Strong-Field Control of Laser Filamentation Mechanisms
ROBERT LEVIS, DMITRI ROMANOV, ALESKEY FILIN, RYAN COMPTON,
Temple University — The propagation of short strong-file laser pulses in gas and
solution phases often result in formation of filaments. This phenomenon involves
many nonlinear processes including Kerr lensing, group velocity dispersion, multi-
photon ionization, plasma defocusing, intensity clamping, and self-steepening. Of
these, formation and dynamics of pencil-shape plasma areas plays a crucial role.
The fundamental understanding of these laser-induced plasmas requires additional
effort, because the process is highly nonlinear and complex. We studied the ultrafast
laser-generated plasma dynamics both experimentally and theoretically. Ultrafast
plasma dynamics was probed using Coherent Anti-Stokes Raman Scattering. The
measurements were made in a room temperature gas maintained at 1 atm in a flow-
ing cell. The time dependent scattering was measured by delaying the CARS probe
with respect to the intense laser excitation pulse. A general trend is observed be-
tween the spacing of the ground state and the first allowed excited state with the
rise time for the noble gas series and the molecular gases. This trend is consistent
with our theoretical model, which considers the ultrafast dynamics of the strong
field generated plasma as a three-step process; (i) strong-field ionization followed
by the electron gaining considerable kinetic energy during the pulse; (ii) immediate
post-pulse dynamics: fast thermalization, impact-ionization-driven electron multi-
plication and cooling; (iii) ensuing relaxation: evolution to electron-ion equilibrium
and eventual recombination.

Robert Levis
Temple University

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