§4. Optimization of ECH Injection Polarization in Real-time Polarization Scan Experiments

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Stable steady plasma discharge with a high central electron temperature and an electron internal transport barrier in a high efficient ECH system are required for future thermonuclear fusion reactors. The operation scenario of the ECH injection system optimally preset before a discharge may result in a high performance plasma. In addition to that, feedback control of the ECH injection system set to a optimum target can flexibly extend the operational regime.

In the last 18th experimental campaign, we observed plasma response to the change of the injection polarization in real time in order to optimize the polarization during a discharge by fast rotation of the polarizers installed in a transmission line. This fast polarization scan experiment in one shot also contributes to improvement in experimental efficiency.

The 5.5-U 77 GHz ECH modulated at 15 Hz was injected to a low-density plasma with $n_e \sim 1 \times 10^{19}$ m^{-3} sustained by ICRF heating. During the injection, the polarizers on the miterbends installed in the transmission line were rotated fast, as shown in Fig. 1. In this discharge, the two polarizers were controlled in order to change only the polarization angle α with the ellipticity β fixed (i.e. α scan experiment). The absorbed power was experimentally estimated with change of the plasma stored energy, as shown in Fig. 2. α was scanned from 25° to 65° within 2 seconds. This result indicates that the α scan in real time clearly changes the absorbed power and the power at $\alpha \sim 45°$ is observed to be maximum, as expected, while $\alpha \sim 25°$ and $\alpha \sim 65°$ exhibit low heating efficiency. The ray-tracing calculations with the *LHDGauss* show that the injected millimeter wave with $\alpha = 45°$ couples to the plasma wave with the fundamental ordinary mode, while that with $\alpha = 25°$ or $\alpha = 65°$ couples not only to the ordinary mode but also to the extraordinary mode to some extent, which gives rise to degradation of the power absorption. The calculated absorbed powers based on the mode purity analyses are in good agreement with those evaluated experimentally. These valuable results suggest that prediction of optimum polarization with the help of the *LHDGauss* can be used for a control model in a real-time feedback control system if information on an electron density profile is used as a sensor for the feedback system.

In summary, the fast scan experiment enables us to search the optimum injection polarization state during a short pulse discharge. These results are to be utilized for design of a real-time feedback control system to optimize ECH injection polarization.

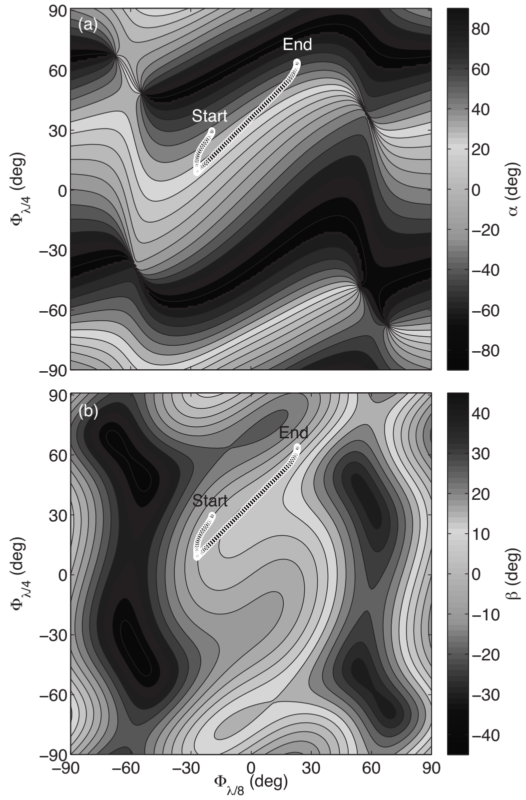

Fig. 1: Time evolutions of EC wave injection polarization during discharge, shown on the polarization map of the ECH #1 (5.5-U, 77 GHz) transmission line. (a) Polarization angle α and (b) ellipticity β as a function of polarization angles $\Phi_{\lambda/8}$ and $\Phi_{\lambda/4}$ of the two polarizers installed on the miterbends in the transmission line.

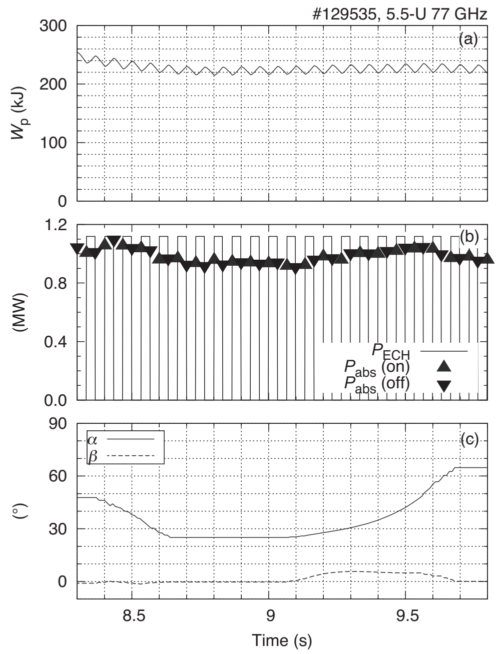

Fig. 2: Time evolutions of (a) plasma stored energy, (b) absorbed power along with injection power, and (c) α and β. The absorbed power is evaluated when the ECH is turned on and off, respectively. α is scanned while β is almost fixed.