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Laser Wakefield Acceleration with Multi-Color Pulse Stacks: Designer Electron Beams for Advanced Radiation Sources

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Photon engineering [S. Kalmykov et al., New J. Phys. 14, 033025 (2012)] offers new avenues to coherently control electron beam phase space on a femtosecond time scale. It enables generation of high-quality beams at a kHz-scale repetition rate. Reducing the peak pulse power (and thus the average laser power) is the key to effectively exercise such control.

A stepwise negative chirp, synthesized by incoherently stacking collinear sub-Joule pulses from conventional CPA, affords a micron-scale bandwidth. It is sufficient to prevent rapid compression of the pulse into an optical shock, while delaying electron dephasing. This extends electron energy far beyond the limits suggested by accepted scalings (beyond 1 GeV in a 3 mm plasma), without compromising beam quality [S. Kalmykov et al., Phys. Plasmas 22, 056701 (2015) - Invited Paper at 56th Annual Meeting of the APS Division of Plasma Physics]. In addition, acceleration with a stacked pulse in a channel favorably modifies electron beam on a femtosecond time scale, controllably producing synchronized sequences of 100 kA-scale, quasi-monoenergetic bunches. These comb-like, designer GeV electron beams are ideal drivers of polychromatic, tunable inverse Compton gamma-ray sources [S. Kalmykov et al., AIP Proc. (2015), to appear].

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