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Laser-induced double ionization of helium gas and pulse self-compression for table-top light sources

We investigate the spatiotemporal dynamics of a high-intensity laser pulse in a tunnel ionizing gas. We propose a way to compresss the laser pulse using gas ionization in high-intensity regime. Transverse focusing and longitudinal compression are examined by characterizing the beam spot size in space and time, incorporating the gas ionization processes, relativistic mass variation, and ponderomotive effects. The results show that the inclusion of laser-induced double ionization of helium gas modifies the plasma density, which significantly affects the laser pulse evolution. For intense laser pulse, relativistic-ponderomotive nonlinearity enhances the pulse compression and consequently the self-focusing of the laser pulse. The compression mechanism and the localization of the pulse intensity both are boosted by the modified electron density via a dielectric function. Our results show the genertaion of 20 femtosecond laser pulses focused to 20 mircometer spot size. These results promise to be a method for the generation of table-top light sources for ultrafast high-field physics and advanced
optics.

Presenting Author

DEVKi NANDAN GUPTA

Presenting Author Affiliation

University of Delhi

Presenting Author Gender

Male

Country

India

Presenting Author Email Address

dngupta2001@gmail.com

Primary author: GUPTA, DEVKI NANDAN (University of Delhi)

Presenter: GUPTA, DEVKI NANDAN (University of Delhi)

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