§24. Analytical Model for ICRF Sustained Plasma of LHD

Watanabe, T., Matsumoto, Y. (Hokkaido Univ.), Nagaura, T. (Hokkaido Univ.), Oikawa, S. (Hokkaido Univ.)

We have carried out detailed numerical computations for particle orbits in LHD, and have confirmed that reflecting particles can show better confinement compared to those of transit particles in LHD. The representative results of this nature is shown in the fact that reflecting particles can be confined in the chaotic filed line region outside of the outer most magnetic surface of LHD. Reflecting particles can circulate helically around the magnetic axe due to no toroidal coils in LHD and reflecting motions have stronger adiabaticity due to the the fact that 'periodic length' of reflecting particles is shorter than those of passing particles. Further more, typical lifetime of transition particles are confirmed far longer than the excursion time, which is determined by the ratio of machine size and thermal speed of particles, in core region of LHD. These particle orbits nature show that LHD has no losscone region and ICRF heating scheme is very promising for the LHD magnetic field configuration.

Based on these particle orbits nature, an analytical model for ICRF sustained plasma of LHD is constructed and analyzed numerically. We have assumed that

- Vacuum chamber of LHD is considered as a resonant cavity and ICRF power loss is expressed by the Q_0 value (figure of merit of cavity), when plasma is not present. Because main ICRF power loss mechanism are escaping of rf wave through ports of vacuum vessel and ohmic loss on the surface of vacuum chamber wall, ICRF power loss is assumed to be proportional to the averaged field intensity in vacuum space out side of plasma region.
- Electrons are assumed to be Maxwellian and ions are assumed to be summation of bulk and hot components with Maxwellian distribution function, because ICRF heated particles can be accelerated more effectively.
- LHD confinement performance is expressed by energy confinement time.
- Ion cyclotron heating process is taken into account but electron heating process is neglected.

Numerical computations show

- Clear threshold value is present for ICRF power to sustain the state steady plasma.
- Hot ion temperature is determined by the spectrum of ICRF wave and electron temperature and almost independent to the electron density and ICRF power.
- Heating efficiency η_H is very high (almost $\eta_H \simeq 1$ when ICRF power level exceed the marginally ones for plasma sustaining).

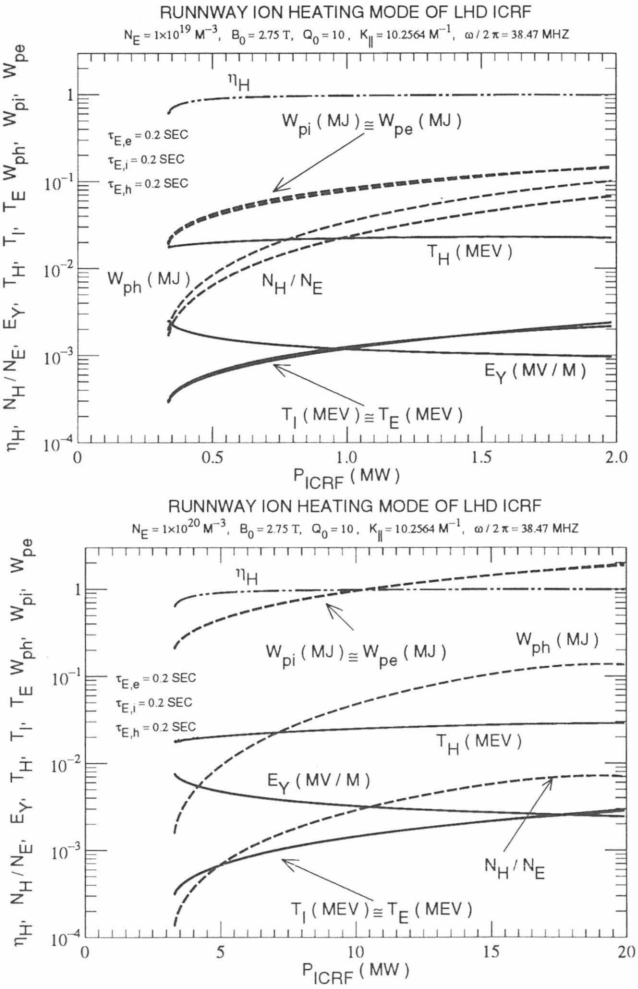

Fig.1 ICRF sustained plasma of LHD (high and medium density case). Parameters used for computations are shown in figures. T_E, T_I and T_H represent the temperature of electrons, bulk ions, and hot ions, respectively. Stored thermal energy (W_E, W_I and W_H) and averaged ICRF field intensity are also plotted. η_H is efficiency of ICRF power for plasma sustainment. When ICRF power P_{ICRF} is increased, hot ion density N_H is increased but hot ion temperature T_H remain almost constant.