§11. Heating and Current Drive Experiments on the TST-2 Spherical Tokamak

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The purpose of this collaborative research is to perform heating and current drive experiments using radiofrequency (RF) waves on spherical tokamak (ST) plasmas. This research aims at establishing the scientific basis for RF heating and current drive in plasmas with very high dielectric constants, with the eventual objective of developing innovative methods for plasma start-up and steady-state sustainment.

The TST-2 spherical tokamak at the University of Tokyo is presently the largest ST device in Japan, with R = 0.38 m and a = 0.25 m (aspect ratio R/a = 1.5). It has already achieved toroidal magnetic fields of up to 0.3 T and plasma currents of up to 0.14 MA. RF power of up to 400 kW in the frequency range 10–30 MHz is available for this experiment. Heating and current drive experiments using the high-harmonic fast wave (HHFW) are being performed using this equipment.

The preparation of RF heating experiments on TST-2, including improvements to and testing of the high-power transmitters, adjustment of impedance matching, and high power testing of the antenna, was carried out by collaboration between the University of Tokyo RF group and the NIFS ICRF group. During Fiscal Year 2006, further optimizations of the transmitters were performed.

Interlocks against overcurrent of the cathode and the control grid are implemented to protect the tetrode used in the final power amplifier (output power 200 kW). Normal operation of these interlocks was hindered RF noise entering the current measurement device and the comparator. This problem was solved by inserting a line filter in the power supply line and the control circuit. This has eliminated abnormal operation, enabled control of the RF output power and pulse length, as specified by the control system.

The output cavity consists of an inductance and a variable capacitor. However, the inductance could only be varied discretely. Modification of the inductance to be continuously variable has enabled selection of the resonant mode over a wider range. As a result, higher output powers can now be obtained. In addition, wave diagnostics have been upgraded, and heating experiments were performed.

In order to understand wave physics, it is very important to measure the wave excited in the plasma directly. A diagnostic to measure the excited wave in the plasma interior using microwave reflectometry was developed on TST-2. It is indispensable to take diffraction effects into account in order to evaluate the experimental data quantitatively. Imaging optics were designed based on wave calculations taking this effect into account. A substantial RF noise reduction has improved the signal-to-noise ratio dramatically. The reflectometer measures the phase of the reflected wave from the plasma. The RF electric field amplitude can be evaluated from the density fluctuation amplitude obtained from its variation. As shown in Fig. 1 parametric decay activity was observed. The strength of parametric decay amplitude correlated with the degraded electron heating by HHFW.

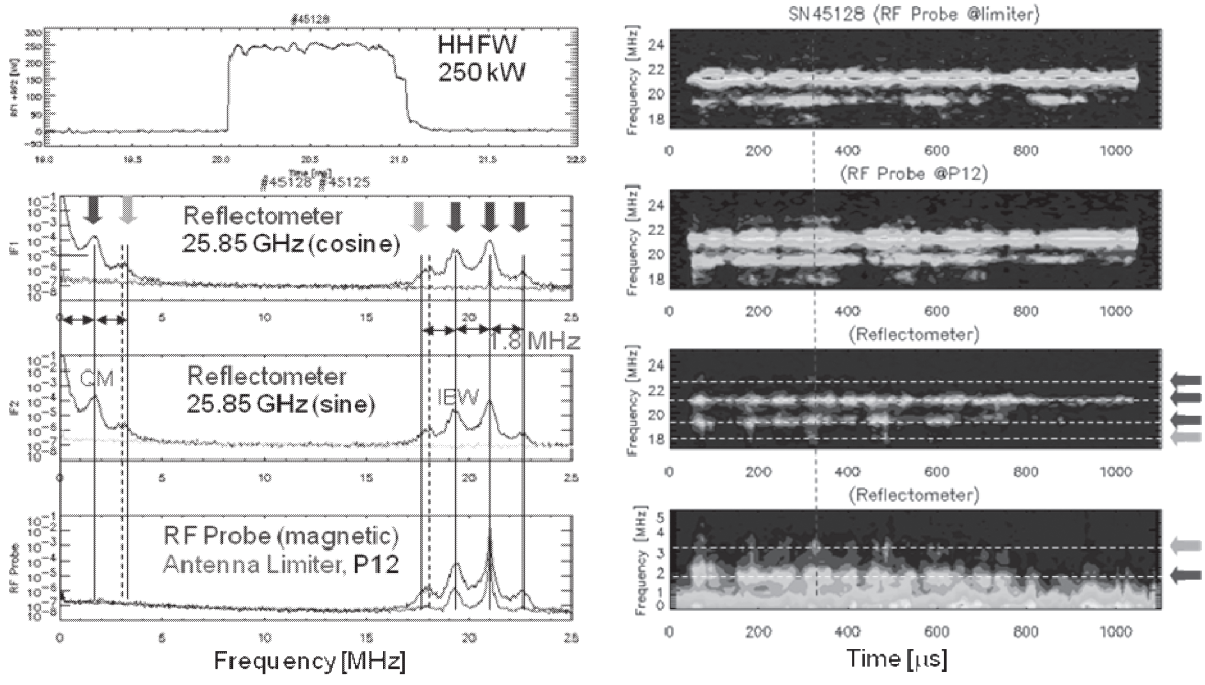

Fig. 1. Detection of the HHFW in the plasma by a reflectometer.