



Iranian Journal of Physics Research, Vol. 26, No. 2, 2026
DOI: 10.47176/ijpr.26.2.22296

Controlling terahertz waveforms through dual-pulse two-color laser excitation in air

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(Received 18 February 2026 ; in final form 14 July 2026)

Abstract

Terahertz (THz) radiation generation through two-color femtosecond pulse filamentation has become a standard method in ultrafast optics due to its broadband nature and high intensity. However, achieving precise control over the temporal characteristics of this radiation at the sub-picosecond scale—which is vital for applications such as time-domain spectroscopy and coherent control of light-matter interactions—remains a fundamental challenge. In this article, a novel approach is presented for engineering the waveform of emitted terahertz radiation by redesigning the temporal profiles of the input optical pulses and employing a dual pulse excitation scheme. Using the “photocurrent” model, the effect of temporal interference between plasma currents generated by the combination of Gaussian pulses with different time delays was investigated. Numerical results show that, by carefully adjusting the pulse intensities to avoid premature saturation of ionization, a stepwise evolution of the plasma density can be induced, which in turn leads to shaping of the net photocurrent. The findings indicate that for time delays shorter than the current relaxation time, constructive or destructive interference between currents enables selective control of certain field half-cycles and the generation of novel temporal profiles. In contrast, for delays longer than the current decay time, the terahertz pulses form separately as multi-component waveforms. These results outline a new pathway for developing tunable terahertz sources and their applications in ultrafast dynamical studies.

Keywords: Femtosecond filamentation; Two-color filamentation; Terahertz; Photocurrent model.

For full article, refer to the Persian section