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MEASUREMENT OF DISPLACEMENT BY SPECKLE CORRELATION.

MERANIE POSUNUTIA POMOCOU SPECKLE KORELÁCIE.

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V článku je popísané meranie posunutia pomocou speckle korelácie. Veľkosť posunutia je odvodená z polohy maxima medzikorelačnej funkcie intenzitných rezov objektívnym speckle poľom pred a po posunutí.

Keywords: cross-correlation function, speckle, displacement

Several methods are available for measuring displacement by using holographic and speckle interferometry [1],[2]. Speckle patterns, which result from random interference of laser light scattered by a diffusive surface, enable to measure displacements and strain in a wide range. In this paper is presented a method of measuring displacement from speckle displacement, which was proposed by Yamaguchi [3].

Speckle displacement caused by surface displacement [4] can be theoretically derived from the peak position of the cross-correlation function between the intensity distributions at an observation plane before and after the displacement. The cross-correlation function can be expressed [5] through

$$\langle I_{1(x')} I_{2(x'+t)} \rangle = \langle I_{1(x')} \rangle \langle I_{2(x'+t)} \rangle + \left| \langle U_{1(x')} U^*_{2(x'+t)} \rangle \right|^2 \quad (1)$$

where I_1 , I_2 are intensity distributions before and after the displacement, respectively. Complex amplitude U, at the observation point before object displacement is given by Fresnel-Kirkhoff diffraction integral [6]

$$U_{1(x')} = \iint \sqrt{I_{o(x)}} \exp[ik(L'_{z(x)} + L'_{p(x,x')})]ds \quad (2)$$

and after object displacement

$$U_{2(x')} = \iint \sqrt{I_{o(x+\Delta x)}} \exp[ik(L'_{z(x+\Delta x)} + L'_{p(x+\Delta x, x'+\Delta x')})]ds \quad (3)$$

If we substitute (1),(2),(3), assume intensity fluctuation $\Delta I = I - \langle I \rangle$ and assume that the correlation patch of the microscopic fluctuation of complex amplitude on the object is much smaller the the beam spot and that the root mean square surface roughness is larger than the laser wavelength [7], cross-correlation function becomes to reflect fig.1

$$\langle \Delta I_{1(x')} \Delta I_{2(x'+t)} \rangle = \left| \iint \sqrt{I_{o(x)} I_{o(x+\Delta x)}} \exp\{ik[x/L_p(t-\Delta X')]\}ds \right|^2 \quad (4)$$

For range of the correlation i.e. for small value of Δx, the cross-correlation function given by (4) takes its maximum at $t=\Delta X'$ and thus $\Delta X'$ means the speckle displacement caused by the object displacement. In the case of fig.1, the speckle displacement is given by

$$\Delta X = (L_p/L_z \cos^2\alpha + 1)\Delta x \quad (5)$$

An example of the intensity distributions is shown in fig.2. The signals represent displacement $x=100\mu m$. It was measured and verified that speckle displacement is proportional to object displacement, as shown fig.3. We can see good proportionality between object displacement and the peak shift of the cross-correlation function.

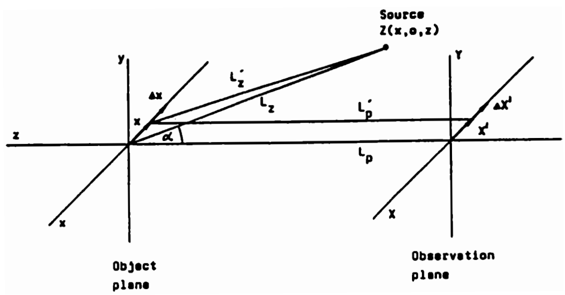

Fig.1. Coordinate systems for experimental arrangement.

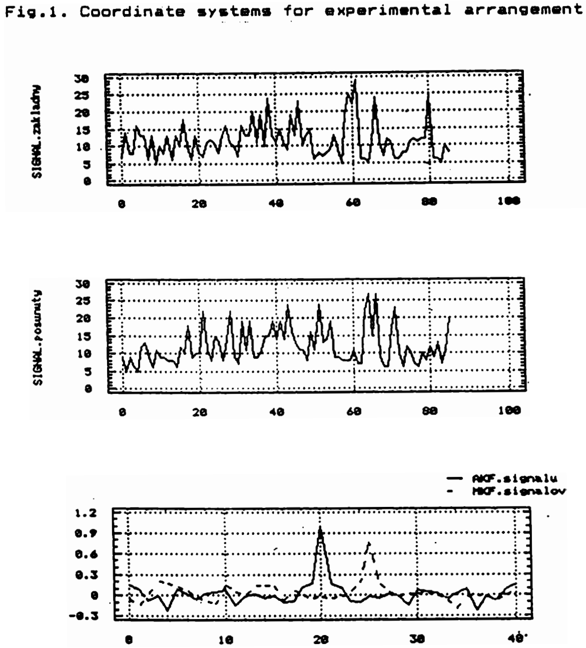

Fig.2. Intensity distributions in observation plane before and after object displacement.Bottom dependence shows a shift between cross-correlation function and autocorrelation function.

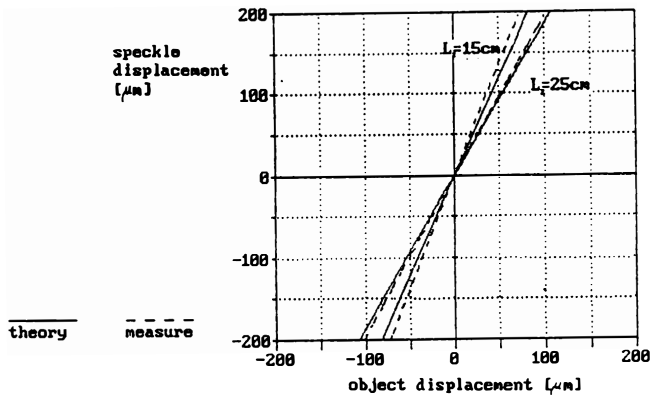

Fig.3. Dependence of the speckle displacement on the object displacement for different Lz.

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References

[1] Vest,Ch.M.:Holographic Interferometry.New York,Wiley Inc.1979

[2] Wernicke,G.-Osten,W.:Holografische Interferometrie. Leipzig,VEB Fachbuchverlag 1982

[3] Yamaguchi,I.:Jap.J.of Appl.Phys.Vol 19,No3,133-136 1980

[4] Francon,M.:Speckle et ses applications en optique. Russian version.Moscow 1980

[5] Bakut,P.A.-Matveev,I.N.:Teorija kogerentnych izobražeņij.Moscow 1987

[6] Yamaguchi,I.:J.Phys.E,19(1986),944-948

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