§7. Monte-Carlo Simulation Study of ICRF Minority Heating in the LHD Plasma

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ICRF heating method has attracted much attention as an effective heating method and has been used in helical systems. Because of the complicated particle motions in a helical system it is necessary to include the finite particle orbit effects and particle direct losses on considering the efficient ICRF heating.

We have developed the Monte-Carlo simulation code for the ICRF minority heating in a helical systems, which takes into account complicated orbits of high energetic particles, collisions, and interactions between particles and applied RF waves.

The LHD magnetic configurations under the MHD equilibrium state is calculated by VMEC code and the particle orbits are followed in the Boozer coordinates constructed based on the equilibrium. We assume the last closed magnetic surface as the boundary of particle confinement. We consider only the fundamental cyclotron resonance of the minority ion with RF wave and the perpendicular velocity modulation due to the resonance. The interactions with background ions and electrons are introduced using the Monte-Carlo collision operator[2].

The finite \( \beta \) effects on the transferred powers to majority ions and electrons have been investigated. The clear change in the radial profile of transferred power can be seen when the plasma \( \beta \) is increased (Fig. 1). This comes from the deformation of the trapped particle orbits due to the finite \( \beta \) effects.

The heating efficiency decreases with increasing input ICRF power, but efficiencies are no changed so much for different \( \beta \) values if the ICRF power is high (Fig. 2). The dependency of the heating effi-

ciency on the resonance layer position is also found in the finite \( \beta \) case and the maximum heating efficiency is given when the resonance magnetic field strength is adjusted to the strength at the magnetic axis.

The introduction of the radial electric field, \( E_r \), improves the heating efficiency when \( E_r \) is positive (\( E_r \) is directed radially outward). It has been also found that the heat efficiency for the \(^3\)He minority case is up to 30% higher than that of proton minority case.

![Fig. 1: Radial profile of the transferred power; (a) \( \beta_0 = 0.0\% \) and (b) \( \beta_0 = 6.0\% \)](image)

![Fig. 2: Plots of the heating efficiency with changing the plasma \( \beta \) and the RF power.](image)

References
