Electron acceleration and THz emission during laser-cluster interaction

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Abstract— We have studied the processes of electron acceleration and THz emission, undergoing simultaneously during laser excitation of the gas-cluster jet. The properties of the electron beam and THz radiation power were measured under various conditions of the cluster excitation and parameters of the laser radiation.

Keywords— laser-driven acceleration, gas clusters, terahertz radiation

I. Introduction

The gas cluster jet is of interest as a target for laser-driven electron acceleration [1]. This is due to the unique features of the cluster jet, such as high local density of clusters and low average density of the jet, possibility of self-guided propagation of laser pulses [2]. Laser-cluster interaction also may be accompanied by emission of THz radiation [3]. It seems appropriate to carry out analysis of simultaneously occurring phenomena of electron acceleration and THz emission in laser-excited cluster target for better understanding of physical processes in cluster plasma.

II. Experimental Setup and Results

Our experiments were performed with a compact Ti:Sapphire laser system provided 1-kHz pulses with 35-fs duration and up to 6 mJ energy. The gas-cluster target consisted of large molecular clusters was formed during the adiabatic expansion of a gas mixture SF_6+Ar in a molar ratio (1:8) through a supersonic conical nozzle. Previously the possibility of efficient generation of characteristic X-ray radiation was demonstrated in SF_6 clusters from such a mixture under laser excitation [4]. In our studies, this cluster target showed the optimal result for the efficiency of electron beam generation in comparison with other tested gases and gas mixtures. The experimental setup provided the measurement of the power of THz radiation propagating at an angle of 45º to the direction of laser radiation.

Under optimal conditions, the main properties of the emitted electron beam were following: average energy 90 keV, total electric charge 80 fC, divergence angle 90 mrad. The position of the laser focus inside the cluster jet was significantly different for the effective generation of electrons and for THz radiation emission. We have found that changing the polarization state of laser radiation from linear to circular results in decrease of electron emission whereas THz emission power increases under these conditions (Fig. 1).

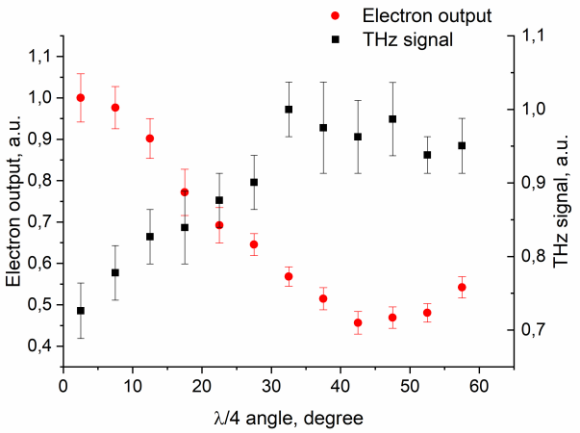

Fig. 1. Normalized signals of electron beam and THz radiation detectrors as a function of quarter-wave plate rotation angle. At zero degree angle laser polarization is linear, at 45 degree is circular.

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