§19. Effect of Plasma Inertia on Vertical Displacement Instability in Tokamaks

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It is believed that elongated D-shaped configurations show their advantages in achieving higher plasma performance on tokamaks. Nevertheless elongated configurations are unstable against vertical displacement instability(VDI) . VDI is known of importance because it may lead to plasma disruption and even the damage of the device if it can not be well controlled.

Efforts have been put on the study of the effect of various parameters,for example, plasma geometry, pressure and profile, on VDI as well as the analysis of the VDI behavior in tokamaks. It is believed that VDI in tokamak is composed mainly of two components, namely a fast oscillation components and a period of few microseconds ,as well as a slow shifting component with a characteristic time(or inverse of the growth rate) of the resistive time of the conductors, usually, about 10~100 milliseconds. An active feedback scheme is widely used to stabilize VDI in a longer time period.

For weakly elongated plasma the vertical displacement can be considered as a small quantity and a linearized theoretical model is applied. The solution of the dispersion shows the existence of a critical elongation with respect to a certain configuration of conductors. Beyond the critical elongation VDI can not be stabilized no matter how the parameters in active displacement in a period much longer than that of the fast oscillation the plasma inertia is usually neglected.

For highly elongated case the plasma displacement can no longer be thought to be small. The problem should be treated in a nonlinear frame of work and a numerical solution is needed.

In the present work, the effect of plasma inertia on vertical displacement instability(VDI) is investigated in both linear and nonlinear regimes. In a linear case, the solution of the dispersion shows the existence of a critical elongation for a certain distance of the conducting wall. In the nonlinear case,a difference between the cases with and without inclusion of plasma inertia is found. The inclusion of the inertia leads to a "softening" of the critical behavior of the displacement against the distance of the resistive wall. Without inclusion of plasma inertia there exists a critical distance between the wall and the plasma below which VDI can not be stabilized even the parameters in feedback control scheme are set. An analysis of the dispersion of linear VDI shows that the plasma inertia plays an important role in the properties of the solutions of dispersion and hence in the behavior of VDI.

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