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回転磁場法を用いた弱電離磁気リコネクション実験
Experimental Study of Magnetic Reconnection in Partially Ionized Plasmas using Rotating Magnetic Field

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Magnetic reconnection is a phenomenon which changes global magnetic topology and converts magnetic energy into kinetic energy in magnetized plasmas. The behavior of magnetic reconnection in partially ionized plasmas such as solar chromosphere is predicted to be different from that in fully ionized plasmas because of the interaction between plasmas and neutral particles. In addition to solar physical aspect, magnetic reconnection in partially ionized plasmas is important from the view of space weather forecast. Although it is studied by numerical and satellite observations, the effect of neutral particles in magnetic reconnection has never been directly observed in laboratory experiments due to short discharge periods of previous devices.

Rotating magnetic field (RMF) is one of the techniques to drive toroidal plasma current and form field reversed configuration (FRC). By applying transverse magnetic field rotating in azimuthal direction with frequency much higher than ion cyclotron frequency and much lower than electron cyclotron frequency, only electron can keep up with the variation of magnetic field, and electron current is driven. This net toroidal plasma current creates poloidal magnetic field and finally forms FRC's closed magnetic surfaces surrounded by open magnetic field created by external coils. In this research, two FRC plasmas aligned in the axial direction are formed at a time, and reconnection between poloidal magnetic fields is driven by contact of these FRC plasmas.

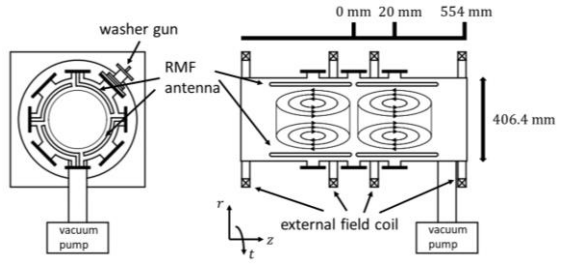

Fig.1. Schematic view of the plasma chamber

New experimental device (see Fig.1) using rotating magnetic field technique has been developed to observe the effect of neutral particles on magnetic reconnection experimentally. Using this device, we succeeded in driving two FRC plasmas for 15 ms which is long enough to observe the effect of neutral particles. Between left and right RMF antennas (midplane of chamber, z=0), toroidal current opposite to toroidal current driven by RMF is observed, suggesting that magnetic reconnection happens.

Measured reconnection magnetic field was 1 G in the discharge with filled gas pressure (hydrogen) of 0.3 mTorr and ionization degree of order of 1%. In the magnetic field diffusion equation, calculated diffusion term by ion-neutral collision is larger than resistive term (caused by electron-ion collision and electron-neutral collision) and Hall term, indicating that a new experimental regime in which the effect of neutral particle might affect the reconnection process was successfully established.

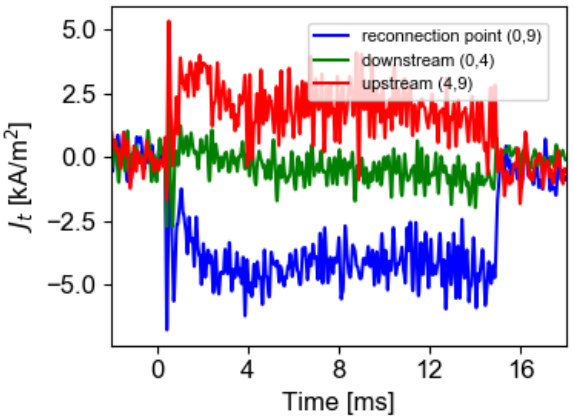

Fig.2. Time evolution of toroidal current density of reconnection point, downstream and upstream (unit of coordinate is cm)