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Progress towards high-repetition-rate plasma accelerators

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We provide an overview of three areas of our programme which seek to address the challenge of realizing controlled laser wakefield accelerators (LWFAs) operating at kilohertz repetition rates. Driving plasma accelerators with trains of laser pulses offers the potential to use laser systems capable of multi-kilohertz pulse repetition rate with high wall-plug efficiency. We describe a proof-of-principle demonstration of the multi-pulse laser wakefield accelerator (MP-LWFA) concept in which wakefields were driven by trains of up to seven laser pulses generated from a Ti:sapphire laser. Controlling the injection and trapping of electrons is necessary to improve the bunch parameters produced by LWFAs, but this is challenging for the quasi-linear regime in which MP-LWFAs operate. We describe how simultaneous space-time focusing can improve the properties of bunches trapped following two-pulse ionization injection in the quasi-linear regime. Finally, we describe our work to develop hydrodynamic optical-field-ionized (HOFI) plasma channels which are capable of generating long, low-density channels well suited to all types of LWFA. We present our latest results, which include demonstration of guiding of high-intensity laser pulses in HOFI plasma channels with axial densities as low as $n_e(0) = 1.5 \times 10^{17} \text{ cm}^{-3}$ and lowest-order modes of spot size $W_M \approx 40 \mu\text{m}$.

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