Dual-Channel Multiterawatt Laser System with Coherent Beam Combining

S. N. Bagayev, V I Trunov, E. V. Pestryakov, S. A. Frolov, V. E. Leshchenko, V. A. Vasiliev
Institute of Laser Physics SB RAS
Novosibirsk, Russia, 630090
trunov@laser.ncs.ru

Abstract—The dual-channel femtosecond laser system with each channel consisting of three BBO and LBO crystals based broadband parametric amplification stages of Ti:Sa laser radiation and relative jitter stabilization system to 110 as level is presented. For the first time coherent combining of two sequences of parametrically amplified femtosecond pulses with energy of ~ 150 mJ, 10 Hz repetition rate is experimentally realized. Coherent combining efficiency of over 90% is reached. Experimental results of parametrically amplified contrast measurement are presented with further comparison with simulation results based on the model of parametric luminescence evolution developed by us. In order to achieve petawatt power level schemes of multibeam pumping of the booster cascade of developed laser system are considered.

Keywords—femtosecond pulses, parametric amplification, coherent beam combining, contrast, petawatt, multibeam pump

I. INTRODUCTION

The development of principles of extreme light field generation and creation of multichannel ultrarelativistic intensity laser system is being carried out in ILP SB RAS. At the basis of laser system being created lays coherent combining of femtosecond OPCPA-amplified pulses. For the present moment it is the most promising method that allows to overcome amplifiers and compressors aperture limitation and thus reach ultrarelativistic intensities level [1].

It should be noted that during development of high-intensity femtosecond laser systems, it is contrast of amplified pulses that has fundamental importance and defines quality of radiation of such systems. This is connected by that detrimental effects such as plasma generation at the front of the pulse [2] may be caused by low contrast.

II. MULTICHANNEL LASER SYSTEM

At present dual-channel laser system based on broadband parametric amplification of chirped Ti:Sa laser pulses in BBO and LBO crystals is designed and created at ILP SB RAS. Each channel consists of three-stage parametric amplifiers with pump pulses of 532 nm wavelength and 90 ps pulse duration. The amplified pulses are further compressed with grating compressor to duration of about 20 fs in each channel. For the first time the coherent combining of two pulse sequences with energy of ~150 mJ and 10 Hz repetition rate is experimentally realized. The coherent combining efficiency of 90% is reached with use of original relative jitter stabilization system that allows to keep it as low as 110 as.

III. LASER SYSTEM CONTRAST

To analyze contrast of our laser system the model of parametric luminescence evolution that takes diffraction, birefringence, group delay dispersion and gain saturation into account was developed. The distinctive feature of our model is capability to compute full frequency-angular spectrum of amplified luminescence generated during parametric amplification of chirped pulses. Besides contrast that feature allows to estimate superluminescence energy in full frequency-angle range that may be important for optimization of gain efficiency.

Experimental results for our laser system are presented in comparison with simulation results. It is shown that model developed by us is in good agreement with experimental results that allows to use it for contrast optimization of real-life systems. With our model we investigated methods of contrast improvement in multiterawatt laser systems based on OPCPA.

IV. MULTIPLE BEAM PUMP

In prospect it is planned to increase pulses energy up to several joules by addition of booster amplification stages. The analysis results for multibeam pumping usage in order to achieve petawatt power level are presented. It is demonstrated that such power level is achievable in booster parametric amplifier with LBO crystal and six incoherent 10 J pump pulses.

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