# THE WHOLE FIELD NON-DESTRUCTIVE OPTICAL SLICING METHOD IN THREE-DIMENSIONAL PHOTOELASTICITY

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*Summary:* The whole field non-destructive optical slicing method in three-dimensional photoelasticity is based on the analysis of the scattered light field is presented. This method is based on the combination of the scattered light photoelasticity method, of the speckle photography method and the moiré technique. For the determination of the stressed state in the thin optical slice is suggested analyse of the two-dimensional scattered light field from each plane sheets and theirs interference.

## INTRODUCTION

In a photoelastic medium a basic hypothesis consist in assuming the medium must be slightly anisotropic, and that the secondary principal directions of the refractive indices tensor and that of the stress tensor coincide. It follows that for a ray of light propagating along straight - line direction, the wave planes are orthogonal to this direction. In three-dimensional photoelasticity it is usually assumed that the directions of the secondary principal stresses and their values are constant through the thickness of a slice having its parallel faces. This assumption allows to consider this slice as a birefringent plate characterized with the two parameters - the difference of secondary principal stresses and the secondary principal directions.

It is known that optical techniques, such as holographic, speckle and moiré have been used for measurement of small displacements of objects. During the last decade increasing attention to speckle metrology and its applications in experimental mechanics has taken place. Moiré technique is also optical measurement method for strain analysis of materials and structures. These methods have been successfully applied to study of the static and dynamic problems.

The main disadvantage of optical methods in experimental mechanics is that they, in general, determine the displacement field or the difference of principal stresses, while the more important parameter is the strain and stress fields. Therefore the investigator is dependent on the critical task of differentiation of the displacement field or to integrate the equilibrium equations using the finite difference calculus with known boundary conditions.

The purpose of this paper is to present a new optical technique for studying of the stressed state in the three-dimensional photoelasticity. The method is based on the combination of the scattered light photoelasticity method, of the speckle photography method and the moiré technique.

## BACKGROUND

The thin isolated optical slice of the photoelastic model is formed by two plane sheets [1] of light emitted from the same laser beam propagated in the direction of the axis **x** (Fig. 1). The polarization of the laser beam is linearly polarized along of the axis **ó**. The two-dimensional scattered light field is analyzed in the direction of the axis **z** orthogonal to the plane of the two these illuminated plane sheets. The scattered light (according to Rayleigh's law) that is analyzed in the direction of the axis z is linearly polarized too and orthogonal to this axis. The two-dimensional scattered light field from the two plane sheets is analyzed by the analyzer **A**. For the determination of the stressed state in the thin optical slice is suggested analyse of the two-dimensional scattered light field from each plane sheets and theirs interaction.

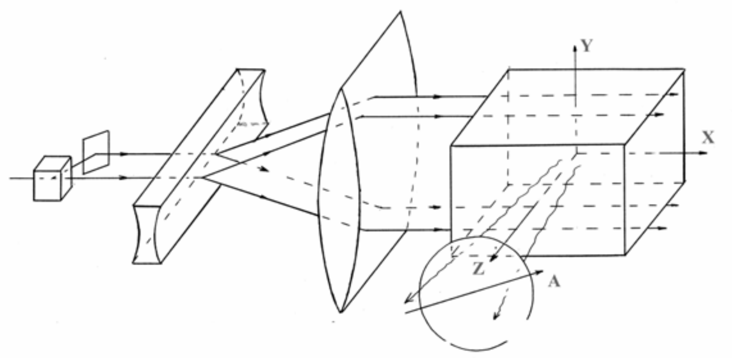
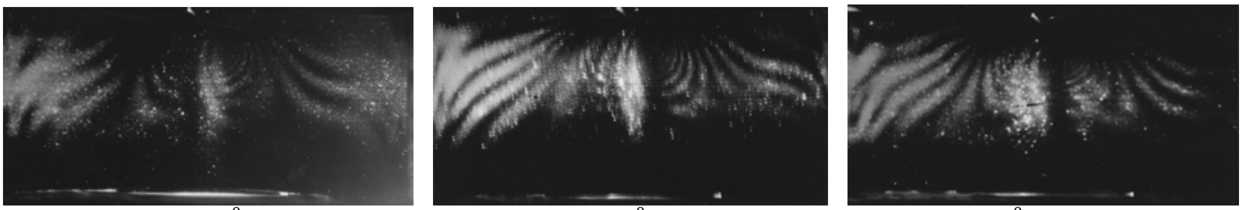



Fig. 1. Schematic of optical slicing method.

Figures 2, 3 and 4 show an example of the experimental interference patterns that are observed for various directions of the analyzer **A**. The corner of turn of the analyzer A was measured from a direction of polarization of the laser beam. Using Jones's method [1], the equations which describe formations of the interference patterns have been received.



$0^0$ $45^0$ $90^0$

Fig. 2. The interference patterns observable from the first plane sheet.

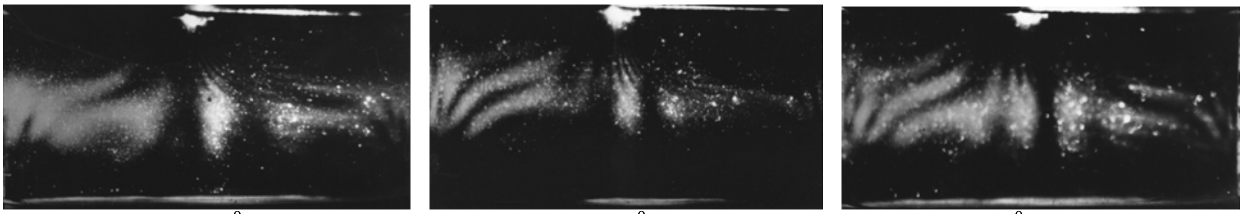


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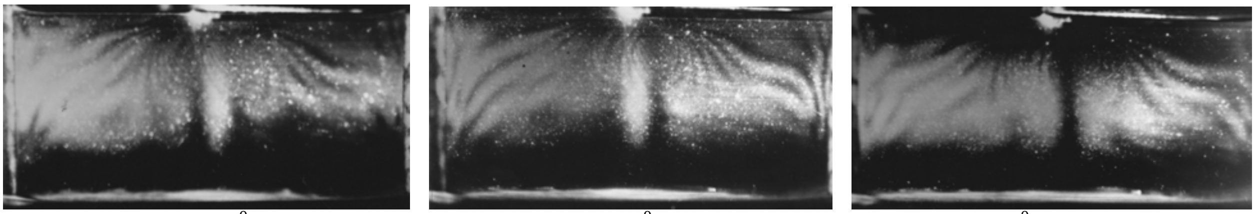
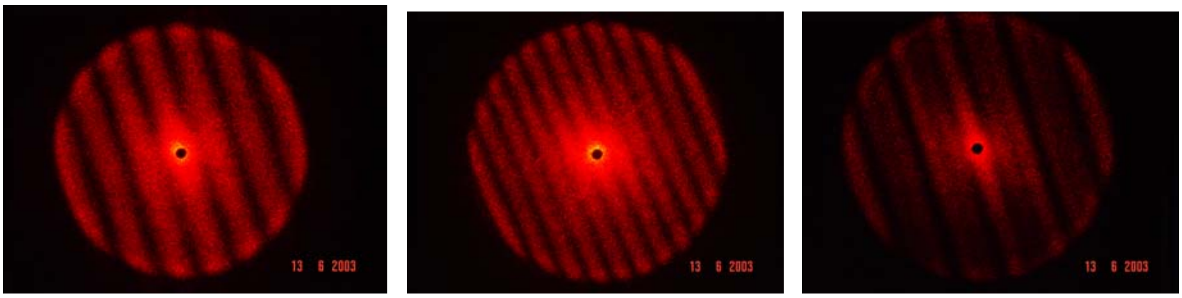
Fig. 3. The interference patterns observable from the second plane sheet.



$0^0$ $45^0$ $90^0$

Fig. 4. The interference patterns observable from interaction of two plane sheets.

Using combined method of the speckle photography with a ring aperture and moiré technique, have been received specklegrams for these two planes [2]. Photos on a figure 5, show an example of the experimental Young′s fringe patterns (a, b) and moiré pattern (c) that is formed from their imposing.




a b c

Fig. 5. Young′s fringe patterns (a, b) and moiré pattern (c).

## CONCLUSIONS

The combination of the scattered light photoelasticity method, of the speckle photography method and the moiré technique allows to define the stressed state in the thin optical slice. Experimental optical arrangement with a C.C.D. camera is suggested to put this method in to practice. Work is fulfilled at support RFBR 02-01-00211.

### References

[1] Lagarde A.: Progress in Photomechanics. *Proceeding of the 10th International Conference on Experimental Mechanics, Invited Lectures,* Lisbon, Portugal, 18-22 July, 1994.

[2] Osipov M.N., Shaposhnikov M.Y.: Strain measurements by combining of the speckle photography and moiré method. *Abstracts of the 20th International Congress of Theoretical and Applied Mechanics*, Chicago, USA, 27 Aug. - 2 Sept., 2000.