§15. Study of Relations between the Spatial Structure of Potential-Trapped Electron Distribution Functions and the Physics Scaling Law of Plasma Confining Potentials

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In tandem-mirror devices, the second-harmonic ECH in the barrier region is utilized for the formation of a thermal-barrier potential, which reduces the electron heat flow between the central cell and the plug region. The fundamental ECH is employed for the formation of an ion-confining potential in the plug region. Scaling laws of potential formation and associated effects along with their physical interpretations are consolidated on the basis of experimental verification using the GAMMA10 tandem mirror. A proposal of extended consolidation and generalization of the two major theories—(i) Cohen's strong ECH theory for the formation physics of plasma confining potentials and (ii) the generalized Pastukhov theory for the effectiveness of the produced potentials on plasma confinement is made through the use of the energy balance equation.

Therefore, it is important to investigate electron-velocity distribution functions using x-ray diagnostics in these thermally isolated regions (i.e., the plug, the central-cell, and the barrier regions), since these electron distribution functions are directly affected by electrostatic potentials in the kilovolt range, although these regions are connected through magnetic-field lines. These kilovolt-range potentials may form various shapes of distribution functions in the thermally separated regions. Several types of x-ray diagnostics, such as x-ray energy spectrum analyses, x-ray absorption methods, and x-ray tomographic reconstructions using various types of x-ray detectors have been employed for obtaining various shapes of electron-velocity distribution functions as well as their spatial profiles.

This report is described the electron behavior of the potential confined electrons in the central-cell and plug region. In particular, the energy spectra, from pulse height analysis ranging from 1-keV down to a few hundred eV, are measured with a newly developed "ultra-low-energy measurable" pure-Ge (ULE Ge) detector (see Fig. 1). A ULE Ge detector has been characterized using synchrotron radiation from the storage ring at the National Institute of Advanced Industrial Science and Technology (AIST) (see Fig. 2). As a result, it is confirmed that this detector is able to be employed for less than 1-keV x-ray measurement, and therefore this detector makes it possible to observe simultaneously the electron velocity distribution function that consisted of the lower-energy bulk electron component and also the high-energy electron component in the central cell and the plug region of the GAMMA10 tandem-mirror. For the x-ray spectrum analyses, the relativistic Born approximation corrected by the Elwert factor is used for the values of the x-ray cross section. The analysis code is made under this collaboration between Niigata Univ. and Plasma Research Center, University of Tsukuba.

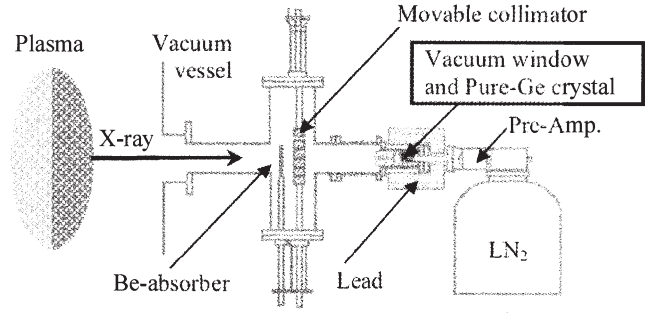

Fig. 1. Schematic view of soft-x-ray pulse-height analysis system with an ultra-low energy pure germanium (ULE Ge) detector for less than 1-keV x-ray measurement,.

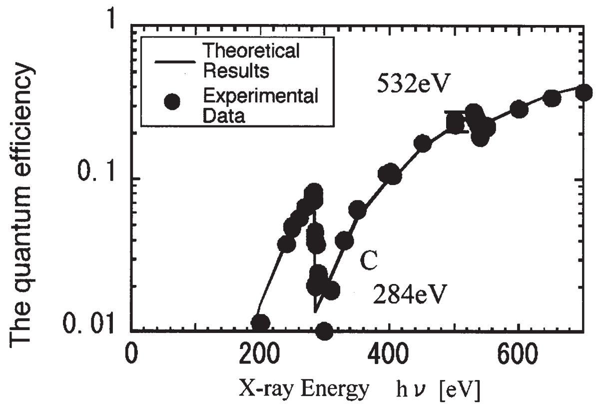

Fig. 2. The quantum efficiency of the ULE Ge detector normalized by the incident x-ray energy. The solid curve is calculated using the x-ray absorptions by the special polymer window and a 0.12- m thick Be. The data points with the Be filter are plotted. In general, the obtained data tend to fit the calculated curve, having some reasonable discrepancies near the absorption edges of O and C are found.

References

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