Divergent and confined low-frequency radiation from femtosecond filaments in gases

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An extended femtosecond filament is a nonlinear light structure, which can emit a continuum of frequencies as well as quasi-isolated pulses in certain spectral ranges [1-4]. If there is a seed created by means of optical parametric amplifier or other techniques, the conversion efficiency to the desired spectral range can be increased significantly [5]. The specific case is the dual-frequency (800 nm and 400 nm) interaction in the gaseous filament leading to an efficient production of terahertz pulses [6-8]. However, the major part of terahertz radiation from filaments diverges forming a ring in the far-field [9]. The degree of divergence of the newly formed frequencies is crucially important for applications including a distant object inspection. In this paper we use a unidirectional pulse propagation equation model [10] to study numerically the intensity growth, spectral content and spatial divergence of quasi–isolated pulses generated by extended femtosecond filaments in gases. All the newly-created frequencies are generated self-consistently in the course of propagation with the resolution of 0.25 THz. We demonstrate that the major reason for the on-axis propagation of the quasi-isolated pulse centered in the vicinity of 900-1000 nm is the third-order nonlinearity of neutral molecules. The THz pulse at 1-5 THz frequency originates from the free electron photocurrent and propagates in the cone surrounding the filament.

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The Figure shows the spectrum from terahertz to 3d harmonic of the dual-frequency pulse in argon filament. The initial pump pulse has 3.2 mJ energy and 50 fs duration; the initial second harmonic energy is 10 mJ.

We acknowledge support from RFBR (12-02-01368, 12-02-33029), the Council of RF President for Support of Young Scientists (N5996.2012.2), RF President grant for Leading Scientific Schools (NSh-3796.2014.2) Dynasty Foundation, and CEA-France.

References


This is joint work with N.A. Panov, V.A. Andreeva, D. Shipilo, A.P. Shkurinov, V.A. Makarov, L. Bergé, and S.L. Chin.