METHOD FOR INVESTIGATING THE SPATIAL CORRELATION PROPERTIES OF STOCHASTIC WAVE FIELD WITH A WIDE ANGULAR SPECTRUM BASED ON THE CORRELATION ANALYSIS OF THE REALIZATION OF THE SPATIAL DISTRIBUTION OF THE COMPLEX AMPLITUDE OF THE FIELD FORMED USING NUMERICAL MODELING

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In the work the method for investigating the spatial correlation properties of a stochastic wave field with a wide angular spectrum based on a correlation analysis of the realization of the spatial distribution of the complex amplitude of this field formed using numerical modeling is proposed and tested. A comparison of the results of determining the lateral correlation properties of a monochromatic field based on correlation analysis of modeled distributions of the complex amplitude of this field in its various sections with the results obtained on the basis of analytical formulas showed their very good agreement. Studies based on the proposed method have shown that the lateral spatial coherence – the form of the coherence function and the coherence length of a quasi-monochromatic wave field is determined by the value of the numerical aperture and the shape of its angular spectrum. The proposed method for investigating the correlation properties of stochastic wave fields with wide angular and frequency spectra based on computer modeling of spatial distributions of complex amplitudes of wave field realizations has shown its effectiveness and prospects for further development and using as an alternative or complement to a natural experiment. The distribution of the complex amplitude of the optical wave field with a wide angular spectrum of spatial harmonics has been numerically simulated at various intervals of variation of random initial phases of harmonics in the range from 0 to 2pi radians. The numerical correlation properties of the fluctuation components of the generated fields of disturbance in the transverse plane of the wave field are investigated. It is established that the length of the transverse correlation of field fluctuations does not change with a change in the interval of the initial phase difference.

The autocorrelation function of the calculated field of disturbances $U(x,y)$: $\Gamma(\Delta x,\Delta y)=\mathbf{F}^{-1}\left\{\mathbf{F}\{U(x,y)\}\cdot\left[\mathbf{F}\{U(x,y)\}\right]^*\right\}=\mathbf{F}^{-1}\left\{\left|\mathbf{F}\{U(x,y)\}\right|^2\right\}$

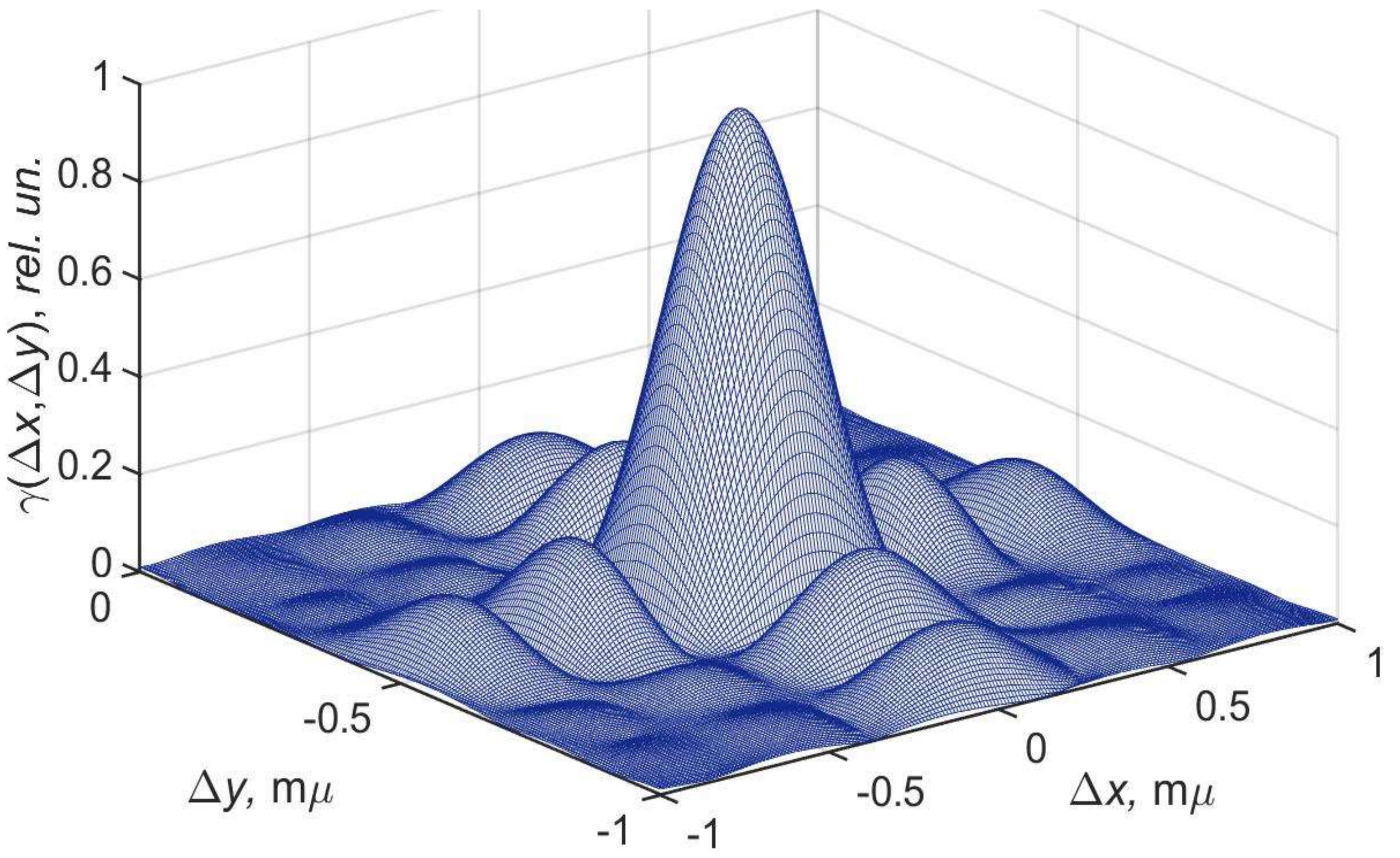

Fig. 1 Correlation function of the complex amplitude of the wave field in the lateral section; λ_0 =0.55 µm; Δ λ≈0; square aperture of the angular spectrum with NA_i=0.5

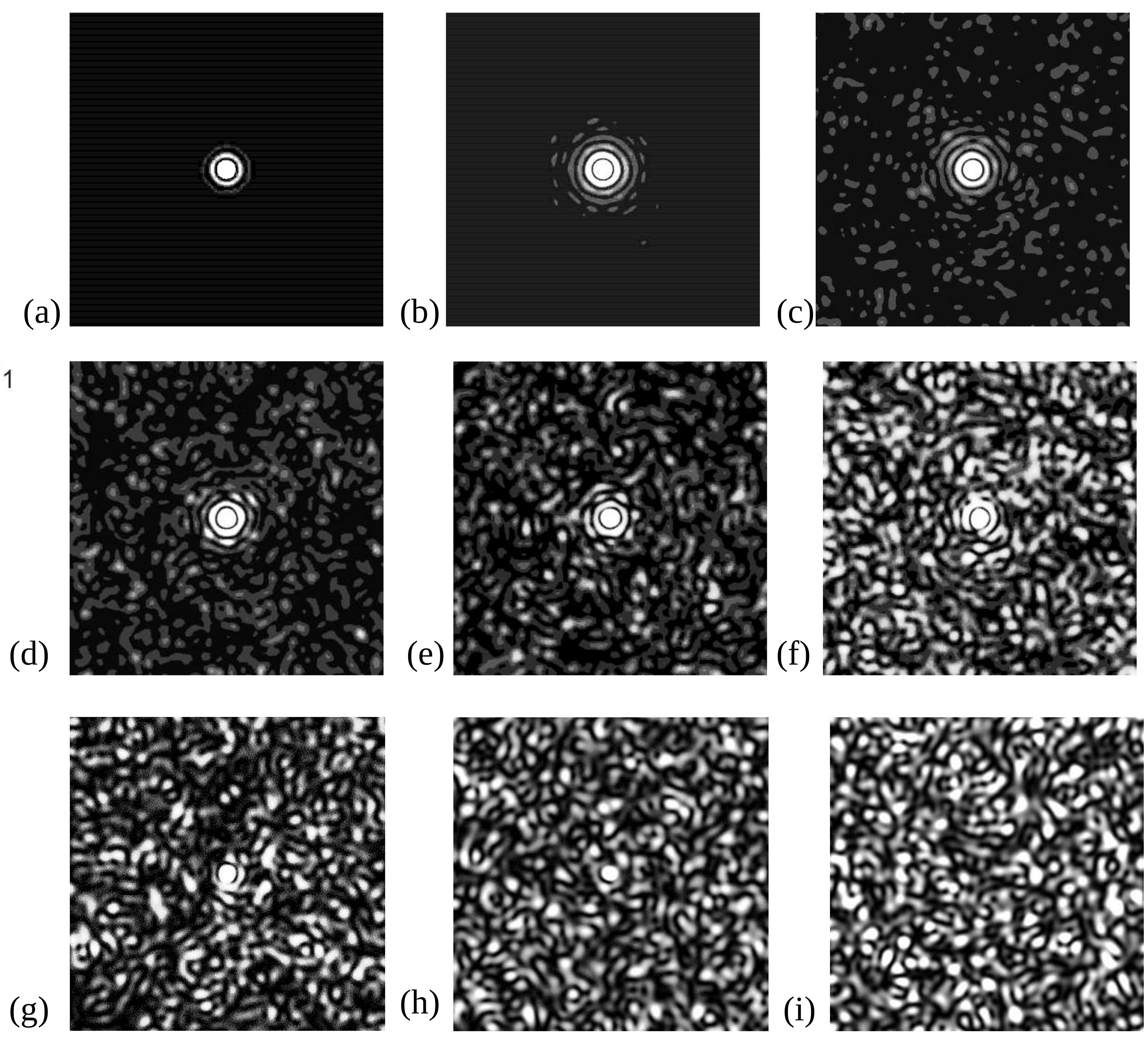

Fig. 2 Simulated speckle pattern of the wave field in the lateral section to a round aperture; interval random initial phases Δφ and brightness of the speckle patterns: a – 0, +95%; b – 0,4π , +95%; c – 0,8π , +95%; d – π , +95%; e – 1,2π , +95%; f – 1,4π , +95%; g – 1,6π , +90%; h – 1,8π , +60%; i – 2π , +30%; λ_0=0,55 µm, round shape aperture angular spectrum with *NAi*=0,5; Δ λ≈0; the size of the fragments speckle patterns 20x20 µm

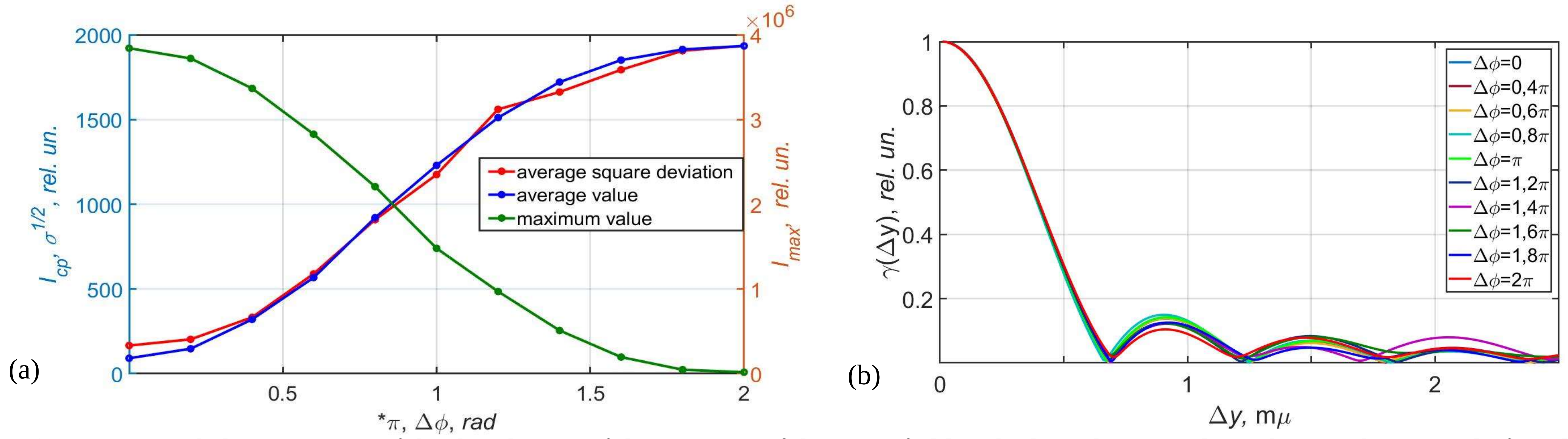

Fig. 3 Statistical characteristics of the distribution of the intensity of the wave field in the lateral section depending on the interval of random initial phases of the harmonic components of the field Δφ (a); the degree of correlation of the complex amplitude of the wave field in the lateral section (b); Δφ – the interval of random initial phases; λ_0 =0.55 µm; Δ λ≈0; the round shape of the aperture of the angular spectrum NA_i=0.5

The results of numerical simulation show that the transverse coherence length of the quasi-monochromatic wave field obtained by superposition of plane waves with different random phases Δφ does not depend on the interval of phase variation - phase dispersion, but depends on the width and shape of the angular spectrum of the wave field.