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Study of photoionized plasmas emission spectra of atomic and molecular gases excited by intense EUV pulses

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Light-matter interaction is one of the most vital research topics in physics nowadays. In particularly, the advent of novel radiation sources, synchrotron radiation and free-electron laser (FEL), increased the experimental studies of matter at the atomic and molecular scales. The emitted radiation by electrons in particle accelerators is extremely intense and extends over a broad energy range from the infrared through the visible and ultraviolet, into the soft and hard x-ray regions of the electromagnetic spectrum. Using this energetic beam, photoionization with synchrotron radiation in the vacuum ultraviolet (VUV) or X-ray spectral range has been established for many years as a powerful tool to study many-electron dynamics on free atoms and molecules [1]. However, extremely short and powerful X-ray flashes from FEL make possible to study multiphoton ionization [2]. Furthermore, in a different way, photoionized plasmas are created with irradiation of atomic and molecular gases with high-intensity laser based on EUV sources [3].

In this context, we present the results of experimental and theoretical modeling of photoionized plasma emission spectra from atomic and molecular gases in the ultraviolet and visible light (UV/Vis) region by intense EUV pulses. In the experiment, the source was based on a debris-free gas-puff target [4,5] irradiated with 10 ns/10 J/10 Hz Nd:YAG laser systems. The EUV radiation pulses were collected and focused using a grazing incidence multifoil EUV collector. The laser pulses were focused on a gas stream, injected into a vacuum chamber, synchronously with the EUV pulses. Irradiation of gases resulted in the formation of low temperature photoionized plasmas, emitting radiation in the UV/Vis spectral range. Photoionized plasmas produced in this way consisted of atomic and molecular ions with various ionization states. However, the most observed spectral lines were originated from radiative transitions in singly and doubly charged ions. To get insight into plasma conditions, a collisional-radiative code PrismSPECT [6] and an atomic multiplet code based on Cowan's programs [7] have been used to obtain theoretical spectra. We compare the computed spectral lines with experimental data. Furthermore, the electron temperature was deduced using Boltzmann plots for some selected spectral lines. A detailed discussion of the results is presented.

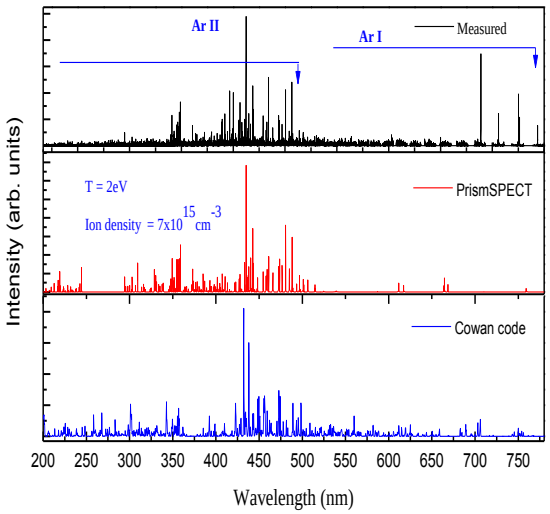

Figure 1. UV/Vis measured emission lines for Argon photoionized plasma induced using the laser-produced plasma EUV source pulses. Where most observed spectral lines were originated from radiative transitions in singly and up to doubly ionized charged ions. A comparison is presented with a theoretically computed spectra from PrismSPECT and Cowan code.

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