Impact of injection-gas concentration of the quality of electron beam generated by laser plasma acceleration

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Since the time laser wakefield acceleration (LWFA) was proposed [1], it had rapid progress speeding out with the availability of commercial tabletop ultra-fast high power laser systems [2]. With development of such laser systems, higher electric field where achieved and gave possibility of electron acceleration from the plasma itself (instead of external injection) to reach higher energy. Later, generation of high-quality electron beam in terms of energy, energy spread, charge, divergence angle and bunch duration became very important. To improve the high quality electron beam parameters, several injection mechanisms were proposed and demonstrated experimentally. Among those injection mechanisms, self-truncated ionization injection (STII), a modified version of ionization injection mechanism, have shown promising results for generating high energy and low energy spread electron beam [3,4]. In this mechanism high intensity laser pulse with unmatched large laser spot size interacts with a gas target, mixture of high-Z gas (injection gas) and low-Z gas (host gas).

In this work, using intense (30 TW), ultrashort (30 fs) laser pulses we report the impact of the injection gas concentration on the quality of electron beams generated by a laser-driven wakefield acceleration employing the ionization injection. The host gas was helium while the injection gas was nitrogen. In the experiment depending on the amount of nitrogen added to the helium host gas, we could distinguish a clear trend on the quality of the generated electron beams in terms of energy, energy-spread, divergence angle and beam charge. The results have shown that the lower the nitrogen concentration the higher the generated electron beam quality. A 2D PIC simulation also was performed to support the experiment. The simulation result was in good agreement with the experimental results.

References

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