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Influence of a prism refracting starlight on the observed positions of a star

J. Wilczyński

Mailing address: Skr. p. 2057, Wrocław 1, Poland.

The Fresnel's considerations on Arago's experiment when made within the framework of the photon theory of light and for any position of a star result in conclusions contrary to those stated by Fresnel; the measured position of a star depends on the passage of starlight through the prism, but this dependence is diametrally different from that presented by us for the wave theory of light in [1]. The considerations are also performed from the viewpoint of the special relativity as well as of classical physics when the image is observed also at the focus of inclined lunette. The changes of the position of the star being observed depend on the prism parameters, on the angle of incidence on the prism (the angle of the entering prism surface with the lunette axis), and on the R- and L-orientations of the prism. Special relativity predicts no changes in the position of a star within the frames of both the wave and photon theories of light. Arago's experiment must be repeated; the accuracy of his measurements was not sufficient enough to decide which theory (i.e., wave or photon theory in classical physics or special relativity) is right and to check whether some additional effects or/and phenomena are not superimposed.

1. Introduction

While repeating Fresnel's consideration [2], within the frame of the *wave* theory of light, but for *any* star in the sky, we have shown [1] that in Arago's experiment [3] the measured position of a star depends on the orientation of the prism and on the angle between the Earth speed down the orbit and the direction of the star. Then three values can be measured: one for the direct starlight beam and two for the beam first passing through an achromatic prism. In the same conditions special relativity predicts only one value.

In Section 2 we consider the same situation as that in [1] but from the viewpoint of the *non-wave* theory of light, assuming the same initial conditions and numerical qualities. The following new situations will be considered, namely: those dependent on different angles of incidence on the entering prism surfance and on different parameters of the prism, and that occurring when the inclined lunette with prism is a little deviated for the focus to coincide with the image. Starlight is treated as photons or chains of dimagrans [4], [5]. A chromatic prism is taken in consideration in order the formulae be more easily derived: in the case of an achromatic prism only quantitative differences can exist.

The considerations will be conducted from the positions of classical physics and special relativity. It is more convenient and above all the effects are more readable when the classical inclination of the lunette is referred to the relativistic one. The symbols, which ought to be distinguished or can have different values or positions, are primed in special relativity.

2. Fresnel's case for any star in the photon theory of light

Let us take Fig. 4(ab) in [1]. The starlight beam is representend by the ray b_o passing through the centre of the lunette objective. Now, too, the ray b_o is always perpendicular to the entering prism surface for any angle φ_o (between the Earth speed V down the orbit and the direction of a star). Thus, the ray b_o enters the prism with no refraction. Inside the prism it is dragged in the direction of speed V. In the non-wave theory of light the dragging has no meaning as it only shifts the path and changes the point at which the ray b_o emerges from the prism. The angle of refraction at leaving the prism does not depend on this dragging being such as if $V = 0$. Otherwise, Airy's result would not explain the fact that the aberration of starlight is independent of filling a lunette, and in all the considerations or/and derivations of the formulae the authors (Fresnel included) follow the above reasoning. In order to explain Airy's and Klinkerfues's experiments, in which the lunette was fully or partially filled, even the longitudinal dragging cannot be taken into account.

A shift of the ray b_o emergence does not influence the appearence of the image in the focal plane of the lunette (another ray in the parallel beam will pass through the objective centre). Thus, after refraction, the beam will travel parallelly to the ray b in Fig. 4(ab) in [1] and give the image T in the inclined lunette. The focus S moves to S_1 during the time of the ray b passage through the lunette tube. The distance of the image T from the focus at S_1 is

$$(S_1T)_L = ST - SS_1 \tag{1}$$

in the L-orientation of the prism (Fig. 4(a) in [1]), and

$$(S_1T)_R = ST - SS_1 \tag{2}$$

in the R-orientation (Fig. 4(b) in [1]). The corresponding *angular* distances are:

$$\eta_L = \alpha_o - \alpha_L = \alpha_o \; - \; \text{arctan.}\left[\frac{V}{c}\sin(\alpha_o - \delta)\right], \tag{3}$$

and

$$\eta_R = \alpha_o - \alpha_R = \alpha_o \; - \; \arctan\left[\frac{V}{c}\sin(\alpha_o + \delta)\right] \tag{4}$$

where:

$$\alpha_o = \arctan\left[\frac{V}{c}\sin\varphi_o\right], \tag{5}$$

$$\delta = 90° - \Delta - \arcsin[\mathrm{n}\sin\Delta], \tag{6}$$

and Δ is the refracting angle of the prism. The calculated values of η_L and η_R are given in Table 1. Here, too, η_L and η_R depend on the angle φ_o, and we can receive three different positions of the same star. But here the dependence on the angle φ_o is diametrally different from that given in Table 1 in [1]. Now, moreover, the image T can behind as well as in front of the focus, even in the same orientation of the prism, and this position depends on the angle φ_o.

Table 1. The calculated angular distances of the star image from the focus of an inclined lunette in the non-wave theory of light, angles η_R and η_L, in a function of the angle φ_o when starlight is perpendicular to the entering prism surface

φ_o	α_{φ_o}	$i'_1 = 0°0'0.000''$			
		R-orientation		L-orientation	
		α_R	η_R	α_L	η_L
1	2	3	4	5	6
0°	0.00″	7.85″	−7.85″	−7.85″	7.85″
15	5.34	12.52	−7.18	−2.65	7.99
30	10.31	16.34	−6.03	2.73	7.58
45	14.58	19.04	−4.46	7.93	6.65
60	17.86	20.44	−2.58	12.59	5.27
75	19.92	20.46	−0.53	16.39	3.53
90	20.63	19.07	1.55	19.07	1.55
105	19.92	16.39	3.53	20.46	−0.53
120	17.86	12.59	5.27	20.44	−2.58
135	14.58	7.93	6.65	19.04	−4.46
150	10.31	2.73	7.58	16.34	−6.03
165	5.34	−2.65	7.99	12.52	−7.18
180	0.00	−7.85	7.85	7.85	−7.85

3. Relativistic description

We must assume that in the same starlight beam coming from a given star there are two so-called components: the relativistic one represented, e.g., by the ray s' and the classical one represented, e.g., by the ray s. These rays pass through the centre of the lunette objective. These rays form in the beam the aberration angle

$$\alpha_{\varphi_o} = \arctan\left[\frac{V}{c}\sin\varphi_o\right] \tag{7}$$

(multiplied by factor $\gamma = (1 - V^2/c^2)^{-1/2}$ in special relativity). In special relativity the starlight beam "refracts aberrationally" to the back relative to speed V somewhere at point F' in Fig. 1 when this beam passes from the "stationary" frame of the Sun into the "moving" frame of the Earth. After such a "refraction" the path of the ray s' is as if "locked-up" in the Earth's frame, i. e., there is no relative motion between them; the Earth and the path of ray s' are both moving with the same speed relative to the Sun (the Earth's rotary motion is neglected here).

In special relativity the aberration effect, as a single (instant) "refraction" takes place before the ray falls into the lunette or experimental arrangement (both remaining on the Earth). Therefore, the orientation of the ray falling *directly* into the lunette and *giving the image at the focus* must be always parallel to the axis inside and to that outside the empty or/and filled lunette [6]–[9]. In other words, all what happens after this "refraction" does not depend on the Earth speed relative to a given star or to the Sun; all the phenomena run as if $V = 0$. Therefore, the deviation of the ray after its passage through the prism can be and is only a function of the prism parameters and of the angle i_1' of incidence on the entering prism surface. This deviation *cannot* depend on the position of a star in the sky, that is, on the angle φ_o.

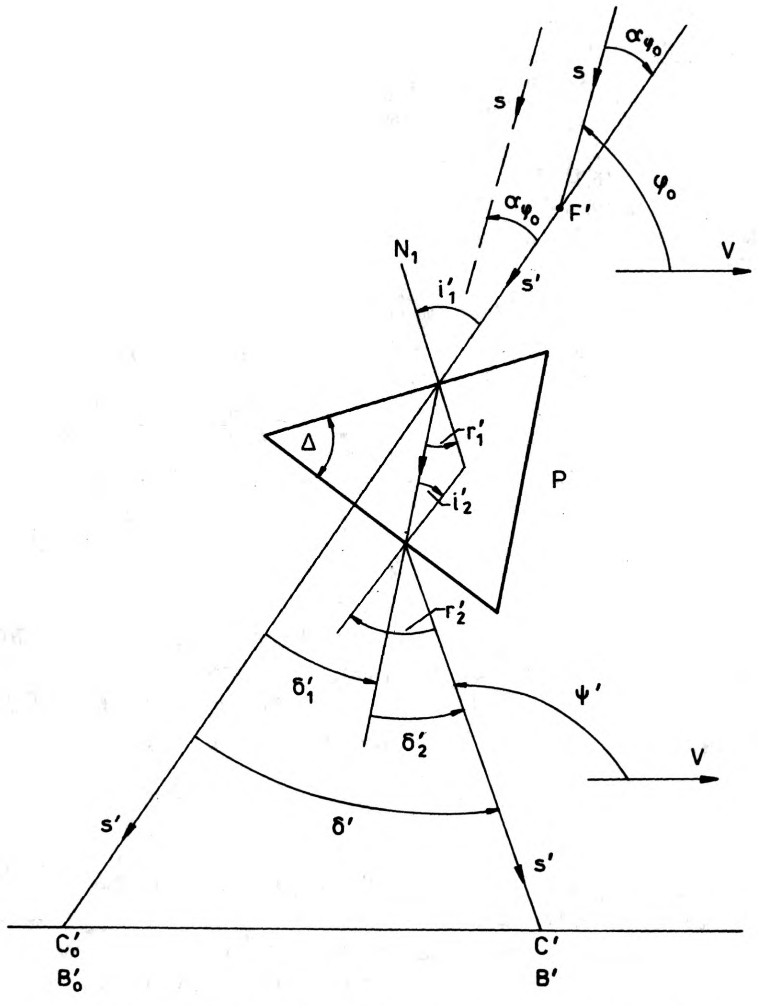

Fig. 1. In special relativity the ray s' forming the angle φ_o with the Earth speed V is "refracted aberrationally" at F', angle α_{φ_o}, and as the ray s' gives a direct image B_o' at the focus C_o'. After passing through the prism P, there arises the image B' at focus C'. δ' – angular deviation between the two images

The ray s' forms the angles i_1' and r_1' with the normal of entering prism surface (Fig. 1) and the angles i_2' and r_2' with the normal of emerging prism surface; the refracting prism angle is Δ, $(\Delta = r_1' + i_2')$. The deviation of the ray (after its passage through the prism with refractive index n), i.e., the angle δ', is equal to

$$\delta' = \delta_1' + \delta_2' = i_1' + r_2' - \Delta \tag{8}$$

or

$$\delta' = i_1' - \Delta + \arcsin\left\{ \mathrm{n}\sin\left[\Delta - \arcsin\left(\frac{1}{\mathrm{n}}\sin i_1'\right)\right]\right\}, \tag{9}$$

after taking into account the relationship between the angles of incidence and of refraction. Here, there is no transverse dragging of starlight in special relativity. If the star image is observed at the focus, after the passage of starlight through the prism, the lunette is inclined by the angle

$$D_{\mathrm{rel}} = \delta'(\mathrm{n}, \Delta, i_1') = \mathrm{const} \tag{10}$$

from the direction shown by the lunette when the direct ray s' is observed at the focus. Then the lunette axis forms with the ray s' the angle

$$\psi' = (\varphi_o - \alpha_{\varphi_o}) + \delta' \tag{11}$$

with speed V, which is also independent of the L- and R-orientations of the prims. In the L-orientation the vertical (refracting) angle of the prism shows the direction of the speed V (when $\varphi_o \sim 90°$), and in the R-orientation (as in Fig. 1) this angle shows the direction opposite to the speed V (when $\varphi_o \sim 90°$).

To sum up, the inclination of the lunette with prism when the starlight passes through the prism is constant, independent of the angle φ_o and of the prism orientation; the image is also at the focus, provided that it was there for the direct starlight beam.

4. Classical description

In both theories the lunette axis has the same orientation, when the *direct* starlight beam falls into it; the two focuses coincide, $C_o' \equiv C_o$ in Fig. 2, at the moment at which the beam falls into the objective. The ray s' is parallel to the extension of the lunette axis, and the ray s forms the aberrational angle with this extension and the ray s'. In classical physics the aberration effect arises *inside the lunette* as a motion of the (empty) lunette relative to the path of starlight beam; this effect persists as long as the beam travels the distance between objective and focal plane. Thus, the aberration effects in the two theories differ from one another in the place and way of their realization.

Since the ray s of the same *direct* starlight beam forms the angle α_{φ_o} (defined in (7)) in the extension of the lunette axis, the image is made at B_o, that is, at the point at which the extension of the path of ray s pierces the focal plane at the moment the ray

s passes through the objective. When the direct ray s reaches B_o, the focus moves from C_o to $C_{o1} \equiv B_o$.

The ray s, *passing first through the prism,* forms with the normal of the entering prism surface (in Fig. 2) the angle

$$i_1 = i_1' - \alpha_{\varphi_o}. \tag{12}$$

Analogically to the formulae (8) and (9) we get

$$\delta = \delta_1 + \delta_2 = i_1 + r_2 - \Delta \tag{13}$$

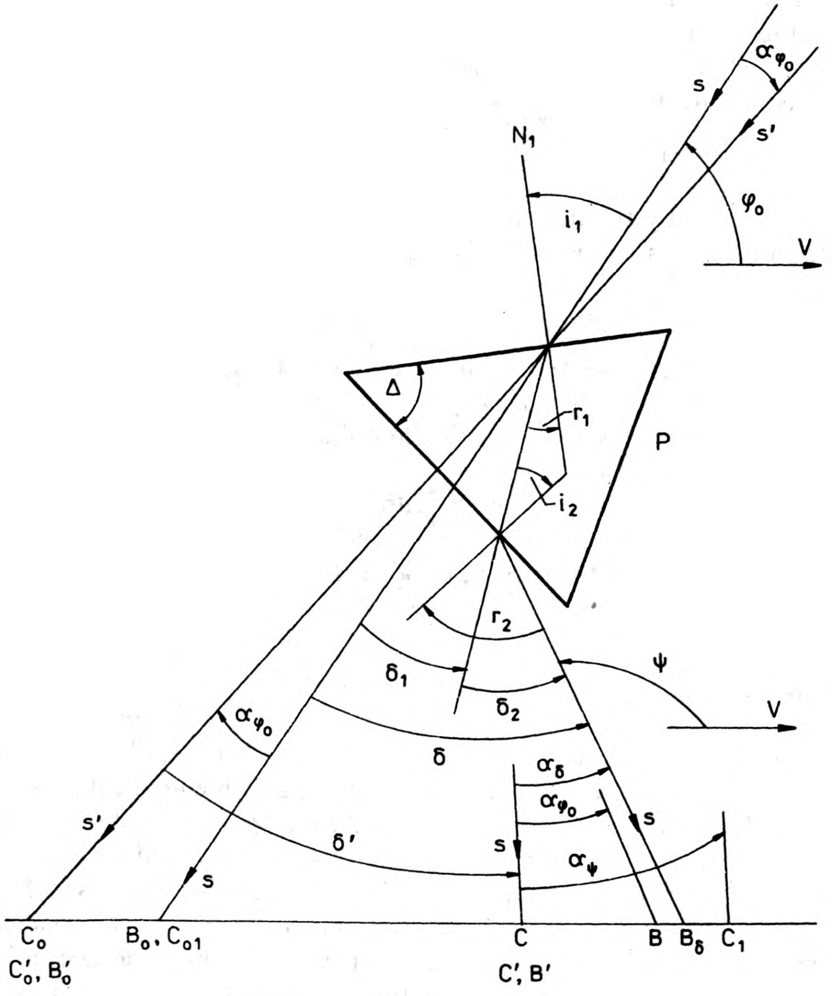

Fig. 2. Rays s' and s of the same starlight beam from the aberration angle α_{φ_o} before entering into the prism P. The primed symbols and letters are in special relativity. The direct beam gives the images: B_o' at focus C_o', and B_o at focus C_o moved to C_{o1}. After passing through the prism P, when the ray s' gives the image B' at focus C', the ray s gives the image at B_δ and the focus C moves to C_1

or

$$\delta = i_1 - \varDelta + \arcsin\left\{ n \sin\left[\varDelta - \arcsin\left(\frac{1}{n} \sin i_1 \right) \right] \right\} \tag{14}$$

after taking into account the relationships between the incidence and refraction angles.

In classical physics the transverse dragging of the starlight beam in the moving prism does not change the travelling direction of this beam, but only shifts its path. Here the longitudinal dragging its existence or absence need not be taken into the consideration, because it can only influence the magnitude of the transverse shifting. The latter, however, takes place *before the objective*, thus it does not influence the position of the image in the focal plane.

The refraction of the ray s emerging from the prism is such as if the prism was not moving. Such an assumption must be taken if Airy's experiment is to explain the independence of the starlight aberration of filling the lunette (see also Sect. 2).

After the starlight beam leaves the prism, the function of the central ray s passing through the objective centre will be performed by another ray. The angular difference between the ray s and the ray s' is equal to

$$\alpha_\delta = \alpha_{\varphi_o} + (\delta - \delta') = \alpha_{\varphi_o} + \varepsilon. \tag{15}$$

The linear distance $BB_\delta = CB_\delta - CB$ corresponds to the angle

$$\varepsilon = \alpha_\delta - \alpha_{\varphi_o} = \delta - \delta' \tag{16}$$

in Fig. 2. The extension of the path of ray s passing through the objective centre pierces the focal plane at B_δ at which the image arises. When the ray s travels the distance between the objective and the focal plane, the focus moves from C to C_1. Now, the ray s forms the angle

$$\psi_s = \varphi_o + \delta' + \varepsilon = \varphi_o + \delta \tag{17}$$

with the speed V, while the lunette axis forms with it the angle

$$\psi = (\varphi_o - \alpha_{\varphi_o}) + \delta'. \tag{18}$$

Therefore, the *angular* motion of the focus from C to C_1 is

$$\alpha_\psi = \arctan\left[\frac{V}{c} \sin\psi \right] \tag{19}$$

in the time when the ray s travels through the lunette tube. Angularly, $C_oB_o = CB$.

Let us see the changes of the angular values of δ, δ' and ε as the function of the relativistic incidence angle i_1', $i_1' - i_1 = \pm 15''$ (seconds of arc). We take: $n = 1.5$, $\varDelta = 33.5°$, $V = 30$ km/s and $c = 300000$ km/s. The difference $(i_1' - i_1)$ can have either positive or negative value, this refers to both the orientations of the prism. The positive value is stated when the starlight beam is placed between the speed V and the normal of the entering prism surface, i.e., when $i_1' > 0$ in the R-orientation of the prism (as in Fig. 2) or when $i_1' < 0$ in the L-orientation ($i_1' > 0$ in Fig. 3b).

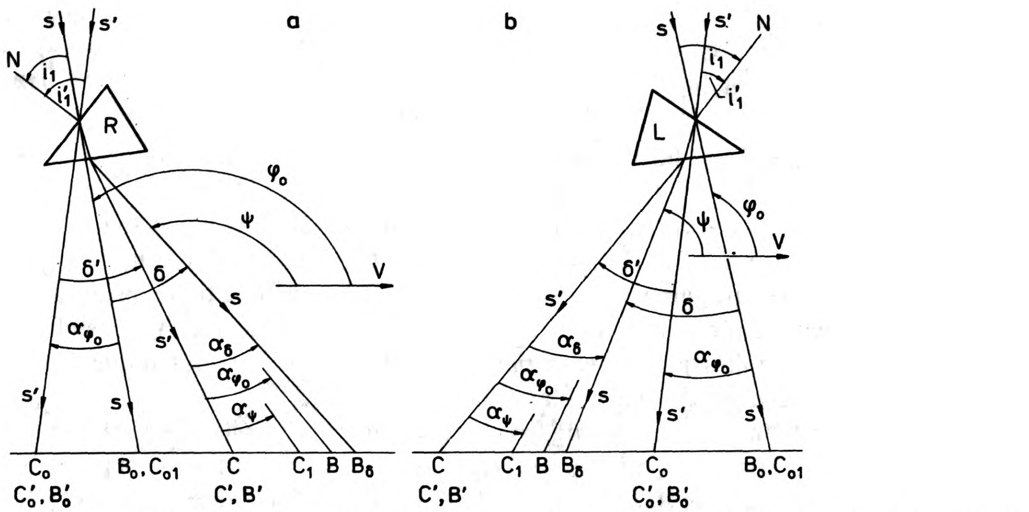

Fig. 3. Simplified scheme of Fig. 2 but for greater angles φ_o (a). Simplified scheme of Fig. 2 but with the L-orientation of the prism P (b)

The calculated values are shown in Table 2. For the same starlight whose direct beam gives the aberration effect $\alpha_{\varphi_o} = 15''$ (i.e., when the angle between the ray s and the ray s' before entering the objective or prism is the same), the relativistic deviation of the beam passing through the prism, the angle δ' (column 2 in Table 2), depends on the angle i_1' of incidence on the entering prism surface; there exists one minimum deviation for one angle $i_1' = i_{1m}'$. When the angle i_1' increases ($i_1' > i_{1m}'$) or decreases ($i_1' < i_{1m}'$), the values of angle δ' become greater and greater and are not symmetrical.

Table 2. The calculated angular values of the angle δ', and the differences of the angles $\varepsilon_R = \delta_R - \delta'$ and $\varepsilon_L = \delta_L - \delta'$, all as a function of angle i_1', within the frame of the non-wave theory of light for $i_1' - i_1 = -15''$ (column 3) and $i_1' - i_1 = +15''$ (column 4)

i_1'	δ'	ε_R	ε_L
1	2	3	4
−12°	37°51′29.45″	81.171″	−80.796″
−10°	31 46 17.78	29.730	−29.699
0°0′00″	22 23 3.04	7.3044	−7.3008
10°	19 9 5.13	3.040	−3.041
20°	17 53 31.34	0.905	−0.903
25°36′50.40″ $i_{1m}' = 25.614°$	17 43 35.45	0.00044	0.00066
30°	17 49 20.29	−0.650	0.651
40°	18 44 27.96	−2.117	2.117
50°	20 41 12.27	−3.767	3.771
55°53′3.03″	22 23 3.04	−4.91228	4.90986
60°	23 51 10.41	−5.808	5.810
70°	28 33 5.26	−8.381	8.384
80°	35 9 14.20	−11.506	11.511

The deviation of the ray s, i.e., the angle δ, is equal to the angle δ' only when $i_1' = i_{1m}'$ for both the orientations of the prism. For other angles i_1' and for R-orientation of the prism ($i_1' = i_{1m}' - 15''$) the difference $\varepsilon_R = \delta - \delta'$ is growing and being positive when the angle i_1' decreases ($i_1' < i_{1m}'$), while ε_L decreases and is negative when the angle i_1' decreases ($i_1' < i_{1m}'$); here an asymmetry is also observed. For the L-orientation of the prism ($i_1 = i_1' + 15''$) the values of ε_L change their sign with respect to ε_R.

5. Coincidence of the focus with the image

When the image B' is at the focus C' in special relativity, the image B_δ in classical physics ought to be behind the focus C_1, for the situation shown in Fig. 2 (cf. with Fig. 3**a** for higher values of φ_o) at the linear $B_\delta C_1$ and angular $(\alpha_\psi - \alpha_\delta)$ distances. In order for the focus to coincide with the image in classical physics the inclination of the inclined lunette should be changed (i.e., the angle ψ should be reduced in Fig. 2) until B_δ and C_1 are overlapped. Note, that when the angle ψ decreases, C_1 shifts *to the left* and the angle i_1' decreases. Therefore, the difference $\varepsilon_R = \delta - \delta' = \alpha_\delta - \alpha_{\varphi 0}$ increases (Table 2) and thus B_δ must be shifted *to the right.*

While the distance $B_\delta C_1$ is reduced to zero these points are approaching to each other with different speeds. That of B_δ can be obtained by calculating the coefficient χ when the angle ψ or i_1' or i_1 is changed by $\pm 1''$; it appears that this dependence is almost linear even when the lunette is turning by $\pm 20''$. When the focus covers the image, the inclination of the lunette from the direction shown by the direct ray s will be equal to

$$D_{cl} = D_{rel} - (\alpha_\psi - \alpha_\delta)/(1+\chi). \tag{20}$$

Thus, the difference between constant inclination D_{rel} in special relativity and variable inclination D_{cl} in classical physics is

$$\Delta D_R = D_{cl} - D_{rel} = -(\alpha_\psi - \alpha_\delta)/(1+\chi) \tag{21}$$

for the R-orientation of the prism (as in Fig. 2). This difference is a function of the angle φ_o as well as of the angle δ' and can be either negative or positive.

Let us calculate the values of ΔD_R. To compare them with the data contained in Table 1 in [1] we assume that the ray s' passing through the prism is always perpendicular to the entering prism surface, that is, $i_1' = 0°0'0.000''$, to which there corresponds $\delta' = 22°23'3.04''$ ($= 22.384177°$) in Table 2, for all the angles $0° \leqslant \varphi_o \leqslant 180°$. Now, angles i_1 and δ will be obviously the functions of angle φ_o. For calculation, the angle ΔD_R in (21) will be rewritten as

$$\Delta D_R = -\left\{\arctan\left[\frac{V}{c}\sin(\varphi_o - \alpha_{\varphi_o} + \delta')\right] - [\alpha_{\varphi_o} + (\delta - \delta')]\right\}/(1+\chi) \tag{22}$$

where α_ψ is defined in (19), ψ in (18), α_{φ_o} in (7), δ in (14), α_δ in (15) and

$$\chi_R = \chi_R = \varepsilon_R/15 = 0.48696, \tag{23}$$

$$\chi_L = \chi_L = \varepsilon_L/15 = 0.48672. \tag{24}$$

ε_R and ε_L are given in Table 2 for $i'_1 = 0°0'0.0000''$ when $\alpha_{\varphi_o} = 15''$. Generally, the angle ε, as being now ε_φ, must be a function of the angle α_{φ_o}

$$\varepsilon_{\varphi R} = \alpha_{\varphi_o}\chi_R \text{ (and } \varepsilon_{\varphi L} = \alpha_{\varphi_o}\chi_L). \tag{25}$$

Formula (22) is then reduced to

$$\Delta D_R = -\left\{\arctan\left[\frac{V}{c}\sin(\varphi_o - \alpha_{\varphi_o} + \delta')\right] - \alpha_{\varphi_o}(1+\chi_R)\right\}/(1+\chi_R). \tag{26}$$

The calculated values of ΔD_R and of ΔD_L (for the L-orientation of the prism) are given in Table 3. Following the same procedure as used for deriving the formula (26) for ΔD_R (Figs. 2 and 3**a**), we get (Fig. 3**b**):

$$\Delta D_L = -\left\{\arctan\left[\frac{V}{c}\sin(\varphi_o - \alpha_{\varphi_o} + \delta')\right] - \alpha_{\varphi_o}(1+\chi_L)\right\}/(1+\chi_L). \tag{27}$$

for the L-orientation of the prism. In this case, the focus C_1 "hunts" for the image B_δ which shifts to the right when the angle ψ increases. This situation is shown in Fig. 3**b** (the angles i'_1 and i_1 are decreasing, and $\varepsilon_L = \delta_L - \delta'$ in Table 2 decreases too since δ_L decreases).

Table 3. The calculated angular values of ΔD_R and ΔD_L as a function of the angle φ_o for three values of the angle i'_1 when the image is observed at the focus of inclined lunette

φ_o	α_{φ_o}	$i'_1 = 0°0'0.000''$, $\delta' = 22.384177°$		$i'_1 = 55°53'3.03''$, $\delta' = 22.384177°$		$i'_1 = i'_{1m}$, $\delta'_m = 17.726514°$	
		ΔD_R	ΔD_L	ΔD_R	ΔD_L	ΔD_R	ΔD_L
1	2	3	4	5	6	7	8
0°	0.00″	−5.28″	15.30″	−5.92″	11.68″	−6.28″	6.28″
15	5.34	−3.08	20.63	−4.10	14.48	−5.81	6.32
30	10.31	−0.67	24.55	−1.99	16.29	−4.95	5.93
45	14.59	1.78	26.80	0.24	16.99	−3.75	5.14
60	17.86	4.11	27.22	2.46	16.53	−2.29	3.99
75	19.92	6.17	25.78	4.51	14.95	−0.68	2.57
90	20.63	7.80	22.59	6.26	12.35	0.98	0.98
105	19.92	8.90	17.86	7.58	8.90	2.57	−0.68
120	17.86	9.40	11.91	8.38	4.85	3.99	−2.29
135	14.59	9.25	5.15	8.61	0.47	5.13	−3.75
150	10.31	8.47	−1.96	8.25	−3.93	5.93	−4.95
165	5.34	7.12	−8.94	7.34	−8.08	6.32	−5.81
180	0.00	5.28	−15.30	5.92	−11.68	6.28	−6.28

6. Discussion and conclusion

Fresnel's consideration repeated within the frame of the wave theory of light [1] concerning Arago's experiment reveals the dependence on the position of a star on starlight passing through an (achromatic) prism; this change is a function of angle φ_o (between the Earth speed V down the orbit and the direction of the observed star), see Table 1 in [1]. This consideration has been repeated once more in Sect. 2 but within the framework of the *non*-wave theory of light. We have assumed that the light travels through a matter with speed c/n, when $V=0$. Although there also exists the dependence on the angle φ_o (see Table 1), it is, however, diametrally different from that in Table 1 [1]. Note that in both the cases we have assumed that the starlight beam (rays a_o and b_o) is perpendicular to the entering prism surface when the lunette with prism is inclined by angle $\delta=$ const. From the above assumption it follows that the angle between the entering prism surface and the lunette axis has to be the function of angle φ_o. We have accepted this perpendicularity following Fresnel's assumption (for $\varphi_o = 180°$).

In practice, however, the angle between the entering prism surface and the lunette axis is *constant*, it ought to be constant at least in the same series of observations. Just for such a situation our considerations are repeated in Sections 3–5 within the frame of the non-wave theory of light, from the position of special relativity and classical physics (light treated as photons or chains of dimagrans). In special relativity, *for any angle* φ_o, the starlight beam falling on the entering prism surface must have always the same incidence angle i'_1 (dependent on the angle between the entering prism surface and the lunette axis), and the deviation of the beam, i.e., angle δ', is a function of angle i'_1 (see Table 2). In this theory the position of a star does not depend on the starlight passing through the prism. It does not depend on the orientation of the prism, either.

In classical physics, the deviation starlight, i.e., the angle δ, depends on the angle φ_o if $i'_1=$ const, because the angle between the rays s' and s in a given starlight beam is a function of the aberrational angle α_{φ_0}: $i_1 = i'_1 \pm \alpha_{\varphi_0}$. Then $\varepsilon = \delta - \delta' \neq 0$ for any angle i'_1 (except for $i'_1 = i'_{1m}$), as it follows from Table 2. This difference is the greater the further is the angle i'_1 from the angle i'_{1m} (at which δ' is minimum) and this change is asymmetrical. Besides, the sign of ε changes when i'_1 passes through i'_{1m}. In classical physics the value of ε (ε_R and ε_L in Table 2) depends on the orientation of prism and differ in sign for the same i'_1.

The distances of the image from the focus after having inclined the lunette by an angle $\delta' =$ const are given in Table 4 for the R-orientation (see formula (26))

$$\mu_R = \Delta D_R(1+\chi_R), \tag{28}$$

and for the L-orientation (see formula (27))

$$\mu_L = \Delta D_L(1-\chi_L). \tag{29}$$

It is evident that these distances, μ_R and μ_L, can be identical with η_R and η_L in Table 1 only for $\varphi_o = 0°$ and 180° (only then the ray s is perpendicular to the entering prism surface in both situations). As Table 4 tells us, the values of μ_R and μ_L, at $\varphi_o = 0°$ and 180°, depend on the angle δ'; generally, these values increase when δ' is removed from δ'_m. At the same time the angle φ_o, at which the change of the sign of μ_R and μ_L takes place, is removed from that for δ'_m (from $\varphi_o \sim 90°$). As it follows from Table 4, the μ_R and μ_L possess their maxima in the positive values.

Table 3 includes the changes of the lunette inclination, ΔD_R and ΔD_L, from the inclination $\delta' = \text{const}$, *when the image is observed at the focus.* One observes the same singularities as those in Table 4. The additional singularities appear when $\delta' \neq \delta'_m$ and $i'_1 \neq i'_{1m}$. The numerical values of ΔD_R and ΔD_L differ from each other for the same angles δ' and i'_1 as well as for the same angle δ' and two different angles i'_1.

Table 4. The calculated angular distances of the star image from the focus of inclined lunette in the non-wave theory of light, angles μ_R and μ_L, in a function of the angle φ_o for three values of the angle i'_1

φ_o	α_{φ_o}	$i'_1 = 0°0'0.000''$, $\delta' = 22.384177°$		$i'_1 = 55°53'3.03''$, $\delta' = 22.384177°$		$i'_1 = i'_{1m}$, $\delta'_m = 17.726514°$	
		μ_R	μ_L	μ_R	μ_L	μ_R	μ_L
1	2	3	4	5	6	7	8
0°	0.00″	−7.85″	7.85″	−7.85″	7.85″	−6.28″	6.28″
15	5.34	−4.58	10.59	−5.44	9.74	−5.81	6.32
30	10.31	−1.00	12.60	−2.65	10.96	−4.95	5.93
45	14.59	2.65	13.75	0.32	11.43	−3.75	5.14
60	17.86	6.12	13.97	3.27	11.12	−2.29	3.99
75	19.92	9.17	13.23	5.99	10.06	−0.68	2.57
90	20.63	11.60	11.59	8.31	8.31	0.98	0.98
105	19.92	13.23	9.17	10.06	5.99	2.57	−0.68
120	17.86	13.97	6.11	11.12	3.27	3.99	−2.29
135	14.59	13.75	2.64	11.43	0.32	5.13	−3.75
150	10.31	12.60	−1.00	10.96	−2.65	5.93	−4.95
165	5.34	10.59	−4.59	9.74	−5.44	6.32	−5.81
180	0.00	7.85	−7.85	7.85	−7.85	6.28	−6.28

It is evident that the values in Tables 2–4, both calculated as well as those to be measured, ought to depend on the parameters of the prism. In the case of achromatic prisms the changes will be only quantitative. The calculations performed by us with achromatic prisms whose angles of refraction corresponded to those used by Arago (angles of refraction ~ 24° and ~ 48°, deviations of starlight by $\delta \sim 10°4'25''$ and $\sim 22°25'5''$), for stars observed by Arago in that epoch, gave the changes of the lunette inclination of the same order as the inaccuracies in Arago's experiments [10]. Thus, Arago's experiments cannot decide which theory: special relativity or classical wave or photon theory is right. The experiment must be repeated. The changes in inclination calculated by us and given in Tables 1–4 and in Table 1 in [1] are considerably greater than the accuracies of the present astronomical measurements. Furthermore, the prism parameters can be chosen so that these changes still greater.

Thus, the repetition of the Arago experiment ought to test one of the three possible explanations, if other effects in classical physics do not superimpose additionally. And it is or can be possible. At reflection of starlight from a moving surface the so-called deflection effect takes place [11]–[14]. When a light beam passes through a moving prism, in Perot's experiment [15], the wavelength of *refracted* light is subject to changes dependent on the motion of the prism. Is it possible that similar effects could exist also at refraction of starlight? And could an additional deflection of the starlight beam after leaving the prism be a differential effect after two refractions?

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Влияние призмы, отражающей звездный свет, на наблюдаемые положения звезды

Повторение рассуждений Фреснеля относительно эксперимента Араго, в рамках фотонной теории света и для любого положения звезды, дает выводы, отличающиеся от выводов, представленных Френелем; измеренное положение звезды зависит от прехода звездного света через призму, но эта зависимость диаметрально отличается от представленной в [1] для волновой теории света. Существуют также рассуждения, проведенные с точки зрения как теории относительности, так и классической физики, когда образ набюдателя в фокусе откинутого телескопа. Изменение положения наблюдаемой звезды зависит от: параметров призмы, угла падения на призму (угла входной поверхности призмы с осью телескопа) и R- и L-ориентаций призмы. Теория относительности не предусматривает никаких изменений положения звезды в рамках как волновой так и фотонной теории света. Эксперимент Араго надо повторить; точность его измерений была недостаточной для того, чтобы решатъ о том, которая теория (волновая или фотонная в классической физике, или теория относительности) является правильной и чтобы проверить, не накладываются ли добавочные эффекты и/или явления.