Analysis of Propagating Mode Contents in the Corrugated Waveguides of ECH System for Precise Alignment

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Electron Cyclotron resonance Heating (ECH) is one of the most powerful heating methods for plasma heating and current drive in fusion-oriented plasma devices. The high power millimeter-waves for ECH are usually transmitted by over-sized circular corrugated waveguides. The length of such transmission lines becomes longer and longer due to the huge size of plasma confinement devices. In the over-sized corrugated waveguides, imperfect coupling of wave beams to the waveguides, tilt and offset of the waveguide axis easily cause conversion of the transmitted mode of HE_{11} to unwanted modes. Improvement of transmission efficiency is essential in view not only of increase of usable power but reduction of heat load to the millimeter-wave components.

We already proposed an alignment method of transmission lines based on infrared (IR) images on a target irradiated by high power millimeter-waves[1]. As a next step, it is important to identify propagating mode contents in the corrugated waveguides for clarifying what kind of misalignment generates such mode conversion.

It is shown that mode contents of high power electromagnetic waves propagating through the corrugated waveguide in ECH system are well analyzed by using retrieved phase information[2,3], and that the wave field in the waveguide can be reconstructed using the complex amplitude of each mode. This method was applied to the 168GHz transmission line in the ECH system of LHD. The information of the amplitude and the retrieved phase were used for mode-contents analysis. The analyzed mode contents for the orthogonal even- and odd-modes in the corrugated waveguide show that HE_{11} main propagating mode dominates 89% and that the other spurious modes are $HE_{21}/1.1\%$, $HE_{12}/0.9\%$ (even-mode) and $HE_{21}/5.4\%$ (odd-mode). The results give the cause of misalignment between the incident beam axis and the waveguide axis. In special, the phase information at the waveguide entrance gives a good guidance for alignment. It was found that a burn-pattern measurement at two positions was insufficient for the beam alignment, because the center of measurable intensity distribution changes with a period of a beat wavelength between the related modes.

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