Adiabaticity-breaking process and its application to particle separation by using Helmholtz coil

D. Adachi[1], T. Matsui[1], S. Iwata[1], T. Takahashi[1], H. Momota[2]

[1] Gunma University,1-5-1 Tenjin-cho, Kiryu 376-8515, Japan
[2] National Institute for Fusion Science,322-6 Oroshi-cho, Toki 509-5292, Japan

e-mail: t12306003@gunma-u.ac.jp

Adiabatic invariance in charged particle motion is conservation seen in motion in a gradually changing magnetic field, apart from conservation associated with spatiotemporal symmetry. Since the adiabatic invariant is not a strict invariant unlike the constant of the motion, a jump in value is observed, for example, in a place where the magnetic field changes greatly or in the vicinity of the field-null point. In other words, the particle motion becomes non-adiabatic, the particle motion shows a stochastic behavior, and the movement trajectory fills the accessible region uniformly. Takahashi *et al*. show that in a high beta field-reversed configuration plasma with large spatial variation of the magnetic field, breaking of the adiabatic invariance leads to particle loss [1]. Although adiabatic invariance contributes to confinement, a magnetic field structure that provides non-adiabaticity for particle motion can also be applied to separation method by energy or particle species. Therefore, in this study, we discuss the particle separation by the Helmholtz coil.

In this study, we consider a magnetic field structure with a weak magnetic field region is generated over a wide range using a solenoid coil and a Helmholtz coil, and the trapped particle rate when beam ions are injected in the axial direction is investigated. We calculated orbits of beam ions and found a relationship among trapped particle rate, beam diameter and charged particle Larmor radius. In addition, it is found that the degree of magnetic field cancellation by the Helmholtz coil changes the energy dependence of particle trapping rate. When the magnetic field generated by the solenoid coil is perfectly canceled at the center of the Helmholtz coil, the trapped particle rate decreases as the particle energy increases. However, when the Helmholtz coil current is reduced, it is not a monotonous decrease, and an energy region where particles easily pass through the device is present. We will also investigate cases where the Helmholtz coil current is further increased.

[1] T. Takahashi *et al.* , Phys. Plasmas, 11, (2004) 3131.