Anomalous hot electron generation from two-plasmon decay instability driven by broadband laser pulses with intensity modulations

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We present our investigations on the hot electrons generated from two-plasmon decay (TPD) instability driven by laser pulses with intensity modulated by a frequency $\Delta\omega_m$. Our primary focus lies on scenarios where $\Delta\omega_m$ is on the same order of the TPD growth rate γ_0 ($\Delta\omega_m \sim \gamma_0$), corresponding to moderate laser frequency bandwidths for TPD mitigation. With $\Delta\omega_m$ conveniently modeled by a basic two-color scheme of the laser wave fields in fully-kinetic particle-in-cell simulations, we demonstrate that the energies of TPD modes and hot electrons exhibit intermittent evolution at the frequency $\Delta\omega_m$, particularly when $\Delta\omega_m \sim \gamma_0$. With the dynamic TPD behavior, the overall ratio of hot electron energy to the incident laser energy, f_{hot}, changes significantly with $\Delta\omega_m$. While f_{hot} drops notably with increasing $\Delta\omega_m$ at large $\Delta\omega_m$ limit as expected, it goes anomalously beyond the hot electron energy ratio for a single-frequency incident laser pulse with the same average intensity when $\Delta\omega_m$ falls below a specific threshold frequency $\Delta\omega_c$. We find this threshold frequency primarily depends on γ_0 and the collisional damping rate of plasma waves, with relatively lower sensitivity to the density scale length. We develop a scaling model characterizing the relation of $\Delta\omega_c$ and laser plasma conditions, enabling the potential extention of our findings to more complex and realistic scenarios. Interestingly, the $3\omega_0/2$ scattering due to TPD can be lower for $\Delta\omega_m$ that corresponds to enhanced f_{hot}, qualitatively agreeing with the recent experiments on Kunwu broadband laser facility [1-2].

[1] A. Lei *et al.*, Phys. Rev. Lett. 132, 35102 (2024).

[2] P. Wang *et al.*, Matter Radiat. Extrem. 9, 015602 (2024).