Laser-plasma acceleration of electrons and generation of x-rays in an optimized gas-cluster target

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The electrons acceleration in a high-density plasma makes it possible to obtain a high charge electron beam (30 pC). The presence of clusters in a gas (krypton, nitrogen, or argon) jet allows one to effectively absorb the energy of a laser pulse with the generation of hot plasma. The experiment uses a multiterawatt fs (femtosecond) laser, 800 nm, $f/4$ focusing at 8 μm. At intensities of 10^{18} to 10^{19} W/cm^2, laser plasma was obtained from a cluster target with a density $n_e > 10^{19}$ to 10^{20} cm^{-3}. The cluster diameter varied from 50 to 80 nm at 15–40 bar pressure. Optimization of the position of the beam-waist relative to the front boundary of the cluster cloud led to a record yield of the characteristic K line of krypton (12.6 keV)—3×10^8 photon per pulse $\times\, 4\pi$. In this case, accelerated electrons with energies of 0.2–3 MeV were recorded with beam divergence of 100 mrad. For optimal geometry and pulse duration for acceleration, an increase in the temperature of the "hot" electrons from 5 to 7 keV and a shortening of the electron channel to 700 μm were observed. A comparison with the case of a metal target is provided. The complex approach was developed for diagnosing laser acceleration of electrons in gas-cluster jets based on recording optical images of plasma channels, scattering on clusters, and x-ray radiation.