10GeV electron bunch in dual-stage all-optical laser wakefield acceleration

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We propose an all-optical dual-stage laser wakefield acceleration (LWFA), staged with co-propagating two-color laser pulses in a plasma medium, to enhance the electron bunch energy. The two-color dual-stage LWFA can be understood as following: In the first stage, the leading lower frequency laser pulse excites a plasma wave with a lower phase velocity, which triggers electron self-injection (injector stage). The second harmonic laser pulse, trailing just behind the leading pulse, is guided within the bubble. Once the leading pulse is depleted, the trailing second harmonic pulse excites a wakefield moving at a higher phase velocity, therefore increasing the acceleration distance (accelerator stage). The leading part of the electron bunch, trapped and accelerated in the injector stage, can be coupled into the accelerator and can then be further accelerated to the multi-GeV range. Due to the higher frequency of the trailing laser pulse, the acceleration length of the second-stage can be significantly enhanced. In this all optical dual-stage LWFA, the electrons can gain 3 times higher energy as compared to the energy gain from the single stage LWFA driven by a single-color laser pulse with equivalent energy. Our multi-dimensional particle-in-cell simulations demonstrate that a 10-GeV electron bunch with 20-pC charge can be obtained by the two-color dual-stage LWFA using total input laser power of 0.6 PW