FORMATION OF THE LATERAL SHEAR INTERFEROGRAM BY DOUBLE EXPOSURE RECORDING OF THE LENS FOURIER SPECKLOGRAM OF A MAT SCREEN

V.G. Gusev

V.V. Kuibyshev State University, Tomsk

Received October 30, 1996

The paper describes analysis of the lateral shear interferogram based on a double–exposure recording. The investigations revealed theoretically and experimentally that the specklogram reconstruction provides the lateral shear speckle interferogram formation in the far diffraction zone, which determines the axial wave aberrations with double sensitivity at constant lateral shear.

In Ref. 1 the "phase problem" in optics is considered. The investigations showed that the double exposure record of the Fresnel speckle interferogram based on the combination of objective speckle–structures of two exposures in the photoplate plane when illuminating the mat screen by a coherent radiation with quasi–plane wave resulted in the interference pattern formation at the reconstruction stage. The lateral shear interferogram formed in diffusely scattered fields in the Fourier plane in the bands of infinite width characterizes only axisymmetric wave aberrations of an optical system used in the mat screen illumination channel at the stage of the specklogram record. In this case, for a fixed value of the lateral shear, the speckle-interferometer sensitivity increases by a factor of two.

This paper presents analysis of peculiarities in the lateral shear interferogram formation in the case of recording on a photoplate located in the Fourier plane of two subjective speckle structures as compared with the results of the double exposure recording of the Fourier hologram of a mat screen.

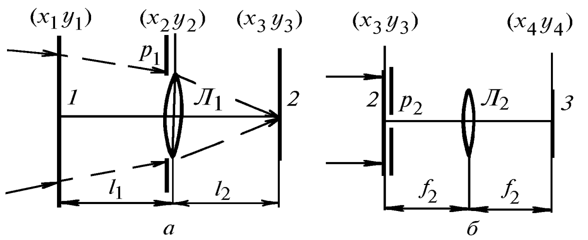


FIG. 1. Optical arrangement of recording (a) and reconstruction (b) of the double–exposure lens Fourier specklogram: 1 is the mat screen; 2 is the photoplate–specklogram; 3 is the plane of the interference pattern recording; L_1, L_2 are lenses; p_1 is the aperture; p_2 is the spatial filter.

Figure 1*a* shows that the mat screen *1* is illuminated with a coherent radiation (a converging quasispherical wave of the radius of curvature R) in its plane (x_1, y_1). Using the lens L_1 with a focal length f_1 and focus on the photoplate *2* during the first exposure the Fourier specklogram is recorded. Before the second exposure the tilt angle is changed by α, for example, in the plane (x, z) of the coherent radiation wave used for illuminating the mat screen. And the photoplate is shifted in its plane by the displacement a along the x axis. After photochemical processing a coherent plane wave from a light source, used at the stage of its recording, arrives at the double–exposure Fourier specklogram of the mat screen, and thus the interference pattern is recorded in the Fourier plane *3* (Fig. 1*b*).

Based on the data from Ref. 2 in the Fresnel approximation without considering the constant amplitude and phase factors, if $-\frac{1}{R}+\frac{1}{l_1}-\frac{L}{l_1^2}=0$, where $\frac{1}{L}=\frac{1}{l_1}-\frac{1}{f_1}+\frac{1}{l_2}$, l_1 is the distance from the mat screen to the main plane (x_2, y_2) of the lens L_1; l_2 is the distance from the main plane to the photoplate and $\sin\alpha = aL/l_1l_2$, the complex field amplitudes, corresponding to the first and second exposures, in the plane (x_3, y_3) of the photoplate are described as follows:

$$u_1(x_3, y_3) \sim \exp\left[\frac{ik}{2l_2}(x_3^2+y_3^2)\right]\times$$
$$\times\left\{\exp\left[-\frac{ikL}{2l_2^2}(x_3^2+y_3^2)\right]\times\right.$$
$$\left.\times\left[F(x_3, y_3)\otimes\Phi_1(x_3, y_3)\right]\otimes P_1(x_3, y_3)\right\}, \quad (1)$$

$$u_2(x_3, y_3) \sim \exp\left\{\frac{ik}{2l_2}\left[(x_3+a)^2+y_3^2\right]\right\}\times$$
$$\times\left\{\exp-\frac{ikL}{2l_2^2}\,)\left[(x_3+a)^2+y_3^2\right]\times\right.$$
$$\left.\times F(x_3, y_3)\otimes\Phi_2(x_3, y_3)\right]\otimes P_1(x_3, y_3)\right\}, \quad (2)$$

where $\otimes$ is the symbol of the convolution operation; k is the wave number;

0235-6880/97/03 159-06 $02.00 © 1997 Institute of Atmospheric Optics

$$F(x_3, y_3) = \iint_{-\infty}^{\infty} t(x_1, y_1) \times \exp[-ik(x_1x_3 + y_1y_3)L/l_1 l_2]\mathrm{d}x_1\, \mathrm{d}y_1$$

is the Fourier transform of the complex transmission amplitude $t(x_1, y_1)$ of the mat screen, being a random function of coordinates;

$$\Phi_1(x_3, y_3) = \iint_{-\infty}^{\infty} \exp i\varphi_0(x_1, y_1) \times \exp[-ik(x_1x_3 + y_1y_3)L/l_1 l_2]\, \mathrm{d}x_1\, \mathrm{d}y_1,$$

$$\Phi_2(x_3, y_3) = \iint_{-\infty}^{\infty} \exp\, i\varphi_0(x_1 + b, y_1) \times \exp[-ik(x_1 x_3 + y_1y_3)\, L/l_1 l_2\,]\mathrm{d}x_1\, \mathrm{d}y_1$$

are the Fourier transforms of the corresponding functions; $\varphi_0(x_1, y_1)$ is the determinate function, characterizing the phase distortions of the wave front of a coherent radiation, used for illumination of the mat screen; b is the value of the wave front shift due to the variation of its till angle before the second exposure;

$$P_1(x_3,y_3) = \iint_{-\infty}^{\infty} p_1(x_2, y_2) \exp i\varphi_1(x_2, y_2) \times$$

$\times \exp[-ik(x_2x_3 + y_2y_3)/l_2]\, \mathrm{d}x_2\, \mathrm{d}y_2$ is the Fourier transform of the generalized function $p_1(x_2, y_2) \times \exp i\varphi_1(x_2, y_2)$ of a lens pupil L_1, Ref. 3, taking into account its axial wave aberrations.

Since the function $P_1(x_3, y_3)$ width is of the order of $\lambda l_2/d$, Ref. 4, where λ is the wavelength used for recording and reconstruction of the specklogram; d is the diameter of the lens L_1 pupil, then we assume that, within the region of definition the variations of the spherical wave phase of the curvature radius l_2^2/L in Eqs.(1), (2) do not exceed π. Then for the area in the plane of a photoplate with the diameter $D \le d(1 + \frac{l_2}{l_1} - \frac{l_2}{f_1})$ the squared phase factor $\exp[-ik(x_3^2 + y_3^2)L/2l_2^2]$ may be removed in Eqs. (1), (2) from the convolution integrand and we obtain

$$u_1(x_3, y_3) \sim \exp\left[\frac{ik(l_2-L)}{2l_2^2}(x_3^2 + y_3^2)\right] \times \{F(x_3, y_3)\otimes\Phi_1(x_3, y_3)\otimes P_1(x_3, y_3)\}, \quad (3)$$

$$u_2(x_3, y_3) \sim \exp\left\{\frac{ik(l_2 - L)}{2l_2^2}\left[(x_3 + a)^2 + y_3^2\right]\right\}\times \{F(x_3, y_3)\otimes\exp(ikbx_3L/l_1 l_2)\Phi_1(x_3, y_3) \otimes \otimes \exp(ikax_3L/l_2^2)P_1(x_3, y_3)\}. \quad (4)$$

From Eqs. (3) and (4) it follows that in the photoplate plane the Fourier transform of the mat screen transmission function is formed. In view of spatial limitedness of the light field by the lens L_1 (see Fig. 1*a*) each its point within the limits of the above-mentioned area is widened up to the speckle size determined by the width of the function $\Phi_1(x_3, y_3)\otimes P_1(x_3, y_3)$, i.e., the data on phase distortions of the wave front of a coherent radiation, used for illumination of the mat screen, is concentrated within every individual speckle in the photoplate plane. Moreover, the Fourier transform of the input function is scaled according to the value of l_1l_2/L, which at $l_1 = f_1$ corresponds to the focal length of the lens L_1, and the scale of transformation does not depend on the curvature radius R. Only the position of the transformation plane depends on the curvature radius and, hence, the pulse response width of the lens L_1, which is always less compared with the case of illumination of the mat screen by a coherent radiation with a quasi-plane wave.

The squared phase factor in Eqs.(3) and (4) characterizes the distribution in the Fourier transformation plane of the phase of a divergent spherical wave for $l_1 < f_1$ and a convergent one for $l_1 > f_1$, and it equals unity for $l_1 = f_1$.

Assume that the photosensitive layer, exposed to light with the intensity $I(x_3, y_3) = u_1(x_3, y_3) \times u_1^*(x_3, y_3) + u_2(x_3, y_3)u_2^*(x_3, y_3)$, is processed and a negative is obtained within the linear portion of the characteristic curve of blackening. Then the transmission amplitude $\tau(x_3, y_3)$ of the double-exposure Fourier specklogram of the mat screen in Fig. 1*b* is determined by the expression

$$\begin{aligned}\tau(x_3, y_3) \sim{}& \left[F(x_3, y_3)\otimes\Phi_1(x_3, y_3)\otimes P_1(x_3, y_3)\right] \times \\ &\times \left[F^*(x_3, y_3)\otimes\Phi_1^*(x_3, y_3)\otimes P_1^*(x_3, y_3)\right] + \\ &+ [F(x_3, y_3)\otimes\exp(ikbx_3L/l_1 l_2)\Phi_1(x_3, y_3)\otimes \\ &\otimes \exp(ikax_3L/l_2^2)\, P_1(x_3, y_3)]\, [F^*(x_3, y_3)\otimes \\ &\otimes \exp(-ikbx_3L/l_1 l_2)\Phi_1^*(x_3, y_3)\otimes \\ &\otimes \exp(-ikax_3L/l_2^2)P_1^*(x_3, y_3)],\end{aligned} \quad (5)$$

where the regular component of light transmission is omitted because its further consideration leads only to illumination distribution over a small spot in the observation plane.

Distribution of the complex amplitude of a diffusely scattered field component in the back focal plane (x_4, y_4) of the lens L_2 with the focal length f_2 (see Fig. 1*b*) is written based on Ref. 5 in the form

$$u(x_4, y_4) \sim \iint_{-\infty}^{\infty} \tau(x_3, y_3) \exp\left[-\frac{ik}{f_2}(x_3 x_4 + y_3 y_4)\right] \mathrm{d}x_3\, \mathrm{d}y_3 \otimes P_2(x_4, y_4), \qquad (6)$$

where $P_2(x_4, y_4) = \iint_{-\infty}^{\infty} p_2(x_3, y_3) \exp\left[-\frac{ik}{f_2}(x_3 x_4 + y_3 y_4)\right] \mathrm{d}x_3\, \mathrm{d}y_3$ is the Fourier transform of the mat screen transmission function p_2 with a round hole, Ref. 6.

As a result of substitution of Eq.(5) to Eq.(6) we obtain

$$\begin{aligned} u(x_4, y_4) \sim & \Big\{\{t(-\mu_1 x_4, -\mu_1 y_4) p_1(\mu_2 x_4, \mu_2 y_4) \times \exp i[\varphi_0(-\mu_1 x_4, -\mu_1 y_4) + \varphi_1(-\mu_2 x_4, -\mu_2 y_4)]\} \otimes \\ & \otimes \{t^*(\mu_1 x_4, \mu_1 y_4) p_1(\mu_2 x_4, \mu_2 y_4) \exp -i[\varphi_0(\mu_1 x_4, \mu_1 y_4) + \varphi_1(\mu_2 x_4, \mu_2 y_4)]\} + \\ & + \{t(-\mu_1 x_4, -\mu_1 y_4) p_1(\mu_2 x_4 - \frac{aL}{l_2}, \mu_2 y_4) \exp i[\varphi_0(-\mu_1 x_4 + b, -\mu_1 y_4) + \varphi_1(-\mu_2 x_4 + \frac{aL}{l_2}, -\mu_2 y_4)]\} \otimes \\ & \otimes \{t^*(\mu_1 x_4, \mu_1 y_4) p_1(\mu_2 x_4 + \frac{aL}{l_2}, \mu_2 y_4) \times \exp -i[\varphi_0(\mu_1 x_4 + b, \mu_1 y_4) + \varphi_1(\mu_2 x_4 + \frac{aL}{l_2}, \mu_2 y_4)]\}\Big\} \otimes P_2(x_4, y_4), \end{aligned} \qquad (7)$$

where $\mu_1 = \frac{l_1 l_2}{L f_2}$; and $\mu_2 = \frac{l_2}{f_2}$ are the coefficients of scaling transformation.

From Eq. (7) it follows that if the diameter D_0 of the illuminated area of the mat screen in recording the specklogram satisfies the condition $D_0 \geq d\left(1 + \frac{l_1}{l_2} - \frac{l_1}{f_1}\right)$ then within the limits of the overlap of functions of a pupil the subjective speckle fields of two exposures are superimposed that causes their correlation. Besides, for the even phase function $\varphi_0(x_1, y_1)$ (or its component), determining axial wave aberrations of the optical system in a channel of formation of the wave front of coherent radiation used for illumination of a mat screen and for maximum value of autocorrelation the distribution of the field complex amplitude in the observation plane has the form:

$$\begin{aligned} u(x_4, y_4) \sim & \left\{\left\{1 + \exp -i\left[\frac{\partial \varphi_0(\mu_1 x_4, \mu_1 y_4)}{\partial \mu_1 x_4} 2b + \frac{\partial \varphi_1(\mu_2 x_4, \mu_2 y_4)}{\partial \mu_2 x_4} 2a \frac{L}{l_2}\right]\right\} \times \right. \\ & \left. \times \left[t(-\mu_1 x_4, -\mu_1 y_4) \otimes t^*(\mu_1 x_4, \mu_1 y_4)\right\} \otimes P_2(x_4, y_4), \right. \end{aligned} \qquad (8)$$

where

$$\frac{\partial \varphi_0(\mu_1 x_4, \mu_1 y_4)}{\partial \mu_1 x_4} b = \varphi_0(\mu_1 x_4 + b, \mu_1 y_4) - \varphi_0(\mu_1 x_4, \mu_1 y_4),$$

$$\frac{\partial \varphi_1(\mu_2 x_4, \mu_2 y_4)}{\partial \mu_2 x_4} a \frac{L}{l_2} = \varphi_1(\mu_2 x_4 + a \frac{L}{l_2}, \mu_2 y_4) - \varphi_1(\mu_2 x_4, \mu_2 y_4).$$

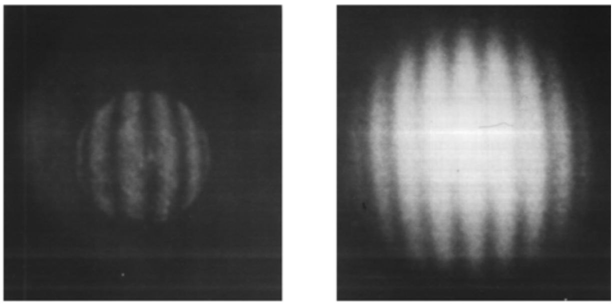
If the period of the function $1 + \exp -i\left[\frac{\partial \varphi_0(\mu_1 x_4, \mu_1 y_4)}{\partial \mu_1 x_4} 2b + \frac{\partial \varphi_1(m_2 x_4, m_2 y_4)}{\partial m_2 x_4} 2a \frac{L}{l_2}\right]$ exceeds by one order [7] the size of a subjective speckle in the observation plane determined by the function $P_2(x_4, y_4)$ width then it can be removed from the convolution integrand in Eq. (8). Then the superposition of correlating speckle-fields of two exposures results in the illumination distribution

$$\begin{aligned} I(x_4, y_4) \sim & \left\{1 + \cos\left[\frac{\partial \varphi_0(\mu_1 x_4, \mu_1 y_4)}{\partial \mu_1 x_4} 2b + \frac{\partial \varphi_1(\mu_2 x_4, \mu_2 y_4)}{\partial \mu_2 x_4} 2a \frac{L}{l_2}\right]\right\} \times \\ & \times \left| t(-\mu_1 x_4, -\mu_1 y_4) \otimes t^*(\mu_1 x_4, \mu_1 y_4) \otimes P_2(x_4, y_4) \right|^2, \end{aligned} \qquad (9)$$

from which it follows that the subjective speckle-structure is modulated by the interference fringes. The interference pattern is of the form of the lateral shear in the bands of infinite width, characterizing the axial wave aberration of the lens L_1 (see Fig. 1*a*) and the optical system in a channel of formation of the coherent radiation wave front used for illuminating the mat screen. In this case the speckle-interferometer sensitivity, as of a holographic interferometer,[2] depends on the distance l_1 between the mat screen and the main plane (x_2, y_2) of the lens L_1. For $l_1 = 0$ it equals zero because of the absence of an appropriate tilt angle between the speckle-fields of the two exposures in the photoplate plane.[2] Besides, as compared with the sensitivity of a holographic interferometer, the sensitivity of speckle interferometer increases by a factor of two for a fixed value of lateral shear. As in Ref. 1, this is explained by the twofold increase in the width of spatial frequencies spectrum of the waves scattered by the specklogram.

It should be noted that the phase distortions in the illumination channel of a mat screen can be excluded in the case of the Fourier image formation, when the mat screen is illuminated by coherent radiation with a diverging spherical wave.[8] Then the speckle-interference pattern will be of the form (9) in the absence of the first component in square brackets.

In the experiment the double exposure recording of the Fourier specklograms of a mat screen was performed on the photoplates of Mikrat VRL1 type using a He-Ne–laser radiation at 0.63 μm wavelength. The technique of experimental investigations consists in the comparison of the results of the double exposure recording of Fourier hologram with the use of an off-axial reference wave for shaping the lateral shear interoferogram in the bands of infinite width[2] with the results of double exposure recording of the specklogram for one and the same value of a lateral shear before the second exposure of the photoplate. As an example, Fig. 2*a* shows the holographic interferogram of a lateral shear characterizing spherical aberration with prefocal defocusing of a portion of coherent wave front used for illumination of the mat screen because of aberrations of the optical system forming it. It was recorded in the focal plane of the camera objective when conducting spatial filtration of the diffraction field in the hologram plane by means of reconstruction of hologram using a small aperture (≈ 2 mm) laser beam.[2] The double exposure recording of the Fourier hologram was performed by means of a planoconvex lens with a focal length f_1 = 250 mm and the pupil diameter of 28 mm, for l_1 = 0, l_2 = 200 mm, α = 2'30" ± 10", a = (0.15 ± 0.002) mm. The wave front diameter in the mat screen plane is 35 mm.



a *b*

FIG. 2. Holographic (a) and speckle-interferogram (b) of lateral shear.

The interference pattern in Fig. 2*b* is formed in the focal plane of the camera objective when reconstructing the double exposure lens Fourier specklogram (see Fig. 1*b*) without conducting spatial filtration of the diffraction field in its plane. Before the second exposure the tilt angle varied by the value α = 2'30" ± 10" and the photoplate was shifted at the distance a = (0.15 ± 0.002) mm. The lateral shear speckle-interferogram characterizes spherical aberration with prefocal defocusing of a portion of coherent radiation wave front used for illumination of the mat screen, but with the sensitivity increased by a factor of two that is shown in Fig. 3. Holographic interference pattern in Fig. 3 corresponds to the values α and a before repeated exposition 5' ± 10" and (0.3 ± 0.002) mm.

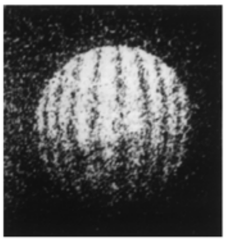
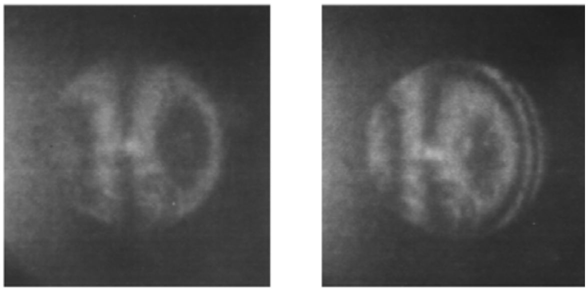


FIG. 3. Holographic interferogram of lateral shear.

The investigations showed that the contrast of the speckle-interference pattern is maximum when the wave front diameter exceeds the lens pupil diameter (see Fig. 1*a*) and decreases with the shear increase, when the diameter of the controlled wave front is less than the pupil diameter. This is explained by the background radiation from nonoverlapping parts of the mat screen for two exposures.



a *b*

FIG. 4. Holographic interferograms of lateral shear characterizing: axial aberrations of the lens and optical system for used forming the illumination wave of a mat screen (a) and additional off-axial lens aberrations (b).

Figure 4*a* presents the holographic interferogram of a lateral shear characterizing spherical aberration with postfocal defocusing of lens and optical system in the channel of coherent radiation wave formation used for illumination of the mat screen. Its recording was performed by spatial filtration of the diffraction field on the optical axis in the hologram plane.[2] The double exposure recording of the lens Fourier hologram was made for l_1 = 110 mm; l_2 = 200 mm. The wave front diameter in the plane of the mat screen was 45 mm. Before the second exposure the tilt angle varied by the value α = 7'40" ± 10" and the photoplate shift was a = (0.5 ± 0.002) mm. In contrast to the previous case, spatial filtration of the diffraction field in the off-axial hologram plane ($x_3 = 10$ mm, $y_3 = 0$) is accompanied by variation of the interference pattern (Fig. 4*b*) because of the off-axial wave aberrations of the lens L_1 (see Fig. 1*a*) and phase distortions of the coherent radiation wave front, used for illumination of the mat screen from another its part.[2]

When reconstructing the double exposure lens Fourier specklogram, whose recording was performed for the same values of α and a, the recorded speckle-interferogram of a lateral shear is shown in Fig. 5. The above speckle-interferogram characterizes the axial wave aberrations of the lens and optical system in the channel of wave front formation for illumination of the mat screen but with the twofold increase of the speckle-interferometer sensitivity. In this case, for the increase of the contrast of the speckle-interference pattern it is necessary to perform spatial filtration of the diffraction field (the diameter of the filtering diaphragm is 3 mm) in the specklogram plane (see Fig. 1*b*) at its reconstruction stage. This is explained by the fact that when the condition of spatial invariance of the pulse response of the lens L_1 does not hold (see, for example, Fig. 1*a*) for small area in the specklogram plane with the center at a point, located outside the optical axis, the field distribution within the limits of speckles in this area is the result of diffraction on the lens L_1 pupil of a wave propagating at some angle to the optical axis. At the same time, vignetting by the lens of the spatial spectrum of waves, scattered by the mat screen, results in the appearance of decorrelation in speckle structures in a local area with the center on the optical axis and outside it since the subjective speckles are formed by light coming from non overlapping segments of the surface diffusely scattering the light.

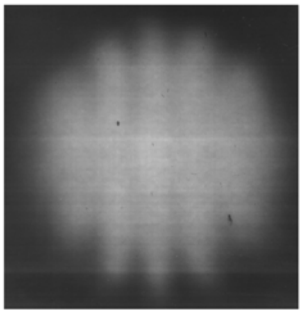


FIG. 5. Speckle-interferogram of lateral shear.

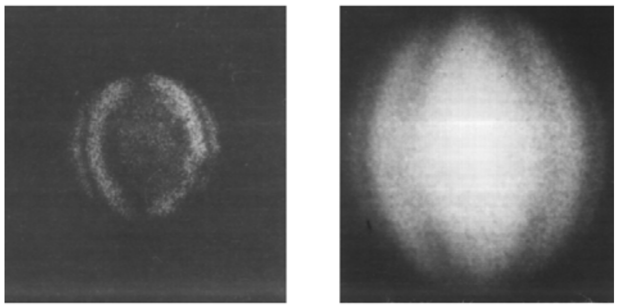
In Ref. 9 the method is described of forming the lateral shear interferogram in the bands of infinite width based on a double exposure recording of the lens Fourier hologram. In this case, before the second exposure the mat screen is shifted in the plane of its location, for example, along the x axis by the value a, and the tilt angle of the off-axial reference wave varies by the value $\sin\beta = aL/l_1 l_2$.

It is evident that the double exposure recording of a lens Fourier specklogram in Fig. 1*a*, when before the second exposure the mat screen *1* is shifted along the x axis by the value a, results, at the stage of its reconstruction, in the formation, in the observation plane *3* (see Fig. 1*b*), of the speckle-interference pattern

$$I(x_4, y_4) \sim \left\{1 + \cos\left[\frac{\partial\varphi_0(\mu_1 x_4, \mu_1 y_4)}{\partial\mu_1 x_4}\, 2a + \frac{\partial\varphi_1(\mu_2 x_4, \mu_2 y_4)}{\partial\mu_2 x_4}\, 2a\,\frac{L}{l_2}\right]\right\}\times$$
$$\times\ \left|t(-\mu_1 x_4, -\mu_1 y_4) \otimes t^*(\mu_1 x_4, \mu_1 y_4) \otimes P_2(x_4, y_4)\right|^2. \qquad (10)$$

The lateral shear speckle-interferogram characterizes the combination of the axial wave aberrations of the lens L_1 and the optical system in the channel of illumination of the mat screen with the twofold increased sensitivity for a fixed value of the lateral shear. In this case the sensitivity of both the speckle-interferometer and the holographic interferometer[9] to the lens L_1 aberrations is not equal to zero for $l_1 = 0$. Besides, phase distortions in the illumination channel of a mat screen can be excluded in the case of Fourier-image formation when illuminating by coherent radiation with a diverging spherical wave.[10] Then the speckle-interference pattern will be of the form (10) in the absence of the first component in the square brackets.

Figure 6*a* presents the holographic interferogram of a lateral shear characterizing spherical aberration in the paraxial lens focus and optical system in the illumination channel of the mat screen. It was recorded when conducting spatial filtration of the diffraction field on the optical axis in the hologram plane,[9] whose double exposure recording was made for $l_1 = 0$, $l_1 = 230$, $a = (0.4 \pm 0.002)$ mm, $\beta = 6' \pm 10''$. The wave front diameter in the mat screen plane was 30 mm. Reconstruction of the hologram outside the optical axis results in the variation of the interference pattern because of the off-axial wave aberrations of the lens.[9]



a *b*

FIG. 6. Holographic (a) and speckle interferograms (b) of the lateral shear.

The speckle-interferogram of lateral shear in Fig. 6*b* is the result of reconstruction of the double exposure specklogram, whose recording was made for the value of shift $a = (0.4 \pm 0.002)$ mm of the mat screen before the second exposure. To record the speckle-interferogram we need not to perform the spatial filtration of the diffraction field in the specklogram plane, i.e., the interferometer is insensitive to the off-axial wave aberrations of the lens L_1 (see Fig. 1*a*), and it characterizes its axial aberrations and optical system in the illumination channel of the mat screen with the twofold increase of sensitivity.

In the case of $l_1 > 0$, if the wave front diameter in the mat screen plane exceeds the value $d(1 + \frac{l_1}{l_2} - \frac{l_1}{f_2})$ then because of decorrelation of speckle-structures a necessity appears in conducting spatial filtration of the diffraction field in the specklogram plane to increase the contrast of the interference pattern.

Thus, on the basis of the above investigations the conclusion has been drawn that at the double exposure recording of the lens Fourier specklogram of a mat screen, when the screen is illuminated with a coherent radiation of a converging quasispherical wave, at the stage of its reconstruction the lateral shear interferogram is formed in the bands of infinite width with the twofold sensitivity increase at a fixed value of the shift. In this case, the speckle-interference pattern characterizes only axial wave aberrations of the lens and the optical system in the illumination channel of the mat screen (or in a particular case the axial wave aberrations in the illumination channel of the mat screen). The speckle-interferometer is insensitive to the off-axial wave aberrations.

REFERENCES

1. V.G. Gusev, Izv. Vyssh. Uchebn. Zaved., Ser. Fizika, No. 9, 36–42 (1996).
2. V.G. Gusev, Formation of Lateral Shear Interferograms in Diffusely Scattered Fields Using Double-Exposure Recording of Lens Fourier Hologram, 18 pp., Dep. v VINITI, Reg. No. 697–1394, Febr. 16, 1994.
3. D. Goodman, *Introduction to Fourier-Optics* (McGraw Hill, New York, 1968).
4. M. Franson, *Optics of Speckles* (Mir, Moscow 1980) [Russian translation], 158 pp.
5. V.G. Gusev, Opt. Spektrosk. **69**, No. 5, 1125–1128 (1990).
6. M. Born and E. Wolf, *Principles of Optics* (Pergamon, New York, 1959).
7. R. Jones and C. Wykes, *Holographic and Specle Interferometry* (Cambridge University Press, 1986).
8. V.G. Gusev, Formation of Lateral Shear Interferograms in Diffusely Scattered Fields Using Double-Exposure Recording of Lens Fourier Hologram, 15 pp., Dep. v VINITI, Reg. No. 4892–1391, April 14, 1993.
9. V.G. Gusev. Formation of Lateral Shear Interferograms in Diffusely Scattered Fields Using Double-Exposure Recording of Lens Fourier Hologram, 20 p., Dep. v VINITI, Reg. No. 4892–1391, December 11, 1991.
10. V.G. Gusev, Atmos. Oceanic Opt. **5**, No. 2, 73–78 (1992).