§10. Particle Separation of End Flux of GAMMA 10 Tandem Mirror Using a Slanted Type CUSPDEC

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A cusp-type direct energy converter (CUSPDEC) was proposed as an efficient charge discriminator applicable to a D-^{3}He fusion reactor. The authors have been studying CUSPDEC experimentally. Following to experiments using a small-scale plasma source, the experimental device was installed in the GAMMA 10 tandem mirror, and experiments of particle separation with keV order energy started[1]. The CUSPDEC device used can form a variable slanted cusp field by adjusting coil currents of I_A and I_B. This report shows an experimental result of particle separation and discussion with concerning theoretical consideration about effects of the slanted cusp field.

As electrons are restricted to move along a magnetic line, ions going straight are separated from electrons in the CUSPDEC. This difference of particle motion can be understood by Störmer potential[2]. When we determine a configuration of magnetic field, particle energy, and incident position and velocity of the particle, we can calculate accessible region based on Stömer potential. In this calculation, we also consider an electric potential $\phi(r, z)$ which is provided by an ion collector plate installed at the point cusp.

Figure 1 shows accessible regions of electrons in the CUSPDEC device. Four figures indicate $r - z$ profiles for indicating values of I_B/I_A. Curves indicate magnetic lines and black tiles mean accessible regions of electrons, the incident point of which is shown by arrows. The collector plate indicated at right edge of each figure is biased with $\phi_0 = 1\,\mathrm{kV}$. The incident electron energy was settled to be $e\phi_0/20$.

When the collector plate is not biased ($\phi_0 = 0$), the accessible regions are limited along a magnetic line, but they spread near the collector plate due to $\phi(r, z)$. As a value of I_B/I_A increases, however, the accessible regions become narrow. In the case of $I_B/I_A = 1.3$, the accessible region in some axial position near the cusp point completely disappear, and this means electrons cannot reach the collector plate.

Based on this consideration, we performed an experimental measurement of electron transmission ratios. We defined the transmission ratio as a ratio of the flux detected at the point cusp to the incident flux in the CUSPDEC. Figure 2 shows variation of the electron transmission ratio to the value of I_B/I_A. According to the figure, the transmission ratio decreases as the value of I_B/I_A increases (*i.e.* the slant of the cusp becomes large) both in the cases with ECH and without ECH. In the experiment, the ion flux was not changed so largely, thus more efficient charge separation was achieved as the slant of the cusp became large. In the case with ECH, over 10 % of electrons were in the order of 10 keV, and the slanted cusp separated those electrons.

Particle separation of end flux of GAMMA 10 for the purpose of direct energy conversion was achieved. The efficient separation was achieved by using the slanted cusp field.

Reference
1) Yasaka, Y., *et al.*, Ann. Rep. NIFS April2005-March2006 (2006) 494.
2) Tomita, Y., *et al.*, Ann. Rep. NIFS April2005-March2006 (2006) 495.

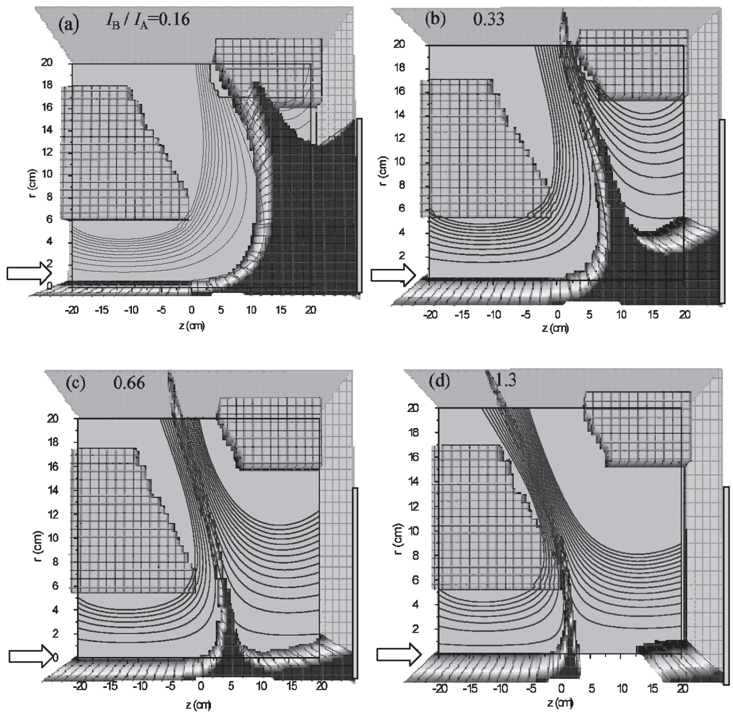

Fig. 1. Accessible regions of electrons in the CUSPDEC device.

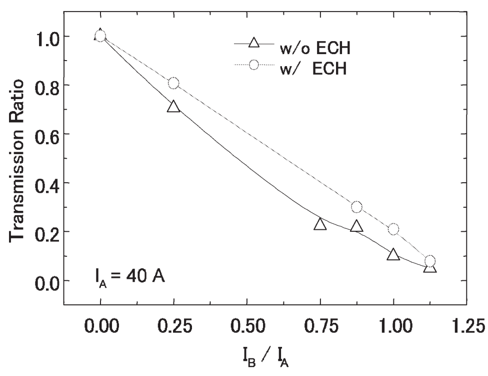

Fig. 2. Electron transmission ratio versus I_B/I_A.