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Delayed ionization and excitation dynamics in filament wake channels in dense gases and related transient optical nonlinearities.[1]

ROBERT LEVIS, DMITRI ROMANOV, Temple University — The processes of subnanosecond evolution of filament wake channels in dense gases, which determine transient, inhomogeneous optical nonlinearities, are investigated theoretically for the case of high-pressure argon. The initial radial profiles of electron density and temperature, as well as the density of ions and excited neutral atoms are set by the energy intake and redistribution during the laser pulse, when the electrons are released via strong-field ionization and forcefully driven by the oscillating laser field, colliding with neighboring neutral atoms. The emerging electron gas thus gains energy via a short-range inverse Bremsstrahlung interaction and is engaged in collisional excitation and impact ionization of the atoms. A kinetic model predicts the prevalence of excited atoms over ionized atoms by the end of the laser pulse. Following fast thermalization in the pulse wake, the system evolution is determined by the continuing impact ionization (from the ground and from the excited states) and excitation of the residual ground-state neutral atoms by hot electrons, as well as by thermal conduction in the cooling electron gas. Solving numerically the system of diffusion-reaction equations, we obtain the spatio-temporal dependences of electron and excited-atom densities and the built-in radial electric field, which allow for tracing the wake channel evolution via linear and nonlinear light-scattering experiments.

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Dmitri Romanov
Temple University

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