§17. Experimental Study of Current Drive Using Nernst Effect

Kawamori, E. (High Temperature Plasma Center, The Univ. of Tokyo),
Tokuzawa, T.

Development of current-drive technique is the most urgent issue in low-q compact torus plasmas. A method of plasma current drive in a low-q plasma using the Nernst effect is proposed by Hassam.[1] If a plasma has a steep temperature gradient in radial profile, the cross-field thermoelectric force is in the opposite direction to the usual resistive friction, thus maintaining the plasma current. In low-q plasmas such as a Field Reversed Configuration (FRC), however, maintaining the electron temperature profile is difficult because of its high beta property. Electron Cyclotron resonance heating (ECRH) is a very powerful method to heat magnetically confined plasmas. However, the accessible plasma density is limited by a critical density. Electron Bernstein wave is considered as a possibility for overcoming the density limit. Therefore, we plan to employ an EBW in order to increase and maintain the electron temperature of a low-q plasma in the TS-4 device. A 2.45 GHz magnetron with microwave power of 20kW for up to 200 μs was installed to TS-4 at the University of Tokyo. A launched O-mode (or X-mode) electromagnetic radiation will efficiently couple power to EBWs through a mode conversion process at the upper hybrid resonance UHR.

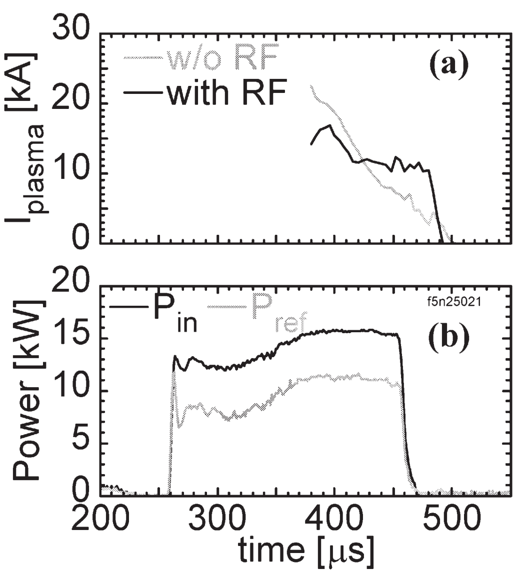

Fig. 1. Waveforms of (a) plasma current I_{plasma} of FRCs without and with RF injection, (b) incident (P_{in}) and reflected (P_{ref}) microwave powers in the case of the above shot with RF injection.

An electromagnetic wave injection experiment was carried out using O-mode. Electromagnetic wave was injected into FRC plasmas produced by counterhelicity merging of two spheromaks. Figure 1 shows waveforms of (a) plasma current I_{plasma} of FRCs without and with RF injection, (b) incident (P_{in}) and reflected (P_{ref}) microwave powers in the case of the above shot with RF injection. The FRC formation was completed at t= 380 μs. The steady-phase of the plasma current was observed around t =400-480 μs in the FRC with RF injection while the plasma current of the FRC without RF injection was decreased with time. However, this difference was not clear because discharge conditions for both cases were slightly different. Another problem is the reflection of a large fraction of the launched microwave power under the present experimental condition as shown in Fig.1 (b). Optimization of the RF injection is needed. At the next stage, we are also planning an X-mode injection experiment.

In order to investigate the heating effect by EBW and a principle of the current drive by the Nernst effect, Two-Dimensional (2-D) Thomson scattering system for electron temperature measurement has been designed and constructing [2]. This new approach using multiple reflections and the time-flight of laser light enables us to measure the r (radial)-z (axial) profiles of electron temperature and density: In this approach, (1) multiple

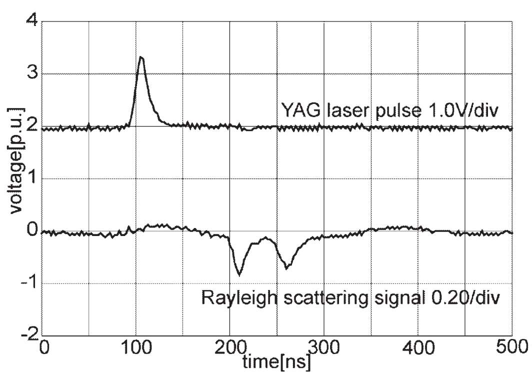

Fig. 2 Rayleigh scattering light from two adjacent measurement points.

reflections of YAG laser light are used to cover the whole r-z plane of the CT plasma, and (2) the time delay of the scattered light along the laser beam is arbitrarily arranged by adjusting the multiply reflected laser light path in order to reduce the necessary number of detectors.

The two Rayleigh scattering signals were measured by the APD detectors as shown in Fig. 2. These data indicate that four sets of the preliminary results will constitute a new 2-D (3×4 points) measurement of the Rayleigh scattering and probably suggests that the basic principle of the 2-D TS system works reasonably well. We are now planning to perform full 2-D measurement of Thomson scattering light for 2-D Te and ne profiles.

Reference

[1]. Hassam, et.al., Phys. Rev. Lett, **83**, (1999) 2969.
[2]. T. Sumikawa, et.al., Plasma Fusion Res. **1**, (2006) pp. 014-106.