Interrogation of Terahertz Wave Using Laser-Induced Photoluminescence and Photoacoustics for Standoff Sensing Application

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Introduction

Broadband detection of Terahertz (THz) waves has led to various promising applications of THz technology in security screening, biomedical diagnostics, and industrial inspection. We develop unique methods to coherently interrogate THz pulses through using photoemission and acoustic emission from laser-induced air plasma that interacts with the THz wave. THz field influences the plasma dynamics by accelerating free electrons and inducing electron-molecule energy transfer. Consequent plasma temperature increase results in an enhancement of photoemission in ultraviolet range and uniform acoustic emission at frequencies between 0 and 140 kHz. Theoretical calculation using a semiclassical model and detailed experimental verification show that these enhancements are mainly determined by the THz waveform shape, electron drifting momentum, and time delay between the THz pulse and laser pulse. By using two-color laser fields to manipulating the electron drifting in the plasma and measuring photoemission/acoustic signals under opposite electron drifting conditions, we demonstrate that information concerning polarity and magnitude of the THz wave can be obtained in forward, sideways and backward directions. Coherent detection of ultrashort THz pulses at a distance of 10 meters has been realized by minimizing strong ambient water vapor absorption. This achievement opens new ways to further uncover the potential of THz technology in homeland security and environmental control.

Terahertz detection using plasma photoluminescence

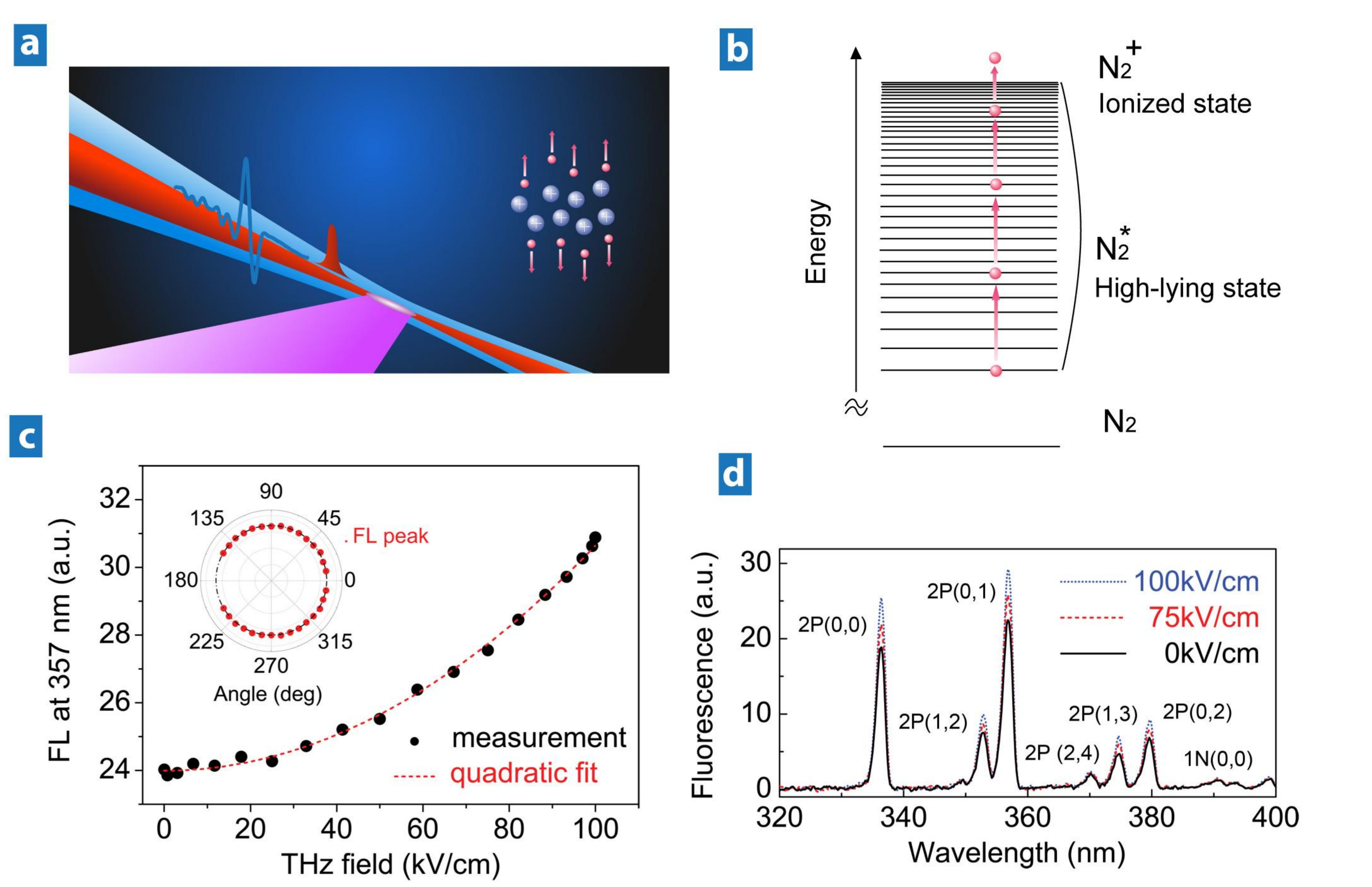

Fig. 1 The interaction between the THz pulse and laser-induced plasma. (b) Collisional excitation and ionization of molecules. (c) The THz field dependence of the enhanced fluorescence. (d) Nitrogen fluorescence spectra in THz field..

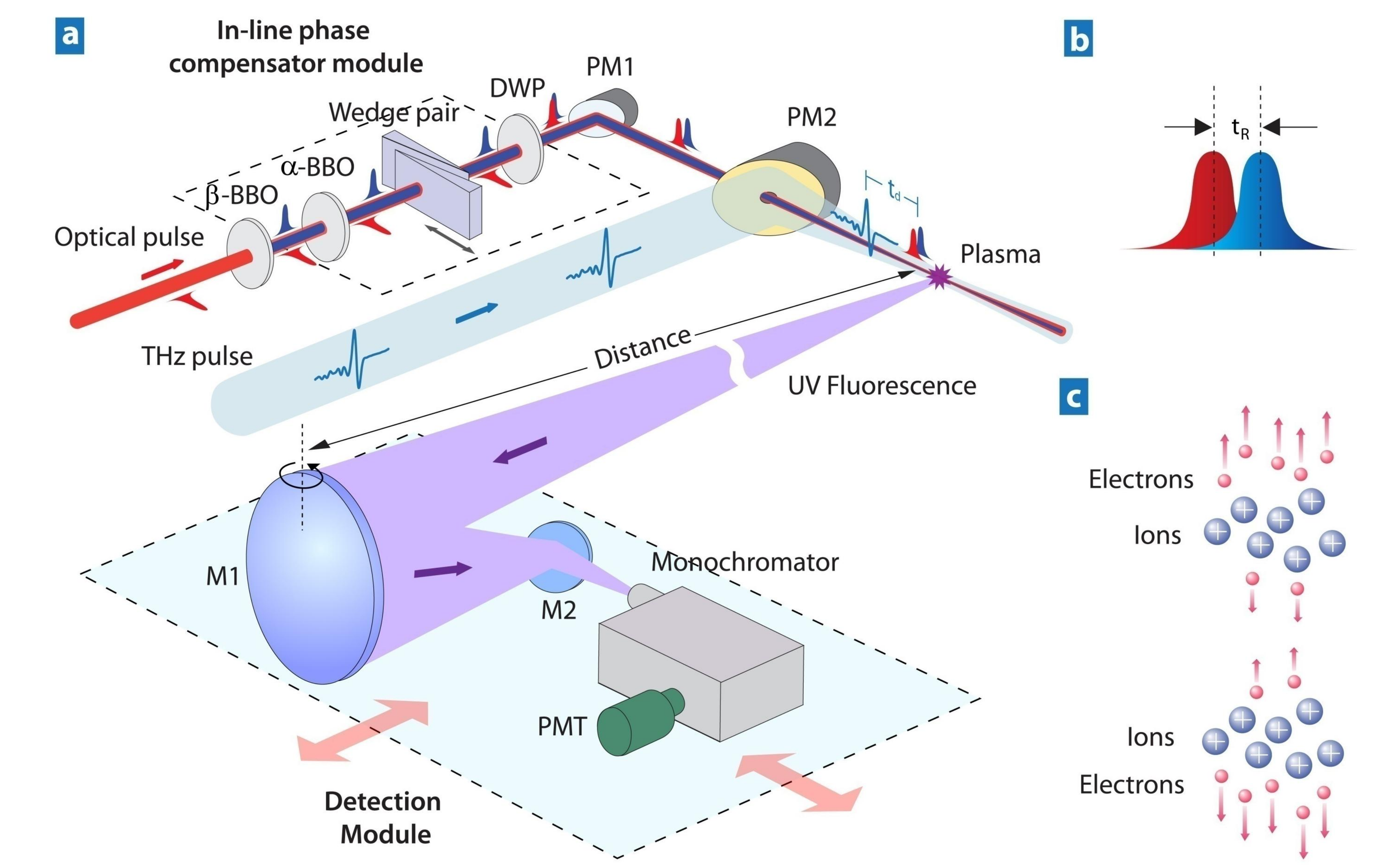

Fig. 2 (a) Schematic of the remote THz wave detection. (b) Temporally delayed two color pulses. (c) Asymmetric electron velocities generated by two-color fields ionization.

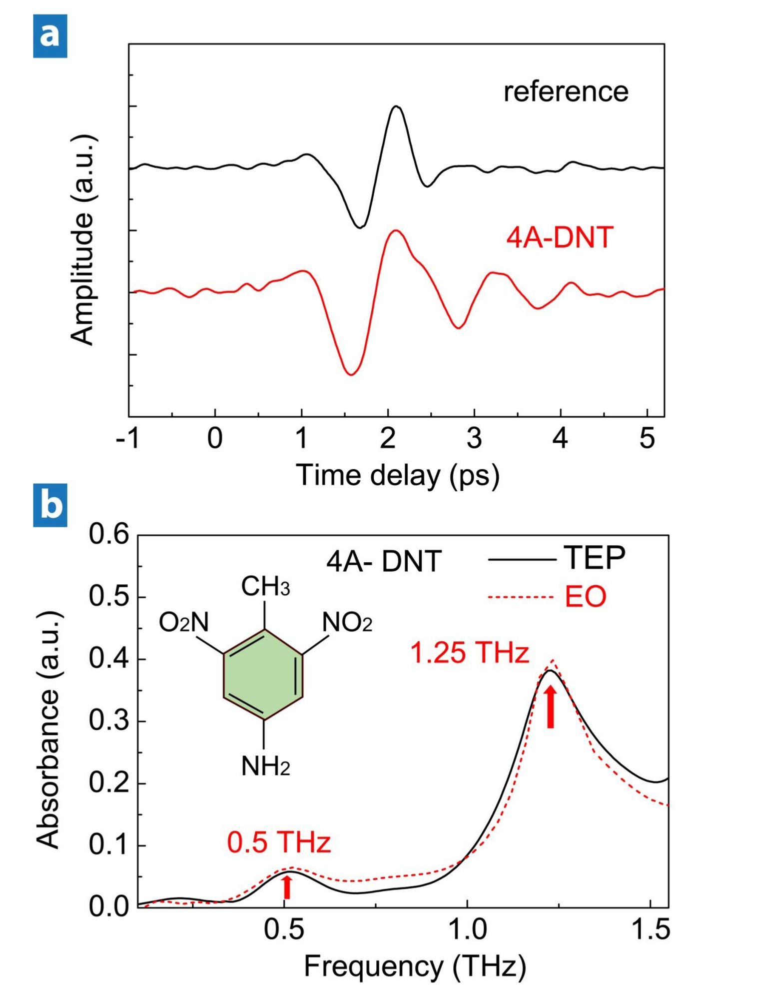

Fig. 3 (a) Transmitted THz waveform through 4A-DNT and reference waveform. (b) Absorption spectra.

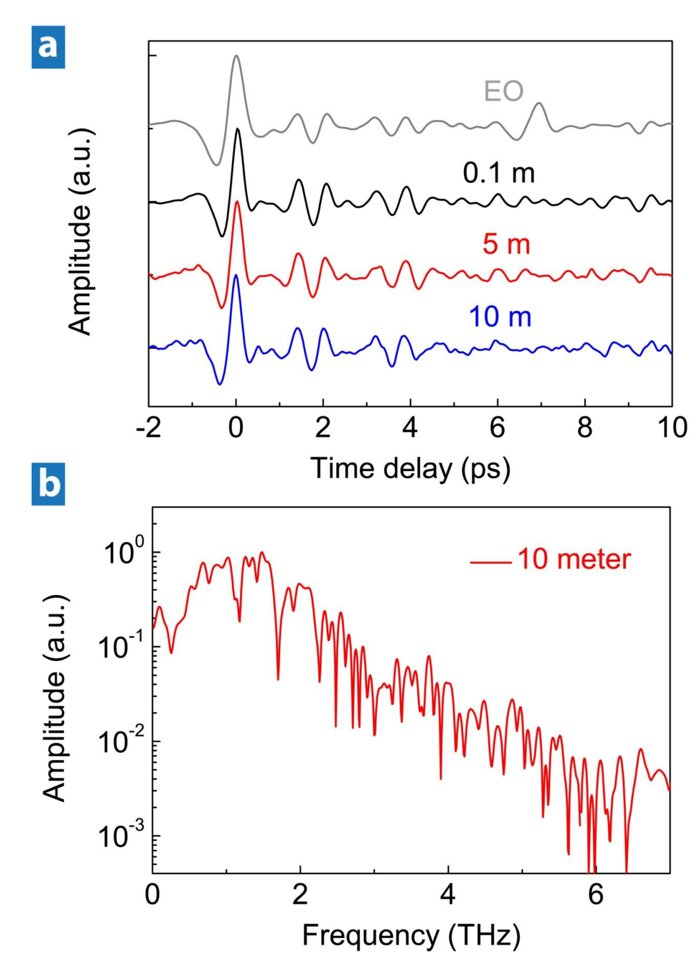

Fig.4 (a) THz waveforms measured by photoemission at different distances, (b) THz spectrum at distance of 10m.

Terahertz detection using plasma acoustic wave

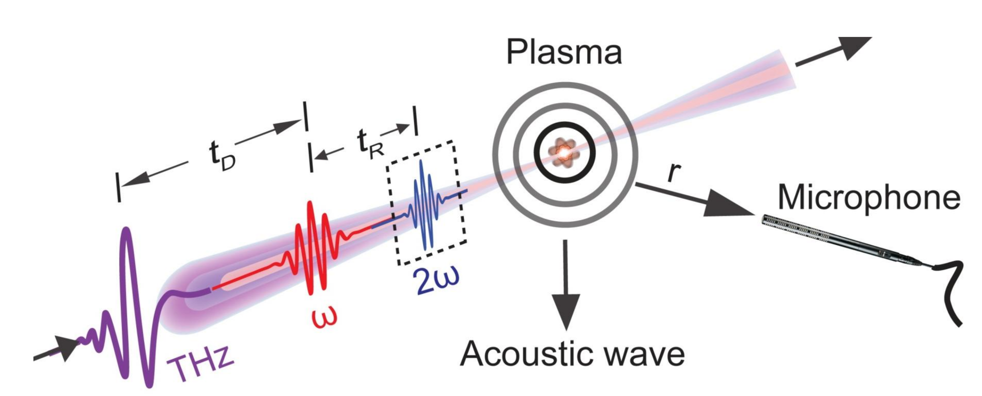

Fig. 5 Experimental schematic for the TEA using single-color or dual-color femtosecond laser excitation

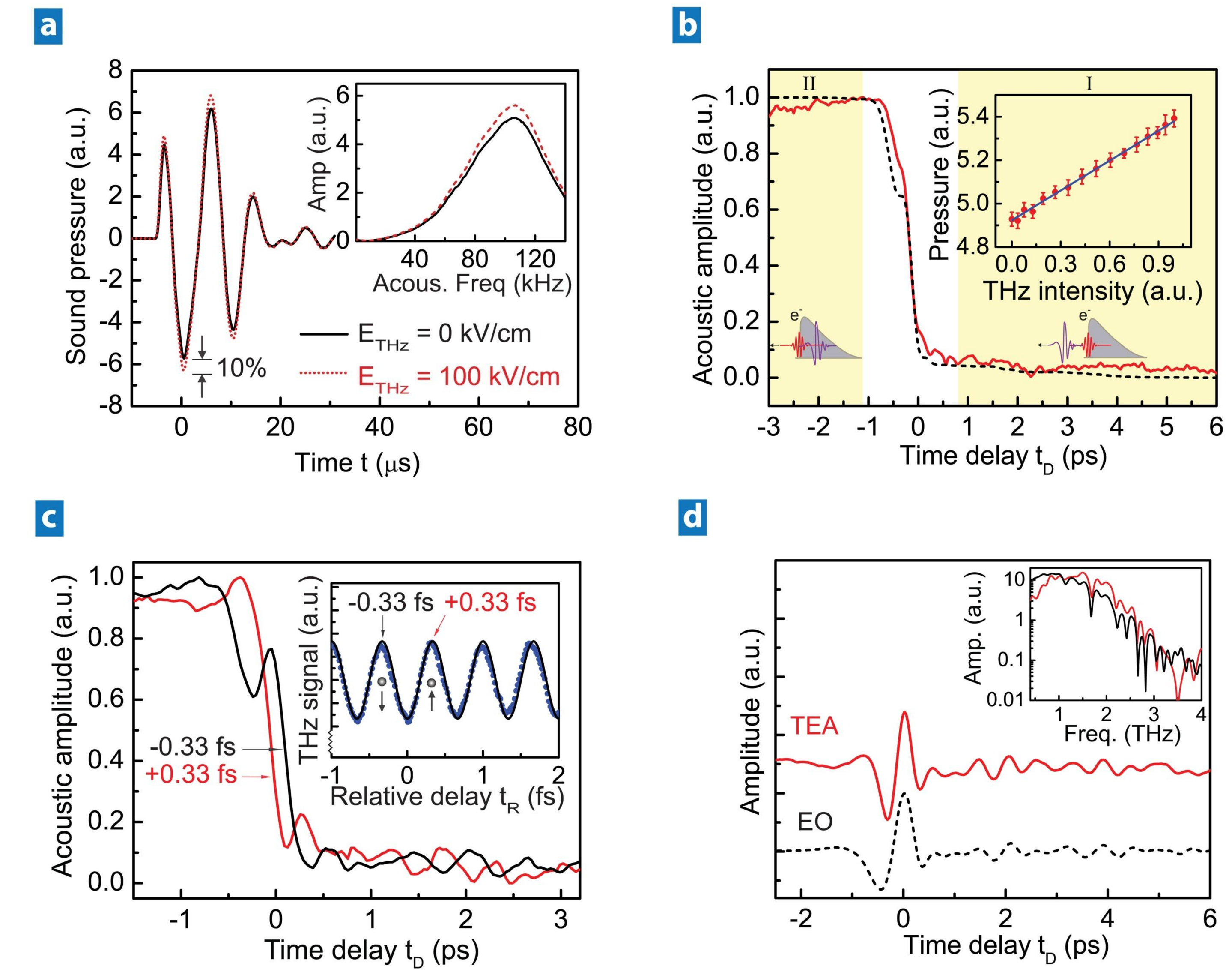

Fig. 6 (a) Single photoacoustic waveforms . (b) Time resolved THz-enhanced-acoustics (TEA). (c) Two-color laser excited TEA. (d) Coherent THz detection using TEA.

Acknowledgement

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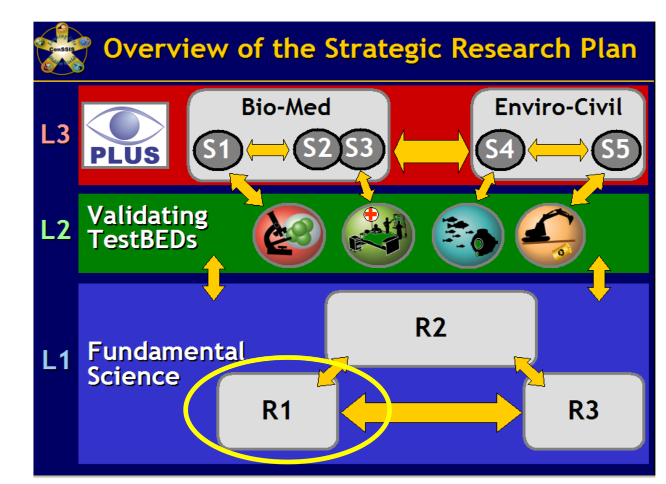

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