the glass. This coefficient is of greater value in the glass melted in platinum than in the glasses melted in ceramics. The coefficients Δ_0 connected with the sizes of microheterogeneity has been calculated earlier from the formula $\Delta_0 = 1+\Delta_h/1+(\Delta_v)^{-1}$.

The measurements of the scattered light allows to distinguish the glass melted in ceramics from that melted in platinum. Such measurements may give also some information about the states of polyvalent ions in glasses and about the dependences of the properties of these ions upon the thermal processing, among others. For example, the sample of F2 glass melted in platinum was subject to the thermal postprocessing at the temperature 720 K during 1 h. The results are presented in Fig. 4. The curve 1 shows the spectral dependence of sample transmission after the thermal processing with respect to that of the sample not subject to this process.

The results obtained indicate that two types of reduction processes, i.e,, $Pt^{4+} \rightarrow Pt^{2+}$ (the increase of the absorption band at the border of the UV and visible spectrum [4]), and also of $Pt^{2+} \rightarrow Pt^0$ (nonselective reduction of transmission) take place. The spectral dependence of the scattered light intensity ratio in glasses after and before the thermal processing (curve 2) indicates an increase of microphase sizes. These results show the possibility of observation of changes in polyvalent ions states in the glass depending upon various physical factors.

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A generalized speckle interferometry method for measuring the arbitrarily oriented (small) displacements of a rigid body

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1. Introduction

In the paper [1] a simple speckle interferometry method has been presented for measuring the rigid body displacements oriented perpendicularly to both the free propagating laser beam illuminating the object and the reflected beam producing the respective speckling pattern. Also, the lower and upper bound limits of the measuring range were there discussed.

Below, the principles of a generalized method and a respective setup will be considered which allow to measure the displacements of arbitrary orientations* with respect to the used light beams. This method will be introduced in two versions: as a free-propagation method, and as a diffuser method (comp. [1]).

2. Free-propagation method

The method suggested is closely related to its original counterpart described in [1], where a setup of geometry shown in Fig. 1 was used. It was composed of a laser (producing a collimated illuminating beam), an object under test and a recording film or photo-plate. With this geometry only transversal shifts or rotations could be measured. However, it is easy to notice that this geometry may be further developed to allow the displacement components

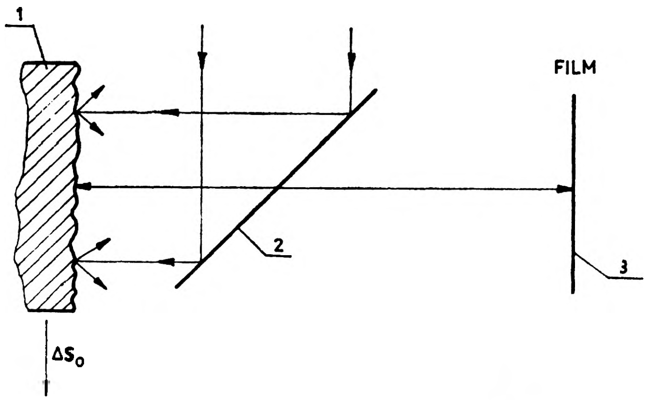

Fig. 1. Setup geometry used in [1]: 1 – object shifted by ΔS_0 distance, 2 – beam divider, 3 – film or photo-plate

in two mutually perpendicular planes to be measured simultaneously. For this purpose the setup shown in Fig. 2 may be used which is composed of: c.w. laser (1), beam splitter (2), two beam deflectors (mirrors or prisms) (3), (4) a special glass cube (5), which is fastened to the tested moving body, and two photo-plates (or films) (6), (7). Two sides of this cube marked by A and B in Fig. 2 are ground while the other two (opposite to the first ones) are polished

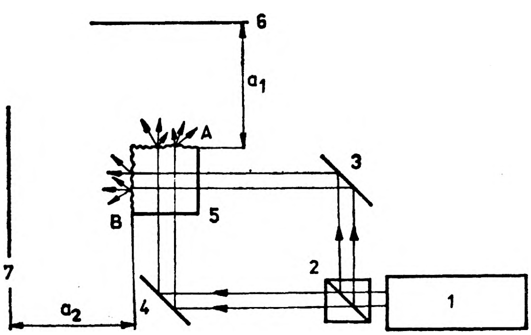

Fig. 2. Modified setup geometry suitable to determine the total displacement vector

(the remaining sides of the cube being of no importance). When the laser is switched on, each of the ground sides of the cube produces its own speckling pattern which is recorded on the respective photo-plate (6) or (7) located at the distances a_1 and a_2 from the cube (object) – comp. [1]. If the measured body (and by the same means, the cube) changes its position

*Obviously, the method is sensitive to the moduli of displacements only, which concerns also the displacement components (see text below).

the two speckling patterns move correspondingly. If the measured displacement is small enough not to introduce too high decorrection effects in the moving speckling pattern structures, the changes of the latters may be interpreted simply as pure displacements of the structurally stable speckling patterns. If a rectangular x, y, z coordinate system used to describe the movement of the body (cube) is chosen in the way shown in Fig. 3 (which presents

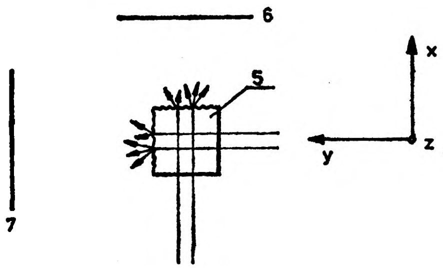

Fig. 3. The coordinate system associated with the setup: 6, 7 – photo-plates, 5 – special glass cube

the setup reduced to the cube and the photo-plates (6), (7), only) the projection ΔS_{yz} of the displacement ΔS_0 on the y, z-plane is recorded on the photo-plate (film) (7); the projection ΔS_{xz} of the same displacement on the x, z-plane being simultaneously recorded on the photo-plate (film) (6). On the base of the method described in [1] it is possible to determine the total displacement as represented either by the two components ΔS_{yz} and ΔS_{xz} or by the three components ΔS_x, ΔS_y, and ΔS_z. In the last case it suffices to notice that

$$\Delta S_x = \cos a_{zx} \Delta S_{xz},$$
$$\Delta S_y = \cos a_{yz} \Delta S_{yz},$$
$$\Delta S_z = \sin a_{zx} \Delta S_{xz},$$

where a_{zx} – the slope angle of the differential fringes with respect to z-axis in the z, x-plane,
a_{zy} – the slope angle of the differential fringes with respect to the z-axis in the z, y-plane.

2.1. Experimental results

An experimental illustration of the method suggested is presented in Fig. 4. Here, three pairs of photos are shown, being the records of three different displacements of a rigid body (cube). The first one (Fig. 4a) corresponds to the total magnitude of the displacement vector ΔS_0 of components: $\Delta S_x = 10.4$ µm, $\Delta S_y = 6.2$ µm, and $\Delta S_z = 12.2$ µm. The second pair (Fig. 4b) of photos corresponds to the total magnitude of the displacement vector ΔS_0 of components: $\Delta S_x = 5.1$ µm, $\Delta S_y = 4.1$ µm, and $\Delta S_z = 4.2$ µm, and finally, the third pair of the photos (Fig. 4c) illuminates the case when: $\Delta S_x = 4.5$ µm, $\Delta S_y = 10.8$ µm, and $\Delta S_z = 19.6$ µm.

3. Diffuser method

In order to widen the measurement range down to include as small displacements as possible the trick with a mate-plate diffuser may be used. As it was explained in [1], if a mate-plate diffuser is inserted somewhere in the space between the tested object and the recording film as indicated in the Fig. 5 (reproduced, for the sake of convenience, from [1]) two important consequences occur:

i) the speckling pattern becomes more tiny and, therefore,

ii) very small shifts of the moving object may be recorded (comp. formulae (4) in [1]).

Now, if the setup shown in Fig. 2 is additionally equipped with two diffusers (8), and (9) to form the geometry presented in Fig. 6, smaller displacements may be measured in both

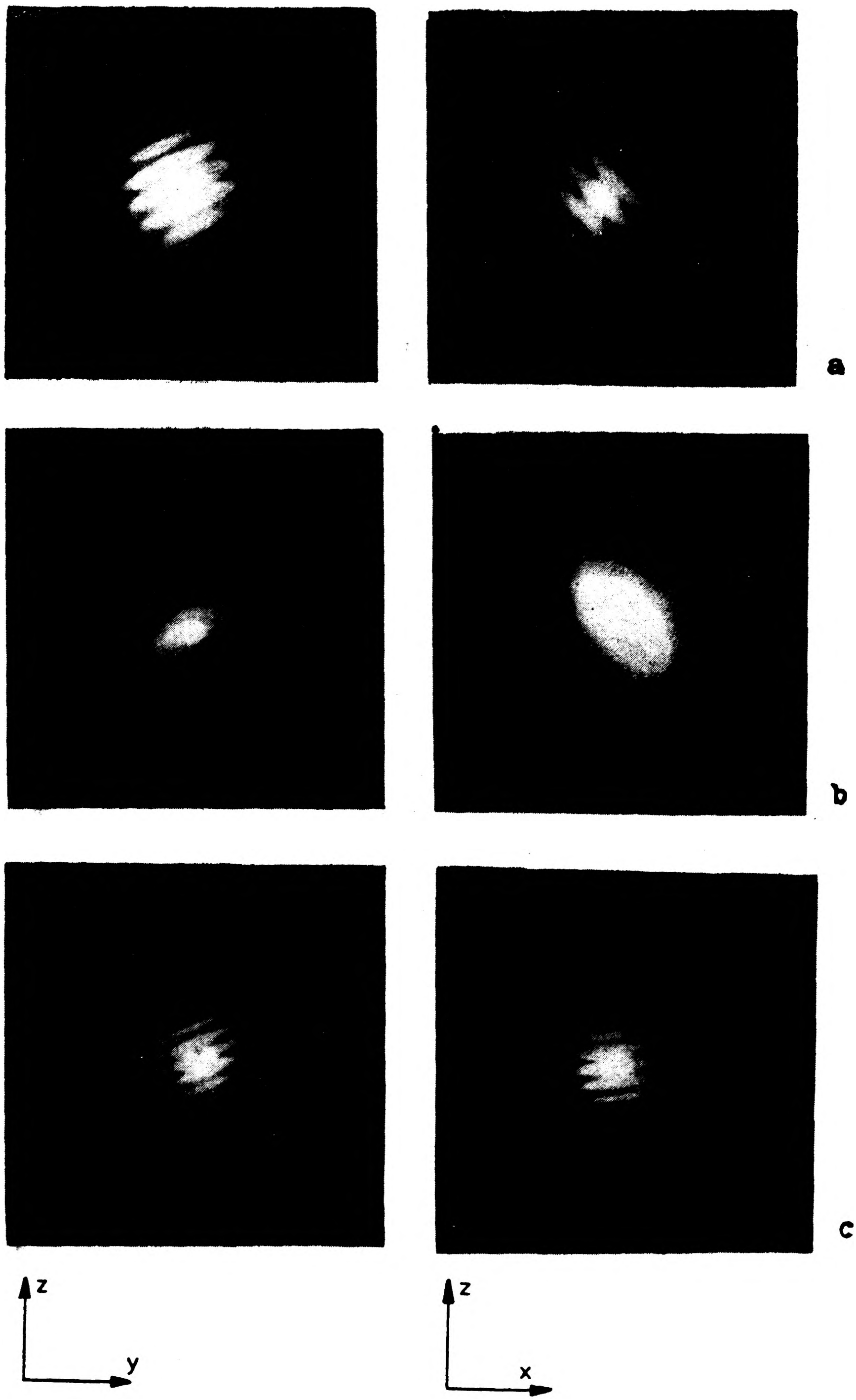

Fig. 4. Three photo-pairs (a, b, c) illustrating three types of the object displacements

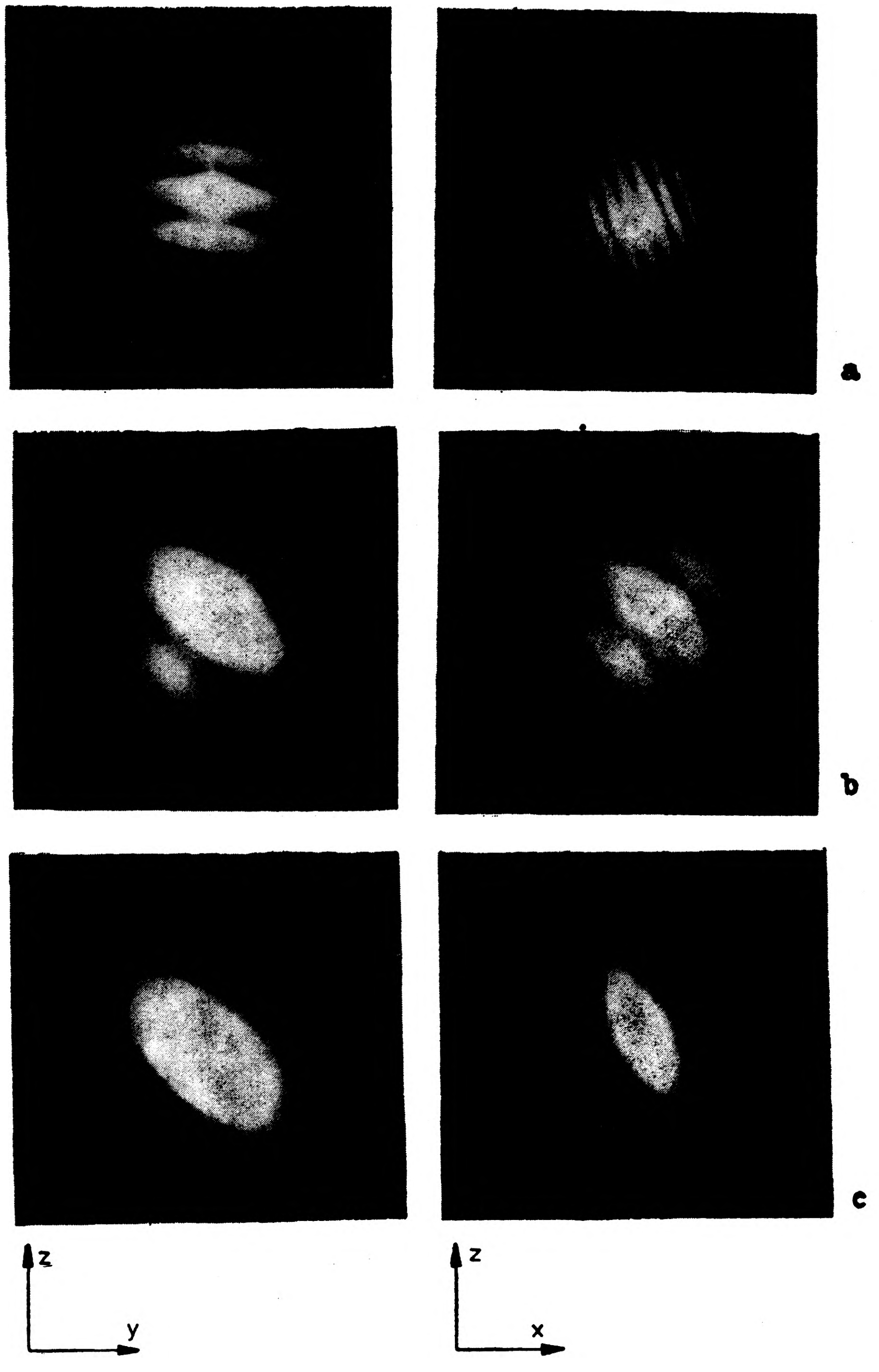

Fig. 7. Three photo-pairs (a, b, c) illustrating three types of the object displacements measured by the different method

arms of the setup. Some experimental results are illustrated in Fig. 7a, b, c, where the three photo-pairs shown correspond to the displacements: $\Delta S_x = 15.4$ μm, $\Delta S_y = 1.1$ μm, and $\Delta S_z = 6.7$ μm (photo-pair a), $\Delta S_x = 3.1$ μm, $\Delta S_y = 2.5$ μm, and $\Delta S_z = 2.9$ μm (photo-pair b), $\Delta S_x = 3.5$ μm, $\Delta S_y = 2.1$ μm, and $\Delta S_z = 2.1$ μm (photo-pair c).

Thus, the applications of the two diffusers (8) and (9) allows to shift the measurement range down to the single micron displacements and less.

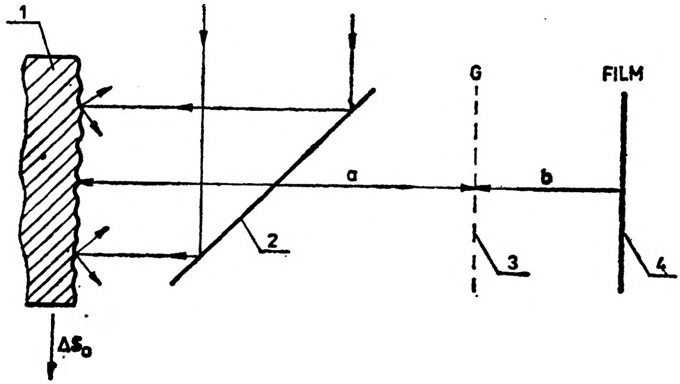

Fig. 5. Mate-plate diffuser method as proposed in [1]

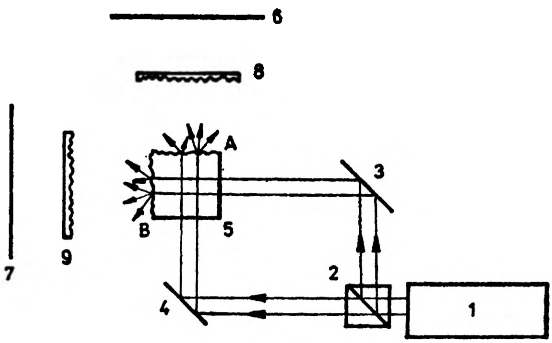

Fig. 6. Modified diffuser setup geometry suitable to determine the total displacement vector

4. Conclusions

The modification of the measuring setup suggested in this paper offers a possibility of complete measurements of the total displacements of a moving rigid object at the cost of some higher complexity of the used geometry if compared with the method suggested in [1]. This higher complexity is by no means dramatic so that the measuring system may be still considered as simple. Being little sensitive to the vibrations (due to small mutual distances of the optical elements) it may work under relatively difficult conditions without any antivibration system.

Obviously, the idea of widening the measurement range to allow also the greater displacements to be measured, suggested in [1], may be also applied to both the measuring systems proposed in this paper, provided that the suitable two cameras (proposed in [1]) are available.

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