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Stable operation of SASE and Seeded FEL driven by a plasma accelerator

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The breakthrough provided by plasma-based accelerators enabled unprecedented accelerating fields by boosting electron beams to GeV energies within few cm.
This enables the realization of table-top accelerators able to drive a Free-Electron Laser (FEL), a formidable tool to investigate matter at sub-atomic level by generating X-UV coherent light pulses with fs and sub-fs durations.
So far, short wavelength FELs had to rely on the use of conventional large-size radio-frequency (RF) accelerators due to the limited accelerating fields provided by such a technology.
Here we report the experimental evidence of a FEL driven by a compact (3 cm) plasma accelerator. The accelerated beams are characterized in the six-dimensional phase-space and have a quality, comparable with state-of-the-art accelerators. This allowed the observation of amplified SASE radiation in the infrared range with typical pulse energy exponential growth, reaching tens of nJ over six consecutive undulators.
On the basis of these first amplification results starting from spontaneous emission (SASE), we upgraded the setup by seeding the amplifier with an external laser. Compared to SASE, the seeded FEL pulses are characterized by a higher pulse energy, two orders of magnitude larger (up to about 1 uJ) and an enhanced reproducibility (up to about 90%) resulting in a higher shot-to-shot stability.

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