MODELING OF SPECKLE INTERFEROMETER OF LATERAL MICRO-DISPLACEMENTS OF A SCATTERING OBJECT WITH GAUSSIAN ILLUMINATING BEAMS AND DIGITAL RECORDING OF INTERFERENCE MEASURING SIGNAL

L.A. Maksimova, N.Yu. Mysina, B.A. Patrushev, V.P. Ryabukho

IPTMU RAS - Separate structural subdivision of FRC "Saratov Scientific Center of the Russian Academy of Sciences"

Saratov State University, Russia

A computer mathematical model of a laser interference system for registration of space-time signal of a speckle interferometer with digital recording of interference images has been developed. The mathematical model of the speckle interferometer of micro-displacements of the scattering surface of technical objects is based on diffraction transformations of wave fields. Numerical simulation of speckle-modulated interference images and signals at the output of a speckle interferometer of lateral displacements of a scattering object is performed. This allows us to identify the properties and quantitative parameters of interference measuring signals. Numerical calculations of the spatial distribution of complex amplitudes of wave fields in an interferometer were used for modeling. The displaced scattering surface of the controlled object was illuminated by two inclined laser Gaussian beams. A statistical numerical experiment for determination the measurement error of the uniform displacement of the scattering surface in speckle interferometry of lateral micro-displacements was performed. Simulated oscillograms of the lateral displacement of the scattering surface of a technical object due to its heating and cooling are obtained. The oscillograms were recorded in the far diffraction region with Gaussian illuminating beams. The simulation results confirm the results of experimental studies of lateral temperature displacements in the range up to 600 micrometers and are in good agreement with the mathematical model of the speckle interferometer of transverse micro-displacements of the scattering surface.

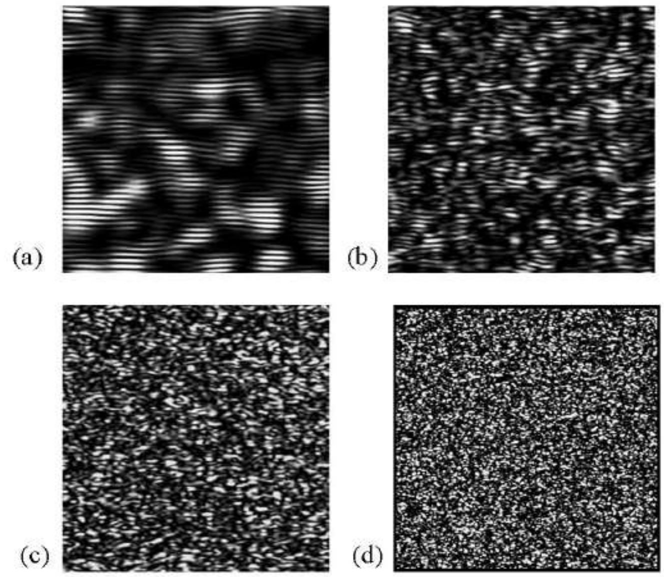

Fig. 1. Simulated speckle-modulated interference patterns formed at the interferometer. The radius of waist of the illuminating laser beams is w_0=3 μm, the distance from the scattering surface to the observation area of 10 cm, the wavelength is λ=0.63μm, the size of the images is ~ 3x3 mm, the distance between the centers of the illuminating beams on the scattering surface 40μm, the angles of incidence of the beams are 30^0, the radius of the beams on the surface *w:* (a) *w* =4,5 μm; (b) *w* =10 μm; (c) *w* =20 μm; (d) *w* =40 μm

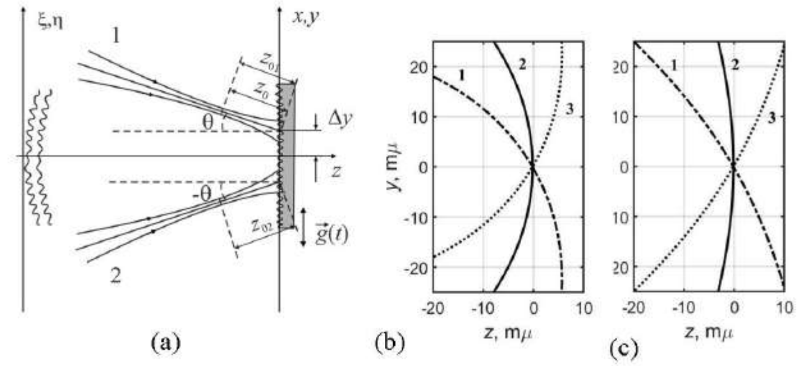

Fig. 2. Scheme of illumination of a surface by two Gaussian laser beams and formation of a diffraction speckle-modulated interference pattern at the output of a speckle interferometer of lateral micro displacements of scattering object (a); (b,c) – equal phase distributions in the plane *y,z*, *x*=0, when Gaussian beams fall at angles: 1 - θ=-30^0, 2 - θ=0^0, 3 - θ=30^0; the radius of waist of the illuminating laser beams is (b) w_0=2 μm, (c) w_0=3 μm, the distance from the waist to the line of the equal phase 30 μm

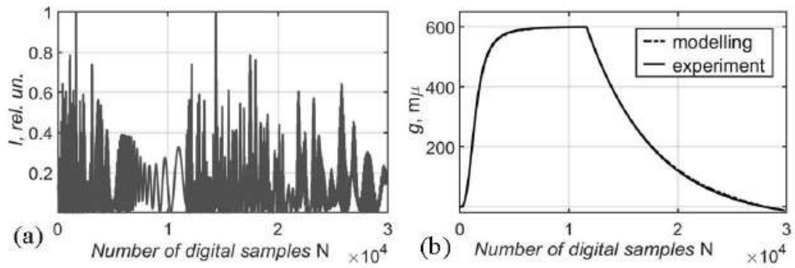

Fig. 3. Simulated interferogram of lateral displacement obtained in far diffraction region with Gaussian illuminating beams, the radius of waist of the illuminating laser beams w_0= 3 μm (a); a graph of lateral displacement of scattering surface obtained from the interferogram (b), the wavelength of the laser radiance λ=0.63μm

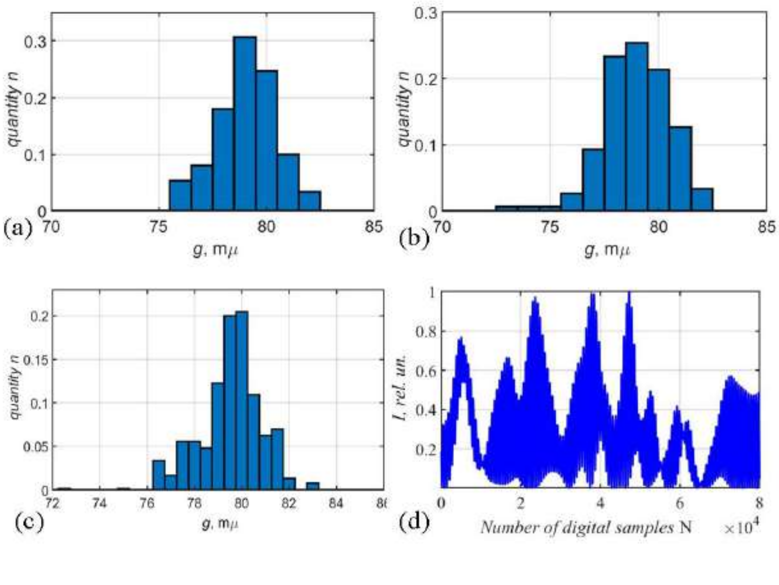

Fig. 4. Histograms of distribution of maximum of uniform lateral scattering surface displacement. The sample of random variables consists of 300 realizations (a,b), and 900 realizations (c); (d) – example of modeled interferogram obtained in the far diffraction region at uniform lateral displacement of scattering surface, the radius of waist of the illuminating laser beams w_0= 3 μm, the distance between the centers of the illuminating Gaussian beams on the scattering surface is h= 20 μm, the angles of beams incidence are ±30^0, the wavelength of the laser radiance is 0.63 μm, the distance from the scattering surface to the observation area is 10 cm, the maximum displacement of the scattering surface is 80 μm