munozj@fusion.gat.com

Kinetic theory and atomic physics corrections for determination of ion velocities from charge-exchange spectroscopy

J. M. Muñoz Burgos[1], K. H. Burrell[2], W. M. Solomon[3], B. A. Grierson[3], S. D. Loch[4], C. P. Ballance[4], and C. Chrystal[5]

[1] *Oak Ridge Institute for Science Education, Oak Ridge, Tennessee 37830, USA*

[2] *General Atomics, P.O. Box 85608, San Diego, California 92186, USA*

[3] *Princeton Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08543, USA*

[4] *Physics Department, Auburn University. Auburn, Alabama 36849, USA and*

[5] *Oak Ridge Associated Universities, Oak Ridge, Tennessee 37831, USA*

Charge-exchange spectroscopy is a powerful diagnostic tool for determining ion temperatures, densities, and rotational velocities in tokamak plasmas. This technique depends on detailed understanding of the atomic physics processes that affect the measured apparent velocities with respect to the true ion rotational velocities. These atomic effects are mainly due to energy dependence of the charge-exchange cross-sections, and in the case of poloidal velocities, due to gyro-motion of the ion during the finite lifetime of the excited states. Accurate lifetimes are necessary for correct interpretation of measured poloidal velocities, specially for high density plasma regimes on machines such as ITER, where l-mixing effects must be taken into account. In this work, a full nl-resolved atomic collisional radiative model coupled with a full kinetic calculation that includes the effects of electric and magnetic fields on the ion gyro-motion is presented for the first time. The model directly calculates from atomic physics first principles the excited state lifetimes that are necessary for a correct gyro-orbit description of the ion. It is shown that even for low density plasmas where l-mixing effects are unimportant and coronal conditions can be assumed, the nl-resolved model is necessary for an accurate description of the gyro-motion effects to determine poloidal velocities. This solution shows good agreement when compared to three QH-mode shots on DIII-D, which contain a wide range of toroidal velocities and high ion temperatures where greater atomic corrections are needed. The velocities obtained from the model are compared to experimental velocities determined from co- and counter-injection of neutral beams on DIII-D.

PACS: 34.70.+e, 52.40.Mj, 52.70.Nc