High-order harmonic generation in an electron-positron-ion plasma

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We show that high-order harmonic generation (HHG) in a solid-density target is significantly changed after an electron-positron pair plasma is produced \([1]\), with strong and well-defined signals at harmonics of the plasma frequency (i.e., \(n\omega_{pe}\)) present in the spectrum. The \(\omega_{pe}\)-radiation comes from the plasma wave excited by the laser-accelerated dense positron beam via the beam-plasma instability \([2, 3]\). The subsequent reflux of the positrons induces a counterpropagating plasma wave. The inverse two-plasmon decay between these counterpropagating waves will radiate harmonics at \(2\omega_{pe}\) \([4]\). Furthermore, \(3\omega_{pe}\)-radiation is also observed due to the higher-order plasma coalescence \([5]\). Particle-in-cell (PIC) simulations with OSIRIS 4.0 show that these signals are prominent and robust with different target density, pair density, and temperature \([1]\). For example, the \(2\omega_{pe}\)-radiation is enhanced by more than 150 times (compared with the same electron-ion target without pair plasma generation) after a pair plasma is produced with a density fraction of just 0.05\%. Therefore, these signals can be used as an \textit{in situ} diagnostic for the pair plasma generation mechanism. In addition, the radiation enhancement at is up to be \(3.9 \times 10^4\) times, paving a way to the bright and compact extreme ultraviolet (XUV) radiation source.

References