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PWFA-FEL: An exploratory study towards an ultra-compact x-ray free-electron laser

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Plasma wakefield accelerators (PWFAs) are routinely accelerating electron beams to multi-GeV energies in cm-scale acceleration distances. This emerging technology is a promising approach towards ultra-compact X-ray free-electron lasers (XFELs). However, producing high-quality electron beams in plasma-based accelerators is still a challenging task. The R&D efforts within the community now concentrate on electron beam quality improvement. Novel avenues, such as the advanced plasma photocathode (aka "Trojan Horse"-injection), allow generating electron beams in PWFAs with 0.1%-level energy spreads, nm-level normalized emittance, and multi-kA peak currents. This results in unprecedented ultrahigh 6D-brightness electron beams. This presentation reports on the UK STFC funded R&D project PWFA-FEL. This project aims to develop PWFA-driven FEL concepts and technologies by combining the expertise of an international expert team in PWFA, Beam Transport and FEL from the University of Strathclyde, UCLA, SLAC FACET-II, and the Daresbury Laboratory CLARA. Further, we show simulation and experimental progress in generating these unprecedented beams and discuss new capabilities such as sub-femtosecond coherent x-ray pulses from ultra-compact XFELs. These bright X-ray flashes may allow, the observation and the study of electron dynamics within molecules on their natural timescale in university and industry-scale laboratories.

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