The Use of Brunel Harmonics of Elliptically Polarized Laser Pulses for High-Resolved Detection of Terahertz and Mid-Infrared Radiation

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One of the methods for measuring the time profiles of terahertz (THz) pulses generated by optical methods is based on the generation of the second harmonic of the gating laser pulse due to the third-order nonlinear response of neutral atoms and molecules [1-3]. The absence of phonon resonances, better phase matching, and continuous renewability makes gases more attractive for detecting broadband and high-power THz pulses than crystals and photoconductive antennas. However, the temporal resolution of detection is limited by the second harmonic duration $\tau_p/\sqrt{2}$, where τ_p is the gating pulse duration [3].

In this work, we propose to use the generation of even Brunel harmonics (BHs) [4] by optical laser pulses for high-resolved sampling detection of THz and mid-infrared pulses. BHs originate from the acceleration of free electrons produced during tunneling ionization, and BHs pulses durations are much shorter than the laser pulse duration [5,6]. The latter makes it possible to significantly increase the temporal resolution of detection compared to second harmonic generation due to the cubic nonlinear response of bound electrons. However, as we show by solving the time-dependent Schrödinger equation for the helium atom, for linearly-polarized intense laser pulse, the atomic response contains a broadband noise signal that interferes with BHs and allows the detection of very high electric fields only. The latter allows one to measure only very strong fields, reducing this detection method's capabilities. We show that the nature of this noise is related to the population of the Rydberg states of the atom, which can be effectively suppressed by using elliptical polarization of the gating pulse.

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References

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