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Conical emission from DC-biased filament at 10 THz

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Femtosecond filament in the external electrostatic field (DC-biased filament) is a prominent source of terahertz (THz) radiation [1]. As the external field grows above ~3 kV/cm [2], the directional diagram of the THz emission from a DC-biased filament in air is unimodal with the maximum on the laser beam axis. This was confirmed by numerous experiments and numerous registration techniques, either narrowband detection [2], wideband detection [3, 4], or spectrally resolved [5, 6]. The excellent directionality of THz emission from DC-biased filament makes this THz source a promising tool for the measurements of low (10^{13}–10^{15} cm^{-3}) densities of free electrons [7]. The measurements of THz directional diagrams [2–6] were done in the low-frequency range below 2–3 THz. However, 3*D* + time simulations of THz generation in DC-biased filament performed in our recent work [6] predicted the appearance of THz conical emission in high-frequency THz range (for our 90-fs pulse at ~10 THz). In this work, we confirm this prediction experimentally.

In our experiment, we focused the 740-nm, 90-fs, 1.8-mJ pulse into the air gap between the electrodes biased by 15-kV/cm static electric field. The plasma filament between the electrodes was a source of THz radiation detected by a superconducting MoRe bolometer Scontel RS-CCR-1-12T-1+0.3-3T-0.1 sensitive in the spectral range of 0.3–10 THz. The bolometer with the bandpass filters (centered at the frequencies $\nu = 0.5$, 1, 3 and 10 THz) was fixed on the 40-cm-long horizontal board and rotated at the horizontal angle α around the vertical axis. The spherical mirror was fixed on the vertical 40-cm post. To vary the vertical angle β, we moved the focusing mirror along the post. So, the variation of the angles α and β allowed us to reconstruct the 2*D* distributions of the THz fluence $F(\alpha, \beta)$ at the frequency ν determined by the bandpass filter. We traced experimentally the transit from the on-axis unimodal angular distribution at 0.5–1 THz to the conical one at 10 THz, see Fig. 1.

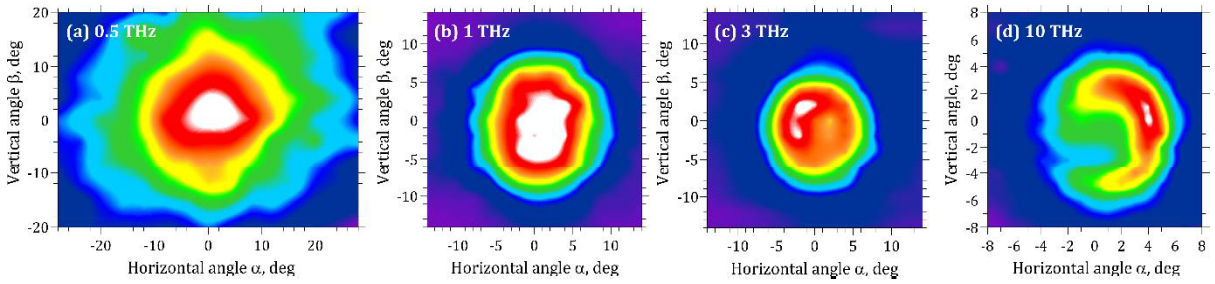

Fig. 1. 2*D* distributions of the fluence $F(\alpha, \beta)$ measured at frequencies (a) $\nu = 0.5$ THz, (b) 1 THz, (c) 3 THz, (d) 10 THz.

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