PROGRESS IN STUDIES OF GIGABAR SHOCK WAVE GENERATION IN LABORATORY EXPERIMENT

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The transition to the investigation of equation of state (EOS) of a substance at a gigabar pressure level has a fundamental importance for the understanding and adequate description of hydrodynamic and thermodynamic processes in astrophysical objects and inertial confinement fusion targets. Promising methods to achieve a record pressure in a laboratory experiment aimed to generation of a plane shock wave, in one way or another, are connected with the exposure of the substance by a powerful laser pulse. Today, namely, using the laser radiation makes it possible to provide a maximal energy flux density on target surface. In the current experiments two methods are traditionally used to generate powerful shock wave. One of them consists in creating the ablation pressure on target surface directly by laser radiation heating the substance. The ultimate pressure of shock wave in this case is about 100 Mbar. The second method is to generate a shock wave by collision of projectiles accelerated under the action of laser pulse. In this case, the ultimate value of pressure close to 500 Mbar. The achieving the ultimate pressure for both methods of shock wave generation has been demonstrated in the experiments. Nevertheless, modern experiments on EOS investigation are performed at a lower pressure level of several tens of Mbar with using the laser systems whose energy no exceeded 10 kJ. This is due to the fact that the requirements for conditions of EOS-experiments, which are a shock wave should remain to be plane and quasi-stationary during the entire period of measurements, impose restrictions on the minimum values of pulse duration and radius of laser beam.

This review focuses on yet another approach of powerful shock wave generation, which is based on heating the solid by a stream of fast electrons produced due to high intensity laser radiation interaction with target. Researches in this area are actively carried out in different laboratories in the last 2-3 years. This approach can provide the generation of shock wave with the pressure behind the front of a few Gbars that could be the way, in perspective, of transition to the study of EOS at a gigabar level of pressure. The results are shown of experiments performed at different laser systems on studying the conversion of laser energy into fast electron energy, heating the solid by fast electron stream, creating the ablation pressure and shock wave generation due to energy transfer by fast electrons. The theoretical models and numerical results are discussed on generation of a plane shock wave with gigabar level of pressure due to the heating of solid by stream of fast electrons with different spectra. The results of computational and theoretical studies show, that the requirements for EOS-experiments at the level of pressure of 1-2 Gbar can be provided in the result of heating the solid by stream of fast electrons produced at the action of laser pulse with intensity 10-100 PW/cm2 and energy of 10-30 kJ.

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