Numerical simulations of Stark-broadened line shapes of Ar K-shell ions for spectroscopic diagnosis of laser-produced plasmas

Marco A. GIGOSOS[1], Ricardo FLORIDO[2], Roberto C. MANCINI[3],
Juan M. MARTÍN-GONZÁLEZ[2]

1) Departamento de Física Teórica, Atómica y Óptica, Universidad de Valladolid, Spain
E-mail: gigosos@coyanza.opt.cie.uva.es
2) Departamento de Física, Universidad de Las Palmas de Gran Canaria, Spain
3) Department of Physics, University of Nevada, Reno, USA

Analysis of Stark-broadened spectral line profiles is one of the most often used plasma diagnostics techniques, especially to determine the electron density in both laboratory and astrophysical plasmas. The increasing number of applications and the wider availability of spectroscopic measurements under extreme conditions have encouraged studies comparing different computational and analytical methods [1]. In this work we perform numerical simulations to compute Stark-broadened line shapes of several K-shell X-ray line transitions in highly charged Ar ions, i.e. Heα, Heβ and Heγ in He-like Ar and Lyα, Lyβ and Lyγ in H-like Ar, which have been extensively used for spectroscopic diagnosis of implosion cores in indirect- and direct-drive inertial confinement fusion (ICF) experiments [2]. Two different simulations are done: a) within the independent particle approximation using a Debye screened field to account for coupling effects between charges [3] and b) using a molecular dynamics code of interacting particles [4]. Simulation methods permit the extraction of a representative statistical sample of time histories of the local electric microfield produced by plasma electrons and ions responsible for the Stark broadening and shift of line transitions. Specifically, simulations numerically integrate the time-dependent Schrödinger's equation of the radiator in order to compute the dipole-dipole autocorrelation function. The corresponding Fourier transform produces the Stark-broadened line profile. The simulation techniques naturally incorporate ion dynamics effect. Comparisons are made with line shapes calculated in the standard Stark-broadening theory approximation [5,6]. Furthermore, we will assess the impact of employing line profiles computed with different methods on the diagnosis of core conditions in implosion experiments performed at OMEGA.

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