Experimental and numerical investigations of ion acceleration by ultraintense laser pulses in near-critical transparent gas jets

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Fast ion sources driven by ultraintense lasers are promising in many fields of fundamental and applied science. While laser-based ion acceleration from solids has been extensively studied, near-critical-density plasmas have been little addressed so far due to difficulties in achieving well-controlled high gas densities. Such plasmas are predicted to give rise to a mix of acceleration mechanisms combining target normal sheath and collisionless shock acceleration, as well as hot-electron production beyond the standard ponderomotive scaling. Here we report on a particle-in-cell simulation study of this process and on two experiments conducted at the 200 TW VEGA II and 1 PW VEGA III laser systems (CLPU, Spain). The first aimed at studying the potential for ion acceleration of a state-of-the-art gas jet coupled with shock nozzles. The second revealed, through time-of-flight measurements, the generation at a moderately high repetition rate of ~ 0.6 MeV/amu. alpha particles with relatively low energy dispersion and divergence. It also confirmed the copious hot electron generation predicted by numerical simulations.