Extraction of temperature in a laboratory photoionized plasma experiment at Z

T. Durmaz[1], T. Lockard[1], D. Mayes[1], I. M. Hall[1], R. C. Mancini[1], J. Bailey[2], G. Rochau[2], D. Cohen[3], R. Heeter[4], and D. Liedahl[4]

[1]Physics Department, University of Nevada, Reno, NV
[2]Sandia National Laboratories
[3]Swarthmore College
[4]Lawrence Livermore National Laboratory

March 22, 2012

Abstract

We report on a method to extract the electron temperature of a laboratory photoionized neon plasma produced in Z experiments at Sandia National Laboratories based on the population ratio of two energy levels close in energy. Preliminary studies revealed evidence of dominant electron collisional excitation and de-excitation over photo-excitation and spontaneous radiative decay between the $1s^22p$ and $1s^22s$ levels. Since the populations of these levels were determined from the analysis of transmission spectra, it was then possible to estimate the temperature via a Boltzmann factor. Further studies were performed for various plasma conditions such as temperature and density in order to confirm the reliability of the method. Calculations were performed for a sequence of steady states and in a full time-dependent mode. The neon atomic kinetics model considers several ionization stages of neon ions as well as a detailed structure of non-autoionizing and autoionizing energy levels in each ion. Atomic processes populating and de-populating the energy levels consider photoexcitation and

photoionization due to the external radiation flux, and spontaneous, and collisional atomic processes including plasma radiation trapping. Relevant atomic cross sections and rates were computed with the FAC code. The calculations were performed at constant particle number density and time-histories of temperature and external radiation flux were selected in order to approximate the experimental conditions at Z. For the same set of time-histories, calculations were done in a full time-dependent mode and also as a sequence of instantaneous, steady states in order to assess transient effects.

This research was sponsored in part by the National Nuclear Security Administration under the High Energy Density Laboratory Plasmas grant program through DOE Grant DE-FG52-09NA29551, and SNL.