Fast Neutral Generation by Charge Exchange Reaction and its Effect on Nuclear Burning in Inertial Electrostatic Confinement Fusion Systems

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The inertial electrostatic confinement (IEC) is a concept for electrostatically confining high-energy fuel ions in potential well. In ideal IEC plasmas, the ions converge toward the center of the device, and their space charge forms a virtual anode. The IEC fusion system has intrinsic potential for earlier practical use of fusion energy as a compact and economical neutron/proton source. So far, neutrons/protons more than $10^8 ns^{-1}$ produced by $D(d,n)^3He$($^3He(d,p)^4He$) fusion reactions have been observed on several devices. To improve further the device performance, it is important to understand the physics of the IEC plasmas.

In the device several kinds of ion-neutral collisions occur, e.g. elastic-scattering, ionization, charge exchange in parallel with the fusion reaction. Especially, the charge exchange reaction (CX) changes accelerated ions to fast neutrals which can cause fusion reaction with background neutral gas. In previous researches, it has been shown that fusion reaction between the fast neutral and background gas is comparable with those between ion and background gas [1, 2]. We have previously examined correlation between the ion distribution function and neutron production rate between ion and background gas in spherical IEC devices [3]. The fusion reaction between fast neutral, which produced by CX, and background gas would also be influenced by the shape of the ion distribution function. In this paper, we investigate the influence of the ion distribution function on fusion reaction between fast neutral and background gas.

We assume the spherical IEC device. Within the spherical cathode, the potential structure is determined by solving the Poisson-Equation, and the Child-Langmuir radial potential is assumed outside the spherical cathode region. The Boltzmann-Equation for first neutrals is solved considering the fast neutral generation and loss by CX reactions, together with the particle transport loss from the device. It is shown that fusion reactions carried by the CX fast neutrals becomes appreciable especially in the high-voltage operations, and the fusion reaction between fast neutral and background gas is sensitively affected by the shape of the ion distribution function.

[1] Thorson T.A, et al.,Nucl.Fusion.,**38** (1998) 495.
[2] Santarius J.F, et al.,presented at 5th US-Japan Workshop on IEC Fusion, Madison, USA, October 2002.
[3] H.Matsuura, et al.,Nucl.Fusion.,**43** (2003) 989.