Ultraviolet Channeling Dynamics in Gaseous Media for X – Ray Production

Doctoral Dissertation Defense

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Abstract

The development of a coherent high brightness / short duration X – ray source has been of considerable interest to the scientific community as well as various industries since the invention of the technology. Possible applications include X – ray lithography, biological micro-imaging and the probing of molecular and atomic dynamics. One such source under investigation involves the interaction of a high pulsed power KrF UV laser with a noble gas target (krypton or xenon), producing a photon energy from 1 – 5 keV. Amplification in this regime requires materials with very special properties found in spatially organized hollow atom clusters. One of the driving forces behind X – ray production is the UV laser. Theoretical analysis shows that above a critical laser power, the formation of a stable plasma channel in the gaseous medium will occur which can act as a guide for the X-ray pulse and co-propagating UV beam. These plasma channels are visualized with a triple pinhole camera, axial and transverse von Hámos spectrometers and a Thomson scattering setup. In order to understand observed channel morphologies, full characterization of the drive laser was achieved using a Transient Grating – Frequency Resolved Optical Gating (TG-FROG) technique which gives a full temporal representation of the electric field and associated phase of the ultrashort pulse. Insights gleaned from the TG – FROG data as well as analysis of photodiode diagnostics placed along the UV laser amplification chain provide explanations for the plasma channel morphology and X – ray output.