Contrast Inversion by Focusing Laser Beam in an Absorbing Medium

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Abstract—Method for obtaining an inverted brightness image of opaque objects is described. Obtained transformation to a positive image up to 350%, relative to the intensity of the incident beam, is in agreement with numerical calculations.

Keywords—contrast inversion, nonlinear Zernike phase-contrast, thermal self-action.

Visualization the image transparent objects in the scheme to focus the beam into the absorbing medium in a weak thermal self – action is considered in [1,2]. This paper presents the results of research of image conversion opaque object in the same scheme. Experimentally observed processes image inversion and partial disappearance of small-scale visibility opaque object taking place in their image plane, under certain radiation powers. Optical scheme for obtaining an inverted image of an opaque object or structure is shown in Fig. 1.

![Optical scheme of the setup.](image1.png)

Fig. 1. Optical scheme of the setup.

Such schemes relate to phase-contrast schemes using nonlinear Zernike filter [3], in this case based on a thermal nonlinearity.

In the experiment and in the calculations, we have used a single lens imaging scheme photothermal cell located at the focus of the lens. Opaque structures located in the object plane 3 illuminate a Gaussian beam of linearly polarized single-modal He - Ne laser power $P \leq 6\text{mW}$, wavelength $\lambda = 0.63 \mu\text{m}$, diameter $D \approx 1\text{cm}$. Adjusting the radiation power have been performed by means of turning the Glan prism 2 on its axis. Light output has been measured by a colorimeter Ophyr. As photothermal filter we have used absorbing liquid layer or thin polymer plate. Using the plate is more convenient, although the inversion of the illuminating laser power required is approximately 4 times greater. In the image plane CMOS camera 6 (model DCC1545M) is located. Figure 2 shows images of opaque mesh on a glass substrate and a corresponding image processing . The distance between the grid dashes is $100?m$. Images obtained with different capacities mW illuminating beam. Results showed an image processing (Fig. 2b), which is achieved by converting to a positive image to 350% , relative to the intensity of the incident beam, which is in agreement with numerical calculations, carried out in accordance with [2]. To calculate the output field in the optical system we have used Fresnel-Kirchhoff diffraction integral in the paraxial approximation. Time for regime change is determined by the temperature at the point of establishing a photothermal heating filter by changing the beam power and is a fraction of a second.

Contrast inversion of the object by megawatt power femtosecond pulses illumination beam was obtained in [4].

![Images of opaque structures and corresponding intensity sections.](image2.png)

Fig. 2. Images of opaque structures and corresponding intensity sections.


