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Progress towards resonantly-driven, high-repetition-rate GeV-scale plasma accelerators

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We describe our programme to develop GeV-scale laser-driven plasma accelerators operating at pulse repetition rates in the kHz range. This is based on two novel approaches.
First is the hydrodynamic optical-field-ionized (HOFI) plasma channel. We describe the operation of HOFI channels, and demonstrate that they can guide relativistically-intense pulses through metre-scale channels with axial densities of order $10^{17}\,\mathrm{cm}^{-3}$, and power attenuation lengths of order $20\,\mathrm{m}^{-1}$.
Second is excitation of the wakefield by a train of short pulses —- or a longer, modulated pulse — which allows the use of novel, efficient, high-repetition-rate lasers, such as thin-disk lasers. We describe the plasma-modulated plasma accelerator (P-MoPA), which has three stages: (i) a modulator, in which a joule-scale, ps-duration pulse is guided in a HOFI 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, also based on a HOFI channel. We outline the operation of P-MoPAs, describe new experimental results demonstrating resonant excitation of plasma wakefields in a HOFI channel, and outline progress of the kilohertz Plasma Accelerator (kPAC) Consortium to demonstrate each of the P-MoPA stages.

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