Spectroscopic Diagnostics Using Line-Radiation in Laser Driven Non-equilibrium Plasmas*

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X-ray spectroscopy is used to diagnose plasma conditions in experiments at two different facilities at the Lawrence Livermore National laboratory (LLNL). First, we investigate the plasma conditions using Kr line emissions from an ignition target of an indirect drive ICF implosion on the NIF, where small traces of Kr are used as a dopant to the DD fuel gas for diagnostics. The fraction of krypton dopant was varied in the experiments and was selected so as not to perturb the implosion. Our goal is to use X-ray spectroscopy of dopant line ratios produced by the hot core to provide a precise measurement of electron temperature. Simulations of the Kr spectra in the indirect-drive exploding pusher with a range of electron temperatures and densities show discrepancies when different atomic models are used. Next, we investigate experiments performed at the Jupiter Laser Facility, where X-ray spectroscopic measurements were acquired from sub-critical-density, Ti-doped silica aerogel foams driven by a 2ω laser at ~ $5x10^{14}$ W/cm^2. The ultimate objective is to study the effect of an external B-field in thermally insulating the hot plasma and investigating line-radiation in multi-keV, non-equilibrium plasmas. However, the near term goal is to infer a time-integrated temperature at several positions along the laser propagation axis for several B-field cases and observe any sensitivity to density with 4.5% of Ti by atomic fraction in SiO_2 foam target. We use our non-LTE atomic model with a detailed fine-structure level atomic structure and collisional-radiative rates to investigate the Kr and Ti spectra at the estimated plasma conditions of density and temperature conditions. Synthetic spectra are generated with a detailed multi-zone, 1D multi-frequency radiation transport scheme from the emission regions of interest to analyze the experimental data and compare and contrast with the existing simulations at LLNL.

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