

Dynamic Holography in Liquid Crystalline Matrix in Adaptive Optics

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Purpose

The problem of dynamic (real-time) asymmetrization of the profile of interference pattern formed by two light waves is related to the problem of increasing diffraction efficiency (DE) of thin (plane) dynamic holographic gratings, recorded, in particular, in liquid crystal spatial light modulators (LC SLMs). In this paper, we present an analog scheme of dynamic asymmetrization of interference pattern (holographic grating) profile based on using the matrix electrically addressed LC SLM. We also consider the prospects of such holograms use in adaptive optics.

Methods

A schematic of the experimental setup is shown in Fig. 1. The beam of an He–Ne laser 1 ($\lambda = 0.6328 \mu\text{m}$) is expanded by a collimator 2 and supplied to the Michelson interferometer, formed by a beamsplitting cube 4 and plane mirrors 3 and 6. One of the interferometer leg contains a matrix EA LC SLM 5 (Holoeye LC2002). The modulator has a rectangular shape $26 \times 21 \text{ mm}$ in size and contains 800×600 pixels. In the standard mode it is used as a transmission element, providing an arbitrary phase modulation up to 2π at a wavelength of $0.532 \mu\text{m}$ in one pass. In our case, laser radiation was transmitted through it twice to provide the necessary modulation depth at the operating wavelength. Lens 7 imaged the exit aperture of the modulator onto a Watec 902B CCD matrix, $8 \times 6 \text{ mm}$ in size (800×600 pixels). A digital video signal from the camera was sent to a personal computer and transferred (without any processing) to control the phase delay in the modulator 5. The modulator control system can be implemented in several versions; we chose it based on the use of a VGA signal. In this mode, a standard analog VGA signal, which is formed by the video card of personal computer and is generally used to control the computer display, is applied at the modulator input. In this scheme, brightness gradations of a black and white image transferred by the computer are reproduced by the modulator as phase delay gradations. We used a standard personal computer working in MS Windows XP with a video card with two outputs. The primary output with a connected display was used to control the computer. A secondary output tuned to reproduce the VGA signal (800×600 pixels) was connected to a splitter to transmit the signal through two channels, i.e., to the modulator input and the test display, which made it possible to observe the video signal from the CCD camera.

The operation of this system turned out to be similar in many respects to the previously implemented [1] system, equipped with an optical channel for controlling signal transmission. After three or four iterations, which took a few tenths of a second, the system reached a relatively stable state, in which the intensity distribution in the recorded interference pattern profile (and, therefore, in the distribution of the phase delay introduced by the modulator) was essentially asymmetric. Some examples of implementing experimental patterns of this type are shown in Fig. 2.

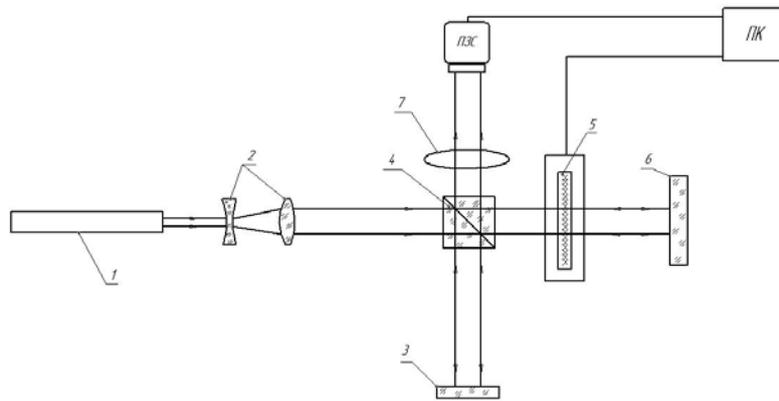


Fig. 1. Schematic of experimental setup.

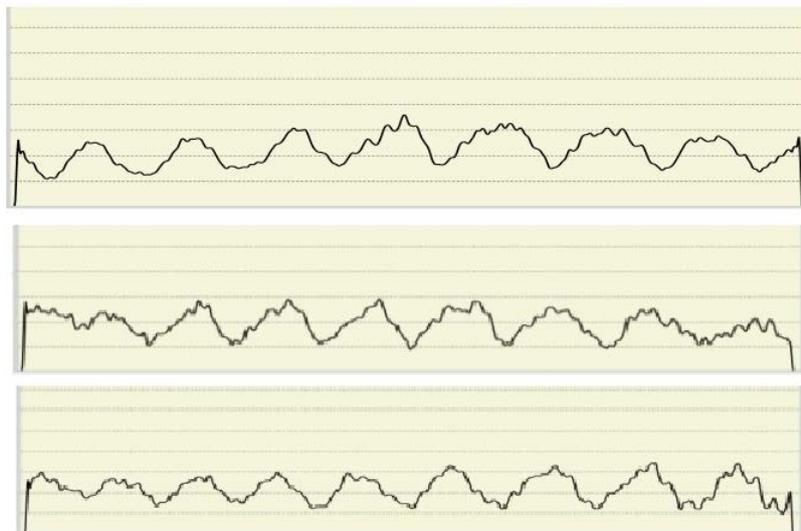


Fig. 2. Cross section of interference pattern intensity distribution.

As in [1], the potential DE in one of the first orders was estimated by direct calculation of the Kirchhoff integral (the corresponding technique was described in [1]) to be about 70–75%. The examples of the saw-tooth profile are shown in the Fig.2.

Conclusions

Thus, we implemented for the first time a system for dynamic (realtime) recording holographic gratings with an asymmetrized (saw-tooth) profile based on the use of an analog feedback loop and a matrix EA LC SLM.

References

1. V. Yu. Venediktov, N. L. Ivanova, V. A. Laskin, and N. N. Freigang, *Kvantovaya Élektron.* 39, 973 (2009) [*Quant. Electron.* 39 (10), 973 (2009)].