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Start-to-end simulations of HOFI waveguides

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To enable the generation of high-quality electron beams from laser plasma accelerators, understanding and tailoring of plasma sources is of critical importance. With limited experimental setups and measurement options, hydrodynamic simulations can be used to study their ns- to ms-evolution in detail and evaluate new concepts.

In recent years, hydrodynamic optical-field-ionized (HOFI) channels have emerged as a promising technique to create laser waveguides suitable for guiding tightly focused laser pulses in a plasma, as needed for laser-plasma accelerators. While experimental advances in HOFI channels continue to be made, the underlying mechanisms and the roles of the main parameters remain largely unexplored.

We propose a start-to-end simulation pipeline describing the formation of HOFI channels, from laser ionization to hydrodynamic expansion, as well as the resulting laser guiding. The approach is benchmarked against experimental measurements and allows us to explore their underlying physics and tunability. HOFI channels are shown to feature excellent guiding properties over a wide range of parameters, making them a promising and tunable waveguide option for laser-plasma accelerators.

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