SOFE05-046

DEVELOPMENT OF QUASI-OPTICAL TECHNOLOGY FOR MICROWAVE DIAGNOSTICS IN LHD

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Fusion research requires understanding of transport of energy and particles in toroidal devices. Microwave diagnostics (electron cyclotron emission and reflectometry) are useful to study transport physics because they are sensitive diagnostics with high time and spatial resolutions. Electron cyclotron emission (ECE) is employed to measure electron temperature (T_e) in toroidal confinement devices. The ECE intensity is proportional to T_e and the ECE frequency is proportional to magnetic field, which is different in different radius. In reflectometry, the reflected frequency depends on electron density (n_e), since higher density plasma reflects microwave with higher frequency, and phase delay or time delay of the reflected signal corresponds to the radial position. Radial energy transport via fluctuations is shown in 3D visualization of computer simulations based on a theoretical model. Microwave imaging diagnostics using the above techniques has a potential to visualize 3D view of turbulence.

This paper presents development of microwave technology for ECE and reflectometry diagnostics in the Large Helical Device (LHD). LHD is the world largest helical confinement system with superconducting magnet. LHD has a capability to confine the high temperature plasma in the steady state because it does not require the toroidal plasma current in contrast with tokamaks. Microwave diagnostics in LHD is based on quasi-optical technology. The ECE microwave is transmitted from the antenna to the microwave diagnostics room. The total length of the waveguide is 100 m. By using corrugated waveguide, which is made by General Atomics, the transmission loss is 30 %. The corrugated wave guide couples to the Gaussian beam. Microwave imaging diagnostics has been also developed in LHD. The antenna system receiving ECE consists of a large concave mirror and a small convex mirror. The concave mirror, which accumulates ECE from LHD plasma, is water cooled for steady state operation. In order to select X-mode, beam splitters using a wire grid polarizer and a universal polarization rotator are used. A microwave imaging reflectometry (MIR) is developed in order to visualize density fluctuations in LHD. To extend the ability of the MIR system to operate with Electron Cyclotron Emission Imaging (ECEI) diagnostic special quasi-optical splitter (dichroic plate) is used. Both the MIR and ECEI techniques take advantage of large aperture optics to form an image of the reflecting/emitting layer onto an array of detectors located at the image plane, enabling localized sampling of small plasma areas.