagating initially to the shadow boundary cannot reach it because of the diffraction from the edge of the screen. Therefore, the light intensity on the shadow boundary from the screen is essentially the intensity of the edge wave. Owing to the common factors forming the diffraction pattern from the screen and determining the illumination on the beam axis, the intensity of the edge wave on the shadow boundary under the considered conditions must be equal to 0.306 $I_{dr}$ or 0.306 $I_a$ (since $I_{dr} \simeq I_a$ for small $t_h$). In such a case the value of $I_e'$ needed for plotting the above-indicated curve, will be equal to $I_e' = 0.306 \cdot 15.1 = 4.62$ relative units on the shadow boundary.

*TABLE IV*

| $l$ = 100 mm; $L$ = 191.5 mm; $\lambda$=0.53 μm | | | | | | | |
|---|---|---|---|---|---|---|---|
| | $t_h'$, mm | $I_{\exp}$ | $I_{hcal}$ | $I_{hcal}/I_{\exp}$ | $\psi$ | $\cos\psi$ | ε° |
| | 0.0713 | 9.85 | 20.45 | 2.076 | −97°55′ | −0.1377 | |
| | 0.0813 | 12.35 | 21.6 | 1.75 | −90°2′ | 0 | |
| | 0.0913 | 14.45 | 23 | 1.59 | −81°6′ | 0.1548 | |
| | 0.1013 | 17.25 | 24.43 | 1.416 | −71°9′ | 0.3231 | |
| | 0.1113 | 19.55 | 25.78 | 1.32 | −60°10′ | 0.4975 | |
| | 0.1213 | 22.05 | 26.9 | 1.22 | −48°8′ | 0.6674 | |
| | 0.1313 | 24.15 | 27.6 | 1.144 | −35°5′ | 0.8183 | 0.114 |
| | 0.1413 | 25.5 | 27.9 | 1.094 | −21° | 0.9337 | 0.123 |
| | 0.1513 | 26.45 | 27.6 | 1.043 | −5°51′ | 0.9948 | 0.132 |
| $\max_1$ | 0.1568 | 26.45 | 27.13 | 1.03 | 2°5′ | 1 | 0.137 |
| | 0.1613 | 26.45 | 26.6 | 1.005 | 10°18′ | 0.9839 | |
| | 0.1713 | 26.65 | 24.9 | 0.97 | 27°30′ | 0.887 | |
| | 0.1813 | 23.95 | 22.6 | 0.944 | 45°44′ | 0.698 | |
| | 0.1913 | 21.5 | 19.84 | 0.923 | 65° | 0.4229 | |
| | 0.2013 | 18.55 | 16.82 | 0.907 | 85°17′ | 0.0823 | |
| | 0.2113 | 15.4 | 13.88 | 0.901 | 106°37′ | −0.286 | |
| | 0.2213 | 12.45 | 11.36 | 0.915 | 129° | −0.6291 | |
| | 0.2313 | 10.55 | 9.73 | 0.929 | 152°28′ | −0.8861 | |
| $\min_1$ | 0.2433 | 9.45 | 9.21 | 0.975 | 181°49′ | −0.9995 | |
| | 0.2513 | 9.65 | 9.85 | 1.02 | 202°17′ | −0.9253 | |
| | 0.2613 | 11.35 | 11.72 | 1.033 | 228°47′ | −0.659 | |
| | 0.2713 | 13.55 | 14.28 | 1.054 | 256°19′ | −0.2366 | |
| | 0.2813 | 16.25 | 17.06 | 1.05 | 284°53′ | 0.2568 | |
| | 0.2913 | 19.1 | 19.38 | 1.015 | 314°29 | 0.7007 | |
| $\max_2$ | 0.3078 | 20.45 | 20.64 | 1.01 | 365°35′ | 0.9953 | |
| | 0.3213 | 18.9 | 18.24 | 0.965 | 416°9′ | 0.557 | |
| | 0.3313 | 16.35 | 16.03 | 0.981 | 443°14′ | 0.1178 | |

If we substitute $I_e'$ taken from the plot for $\varepsilon < \varepsilon_c$, into Eq. (7), $I_{hcal}$ will all the same differ from $I_{\exp}$. This fact can be explained only by the disagreement between the true values of $\psi$ and those determined from the formula

$$\psi = \left[\frac{(t_h')^2(L + l) - 0.69\lambda Ll}{\lambda Ll}\right]180°.$$

This discrepancy may result only from the changes in the initial phase shift. Let us substitute $k_0$ for 0.69 and reduce the formula to the form

$$k_0 = \frac{(t_h')^2(L + l) - \lambda Ll\psi/180^\circ}{\lambda Ll}.$$

Substituting $I_{\exp}$ (for various $t_h'$) and $I_e'$ determined from the plot for $I_{hcal}$ and $I_e$ into Eq. (7) we will find $\psi$ and on their basis $k_0$. The calculated data are listed in Table V. The table shows that the decrease of $t_h$ and, hence, $\varepsilon$ for $\varepsilon < \varepsilon_c$ is accompanied by $k_0$ vanishing with subsequent decreasing to $-1$.

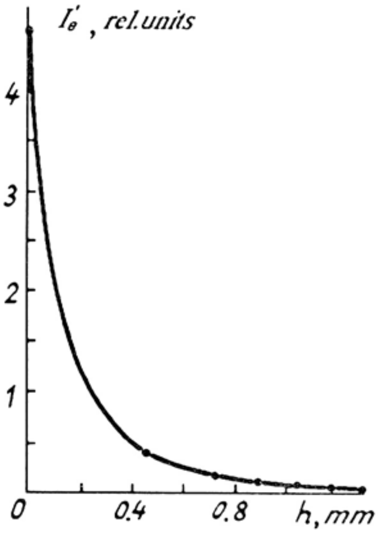


*FIG. 2. The intensity of the edge rays on the beam axis as a function of the distance between the observation point and shadow boundary formed by the screens of a slit of the variable width.*

Thus, for a considered range of variations in $\varepsilon$ the initial phase shift of the edge rays propagating to the illuminated side is no longer constant and varies in such a way that a phase advance is gradually replaced by a phase delay which increases up to $-\pi$.

When a divergent beam incident on $S_2$ is replaced by a parallel beam with $l = \infty$, formulas (1)–(3), (5), and (8) take the form

$$t_h = \sqrt{(0.69 + k)L\lambda}\ , \quad (9)$$

$$I_e = \frac{0.02046\lambda LI_{dr}}{t_h^2}\ , \quad (10)$$

$$I_{\max} = \left[\frac{0.08184\lambda LI_{dr}}{t_h^2} + \frac{4}{t_h}\sqrt{0.02046\lambda LI_aI_{dr}} + I_a\right], \quad (11)$$

$$I_{\min} = \left[\frac{0.08184\lambda LI_{dr}}{t_h^2} - \frac{4}{t_h}\sqrt{0.02046\lambda LI_aI_{dr}} + I_a\right], \quad (12)$$

$$I_{hcal} = I_a + \frac{0.08184\lambda LI_{dr}}{t_h^2} + \frac{4}{t_h}\sqrt{0.02046\lambda LI_aI_{dr}} \times$$

$$\times \cos\left(\frac{t_h^2 - 0.69\lambda L}{\lambda L}\right)180^\circ\ . \quad (13)$$

Let us express the considered light intensity in terms of Fresnel's integrals[4]

$$C_F = \int_0^{\upsilon} \cos\left(\frac{1}{2}\pi\upsilon^2\right)du \quad \text{and} \quad S_F = \int_0^{\upsilon} \sin\left(\frac{1}{2}\pi\upsilon^2\right)d\upsilon$$

By analogy with Ref. 1, the parameter $\upsilon$ can be written as $\upsilon = (2k')^{1/2}$, where $k'$ is the number of the half-waves in $\Delta_g$. Since $\Delta_g = t_h^2(L + l)/2Ll$, then $k' = t_h^2(L + l)/\lambda Ll$. Hence,

$$\upsilon = t_h\sqrt{\frac{2(L + l)}{\lambda Ll}}\ ,$$

where $t_h = t_h'$. We denote by $a_F$ the amplitude of oscillations arrived at the point $Q$ from the wavefront located within the half-width of $S_2$. Since $a_F = (C_F^2 + S_F^2)^{1/2}$, the intensity on the beam axis is $I_F = (2a_F)^2 = 4(C_F^2 + S_F^2)$. To make comparison with the experimental results, we will transfer over from $I_F$ to the intensity $I_F'$ which must be scaled to $I_a$ on the basis of the formula

$$I_F' = I_FI_a/I_{Fi},$$

where $I_{Fi}$ is the Fresnel intensity of the incident light, $I_{Fi} = [2(0.5^2 + 0.5^2)^{1/2}]^2 = 2$. Here 0.5 is the extreme values of Fresnel's integrals ($\upsilon \to \infty$).

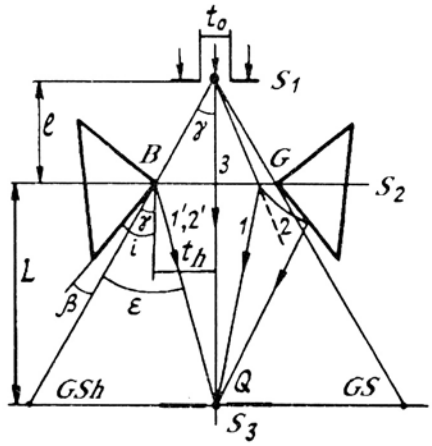


*FIG. 3. The diagram of amplification of the intensity of the edge rays on the light beam axis.*

As can be seen from Table VI, the values of $I_F'$ for the most part agree with $I_{\exp}$. Disagreement appears and gradually increases for $\varepsilon \le 0.1^\circ$, i.e., when the law $I_e = A/h^2$ is violated.

The agreement of $I_F'$ with the experimental values of the light intensity for a wide range of variations in $t_h'$ at first glance testifies the objective reality of Fresnel's description of the nature of light diffraction. But if it were actually the case, then for the constant values of the intensity of incident light and of the parameters of the experimental scheme it would be impossible to form the maxima and minima of the illumination on the beam axis whose intensities were higher or lower than the corresponding intensities listed in the tables. Starting from Young's description, we can easily realize this effect, for example, with the help of the diagram shown in Fig. 3. For the slit $S_2$ in the diagram shown in Fig. 1 the standard slit of the spectral devices can be employed. As is well known, such a slit has the sharp edges with the angles of sharpening much smaller than 90°. In this diagram the slit $S_2$ is formed by two rectangular glass prisms with the sides of 10.6 mm in length. In order to avoid the incidence of the direct rays on the sides of the prisms for not too large $t_h$, the prisms were rotated about the beam axis at the angles $i = 0.224°$.

Owing to this shape of the slit, the edge rays *2*(*2*′) deflected in the region of the edge $G(B)$ toward the shadow boundary are incident on the side of a prism and after reflection they are superimposed on the edge rays *1*(*1*′), diffracting into the illuminated side.

Because of a phase delay of $\pi$ experienced after reflection, the rays *1* and *2* which were initially in antiphase,[2] became matched in phase and for this reason amplify each other. In addition, the smaller the angles $\beta = (i - \gamma)$ the more efficient is the amplification, since a large number of rays *2* reaches the side and reflects from it.

As a result of the increased intensity of the edge waves interfering with the axial rays *3*, the intensities of the maxima turn out to be higher while of the minima – lower as compared with their values observed in the experiments performed according to the first scheme. This can be seen from the data listed in Table VII, where $I_{st}$ and $I_{et}$ are the experimental values of light intensity on the beam axis and the resultant intensity of the edge waves in the case in which the slit $S_2$ is formed by thick screens (prisms); $I_{st} = (I_{st})^{1/2}$; $a_{et} = (a_{st} - a_a)/2$; $I_{et} = a_{et}^2$; $I_e$ is scaled to $I = 16$ relative units. The intensity oscillations would be stronger if the partial refraction of rays *2* by the prism[5] did not happen.

*TABLE V*

| $l$ = 100 mm; $L$ = 191.5 mm; λ=0.53 μm | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $t_h'$, mm | $h_{cal}$, mm | $I_e'$ | $I_{\exp}$ | cosψ | ψ° | $k_0$ | ε° |
| $\max_1$ | 0.1563 | 0.456 | 0.396 | 26.45 | – | – | 0.696 | 0.136 |
| | 0.1513 | 0.441 | 0.43 | 26.45 | 0.9523 | 17.88 | 0.558 | – |
| | 0.1413 | 0.412 | 0.48 | 25.5 | 0.7935 | 37.5 | 0.365 | – |
| | 0.1313 | 0.383 | 0.51 | 24.15 | 0.6315 | 50.8 | 0.213 | – |
| | 0.1213 | 0.354 | 0.6 | 22.1 | 0.3812 | 67.6 | 0.047 | – |
| | 0.1113 | 0.324 | 0.66 | 19.55 | 0.1433 | 0.8177 | –0.1 | 0.1 |
| | 0.1013 | 0.295 | 0.755 | 17.25 | –0.0644 | 93.68 | –0.226 | – |
| | 0.0913 | 0.266 | 0.86 | 14.45 | –0.2837 | 106.48 | –0.352 | 0.08 |
| | 0.0813 | 0.237 | 0.99 | 12.3 | –0.437 | 115.9 | –0.454 | – |
| | 0.0713 | 0.208 | 1.15 | 9.85 | –0.591 | 126.2 | –0.555 | – |
| | 0.0613 | 0.179 | 1.35 | 7.45 | –0.7226 | 136.3 | –0.65 | – |
| | 0.0513 | 0.150 | 1.6 | 5.45 | –0.8163 | 144.7 | –0.728 | – |
| | 0.0413 | 0.120 | 1.9 | 3.45 | –0.8985 | 154.0 | –0.811 | – |
| | 0.0313 | 0.091 | 2.26 | 2.05 | –0.9454 | 161.0 | –0.863 | – |
| | 0.0213 | 0.062 | 2.65 | 1.07 | –0.9734 | 166.8 | –0.911 | – |
| | 0.0113 | 0.033 | 3.4 | 0.35 | –0.989 | 171.53 | –0.948 | – |

*TABLE VI*

| $l$ = 100 mm; $L$ = 191.5 mm; λ=0.53 μm $I_a$ = 15.1 rel.units | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $t_h'$, mm | $I_{\exp}$ | ψ° | $S_F$ | $S_F$ | $I_F$ | $I_F'$ | $I_F'/I_{\exp}$ | ε° |
| $\min_4$ | 0.5163 | 12.32 | 3.913 | 0.4632904 | 0.4275043 | 1.59 | 12.0 | 0.974 | – |
| $\max_4$ | 0.4823 | 18.46 | 3.655 | 0.5447348 | 0.57458 | 2.508 | 18.93 | 1.026 | – |
| $\min_3$ | 0.4453 | 11.92 | 3.375 | 0.447948 | 0.4215657 | 1.514 | 11.43 | 0.958 | – |
| $\max_3$ | 0.4053 | 19.1 | 3.072 | 0.5628183 | 0.582046 | 2.622 | 19.8 | 1.04 | – |
| $\min_2$ | 0.3583 | 11.18 | 2.716 | 0.4390712 | 0.4004868 | 1.413 | 10.67 | 0.954 | – |
| $\max_2$ | 0.3063 | 20.55 | 2.321 | 0.571645 | 0.615639 | 2.823 | 21.32 | 1.037 | – |
| $\min_1$ | 0.2453 | 9.41 | 1.859 | 0.400747 | 0.364105 | 1.173 | 8.85 | 0.941 | – |
| $\max_1$ | 0.1563 | 26.47 | 1.185 | 0.611258 | 0.724905 | 3.597 | 27.15 | 1.026 | – |
| | 0.1513 | 26.45 | 1.147 | 0.5795113 | 0.7449974 | 3.563 | 26.9 | 1.017 | – |
| | 0.1413 | 25.5 | 1.071 | 0.5086403 | 0.7718233 | 3.418 | 25.8 | 1.01 | – |
| | 0.1313 | 24.15 | 0.995 | 0.4332594 | 0.7798542 | 3.184 | 24.04 | 0.995 | – |
| | 0.1213 | 22.05 | 0.919 | 0.3580786 | 0.769916 | 2.884 | 21.77 | 0.987 | – |
| | 0.1113 | 19.55 | 0.844 | 0.28729 | 0.744062 | 2.545 | 19.21 | 0.983 | 0.1 |
| | 0.1013 | 17.25 | 0.768 | 0.223031 | 0.704644 | 2.185 | 16.5 | 0.956 | – |
| | 0.0913 | 14.45 | 0.692 | 0.1666198 | 0.653859 | 1.821 | 13.75 | 0.952 | – |
| | 0.0813 | 12.3 | 0.616 | 0.1193176 | 0.594472 | 1.47 | 11.1 | 0.902 | – |
| | 0.0713 | 9.85 | 0.540 | 0.0812206 | 0.528780 | 1.145 | 8.64 | 0.877 | – |
| | 0.0613 | 7.45 | 0.4646 | 0.0522128 | 0.4596644 | 0.856 | 6.46 | 0.867 | – |
| | 0.0513 | 5.45 | 0.389 | 0.030697 | 0.386808 | 0.602 | 4.55 | 0.834 | – |
| | 0.0413 | 3.45 | 0.313 | 0.0160286 | 0.3122596 | 0.391 | 2.95 | 0.856 | – |
| | 0.0313 | 2.05 | 0.237 | 0.0069663 | 0.2368156 | 0.2245 | 1.695 | 0.827 | – |
| | 0.0213 | 1.07 | 0.161 | 0.002185 | 0.1609733 | 0.104 | 0.78 | 0.731 | – |
| | 0.0113 | 0.35 | 0.086 | 0.000333 | 0.085999 | 0.03 | 0.22 | 0.637 | – |

Taking into account the character of variation in $I_{et}/I_e$, the effect considered is important only for small β. The reason of this is the propagation of the major part of the diffracted rays at small angles with the initial direction which makes it possible to avoid the incidence of rays on the prism side and their subsequent reflection in those cases when β exceeds the value of these angles.

*TABLE VII*

| $l$ = 100 mm; $L$ = 191.5 mm; $\lambda$=0.53 μm | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Band | $t_{hcal}$, mm | $t_{ha}$, mm | $I_{st}$ | $I_a$ | $a_{st}$ | $a_a$ | $a_{st}$ | $I_{et}$ | $I_{st}/I_a$ | $I_{exp}/I_a$ | $I_{et}/I_e$ | β° |
| $max_1$ | 0.155 | 0.160 | 32.17 | 16 | 5.672 | 4 | 0.836 | 0.7 | 2.01 | 1.748 | 1.684 | 0.135 |
| $min_1$ | 0.243 | 0.247 | 6.47 | – | 2.544 | 4 | 0.728 | 0.53 | 0.404 | 0.629 | 3.1 | 0.08 |
| $max_2$ | 0.306 | 0.308 | 26.37 | – | 5.135 | 4 | 0.568 | 0.322 | 1.648 | 1.351 | 3.07 | 0.049 |
| $min_2$ | 0.3585 | 0.361 | 7.97 | – | 2.823 | 4 | 0.588 | 0.346 | 0.498 | 0.748 | 4.74 | 0.019 |
| $max_3$ | 0.404 | 0.405 | 24.17 | – | 4.916 | 4 | 0.458 | 0.21 | 1.511 | 1.252 | 3.68 | 0.008 |

The explanation of the dependence of the axial illumination on the size and position of limiting slit on the basis of Fresnel's description leads to the statement about nonrectilinear light propagation.[6] After establishing the true reason of this phenomenon, this statement become unconvincing.

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