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Ion kinetic effects on MHD instabilities in high beta LHD plasmas

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For the high beta plasmas in the inward shifted Large Helical Device (LHD) configurations, the plasma peripheral region is theoretically MHD unstable region since there is always a magnetic hill in the plasma peripheral region. However, high beta plasmas with about 5% of the volume averaged beta value are stably obtained in the LHD experiments. This implies that the nonlinear saturation level of the MHD instabilities does not significantly affect the plasma confinement. On the other hand, the previous MHD simulation study showed that resistive ballooning modes are unstable in the plasma peripheral region and the central pressure is significantly decreases since the influence of the instabilities expands to the core region. In order to resolve the discrepancy between the experimental results and the simulation results, numerical analyses based on the kinetic MHD model have been carried out in this study.

In the kinetic MHD model used here, the drift kinetic description is used for ions and the fluid model is used for the electron. The plasma density, the velocity parallel to the magnetic field and the ion's pressure are evaluated from the velocity moment of the ion's distribution function. The MHD equilibrium is constructed by the HINT code without assumption of the existence of nested magnetic surfaces. The central beta value is assumed to be 7.5%.

It is found that the linear growth rates of the resistive ballooning modes obtained from the kinetic MHD model are smaller than the linear growth rates obtained form the MHD model. In the radial mode structure of the pressure obtained from the kinetic MHD model, the amplitude of the ion pressure is about half of the amplitude of the electron pressure due to the ion's finite orbit width (FOW) effects. For the saturated state of the MHD instabilities, although the central pressure decreases for both the MHD model and the kinetic MHD model, the decrease of the central pressure for the kinetic MHD model is smaller than that of the central pressure for the MHD model. Since the MHD instabilities are the resistive modes, the stabilizing effects of the ion kinetic effects is expected to be stronger for the experimental high magnetic Reynolds number so that the core crush may be suppressed.

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