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Ultrahigh 6D brightness electron beams from a single plasma acceleration stage

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Plasma photocathode wakefield acceleration ("Trojan Horse") paves a way to deliver electron beams with ultralow emittance, multi-kA peak current, and GeV-class beam energy within a single plasma stage. This consequently leads to ultrahigh 5D-brightness orders of magnitude beyond of the state-of-the-art. However, an intrinsic by-product of the ultrahigh accelerating field gradients inherent to plasma accelerators is substantial correlated energy spread (energy chirp). This significant energy chirp raises serious challenges, i.e. for beam extraction from the plasma stage, witness beam transport and particularly for key applications such as free-electron-lasers. Here we present a novel single-stage plasma-based energy chirp compensation method which potentially allows to minimize the relative energy spread to the <0.1% level while preserving the 5D-brightness. In conclusion, the combination of ultrahigh 5D-brightness and minimized energy spread opens a path towards witness beams with unprecedented ultrahigh 6D-brightness [1]. Such high class electron beams may have a transformative impact for compact light sources of the next generation.
[1] Manahan, G.G. and Habib, A.F. et al. Nat. Commun.8, 15705 doi:10.1038/ncomms15705 (2017)

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