Phase-matched scalable THz generation in two-color filamentation

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We observe phase-matched terahertz generation in long air plasma filaments produced by femtosecond two-color laser focusing. Here phase-matching naturally occurs due to off-axis constructive interference between locally generated terahertz waves, and this determines the far-field terahertz radiation profiles and yields. For a filament longer than the characteristic two-color dephasing length, it emits conical terahertz radiation in the off-axis direction, peaked at ! 4~7 degrees depending on the radiation frequencies. We also examined the radiation profiles of THz waves after being focused by a pair of parabolic mirrors. Unlike the conical radiation profiles, the focused THz intensity is peaked on axis. The bell-shaped THz profiles are favorable for most practical applications. We also find that the total terahertz yield increases almost linearly with the plasma filament length as a result of off-axis phase matching. Due to this, one can effectively increase THz output by simply extending the plasma filament length with more laser power while keeping the local THz wave strength constant. This method can overcome the saturation effect previously reported, mainly caused by overdense plasma creation and laser intensity clamping in filamentation.