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Generation of attosecond electron bunches in a laser-plasma accelerator

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The generation of ultrashort accelerated electron bunches is essential for the production of radiation pulses in the attosecond regime with most current techniques, such as Thomson scattering and free-electron lasers. Using particle-in-cell simulations and analytical models, the suitability for the experimental realization of a novel scheme producing attosecond duration electron bunches from laser-wakefield acceleration in plasma with self-injection in a plasma upramp profile has been investigated. This setup provides control over the point of wave breaking via the plasma density gradient and hence enables a sharp, quasi-1D injection process at the end of the plasma ramp, limiting the accelerated electrons to an extremely compressed bunch.
It is predicted previously that this requires laser power above a few hundred terawatts typically. Here we show that the scheme can be extended with reduced driving laser powers down to tens of terawatts, generating accelerated electron pulses of around 150 attoseconds length and with picocoulombs charge. With the electron properties dependent on, among others, the laser strength, the ramp length and the background plasma density, simple scalings are presented to optimise the output pulse through these initial laser and plasma characteristics.

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