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V. Klimkin, V. Pickalov

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OPTICAL INTERFEROMETRY OF PULSED MICRO-DISCHARGES

V.F. Klimkin and V.V. Pickalov.


Abstract. The investigations of discharge phenomena in continuous medium are connected with the study of the objects of high density gradients, high speeds of movement \(10^5-10^7\text{cm/s}\), small characteristic lengths \(10^{-3}-10^{-2}\text{cm}\). This work is devoted to the analysis of special features of microdisturbances interferometry. The objects of \(10^{-2}\text{cm}\) sizes with stepwise density discontinuity are investigated [1].

For axial symmetry inhomogeneity the changes of refraction index connected with the shift of interferometric fringes \(\hat{k}(\infty)\) by the Abel integral equation (the refraction effects being neglected):

\[
\hat{k}(\infty) = \frac{2}{\pi} \int_0^\infty \frac{\Delta n(\tau)}{\sqrt{\tau^2 - x^2}} \tau \, d\tau.
\]

The method of statistical regularization was used to solve this equation [2,3]. It's need to note the high influence of data errors on the accuracy of restoration. It is a first attempt of retrieval for such class of problems.

Therefore the reliability of the approximate methods of the Abel equation solution was checked up by numerical experiments on model function with stepwise discontinuity on the object's boundary:

\[
\Delta n(\tau) = \exp\left(1 - \frac{R}{\tau}\right).
\]

The real experiment was simulated by introducing of random normal errors 3-10\% relative to maximum of function into appropriate values of \(\hat{k}(\infty)\). The Fig.1 shows the results of restoration of the function (2) with 5\% noise level (4). One can see that the retrieval error of discontinuity value is about 4\% while the radius is dividing into 10 zones (\(\circ\)) and not more than 1\% while it's dividing into 15 zones (\(\bullet\)).

The numerous series of model calculations for smooth functions show the high accuracy of the reconstruction.

The possibilities of the methods applied to microobjects with the stepwise distribution of density were determined on special set up including the Mach-Zehnder interferometer and He-Ne laser as a source of light. The object was a cylinder of melted quarts with the diameter \((0.5\pm2)\cdot10^{-2}\text{cm}\) put into cell with \(CC\ell\). It was possible to regulate the value of refraction index changing \(\Delta n = n_0 - n_q\) by temperature variation of the liquid. An average refraction index of the melted quarts \(n_q\) and the temperature dependence of refraction index of \(CC\ell\) were determined by refractometer for the wavelength of \(\lambda = 632.8\text{nm}\) (the accuracy

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of the measurement being \( \sim 10^{-4} \), the accuracy of thermoregulation being \(-0.1^\circ\rm{C}\).

Fringe shifts were measured by the multiplication of photography (100 or 200 times) with the help of comparator. One can see (Fig. 2) the results of the reconstruction of the stepwise refraction index profile (\( R = 1.05 \cdot 10^{-2}\text{cm}, \Delta n = 1.95 \cdot 10^{-2} \)) by the method of statistical regularization. It is seen that the error of the shock reconstruction is about 7%.

The displacement from the relation \( \Delta n = \text{const} \) may be connected with the fine structure of microsamples. However an average of refraction index changing (----) is in good agreement with measured one (-----).

As a result we come to conclusion about the sufficient reliability of the above method applied in interferometric study of microdisturbances appearing at the initial stages of the electric discharges in liquid dielectrics. In these experiments the ruby laser with the pulse duration of \( 5 \cdot 10^{-9} \) was used.

The analyses of the possible errors show that the main deviations of the shifts values obtained. In the Fig. 3 one can see results of the \( \Delta n(\rho) \) reconstruction beyond the spherical shockwave front, arising as the result of local explosion on the surface of positive electrode in distilled water. Investigations of the shock waves dynamic allowed to estimate the value of maximum pressure and energy density in the region of local discharge [4] with the help of approximate gasdynamic relations.

In the Fig. 4 we can see the results of the \( \Delta n(\xi) \) reconstruction for disturbances in ether (\( \xi \approx 4 \)). The reconstruction of pressure profile for similar disturbances allows to appreciate its value on the boundary of initial ionized channel in liquid (-----), which is very important for understanding of physical processes connected with discharge.

REFERENCES