High-Order Harmonics Quasi-Phase Matching in Perforated Extended Gas Media Interacting with Mid-IR Laser Pulses: Towards the Harmonic Efficiency Drop Overcoming

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One of the most effective methods to generate harmonics having high photon energy is to use mid-IR laser systems as a driver of the non-linear processes in gas [1,2]. However, along with quadratic growth of the maximal number of generated harmonics during the laser field wavelength (λ) increasing, the photon flux scales as $\lambda^{-5.5}$ [3]. To overcome the harmonics efficiency drop the usage of molecular resonances located near the pump spectrum for enhancement of harmonics yield driven by mid-IR fields was recently presented [4]. Here, we suggest another way to increase the harmonics photon flux using the effects of quasi-phase matching (QPM) for high harmonics generated in periodic media [5].

In numerical simulations, we suppose that the perforated gas media consists of a number of gas jets having spatial sizes *d* divided by free spaces also having sizes *d*. The total length of the media is 0.5 cm. It interacts with a two-color (w+2w) laser field consisting of two linearly polarized components with zero degree angle between their polarization directions. Laser field wavelength scales from near IR (800 nm) to far IR (up to 15 mkm) spectral diapason.

Our numerical calculations based on the interference model of extended gas [6] and the non-perturbative theory of single atom response [7] show that, due to the QPM, the group of harmonics enhanced. The position of enhanced harmonics in the spectrum depends on *d* (higher number of enhanced harmonics correspond to shorter *d*) and harmonic photon energy of enhanced harmonics does not depend on the laser wavelength. At the same time, the efficiency of the QPM harmonics increases along with the increase in laser wavelength and the decrease in *d*. Boundaries of the harmonics enhancement method will be discussed.

Enhanced harmonics can be used as a seed in the Free-Electron Lasers [8].

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