Terahertz generation in crystal driven by two-color laser pulses[‡]

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Synopsis We study the generation of terahertz (THz) radiation in 1D crystal driven by two-color laser pulses by solving the time-dependent Schrödinger equations. Our results indicate that stronger THz radiation can be obtained from the interaction of short laser pulse with crystals.

The interaction of intense short laser pulses with solids has attracted considerable attention in the last few years, mainly for the high-order harmonic generation [1-4]. In this work we focus on the other important frequency-conversion process—terahertz (THz) radiation from crystals. We find that stronger THz radiation can be obtained from 1D crystal by using two-color laser pulses with certain laser parameters.

We adopt the method given in Ref. [5] to calculate the total laser-induced current $J(t)$, which comes from both intraband and interband dynamical processes. We then multiply $J(t)$ by a Hanning window [6] to improve the signal-to-noise ratio since the laser intensities used in the present work are relatively low. The THz radiation spectrum is then obtained from a Fourier transform of $\mathrm{d}J(t)/\mathrm{d}t$. In the calculation, the Mathieu-type potential of 1D crystal is chosen as [6]

$$V(x) = -V_0[1+\cos(2\pi x/a_0)], \quad (1)$$

where $V_0=0.37$ and lattice constant $a_0=8$, both in atomic units.

The electric field of the two-color laser pulse can be written as

$$E(t) = f(t)[E_1\cos\omega t + E_2\cos(2\omega t+\varphi)], \quad (2)$$

where E_1 and E_2 are the peak amplitudes of the fundamental (ω) and the second harmonic (2ω) fields, φ is the relative phase between them. $f(t)$ is a $\cos^2$ pulse envelope. In our calculations, we use the total laser intensity $I=8.1\times10^{11}$ W/cm^2 and the fundamental laser wavelength $\lambda=3.2$ μm. The total pulse duration is 8 cycles.

The corresponding THz radiation spectra are illustrated in Fig. 1. It is obvious that stronger THz radiation (0-30THz) is obtained through the two-color laser pulses. The intensity of the THz radiation is enhanced more than 3 orders of magnitude at 14THz compared to that in the single-color field. We also find that the THz spectrum is sensitive to the intensity ratio and the relative phase between two fields, similar to the case of THz radiation from gas samples [7,8].

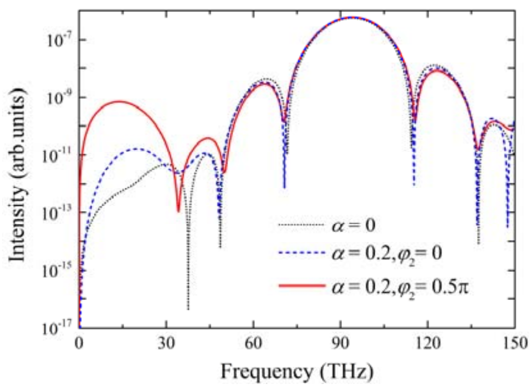

Figure 1. The THz emission spectrum from 1D crystal. Here, $\alpha=I_2/I_1=E_2^2/E_1^2$.

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