DRIFT OF INTERSECTION POINT OF INDICATRICES OF DIFFERENT SHAPE WITH A SPHERICAL INDICATRIX IN THE ULTRAVIOLET REGION OF THE SPECTRUM

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Obviously, the point of intersection φ_i of different indicatrices with a spherical one is determined by the shape of the observable indicatrix $f_H(\varphi)=f_R(\varphi)+f_a(\varphi)+f_2(\varphi)$. To analyze the drift φ_i, it is necessary to divide the scattering process into Rayleigh (f_R), aerosol (f_a), and the multiple scattering (f_2) components. In [1, 2] it was established statistically that the observed brightness indicatrices f_H intersect with the spherical one in the visual region of the spectrum at a scattering angle $\varphi_i \sim 57°$. Similar investigations were carried out by the authors of [3].

It is known for certain that for the Rayleigh indicatrix $f_R(\varphi)$ we have $\varphi_i \simeq 54.7°$. For aerosol indicatrices [4, 5], φ_i varies in a wide range of angles, 45-60°.

In the present paper we analyze the results of calculations of the brightness indicatrices $f_H(\varphi)$ in the ultraviolet (UV) region of the spectrum, carried out by the Monte Carlo method at the Computation Center of the Siberian Branch of the USSR Academy of Sciences [6] on the basis of the Junge aerosol indicatrices $f_a(\varphi)$ with particle-size distribution parameters $\nu^* = 2$ and 4, which determines the asymmetry coefficient Γ_a to be 11.01 and 6.01, respectively, where

$$\Gamma_a = \frac{\int_0^{\pi/2} f_a(\varphi)\sin\varphi\, d\varphi}{\int_{\pi/2}^{\pi} f_a(\varphi)\sin\varphi\, d\varphi}. \tag{1}$$

By varying the observed UV aerosol thicknesses τ_a from 0.15 to 0.70 and the Rayleigh thicknesses τ_R from 0.42 to 1.11, we covered the wavelength interval 373-307 nm in different localities. The zenith distances of the solar almuncantar took on values $Z_\odot$ = 63.72 and 76°, causing different contributions of multiple effects.

TABLE 1

Indicatrix No.	τ_1	f_1	$Z_\odot=60°$ f_2	$Z_\odot=60°$ f_H	$Z_\odot=75°$ f_2	$Z_\odot=75°$ f_H
		$\varphi_i{}^0$	$\varphi_i{}^0$	$\varphi_i{}^0$	$\varphi_i{}^0$	$\varphi_i{}^0$
УII	0,6	57,6	72	60	72	62
	0,8		73	6I	73,7	64,7
УIII	0,6	54,8	67	59	67,5	60
	0,8		68,5	60	69,5	62,2
f_R	0,4	54,7	55,0	54,7	50	53
	0,6		56,5	55	53,5	54,7
	0,8		56	55	52,5	53,5

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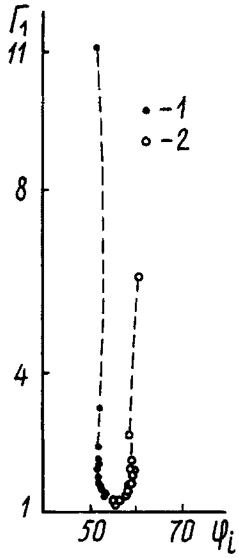

Fig. 1. Displacement of the point of intersection φ_i of the indicatrices of the first scattering act with the spherical indicatrix as the asymmetry Γ_1 is varied: 1) $\nu^* = 2$; 2) $\nu^* = 4$.

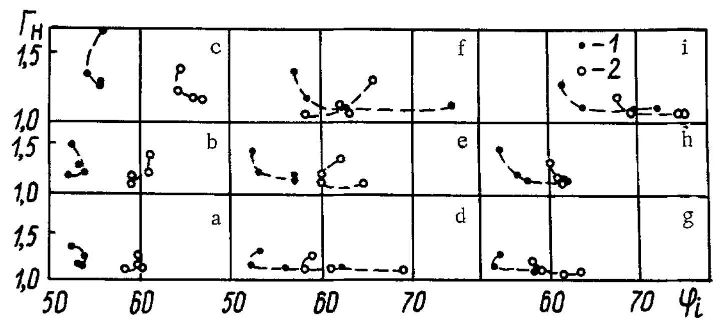

Fig. 2. Drift φ_i with changing optical parameters of the atmosphere. 1) $\nu^* = 2$; 2) $\nu^* = 4$. a-c) $Z_\odot = 63°$; d-f) $Z_\odot = 72°$; g-i) $Z_\odot = 76°$; a,d,g) $\tau_a \sim 0.15\text{–}0.18$; b,e,h) $\tau_a = 0.30$; c,f,i) $\tau_a = 0.7$.

Figure 1 shows the displacement of the intersection point φ_i of the indicatrices of the first scattering act $f_1 = f_R + f_a$ as a function of the asymmetry Γ_1 [see (1)]. As seen from the figure, for aerosol Junge indicatrices with $\nu^* = 2$ and 4, we have $\varphi_i = 51$ and 60.5°, respectively, so that two branches of points are formed, which contract with decreasing Γ_1, owing to the increased role of the Rayleigh scattering, to $\varphi_i \sim 54°.7$, just as for the pure Rayleigh indicatrix.

Figure 2 shows the drift φ_i for all the cases realized in the numerical experiment. It follows from the figure that the ratio of the three factors f_R, f_a, f_2 as functions of τ_R, τ_a, $Z_\odot$ can lead to looping of φ_i. Multiple scattering shifts φ_i toward larger angles 60-70° compared with φ_i for f_1. This is illustrated also in the table, which gives the values of φ_i for two elongated indicatrices f_H, VII and VIII, according to the data of [7], and for the Rayleigh indicatrix f_R [8].

For the asymmetric indicatrices VII and VIII, φ_i varies considerably, and for f_R multiple scattering hardly shifts $\varphi_i \sim 55°$, all the way to $Z_\odot = 75°$.

In conclusion, the observed UV indicatrices are analyzed in various localities. A statistical reduction of the material has shown that $\varphi_i \sim 60°$ for the settlement Kryzhanovka near Odessa ($\tau_a \sim 0.6$), somewhat less for the settlement Kirbaltabai and for the Astrophysical Institute of the Kazakh Academy of Sciences ($\tau_a \sim 0.25$), while for the high-mountain Assa plateau ($\tau_a \sim 0.08$) we have $\varphi_i \sim 55°$.

Thus, on the basis of theoretical and experimental investigations, it was established that the observable and spherical indicatrices in the UV band intersect near scattering angles $\varphi_i \sim 55$-$60°$, so that it is possible to regard the brightness of the sky in this region of φ_i to be independent of the shape of the indicatrix.

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