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Polarimetry of Terahertz Pulses from two-color plasma

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Terahertz (THz) generation by two-color plasma has garnered attention for its capacity of providing intense and ultra-broadband THz pulses. Like any form of electromagnetic radiation, controlling wave polarization is crucial for a wide range of applications [1]. However, accurately characterizing and selectively controlling the polarization of broadband THz pulses remains challenging due to limitations in efficient optics. On the detection side, THz air-biased coherent detection has emerged as a promising solution, employing heterodyne detection and second-harmonic generation (SHG) induced by THz radiation [2]. Nevertheless, recent research has revealed that the laser-induced air plasma in this technique can exhibit birefringence, introducing systematic errors in polarization-state determination [3]. In a recent publication [4], we have proposed a simplified approach that uses a weak probe beam and avoids high-voltage DC bias fields. Unlike the terahertz air-biased coherent detection scheme, our approach provides a unipolar, intensity-proportional signal for SHG. Therefore, we have named this technique THz Unipolar Polarimetry (TUP). In Fig. 1a an example of TUP measurement is shown. In this presentation we will demonstrate the absence of induced birefringence in air in this experimental approach, ensuring accurate measurements of the polarization state of ultra-wideband THz pulses. Regarding the control, we act on the two-colors process by varying the fundamental wave (FW) chirp and the phase difference between the FW and the second-harmonic wave (SHW). These parameters are key factors in controlling different properties of the generated THz pulses: temporal shape, energy, and the polarization state. Specifically, our findings indicate that an elliptical THz polarization can be achieved under conditions where the chirp is optimized for maximum generation efficiency. Furthermore, under these optimized conditions, we observed that as the phase difference between the FW and SHW is increased, the polarization axis of the ellipse undergoes counterclockwise rotation. Nevertheless, measurements conducted with chirp values falling outside the optimal range result in the loss of ellipticity in THz radiation, revealing polarization structures reminiscent of a 'flower' shape. In Fig. 1b we display an example of these measurements.

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