THz beam profile shaping through linear and nonlinear superposition of two-color laser filaments

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Terahertz (THz) beam shaping is desirable in various scientific, industrial, and technological applications ranging from imaging resolution, and spectroscopic analysis to advanced communication systems and material processing. Various methods have been reported for shaping the beam profile of a THz beam including diffractive optical elements, metasurfaces, wavefront phase manipulation to name a few [1]. Albeit efficient, these methods tend to suffer from increased complexity or power losses.

In this work we propose a novel approach to control the shape of a broadband THz beam and the energy redistribution within the beam profile by direct manipulation of the THz emitter. In our experiments, THz radiation is generated by a typical two-color laser filamentation in air induced by ultrashort laser pulses (800nm, 2mJ/pulse, 35fs, 1kHz) and its second harmonic. A Spatial Light Modulator (SLM) operating at the fundamental frequency is used to produce different laser energy distributions, adding off-axis spherical phases, that lead to the formation of multiple filaments in various geometries in space. Using this approach, the typical doughnut-shape THz profile from a single filament (Fig. 1a) can thus be altered as can be seen in the figure for the case of two filaments arranged in different geometries (Fig. 1b). More complex distributions can be achieved through this approach that can be fully controlled through electronic means (phase masks on the SLM). The results can be either attributed to linear interference effects when the filaments do not crosstalk, or through nonlinear energy redistribution between the filaments if they are close enough for Kerr-cross talking.

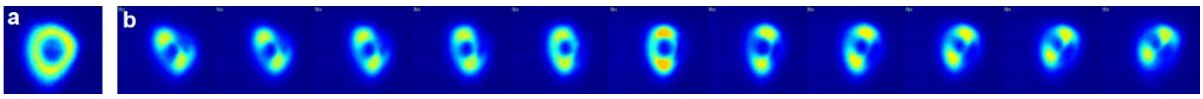

Figure 1: (a) Single-filament doughnut-shape THz beam profile, (b) A typical example illustrating THz beam shape control, when two filaments are appropriately arranged in space through the SLM.

Our all-optical approach with its practicability and straightforward implementation can find applications in THz imaging and beam engineering for telecommunications.

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