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## Ionization-Induced THz Emission

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The generation of strong broadband THz fields by two-color laser-induced plasmas has attracted significant attention because of the high amplitude and broad spectral width of the radiation emitted [1]. The mechanism is based on photocurrents produced by ionization in an asymmetric driving field consisting of the fundamental pulse and its second harmonic [2]. Thus, THz emission is inextricably related to ionization, and its properties have recently been suggested to reveal valuable information about the ionization process itself [3]. Considerable effort has been devoted to optimizing and controlling various characteristics of the THz radiation produced. In particular, the efficiency of THz generation was shown to be influenced by the relative phases between harmonics [2]. Other important factors affecting the produced THz radiation are pump wavelengths [4], polarization of the pulses [5], their durations [6] and, more generally, their wave shapes [7].

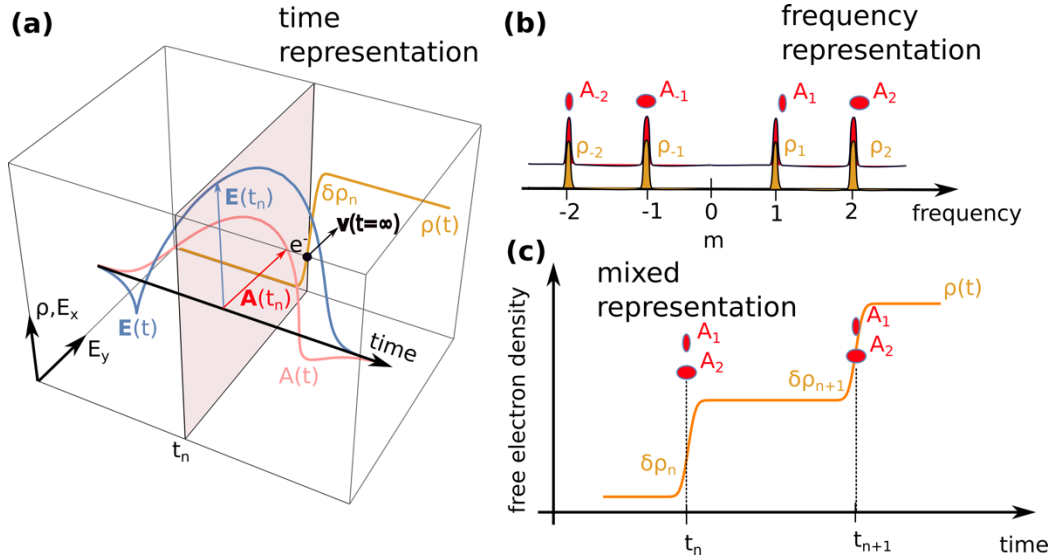


Figure 1: Predicting the THz wave shape: (a) Time representation: Uses information on the vector potential  $A(t_n)$  of the pump in the vicinity of the ionization event  $t_n$  and the corresponding ionization step  $\delta\rho_n$ . (b) Frequency representation: Uses the Fourier components  $A_m$  and  $\rho_m$  of the pump and electron density. (c) Mixed representation: Uses the Fourier components  $A_m$  of the pump, the ionization steps  $\delta\rho_n$  in the time domain, and its phase information  $\exp(imt_n\omega_0)$ .

We will review the ionization induced THz generation and explain its main characteristics in the local current framework -- the locally generated THz waveforms in a small space volume. Three equivalent representations are developed, which allow for a convenient interpretation of difference characteristics, cf. Figure 1. We study the variety of possible THz waveforms, which can appear in two- and multicolor schemes with arbitrary polarization of the pump pulses, with focus on the polarization state of such THz radiation. Starting from general principles, we show how the elliptically polarized THz radiation arises, which degrees of polarization of the THz pulse are possible, and to what extent these can be controlled by the pump configuration. We illustrate our findings by systematically studying the dependence of the THz waveshape on the pump configuration for a two-color scheme with controlled polarization and phase difference between the pump frequency components.

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