Wavefront restoration of pulsed high intensity laser radiation by acousto-optics

Vladimir Molchanov, Konstantin Yushkov, National University of Science and Technology, MISIS, Moscow, Russian Federation

Background, Motivation and Objective

The typical speed of wavefront control by modern active mirrors and liquid crystal phase modulator usually does not exceed 10 kHz. For example, temporal dynamics of atmospheric turbulence is usually substantially less. The situation changes if it is necessary to carry out fast dynamic wavefront control, when the number of iterations during mathematical processing increases sharply. The challenge is to develop a fast laser wavefront correction device with a control speed that is an order of magnitude higher than the existing systems. Acousto-optical (AO) methods of arbitrary transmission function synthesis (Yushkov et. al. *Opt. Lett.* **44:**1500, 2019) allow making a new step in this direction.

Statement of Contribution/Methods

We propose to create a matrix ultrasonic structure in an AO crystal of a multichannel device (Aubin et al. *Electron. Lett.* **40:**448, 2004). Each acoustic column is filled with an ultrasonic field having a programmable amplitude-frequency structure as it is done in dispersive AO delay lines (Verluise et al. *JOSA B* **17:**138, 2000; Molchanov et al. *Appl. Opt.* **48:**118, 2009). Thus, matrix ultrasonic structure is formed, which controls the angular position of the wavefront in the diffraction plane. For the two-coordinate control, after the first matrix, the second matrix should be located orthogonally (Fig.1A). In the proposed method, the matrix of M×N elements requires not M×N drivers but only M+N.

Results/Discussion

The one-coordinate four-channel prototype of the AO corrector was custom designed and fabricated. The AO cell is based on TeO2 crystal. Slow shear BAW propagates along [110] axis. To verify the principle two channels are sufficient: one reference channel PZT2 and one working PZT1 (Fig.1B). A home-made AOM cuts pulses duration of 1 μs from CW laser radiation with the wavelength 532 nm. A phase object (a cylindrical lens) was placed in the working channel and caused a distortion of plane wavefront. Then the wavefront of the diffracted field in the working channel was restored to the original plane. The RF frequency in the reference channel is 63 MHz, the RF chirp in the working channel is 57-69 MHz. The temporal response of the matrix AO prototype does not exceed 27 μs.

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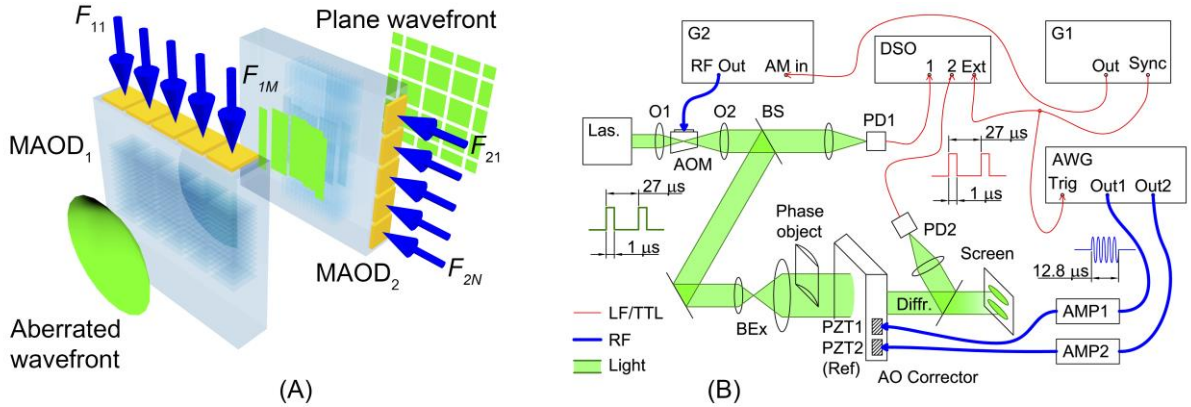

Fig. 1. The architecture of an AO corrector with of 5x5 matrix elements (A) and the experimental setup (B).