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Optically controlled laser-plasma electron accelerators for compact gamma-ray sources

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Optimizing nonlinear evolution of the drive pulse, through adequate photon engineering, is a vital element of the laser-plasma accelerator (LPA) design, offering new avenues to control electron beam phase space on a femtosecond time scale. Stacked pulse-driven LPA is a perfect tool to exercise this control, affording kHz-scale repetition rate at a manageable average power, favoring radiation physics applications dependent on dosage.

An incoherent stack of two sub-Joule, multi-TW pulses of different colors is almost immune to self-compression while driving an electron density bubble. Very slow etching of the stack leading edge suppresses continuous injection and delays electron dephasing, thereby nearly doubling electron energy gain against the predictions of standard scaling. This permits generation, in a mm-scale dense plasma ($n \sim 10^{19}$ cm^{-3}), of low-background, near-GeV, quasimonoenergetic electron bunches with 10^{17} A/m^2 5D brightness. Trains of such bunches, with controlled energy spacing, may be also produced in a single shot. These unconventional beams, inaccessible with standard acceleration techniques, emit trains of highly collimated, quasimonochromatic, gigawatt gamma-ray pulses via inverse Thomson scattering process, each pulse corresponding to a distinct energy band, in the range 3 - 17 MeV.

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