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Terahertz wavefront measurement using 2D electro-optic sampling

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Terahertz (THz) radiation roughly covers the frequency range between 0.1 and 10 THz (corresponding wavelengths between 3 mm and 30 µm) and bridges the gap between optical and radio waves. This radiation can propagate through many non-conducting and non-polar materials providing a specific spectroscopic diagnosis. Contrary to optical beams, the wavelengths associated to the THz beams are not negligible compared to the size of the optical elements used in the experimental setup, leading to diffraction and a possible deviation from the standard Gaussian beam propagation. However, due to the lack of effective THz cameras, it is still challenging to fully measure the spatial profile of the THz beam. In this communication, we propose a simple arrangement for the characterization of a THz beam generated by optical rectification of amplified femtosecond laser pulses (800 nm, 1 mJ, 150 fs).

Our THz beam sensor is based on free-space collinear 2D electro-optic sampling in a ZnTe crystal (Fig. 1a) [1]. By using a femtosecond IR probe pulse, the 2D THz field distribution in the crystal is converted into a 2D optical intensity distribution recorded by a CMOS camera [2]. Signal-to-noise ratio higher than 200 can be obtained thanks to the so-called dynamic subtraction technique [3]. By changing the time delay between both pulses, one can map the temporal evolution of the THz electric field in the crystal. We demonstrate that this system makes it possible to characterize the THz wavefronts of planar (Fig. 1b) or spherical waves (Fig. 1c). From the Fourier Transform of the temporal waveforms recorded by each pixel of the camera, one can also obtain the curvature of the broadband THz wave for every frequency within the 0.1 - 4 THz range, imposed by the spectral bandwidth of the ZnTe crystal. More generally, the system can be used for the analysis of THz beam distortions due to diffraction or optical elements misalignment.

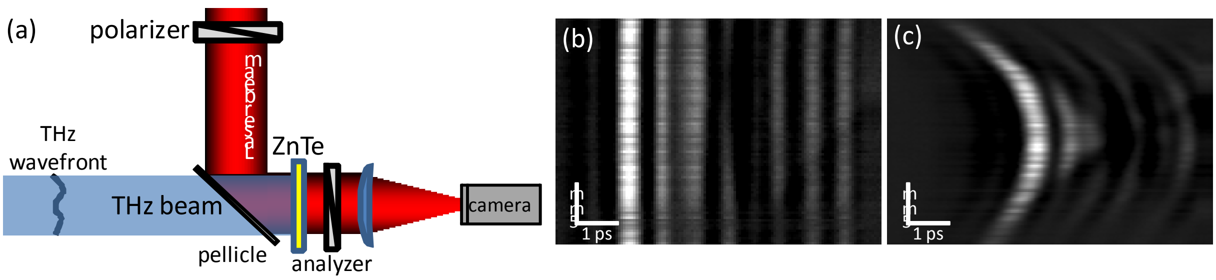

Fig. 1 – (a) Experimental setup. Temporal evolution of the transverse distribution of the THz electric field as the detector position: (b) THz planar wave. (c) THz focusing spherical wave.

Perspectives include the development of a Shack-Hartmann sensor by inserting a specific lens matrix before the pellicle for an instantaneous characterization of the THz wavefront, without the requirement of changing the THz-probe time delay [4-6].

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