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Demonstration of the Excitation and Control of Plasma Wakefields by Multiple Laser Pulses

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We reconsider the idea of exciting plasma wakefields by a train of low energy laser pulses, rather than by a single, high-energy pulse. This "multi-pulse laser wakefield acceleration"(MP-LWFA) approach is related to the plasma beat-wave accelerator, but has significant advantages since, in principle, the properties of each pulse in the train can be tailored to optimize wake excitation. In particular, the pulse spacing can vary within the train, which avoids saturation by relativistic detuning.
We describe a proof-of-principle demonstration of the MP-LWFA concept. In this work, wakefields were driven by trains of up to seven laser pulses generated from a Ti:sapphire laser. Frequency-domain holography measurements of the wakefields show resonant excitation when the laser pulse spacing is a multiple of the plasma period. We also show that a suitably delayed laser pulse can damp the plasma wave driven by an earlier pulse, which is a first step towards an energy recovery plasma accelerator.
Our results are important since they are the first experimental demonstration of wakefield excitation by a laser pulse structure that is long compared to the plasma period, and that also has sufficient control to overcome relativistic saturation.

Primary author: Prof. HOOKER, Simon (University of Oxford)

Co-authors: Mr ARRAN, Christopher (University of Oxford); Dr GREGORY, Christopher (STFC); Mr THORNTON, Christopher (STFC); Dr SYMES, Daniel (Rutherford Appleton Laboratory); Mr CHEUNG, Gavin (University of Oxford); Mr COWLEY, James (University of Oxford); Dr HOLLOWAY, James (The University of Oxford); Dr CORNER, Laura (JAI, Oxford University); Dr MATLIS, Nicholas (DESY); Mr SHALLOO, Robert (JAI, University of Oxford); Prof. WALCZAK, Roman (University of Oxford); Dr MANGLES, Stuart (Imperial College Londond)

Presenter: Prof. HOOKER, Simon (University of Oxford)

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