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Enhancement of Downstream Charged Particle Acceleration in Reconnection with High Guide Field during Spherical Tokamak Merging Start-up

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Magnetic reconnection is an interesting phenomenon involving transformation of magnetic field topology and is observed in various spatial ranges from laboratory to astrophysical plasma. Released magnetic energy of field is converted to the kinetic energy of downstream plasma through magnetic reconnection. The merging start-up method utilizes this mechanism as the initial heating method of the tokamak plasma. This method attracts an attention because of the possibility of generation of high-beta spherical tokamak without the use of center solenoid coils.

In the tokamak system, not only joule heating, but additional heating is also required to achieve high ion temperature to meet Lawson condition. Neutral Beam Injection heating is one of the general methods for additional heating, that requires high initial electron temperature for small radiation loss and effective current drive. Thus, realization of highly efficient acceleration of charged particles, which result in high electron temperature, will improve the performance of spherical tokamak merging start-up.

In this study, for the enhancement of charged particle (especially electron) acceleration in merging start-up, we introduced a novel method to control downstream boundary condition according to the time variation of magnetic reconnection [1]. The left side on Fig. 1 shows its overview. In three-dimensional reconnection, the in-plane static electric field is spontaneously generated [2]. This field (especially E_z showed in Fig. 1) have the counter component to the downstream accelerating electric field. Travelling of charged particle through outer short circuit suppresses E_z, resulting in the enhancement of electric field aligned to magnetic field for the particle acceleration. The right side on Fig. 1 shows the time evolution of electron temperature by a Langmuir triple probe located at the reconnection downstream region, indicating that the change in boundary condition affects the downstream electron heating. In the presentation, we will discuss the enhancement of downstream charged particle acceleration under the controlled condition by the result of electron temperature/density from the multi point Langmuir triple probe and of other measurement systems.

References

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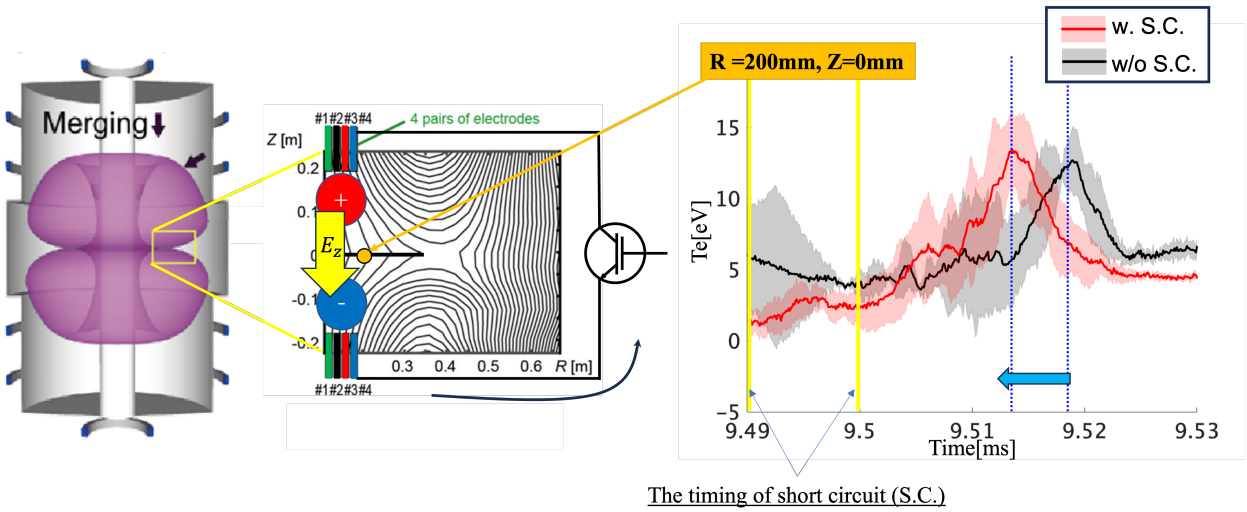

Figure 1. [Left]: the overview of the novel system for the control of in-plane electric field.

[Right]: the measured value of electron temperature from the Langmuir triple probe.