§ 39. Effect of Electron Collectors on Discrimination of Charged Particles in a Cusp Direct Energy Converter

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A direct energy conversion system designed for FRC-based D-^{3}He fusion reactor consists of a CUSP direct energy converter (DEC) and a Traveling Wave (TW) DEC, where, respectively, electrons and thermal ions are separated from fusion protons and decelerated via Venetian blind type electrodes to produce DC power, and protons are velocity-modulated, bunched, and then decelerated by RF traveling waves to produce RF power. For the basic investigation of these DEC's, we use small experimental devices; a single cusp with low-energy plasma and ion sources simulating the CUSPDEC[1)], and a TWDEC simulator consisting of an ion source and an array of modulator-decelerator electrodes driven by a 7-MHz RF[2)].

In the experimental simulator of CUSPDEC, which consists of low-energy plasma and ion sources, a guide field section, and a cusp magnetic field section, a nitrogen plasma beam of density ~2×10^7 cm^{-3} and electron temperature ~7 eV is injected into the cusp field. The cusp field is created by two magnetic coils, A and B as shown in Fig.1. By adjusting the current in the two coils, I_A and I_B, the field line curvature can be varied. Typical values are I_A = 30 A and I_B = 40 A. In the experiment of the separation of electrons and ions in the cusp field, we compared two types of electron collectors, type I and type II, as shown in Fig.1. (Note that when one is used, the other is eliminated.)

We measured the ion and electron fluxes with changing I_B for a fixed I_A = 30 A. We define the transmission ratio of the particles as the ratio of the flux at the point cusp (z = 15.5 cm) to that at the entrance (z = −15cm). When the cusp field is formed, most of the electron flux flows into the line cusp and most of the ion flux into the point cusp, yielding the transmission ratio of electrons to a small value and that of ion close to 1. This is the case for the electron collector of type I. On the other hand, the transmission ratios of electrons and ions for the type II collector exhibit the same behavior as those for the type I for I_B < 40 A, while, for I_B > 40 A, they show the separation characteristics worse than for the type I. The best separation of electrons and ions is obtained in the case of type I collector with the transmission ratio of electrons as low as 0.05.

Figure 2 shows that the degree of discrimination for the type I increases with the curvature of the cusp field. This is consistent with the theoretical prediction that the region of ion motion in the Stoermer potential trough of a cusp magnetic field is wider extending to the region of the point cusp exit for larger curvature.

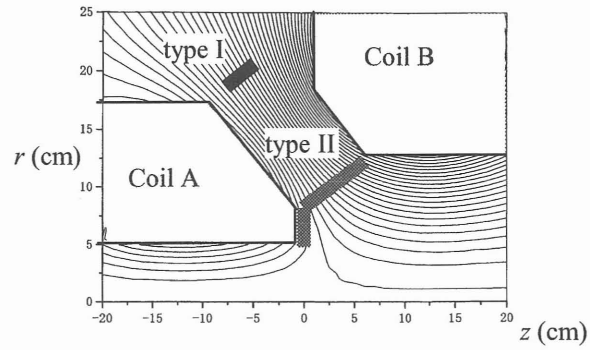

Fig. 1. Two types of electron collectors in a slanted cusp field.

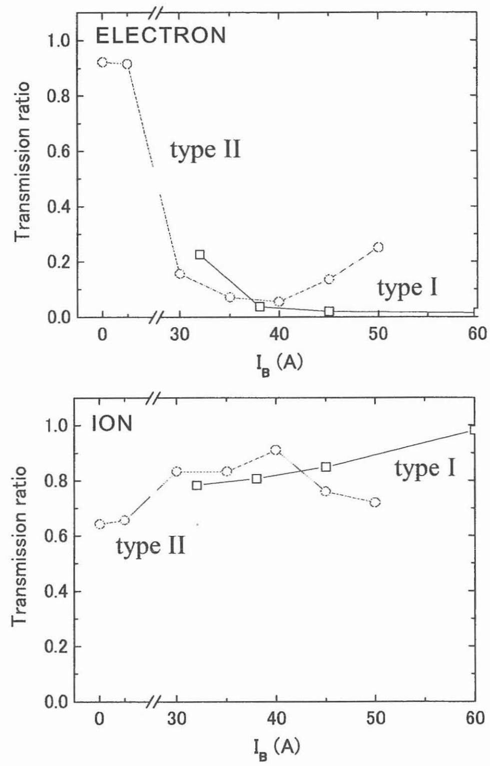

Fig. 2. Transmission ratio of electrons (top) and ions (bottom) as a function of I_B.

In summary, we have tested two types of the electron collectors in the small-scale experimental device for CUSP-DEC. The type I collector is better than the type II in the sense that the separation of electrons from ions is improved for smaller curvatures of the cusp magnetic field.

References

1) Takeno, H. and Yasaka, Y., Trans. Fusion Technol. **39**, (2001) 386.
2) Takeno, H., Ikeda, Y., Yamada, T., Noda, K., and Yasaka, Y., Jpn. J. Appl. Phys. **39**, (2000) 5287.