Multicolor and Supercontinuum Radiation Generation in Terahertz and Mid-Infrared Ranges In a Gas Ionized by Two-Color Chirped Laser Pulses

A A Silaev[1,2], A A Romanov[1,2], and N V Vvedenskii[1,2]

[1] *Lobachevsky State University of Nizhny Novgorod, 603950, Nizhny Novgorod, Russia*
[2] *Institute of Applied Physics of the Russian Academy of Sciences, 603950, Nizhny Novgorod, Russia*
Contact Email: silaev@appl.sci-nnov.ru

One of the directions for generating short mid-IR pulses utilizes nonlinear multiwave mixing of two-color laser pulses in gases, including ambient air [1-8]. In particular, mid-IR generation can be realized using two-color laser pulses with angular frequency ratio $\omega_1/\omega_0 \approx 2$. In this case, the generation occurs at the detuning frequency of the higher frequency from the doubled lower one, $\omega_1 - 2\omega_0$. The underlying physical mechanism can be the hyperpolarizability of neutral atoms or molecules or the ionization-induced response of free electrons in a symmetry-broken electric field [1-8]. Recently we proposed a method for creating and controlling the frequency detuning in two-color laser pulses, which consists of using a stretched-in-time fundamental field and its second-harmonic field, which is assumed to be created by frequency-doubling crystal [8]. The fields have linear chirps and a group time delay, which corresponds to the instantaneous component frequencies $\Omega_0(t) = \omega_0 + \beta t$ and $\Omega_1(t) = 2\Omega_0(t - \tau_d)$, where ω_0 is the fundamental central frequency, β is the chirp of the fundamental field, and τ_d is the time delay. The resulting detuning frequency is $\Omega_1 - 2\Omega_0 = -2\beta\tau_d$ and is constant throughout the laser–gas interaction.

This paper generalizes the proposed method to generate multicolor low-frequency pulses. To do this, we propose to use several second-harmonic components with different group time delays relative to the fundamental field. We show analytically and numerically that for high intensity of the laser pulse, the current density resulting from isotropic gas ionization contains several components: the detuning frequencies and triple combination detuning frequencies. Intensities of the triple combination frequencies can be compared with that of the main detuning frequencies, which significantly enriches the generation spectrum. Moreover, the presence of a large number of generated components and the ability to control their spectra opens up the possibility of generating a broadband supercontinuum covering the THz and mid-IR ranges [9].

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