Simulation of scintillation spectra in stellar occultation by the Earth's atmosphere

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Received July 2, 2003

Some factors limiting the applicability of the phase-screen method to simulation of scintillation spectra at stellar occultation by the Earth's atmosphere are considered, and necessity of using more complicated models, like that based on the first approximation of the method of smooth perturbations, is demonstrated. The results obtained from computer simulations using power-law correlation function of atmospheric refractive index inhomogeneities are presented. The dependence of the scintillation spectra on the receiver's position and direction of its motion is studied.

Introduction

In observations of stellar occultation by the Earth's atmosphere from aboard a space station, random variations of the intensity of the received radiation are observed along with the monotonic decrease of the star brightness.[1–3] These variations are normally related to the scattering of radiation coming from a star on the atmospheric inhomogeneities and bear significant information about the fluctuations of air density in the middle atmosphere. Development of the methods for reconstructing characteristics of the atmospheric inhomogeneities from the parameters of transmitted radiation is one of the urgent problems of modern electrodynamics thus making up the subject for numerous investigations.[4,5]

For investigation of the scintillation spectra, the method of a phase-changing screen is usually used.[6,7] This method provides for a sufficient accuracy when a receiver is far from the atmospheric layer studied, for example, in observing scintillations from a spaceborne platform. However, in analysis of the data obtained using stratospheric balloons, the application of this method may lead to significant errors. This makes it necessary to develop more advanced methods for investigation of scintillation spectra, in particular, the method of solution of the inverse problem for determination of the two-dimensional scintillation spectrum based on the first approximation of the method of smooth perturbations (MSP).[8]

This paper considers the reasons for low accuracy of the results obtained with the method of a phase-changing screen and determines the applicability domain of this method. The results of numerical simulation of the scintillation spectra are presented for the power-law correlation function of the refractive index inhomogeneities in the case that the receiver is located near or inside the atmospheric layer under study.

Scintillation spectra in the first MSP approximation

Let the source of optical radiation S be located quite far from the Earth's atmosphere, so that the wave incident on it can be considered plane (Fig. 1).

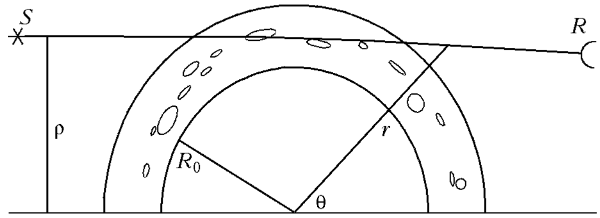

Fig. 1. The geometry of the problem.

The propagation of the electromagnetic field is described in the spherical system of coordinates (r, θ, φ) with the origin at the center of the Earth, and the $\theta = \pi/2$ direction corresponds to the direction toward the light source. In propagating through the atmosphere, the wave experiences the influence of the refractive index inhomogeneities $n_t(\mathbf{r}) = n(r) + \delta n(\mathbf{r})$, as well as of its regular range behavior $n(r) = 1 + N(r)$. The latter is assumed independent of the angular coordinates and leads to ray bending, while the random component $\delta n(\mathbf{r})$ leads to the development of fluctuations of the electromagnetic field of the wave. The dependence of the regular component on the wavelength λ_0 and the mean temperature $\langle T(\mathbf{r})\rangle$ (K) and pressure $\langle P(\mathbf{r})\rangle$ (mbar) is described by the known equation[9]

$$N(r) = 7.76 \cdot 10^{-6} \frac{\langle P(r)\rangle}{\langle T(r)\rangle}\left(1 + \frac{\Lambda^2}{\lambda_0^2}\right), \qquad (1)$$

where the parameter $\Lambda = 8.7 \cdot 10^{-8}$ m characterizes atmospheric dispersion in the wavelength range $\lambda_0 \in (3 \cdot 10^{-7} - 2 \cdot 10^{-5})$ m. The mean pressure-to-

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temperature ratio decreases with height by the close to exponential law with the spatial scale H raging from $6\cdot 10^3$ to $8\cdot 10^3$ m, which allows the radial dependence of the regular component to be approximated by the following equation:

$$N(r) = N_0 \exp\left(\frac{r - R_0}{H}\right), \tag{2}$$

where $R_0 \approx 6.4\cdot 10^6$ m is the height of the lower boundary of the atmospheric layer studied and $N_0 \approx 2\cdot 10^{-5}$ is the refractive index at this boundary. It can be easily seen that for optical waves the condition $L_0 \ll H^2/\lambda_0$ is fulfilled, if the separation between the layer and the receiver L_0 does not exceed several thousands of kilometers. This permits us to use the geometric-optics description for the regular component of the field (hereinafter, the harmonic time dependence is omitted)

$$U_0(\mathbf{r}) = A_0(\mathbf{r}) e^{i\Psi(\mathbf{r})}, \tag{3}$$

where $A_0(\mathbf{r})$ is the amplitude slowly varying at the distances of about the wavelength and $\Psi(\mathbf{r}) = \frac{2\pi}{\lambda_0}\int_\Sigma n(r)\mathrm{d}l$ is the eikonal. The ray trajectory Σ lies in the plane φ = const and is determined by the equation

$$\theta(r,\rho) = \theta_p(\rho) \pm \int_{h_p(\rho)}^{r} \frac{\mathrm{d}r}{r\sqrt{n^2(r)r^2/\rho^2 - 1}}, \tag{4}$$

where ρ is the impact parameter (the distance between the ray and the axis $\theta = 0$ before the ray enters the atmosphere), the height of the perigee point $h_p(\rho)$ is the solution of the equation $n(h_p)h_p = \rho$, and its angular coordinate is determined as follows:

$$\theta_p(\rho) = \pi - \int_{h_p(\rho)}^{\infty} \frac{\mathrm{d}r}{r\sqrt{n^2(r)r^2/\rho^2 - 1}}. \tag{5}$$

Let the receiver be located at the point $\mathbf{R} = (R, \Theta, 0)$. Then the impact parameter of the ray coming to the point of reception can be found from the equation $\Theta = \theta(R, \rho)$. The aperture is assumed small enough as compared to both the correlation length of radiation intensity fluctuations and to the spatial scale of the amplitude variation of the regular component so that its integrating effect is neglected.

Since the sensing ray undergoes the effect of a significant number of independent inhomogeneities, the intensity fluctuations of the received radiation $\delta I(\mathbf{R})$ can be believed a random field and characterized by a three-dimensional correlation function

$$K_I(\mathbf{R},\mathbf{p}) = \left\langle \frac{\delta I(\mathbf{R}+\mathbf{p}/2)}{\langle I(\mathbf{R}+\mathbf{p}/2)\rangle} \frac{\delta I(\mathbf{R}-\mathbf{p}/2)}{\langle I(\mathbf{R}-\mathbf{p}/2)\rangle} \right\rangle, \tag{6}$$

where the angular brackets denote averaging over the ensemble of realizations. It should be noted that $K_I(\mathbf{R}, \mathbf{p})$ depends on the regular part of the field of the component of "fast" variable $p_\diamond = \mathbf{p}\cdot\mathbf{k}(\mathbf{R})/|\mathbf{k}(\mathbf{R})|$ parallel to the wave vector

$$\mathbf{k}(\mathbf{R}) = \frac{2\pi}{\lambda_0}\frac{\nabla\Psi(\mathbf{R})}{|\nabla\Psi(\mathbf{R})|} n(R),$$

much weaker than on the cross components $p_\perp = \mathbf{p}\cdot\mathbf{e}_\varphi \times \mathbf{k}(\mathbf{R})|\mathbf{k}(\mathbf{R})|$ and $p_\varphi = \mathbf{p}\cdot\mathbf{e}_\varphi$ (Refs. 5 and 8). Hereinafter this dependence is neglected.

To determine the relation between $K_I(\mathbf{R}, \mathbf{p})$ and the correlation function of relative fluctuations of the refractive index $\nu(\mathbf{r}) = \delta n(\mathbf{r})/N(r)$

$$B_\nu(\mathbf{r},\mathbf{p}) = \langle \nu(\mathbf{r}+\mathbf{p}/2)\nu(\mathbf{r}-\mathbf{p}/2)\rangle, \tag{7}$$

it is convenient to pass on to the Fourier transforms

$$\tilde{K}_I(\mathbf{R},q_\perp,q_\varphi) = \frac{1}{4\pi^2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} K_I(\mathbf{R},p_\perp,p_\varphi)\times$$

$$\times\exp(-iq_\perp p_\perp - iq_\varphi p_\varphi)\mathrm{d}\mathbf{p};$$

$$\tilde{B}_\nu(\mathbf{r},\mathbf{q}) = \frac{1}{8\pi^3}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} B_\nu(\mathbf{r},\mathbf{p})\exp(-i\mathbf{q}\cdot\mathbf{p})\mathrm{d}\mathbf{p}. \tag{9}$$

Using the approach proposed in Ref. 8 and based on the first approximation of the method of smooth perturbations, one can write the following equation for the spectrum of intensity fluctuations:

$$\tilde{K}_I(\mathbf{R},q_\perp,q_\parallel) = \int_\Sigma \mathrm{d}l \frac{A(\mathbf{R},\mathbf{r})}{\sin^{-2}\left\{\frac{q_\perp^2}{\gamma_\perp(\mathbf{R},\mathbf{r})} + \frac{q_\parallel^2}{\gamma_\parallel(\mathbf{R},\mathbf{r})}\right\}}\times$$

$$\times\tilde{B}_\nu\left(\mathbf{r}, \frac{q_\parallel}{\mu_\parallel(\mathbf{R},\mathbf{r})}\mathbf{e}_\varphi + \frac{q_\perp}{\mu_\perp(\mathbf{R},\mathbf{r})}\frac{\mathbf{k}(\mathbf{r})\times\mathbf{e}_\varphi}{|\mathbf{k}(\mathbf{r})\times\mathbf{e}_\varphi|}\right), \tag{10}$$

where

$$A(\mathbf{R},\mathbf{r}) =$$

$$= \left|\frac{8\pi k_0^2 N^2(r)\theta_r(r,\rho)\theta_\rho(R,\rho)\sin^2\Theta}{n(r)n(R)\theta_\rho(r,\rho)\theta_r(R,\rho)\sin^2\theta(r,\rho)\cos[\theta(r,\rho)-\Theta]}\right|;$$

$$\mu_\perp(\mathbf{R},\mathbf{r}) = \frac{n(R)R}{n(r)r}\frac{\theta_r(R,\rho)\theta_\rho(r,\rho)}{\theta_r(r,\rho)\theta_\rho(R,\rho)},$$

$$\mu_\parallel(\mathbf{R},\mathbf{r}) = \frac{r\sin\theta(r,\rho)}{R\sin\Theta}; \tag{12}$$

$$\gamma_\perp(\mathbf{R},\mathbf{r}) = 2k_0\frac{n^2(R)R^2\theta_r^2(R,\rho)\theta_\rho(r,\rho)}{\rho^2\theta_\rho(R,\rho)[\theta_\rho(r,\rho)-\theta_\rho(R,\rho)]};$$

$$\gamma_\parallel(\mathbf{R},\mathbf{r}) = \frac{2k_0\rho\sin^2\theta(r,\rho)}{R^2\sin^2\Theta\tan(\theta(r,\rho)-\Theta)}, \tag{13}$$

$k_0 = 2\pi/\lambda_0$ is the wave number in vacuum. The subscript of the function $\theta(r, \rho)$ denotes the operation of differentiation with respect to the corresponding variable. The transition to the one-dimensional spectrum of intensity fluctuations, which can be reconstructed from the results of a field experiment, is provided for by the Radon transformation

$$b_I(\mathbf{R},q) = \int_{-\infty}^{\infty} \tilde{K}_I\left(\mathbf{R},(q\sin\beta - v\cos\beta)\frac{\mathbf{k(r)}\times\mathbf{e}_\varphi}{|\mathbf{k(r)}\times\mathbf{e}_\varphi|} + (q\cos\beta + v\sin\beta)\mathbf{e}_\varphi\right)\mathrm{d}v, \quad (14)$$

where β is the angle between the projection of the receiver motion direction onto the phase front plane and the unit vector $\mathbf{e}_\varphi$.

Applicability limits of the method of phase-changing screen

The use of cumbersome equations (10)–(13) makes sense only in the case that the simpler equations obtained in Refs. 5 and 6 within the framework of the method of phase-changing screen give a considerable error. Therefore, it is important to establish the domain of applicability for the assumptions laid in the foundation of this method, namely,

1) The trajectory Σ can be believed straight-line in the height range $r \in [h_p, h_p + 3H]$, which is responsible for the major contribution to formation of intensity fluctuations.

2) Variations of the function (11)–(13) at this part of the trajectory are insignificant, which allows the atmospheric layer to be replaced by a plane screen.

The curvature length of the trajectory Σ acquires the minimum value $R_c \cong H/N(h_p) \ge 3\cdot 10^8$ m at the perigee point, which exceeds by two orders of magnitude the height R_0. Neglecting the trajectory bending leads to the error in determination of the height of the current point by the value of about $3HR_0 \cong 300$ m. At such scales, the relative variations of the amplitude factor (11), as well as the functions (12) and (13), do not exceed 1 to 2%. We will neglect this, using the following approximate equalities:

$$\theta(r,\rho) \approx \theta_p(\rho) \pm \arccos\frac{h_p(\rho)}{r}, \quad (15)$$

$$\theta_r(r,\rho) \approx \pm\frac{h_p(\rho)}{r\sqrt{r^2 - h_p^2(\rho)}}, \quad (16)$$

$$\theta_\rho(r,\rho) \approx \frac{\mathrm{d}}{\mathrm{d}\rho}\theta_p(\rho) + \frac{Hh_p(\rho)r}{\left[H\rho - h_p(\rho)\rho + h_p^2(\rho)\right]\sqrt{r^2 - h_p^2(\rho)}}, \quad (17)$$

where the upper sign corresponds to the ray passed through the perigee point; otherwise, the lower sign should be taken.

At the same time, neglect of variations in the direction of the wave vector in the argument of the spectrum $\tilde{B}_\nu(\mathbf{r},\mathbf{q})$ can lead to significant errors in the case of strong anisotropy of the correlation function of the refractive index inhomogeneities. Taking into account that the angle between the ray and the radius vector of a current point is $\alpha = \arcsin\frac{\rho}{n(r)r}$, the second argument of the spectrum $\tilde{B}_\nu(\mathbf{r},\mathbf{q})$ is represented as follows:

$$\mathbf{q} = \frac{q_\parallel}{\mu_\parallel(\mathbf{R},\mathbf{r})}\mathbf{e}_\varphi - \frac{q_\perp\rho}{\mu_\perp(\mathbf{R},\mathbf{r})n(r)r}\mathbf{e}_r + \frac{q_\perp}{\mu_\perp(\mathbf{R},\mathbf{r})}\sqrt{1 - \frac{\rho^2}{n^2(r)r^2}}\mathbf{e}_\theta, \quad (18)$$

where the sign is selected as in Eqs. (10)–(12).

The assumption that the functions (11)–(13) are constant on the integration path gives the relative error of about l/L_0, where l is the separation between the point of the trajectory Σ on the boundary of the region actively affecting the formation of the fluctuation field ($r = h_p + 3H$) and the perigee point, and can be used for interpretation of observations from aboard a space station orbiting at $L_0 > 3000$ km.

Main properties of scintillation spectra

Within the problem on reconstructing the characteristics of atmospheric inhomogeneities from fluctuations of the transmitted radiation, the analytical approach involving inversion of the integral equations (10) and (14) is likely inefficient. The approach based on parameterization of the problem through the use of some *a priori* ideas on the form of the correlation function of the refractive index and the following determination of unknown parameters from comparison of simulated and experimental results seem to be more promising. The model for the spectrum $B_\nu(\mathbf{r}, \mathbf{q})$ is selected for the reasons discussed in Ref. 5. Assume that the dependence of the spectrum on the fast variable is anisotropic, but reduces to the one-dimensional form

$$B_\nu(\mathbf{r},\mathbf{q}) = F(\mathrm{K}), \quad \mathrm{K} = \sqrt{\mathbf{qq} : \left\{\eta^2(\mathbf{e}_\theta\mathbf{e}_\theta + \mathbf{e}_\varphi\mathbf{e}_\varphi) + \mathbf{e}_r\mathbf{e}_r\right\}} \quad (19)$$

where the parameter η characterizes the degree of anisotropy, the colon denotes double scalar product, and the lack of the sign between the vectors corresponds to the dyadic product. The radius vector of the current point **r** determines only the direction of the separated axis, which coincides with the local vertical.

Assume that the dependence $F(\mathrm{K})$ is a power-law one

$$F(\mathrm{K}) = C_\nu^2\eta^2(\mathrm{K}^2 + \kappa_0^2)^{-\mu/2}\Phi(\mathrm{K}/\kappa_\infty). \quad (20)$$

Here the function $\Phi(\xi) = \exp(-\xi^2)$ characterizes the effect of molecular viscosity; introduction of the parameter $\kappa_0 > 1/H$ corresponding to the outer scale of fluctuations $2\pi/\kappa_0$ provides for convergence of the integrals of $F(\mathrm{K})$ at $\mathrm{K} \to 0$; the scale $2\pi/\kappa_\infty$ corresponds to the boundary of the viscosity interval. The parameter C_v characterizing the variance of fluctuations is taken equal to unity.

Of the main interest is the dependence of the $b_I(q)$ spectrum on the parameters η, μ, and κ_∞, determining the character of atmospheric inhomogeneities, as well as on the receiver location and direction of motion. These dependences were studied through numerical simulation of the spectra (10) and (14) at different values of the above parameters. In calculations the wavelength of the sensing beam was chosen to be $\lambda_0 = 7 \cdot 10^{-7}$ m, and the spatial scale of the regular atmosphere was taken $H = 6$ km.

Figure 2 depicts the $b_I(q)$ spectra calculated for different directions of motion of the receiver, which were characterized by the angle β between the projection of the receiver direction of motion onto the phase front plane and the unit vector $\mathbf{e}_\varphi$.

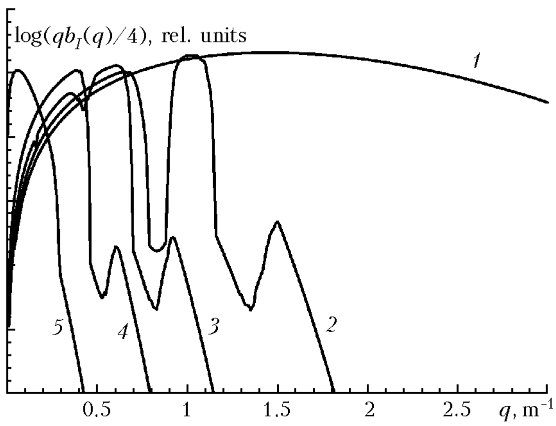

Fig. 2. 1D scintillation spectra for different directions of motion of the receiver. Atmospheric turbulence parameters: $\eta = 10$, $\mu = 11/3$, $\kappa_\infty = \pi/2$ m^{-1}. Receiver coordinates: $R = R_0 + 30$ km, $\Theta = 1.49$ rad; $\beta = \pi/2$ (*1*), $\pi/3$ (*2*), $\pi/4$ (*3*), $\pi/6$ (*4*), 0 (*5*).

It should be noted that for the considered range of distances $L_0 < 3000$ km, the spectrum narrowing along the local vertical due to regular refraction is insignificant and its anisotropy is largely determined by the anisotropy of the spectrum of the refractive index inhomogeneities (20). Scintillation spectra are characterized by the presence of oscillations of the triangular or rectangular shape that are most pronounced, if the projection of the direction of motion of the receiver onto the phase front plane does not coincide with the corresponding projections of the unit vectors $\mathbf{e}_\varphi$ and $\mathbf{e}_r$. Thus, it can be concluded that the most informative are the scintillation spectra with

$$\beta \in [\pi/6, \pi/3].$$

Figure 3 illustrates how the scintillation spectra vary as the receiver moves away from the studied atmospheric region. It can be seen that, along with the increase of the intensity fluctuations, smoothing of oscillations at $q < 1$ m^{-1} and their increase at higher values of the spatial frequency take place.

With the increase of the height of the reception point R, the scintillation spectra do not change considerably, only their intensity decreases monotonically due to the decrease in the length of the layer actively affecting the formation of the field of fluctuations, as well as due to the exponential decrease of the mean air density with height (Fig. 4).

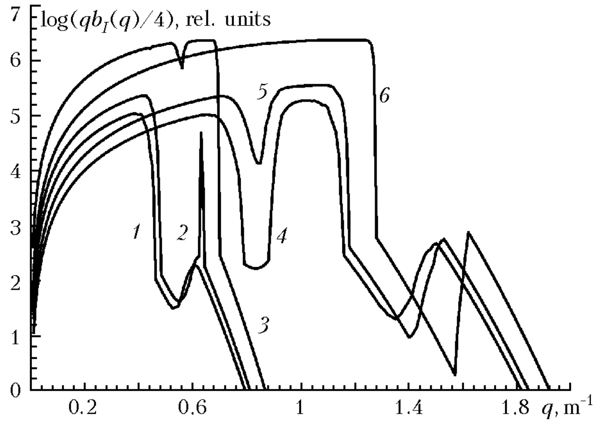

Fig. 3. 1D scintillation spectra at different separations between the receiver and the layer under study. Atmospheric turbulence parameters: $\eta = 10$, $\mu = 11/3$, $\kappa_\infty = \pi/2$ m^{-1}; receiver coordinates and direction of motion: $R = R_0 + 30$ km, $\Theta = 1.49$ rad, $\beta = \pi/3$ (*1*); $R = R_0 + 50$ km, $\Theta = 1.46$ rad, $\beta = \pi/3$ (*2*); $R = R_0 + 115$ km, $\Theta = 1.27$ rad, $\beta = \pi/3$ (*3*); $R = R_0 + 30$ km, $\Theta = 1.49$ rad, $\beta = \pi/6$ (*4*); $R = R_0 + 50$ km, $\Theta = 1.46$ rad, $\beta = \pi/6$ (*5*); $R = R_0 + 115$ km, $\Theta = 1.27$ rad, $\beta = \pi/6$ (*6*).

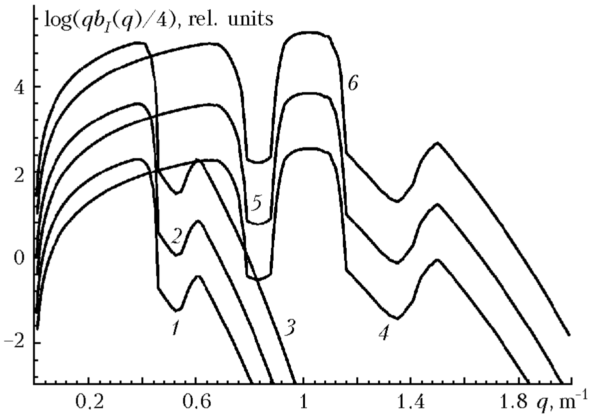

Fig. 4. 1D scintillation spectra at different height of the perigee point of the sensing beam. Atmospheric turbulence parameters: $\eta = 10$, $\mu = 11/3$, $\kappa_\infty = \pi/2$ m^{-1}; receiver coordinates and direction of motion: $R = R_0 + 50$ km, $\Theta = 1.49$ rad, $\beta = \pi/3$ (*1*); $R = R_0 + 40$ km, $\Theta = 1.49$ rad, $\beta = \pi/3$ (*2*); $R = R_0 + 30$ km, $\Theta = 1.49$ rad, $\beta = \pi/3$ (*3*); $R = R_0 + 50$ km, $\Theta = 1.49$ rad, $\beta = \pi/6$ (*4*); $R = R_0 + 40$ km, $\Theta = 1.49$ rad, $\beta = \pi/6$ (*5*); $R = R_0 + 30$ km, $\Theta = 1.49$ rad, $\beta = \pi/6$ (*6*).

Consider now the dependence of the scintillation spectra on the characteristics of atmospheric fluctuations. Anisotropy of the refractive index inhomogeneities essentially affects the spectrum structure (Fig. 5). As η increases, the spectrum narrows along the projection of the unit vector $\mathbf{e}_\varphi$ onto the phase front plane.

It is also worthy to note the development of oscillations in the scintillation spectrum and the fast variation of their structure at $\eta > 10$, which can serve the basis for evaluation of the anisotropy of atmospheric inhomogeneities. The increase of the exponent of the power-law dependence μ (Fig. 6) leads to the decrease in the intensity of fluctuations, as well as to transformation of the shape of oscillations from the rectangular and triangular ones typically observed at $\mu \approx 4$ to close-to-harmonic ones like $\sin(1/x)$ at $\mu \approx 5$.

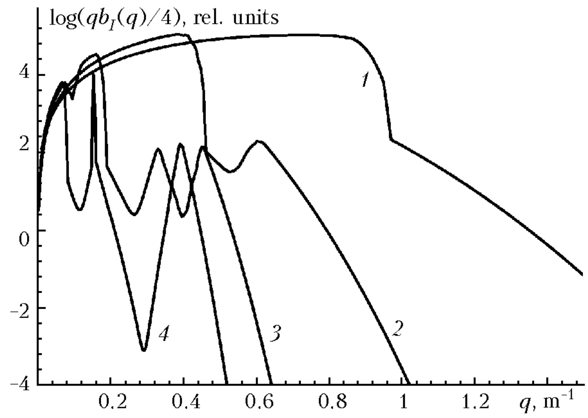

Fig. 5. 1D scintillation spectra at different anisotropy of atmospheric inhomogeneities. Atmospheric turbulence parameters: $\mu = 11/3$, $\kappa_\infty = \pi/2$ m^{-1}; receiver coordinates and direction of motion: $R = R_0 + 30$ km, $\Theta = 1.49$ rad, $\beta = \pi/3$; $\eta = 5$ (*1*), 10 (*2*), 20 (*3*), 30 (*4*).

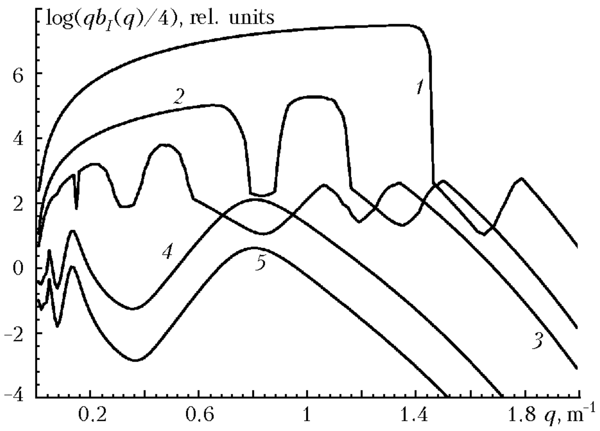

Fig. 6. 1D scintillation spectra at different exponents of the power-law dependence of the correlation function of atmospheric inhomogeneities. Atmospheric turbulence parameters: $\eta = 10$, $\kappa_\infty = \pi/2$ m^{-1}; receiver coordinates and direction of motion: $R = R_0 + 30$ km, $\Theta = 1.49$ rad, $\beta = \pi/6$; $\mu = 3$ (*1*), 11/3 (*2*), 4 (*3*), 5 (*4*), 5.5 (*5*).

For investigation of the structure of air density fluctuations, determination of the boundary of the viscosity interval $l_0 = 2\pi/\kappa_\infty$ is of a significant importance. Analysis of the scintillation spectra shows the sharp change in the dependence $b_I(q)$ at transition from the range $q < (4/3)\kappa_\infty \cos^2\beta$ characterized by the presence of oscillations to the range $q > (4/3)\kappa_\infty \cos^2\beta$ with the exponential decrease of the spectral density (Fig. 7). This fact can give a rather sensitive tool for determination of l_0.

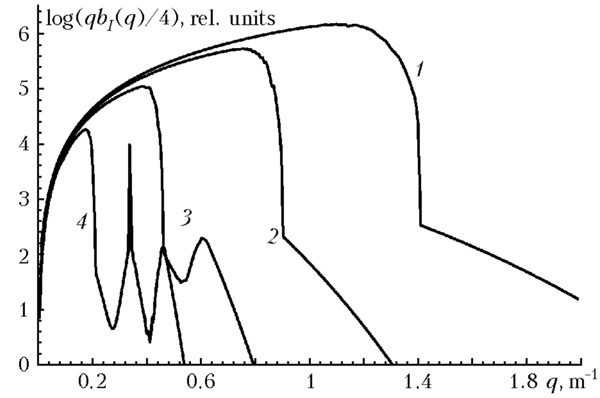

Fig. 7. 1D scintillation spectra at different position of the boundary of the viscosity interval. Atmospheric turbulence parameters: $\eta = 10$, $\mu = 11/3$; receiver coordinates and direction of motion: $R = R_0 + 30$ km, $\Theta = 1.49$ rad, $\beta = \pi/3$; $\kappa_\infty = 2\pi$ (*1*), π (*2*), $\pi/2$ (*3*), $\pi/4$ m^{-1} (*4*).

Conclusion

The domain of applicability of the method of phase-changing screen to simulation of intensity fluctuations of the optical radiation transmitted through a layer of the turbulent atmosphere at the altitudes of 25–75 km has been studied. As a result, it has been shown that this method provides for quite an adequate description of the scintillations in the case that the observer is near the layer under study, for example, aboard a space station. In this case, it is necessary to take into account ray bending in the atmosphere due to refraction for strongly anisotropic inhomogeneities of the air density. For interpretation of experimental findings obtained from a balloon, one should make use of more complicated equations obtained within the first approximation of the method of smooth perturbations.[8]

Numerical simulation of scintillation spectra has shown that the functional dependence may vary significantly depending on the receiver location and the direction of its motion. The conditions, when the receiver moves in the phase front plane at the angle ~ $\pi/4$ to the projection of the local vertical onto this plane are likely most convenient for recording the light flux fluctuations and reconstruction of the air density correlation function from these data.

The studies of the dependence of the scintillation spectra on the parameters of atmospheric inhomogeneities suggest that the characteristics of the optical radiation passed through the atmosphere are rather sensitive to variations of the parameters of atmospheric turbulence. This gives rise to the potential possibility of reconstructing these parameters from the results of occultation observations.

Acknowledgments

The support from the Russian Foundation for Basic Research under Grant No. 02–05–64310 is acknowledged.

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