§46. Analysis and Simulation on Experiments Using RF/mm-Waves

Idei, H., Sato, K.N., Zushi, H., Nakamura, K., Hanada, K., Sakamoto, M., Hasegawa, M. (Kyushu Univ.),
Takase, Y., Ejiri, A. (Univ. Tokyo),
Maekawa, T., Fukuyama, A. (Kyoto Univ.),
Mitarai, O. (Kyushu Tokai Univ.),
Shimozuma, T., Kubo, S., Igami, H., Yoshimura, Y., Takahashi, K. (JAEA),
Takeuchi, N. (Ariake National College of Tech.),
Notake, T. (Fukui Univ.)

In the QUEST experiment, Electron Bernstein Wave Heating and Current Dive (EBWH and EBWCD) is a main heating and current drive method to sustain the steady-state plasma. The establishment of steady-state current drive method is a key issue to study PWI phenomena in the steady-state QUEST plasmas. In the EBWH and EBWCD, some mode conversions from the electron cyclotron (electromagnetic) wave to the electron Bernstein (electrostatic) wave are required. In the X-B mode conversion scenario, the incident X-mode wave meets the R-cutoff, and converts to the B-mode wave by tunneling of the evanescent layer between the R-cutoff and the upper hybrid resonance (UHR). In the O-X-B mode conversion, the incident O-mode wave is reflected at the O-cutoff, and propagates as X-mode wave. The X-mode wave reaches the UHR, and converts to the B-mode wave. The density gradient at the conversion into the B-mode wave is a key parameter to attain high conversion efficiency from the X/O-mode wave to the B-mode wave. Even mixture modes of the X/O-mode are required, depending the density gradient. In addition to the launching mode, the launching angle is also an essential parameter to achieve the high conversion efficiency. In the X-B mode conversion, the beam is injected in perpendicular to the magnetic field of the tokamak, while the beam is obliquely injected to the plasma with an optimum angle in the O-X-B mode conversion. The launching mode/polarization, and the launching angle should be controlled to attain the high conversion efficiency. New phased array antenna system has been designed for the EBWH and EBWCD experiments in the QUEST [1].

The designed antenna system should ensure the controllability of the launching polarization and angle for the EBWH/EBWCD experiments. In order to control the launching polarization, an orthomode transducer was designed to mix two orthogonal electric field components. The arbitrary polarized field was expressed

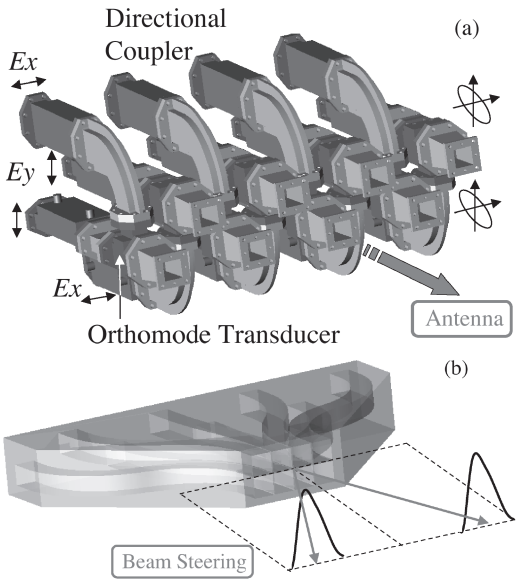

Fig. 1: Conceptual design of (a): orthomode transducer part and (b) phased array antenna.

using the two orthogonal components with the phase difference. The 8.2 GHz system was prepared for the lower hybrid current drive (LHCD) experiment in the previous TRIAM-1M tokamak. Following the TRIAM-1M experiments, the QUEST experiments will begin from 2008. In the system, the power of 200 kW was transmitted to the LHCD antenna using 16 rectangular-waveguide lines. The phase shifters and attenuators in the transmission lines are available to control the polarization states using the orthomode transducer. Figure 1(a) illustrates a conceptual design for the orthomode transducer part. Two field components with different intensity and phase at the rectangular waveguide input were mixed using the orthomode transducer, and were lead to the antenna with the arbitrary elliptical polarization state. All 16 rectangular-waveguide lines in the 8.2 GHz system were used in new antenna system. The output waveguide of the orthomode transducer was square, not rectangular. The directional coupler measured the intensity and phase inputs of each rectangular waveguide, also did the component reflected from the antenna and/or the plasma. The antenna had 8 square-waveguide inputs of the phased array. Figure 1(b) shows the designed phased-array antenna. The output aperture of the antenna was a 4×2 square-waveguide array. Using the phase differences among the 8 square-waveguides, the launching beam was steered. The phase in the array can be controlled by the phase shifter in the 8.2 GHz transmission line.

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[1] Idei,H., *et al.*, Proc .of the 32nd Int. Conf. on Infrared and mm-Waves, 789 (2007).