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Meter-scale supersonic gas jets for multi-GeV laser-plasma accelerators

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Recent ~10 GeV laser wakefield acceleration (LWFA) experiments have been made possible by low-density hydrodynamic plasma waveguides generated by femtosecond Bessel beams in meter-scale supersonic gas jets. Such jets and Bessel beam optics will likely be critical components in next-generation experiments surpassing 10 GeV. Here I describe our gas jet and Bessel beam development, along with detailed measurements of waveguide evolution. These have led to understanding of the self-waveguiding process in low density gas channels and the first all-optical multi-GeV waveguide-based electron accelerator, directly leading to the ~10 GeV results. Our jet designs provide longitudinal control of the gas density and species composition, essential for controlling electron injection, rephasing, and optimizing energy gain in channel-guided LWFA. I will also present results from recent ELI-Beamlines experiments demonstrating density upramps, injection from optical shocks, and the use of funnel mouthed waveguides for improved laser coupling and laser-to-electron efficiency.

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