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Experimental demonstration of a low-density plasma channel capable of high repetition rate operation

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Design parameters for the next generation of laser plasma accelerators show the need for low density (~1e17cm-3) plasma channels of the order of hundreds of millimetres long with the capability to operate at repetition rates up to 1kHz.

Although gas-filled capillary discharge waveguides have been operated at repetition rates of 1kHz, it is not yet clear if they could guide high-energy laser pulses at high repetition rates for extended periods without damage to the waveguide structure. We propose a new approach capable of meeting these challenging requirements based on the hydrodynamic expansion of plasma columns formed by optical field ionization (OFI). Unlike collisional heating, which much of the previous work on laser-produced plasma waveguides was based, OFI heating is independent of the plasma density and hence it is possible to drive a radial shock and form channels at low initial gas densities. Since the channels are laser-generated, and not contained within a physical structure, they could operate at high repetition rates for extended periods.

We present experimental results showing the formation of plasma channels by this mechanism with on-axis densities as low as 2e17cm-3, and matched spot sizes of approximately 30-40μm.

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