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Development of laser wakefield acceleration driven by few-TW pulses in a sub-mm, dense nitrogen gas target

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Laser wakefield acceleration (LWFA) driven by few-TW laser pulses in a thin, dense nitrogen gas target represents a favorable approach for stably generating 10-MeV-scale electron beams with satisfactory beam properties. With a high plasma density > 10^{19} cm^{-3}, the self-focusing effect and the self-modulation instability developed on the pump pulse consequently cause a strong laser intensity to drive nonlinear plasma waves for acceleration, while the free-running ionization-induced injection from the ionization of nitrogen N^{5+} and N^{6+} ions can substantially enhance the energy and charge stabilities of output electron beams. To explore the performance of few-TW LWFA, we created sub-mm nitrogen gas cell and gas jet for interacting with 800-nm, 40-fs laser pulses having a moderate peak power of 1 TW; whereby, electron beams with primary energies scaling up to 10 MeV and a high charge in excess of 50 pC can be routinely generated when an appropriate atom/plasma density in the target and an optimal focal position of the pump pulse were assigned. The output beams showed a typical beam divergence < 40 mrad and the pointing fluctuation of them were estimated to be ~ 15 mrad, accordingly. This scheme exhibits a high potential for generating 10-20 MeV electron beams with an on-target pulse energy less than 50 mJ, from which a high average beam current up to tens of nA can be realized in future development of high-repetition-rate LWFA driven by kilohertz-class laser systems.

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