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Progress towards demonstration of the plasma-modulated plasma accelerator (P-MoPA)

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We describe recent results from our programme to develop high-repetition-rate, GeV-scale plasma-modulated plasma accelerators (P-MoPAs), which seeks to utilize advanced thin-disk lasers (TDLs) that can deliver joule-scale, picosecond-duration pulses, at kHz repetition rates.
A P-MoPA has three stages: (i) a modulator, in which a TDL pulse is guided in a hydrodynamic optical-field-ionized (HOFI) plasma channel and is spectrally modulated by the wake driven by a short, low-energy pulse; (ii) a compressor, which converts the spectrally-modulated drive pulse to a train of short pulses; and (iii) a resonantly-driven accelerator stage.
We describe the P-MoPA concept, and present simulations that establish the operating regime of P-MoPAs and predict acceleration to $\sim 2.5\,\mathrm{GeV}$ with a 5 J drive pulse.
We present the results of proof-of-principle experiments that demonstrate the operation of stage (iii) of a P-MoPA. These show resonant excitation of wakefields, with amplitudes in the range 3–$10\,\mathrm{GV\,m^{-1}}$, by a train of ~ 10 pulses of total energy ~ 1 J guided in a 110 mm long HOFI plasma channel.
We also describe progress towards demonstrating the stage (i) of a P-MoPA, i.e. spectral modulation of a picosecond-duration drive pulse by the low-amplitude wake driven by a short, low-energy seed pulse.

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