Experimental setup for rogue waves registration in a Q-switched laser

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The experimental setup for recording spatial rogue waves in a solid-state laser operating in the Q-switched mode was developed and assembled. This setup made it possible to analyze laser pulses in real time. The maximum intensity value, average, maximum coordinates and the ratio of maximum intensity to average for each frame were recorded on the hard drive. The entire frame was recorded only when a rogue wave occurred. It allowed to analyze the intensity distribution over the cross section of the laser beam in laser pulses and register rogue waves according to the specified criteria. This setup made it possible to record large amounts of information for further analysis of statistical distributions.

Keywords: rogue waves, CMOS sensor, Nd:YAG laser, Q-switched mode

Introduction

Optical rogue waves are rare pulses of light arising during the process of laser generation. These anomalous events have been shown to follow heavy-tailed statistics [1]. These probability distributions are characterized by long tails: large outliers occur rarely, yet much more frequently than expected from Gaussian statistics and intuition. This work is devoted to the development and fabrication of a setup for registration spatial rogue waves in a pulsed solid-state laser operating in the Q-switched mode.

1. Hardware

The schematic diagram of the developed setup for rogue waves recording is shown in Fig. 1. Nd:YAG laser beam hits the camera from which the lens is removed to eliminate the effect of multiple reflections on the lenses. the lens is coated in the visible range, and the camera records the beam at a wavelength of 1064 nm. The setup used a Moticam 1.3 camera with a resolution of 1280x1024 or 1.3 megapixels. The sensor type for this camera is CMOS. The camera is designed to work in the visible range, but the sensitivity of the sensors at a wavelength of 1064 nm is quite high. To adjust the intensity of the incident beam in order to maximize the dynamic range of the sensors, a set of attenuator filters was installed in front of the camera. At the same time, the R, G and B sensors at a given wavelength had approximately the same sensitivity, which in our opinion is due to the fact that the dyes applied to the corresponding sensors for the visible range are transparent in the IR. The camera is connected to a computer via a USB cable. Part of the beam is diverted to the photodetector 3 by means of a glass plate. The photodetector has a fiber input, therefore, the radiation is focused by a lens to enter the core of a multimode fiber with a core diameter of 50 μm. Then the signal from the high-speed photodetector was fed to a digital oscilloscope 4 to control the pulse duration and its shape. The laser was operated at pulse repetition rate of 5 Hz. To obtain a frame with only one pulse, it was necessary to synchronize the camera with the laser. For this, an Arduino Uno 6 board, connected to a computer, was used. The camera worked at its own frequency, set by an internal quartz resonator. After starting the camera, a signal was sent to the Arduino board, which sent a pulse to start the laser through the connector on the control unit 7. In this version, it became possible to automatically record large data arrays with intensity distributions over the beam cross section.

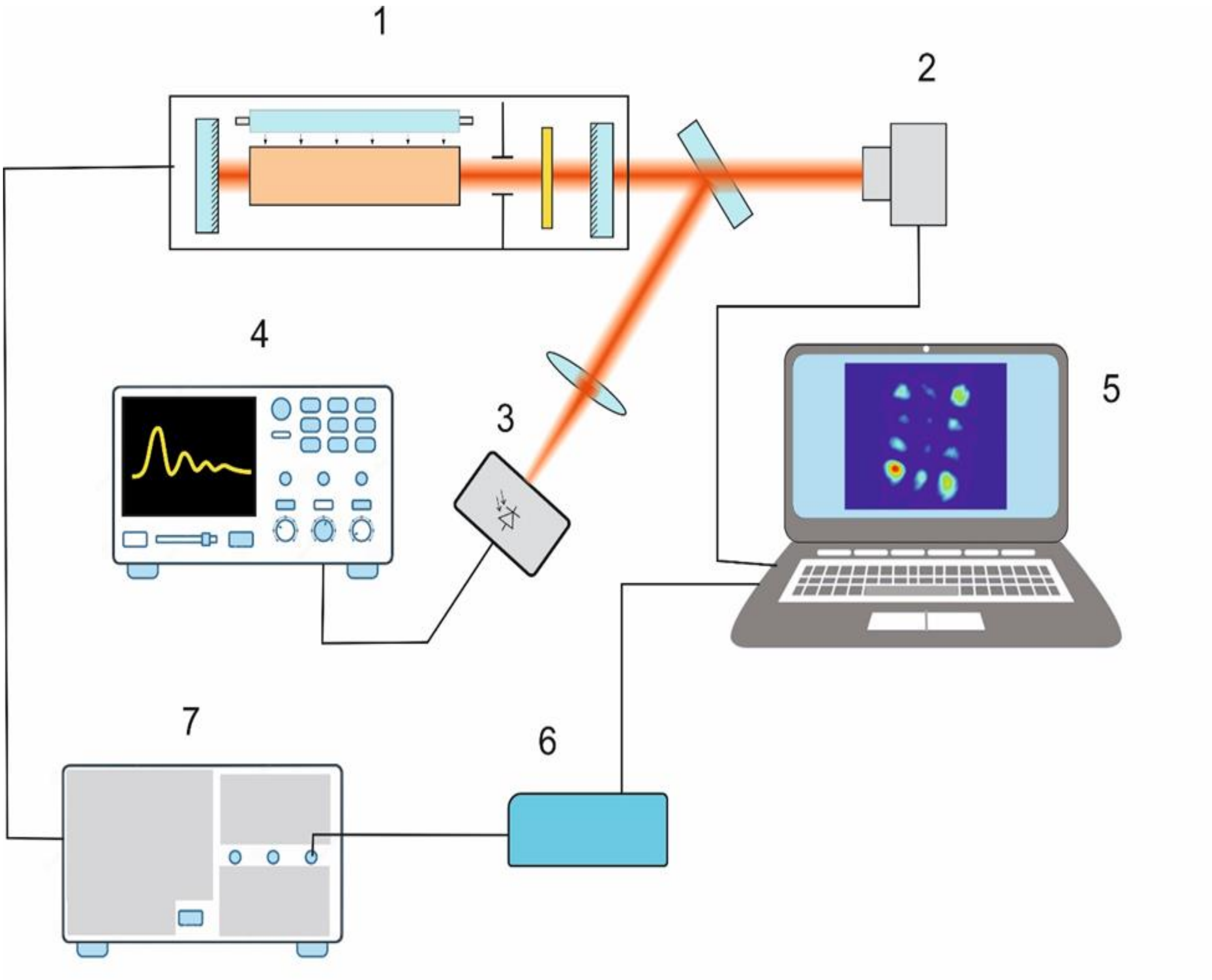

Fig. 1. – Schematic diagram of the developed installation: 1 – laser, 2 – camera, 3 – photodetector, 4 – digital oscilloscope, 5 – computer, 6 – Arduino board, 7 – power supply and laser control unit.

2. Software

To process the signal from the camera, we used the MUCam32.dll driver [2] with a program developed by us on Delphi 7, the interface of which is shown in Fig. 2. The intensity distribution from the camera was recorded in RGB (0-255) bite files. The maximum intensity and the average intensity were found as the sum over all pixels of the camera. At the same time, a picture of the frame was displayed on the computer screen with the indication of the maximum point and intensity graphs along the X and Y axes. The maximum value, average, maximum coordinates and the ratio of maximum intensity to average for each frame were recorded on the hard drive. The entire frame was recorded under the established criteria: the maximum value, the ratio of the maximum to the average, and the average value. In this case, the background value was subtracted, which was measured before the start of the experiment. Due to the fact that recording a full frame required a rather long time (more than the time between laser pulses) and this information took up a lot of space on the hard drive, only frames were recorded in which rogue waves were supposedly arised in accordance with the selected criteria.

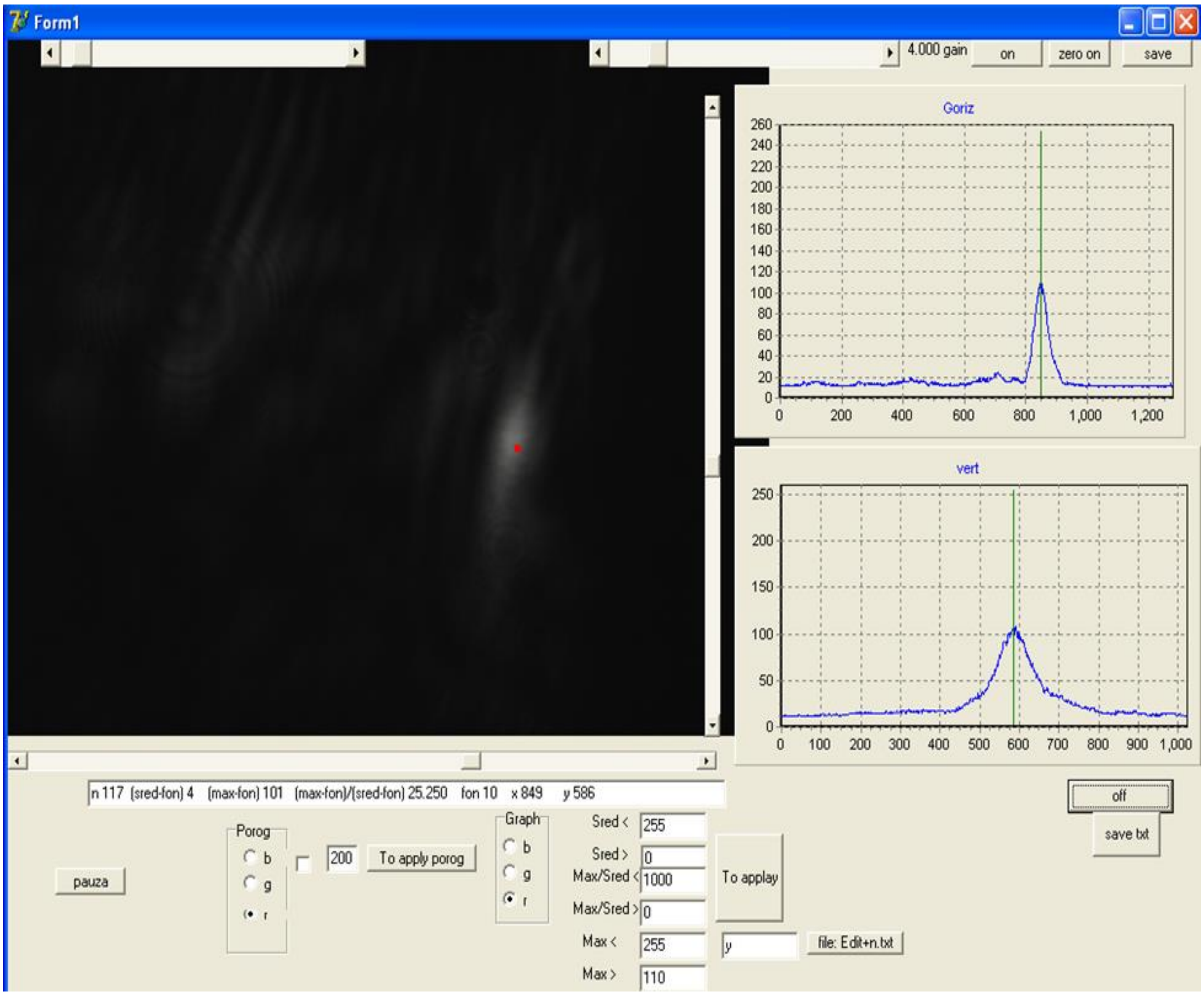

Fig. 2. – The interface of the program for working with the camera.

Conclusion

As a result of the work, an experimental setup for recording spatial rogue waves in a solid-state laser operating in the Q-switched mode was developed and assembled. This made it possible to analyze laser pulses in real time. The setup allowed to analyze the intensity distribution over the cross section of the laser beam in laser pulses and register rogue waves according to the specified criteria. This setup made it possible to record large amounts of information for further analysis of statistical distributions.

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References

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