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Resonant wakefield excitation observed in long plasma channels

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The multi-pulse laser wakefield acceleration (MP-LWFA) scheme provides a route for GeV-scale accelerators operating at kilohertz-repetition-rates driven by picosecond-duration laser pulses, such as those available from thin-disk lasers, which are modulated to be resonant with the plasma wave. We recently published theoretical work proposing a new scheme of GeV accelerator based on MP-LWFA. In this scheme, trains of pulses are generated from a long, high-energy drive pulse via the spectral modulation caused by a low amplitude wakefield driven by a leading short, low-energy seed pulse. Our simulations show that temporal compression of the modulated drive pulse yields a pulse train that can resonantly drive a wakefield, allowing for acceleration of a test electron bunch to 0.65 GeV in a 100 mm-long plasma channel.

In this study, we present the preliminary results of recent experiments with the Astra-Gemini TA3 laser at the Central Laser Facility which are relevant to the accelerator stage of this novel scheme. We demonstrate, for the first time, guiding of 2.5 J pulse trains in a 100 mm long all-optical plasma channel. Measurements of the spectrum of the transmitted laser pulse train suggest that a wakefield was resonantly excited in the plasma channel.

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