§1. HINT Computations and Nonlinear Simulations of Helical Plasmas

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The three-dimensional (3D) equilibrium code HINT has been developed to answer the indeterminate question of whether or not a 3D magnetohydrodynamic finite-beta equilibrium can keep clearly nested magnetic surfaces. The code does not a priori demand the existence of regularly nested magnetic surfaces [1,2]. We have numerically analyzed the island formation for the Heliotron [3-7], Helias [7-10], and Heliac [11] configurations by using this code. One important discovery obtained was that magnetic surfaces are broken by the finite pressure effect in an actual helical configuration, and the breaking often imposes severer limitation on the equilibrium beta than the Shafranov shift. Also, we have found that the way islands appear for each configuration is pretty much different to each other. In the process of equilibrium calculation, we found one remarkable property of magnetic islands induced by the finite pressure effect; the islands, in some cases, show a property of 'self-healing' that the islands tend to shrink as beta increases [10-15]. The HINT code has been modified to include the effects of the net toroidal current on the equilibrium in a fully consistent manner, especially the neoclassical currents such as the bootstrap current [16]. In addition, it has been modified to improve the efficiency of the computations [17].

We execute linear analyses and nonlinear simulations of pressure driven instabilities in a helical device. Nonlinear simulations in a full 3D geometry of a helical device, as are addressed in this study, have seldom been attempted so far. As a first approach for this attempt, we study a configuration with low magnetic shear [18]. In the linear phase of development, the property of the excited modes are consistent with the linear prediction. In the nonlinear phase, however, many modes are excited simultaneously, and strong coupling between those modes occur, thus the pressure profile for those modes becomes complicated. What should be noted is that after some time, all the m odes once excited become stable due to spontaneous relaxation in the overall pressure profile, which is smoothed and becomes broader.

References

[1] T.Hayashi, Theory of Fusion Plasmas (Varenna, 1988), 11 (1989).
[2] K.Harafuji, T.Hayashi and T.Sato, J. Comput. Phys. **81**, 169 (1989).
[3] T.Hayashi, T.Sato and A.Takei, Phys. Fluids B **2**, 329 (1990).
[4] T.Hayashi, A.Takei and T.Sato, *Phys. Fluids B* **4**, 1539 (1992).
[5] T.Hayashi et al, *Plasma Phys. Controlled Fusion Res.* (IAEA,1991), Vol.2, p.143.
[6] T.Hayashi et al, Nucl. Fusion **31**, 1767 (1991).
[7] T.Hayashi, Theory of Fusion Plasmas (Varenna, 1991), 231 (1992).
[8] T.Hayashi, U.Schwenn and E.Strumberger, Jpn. J. Applied Phys. **31**, 2580 (1992).
[9] T.Hayashi et al, *Plasma Phys. Controlled Fusion Res.* (IAEA,1993), Vol.2, p.29.
[10] T.Hayashi, J.Nührenberg et al, Phys. Plasmas **1** 3262 (1994).
[11] T.Hayashi, T.Sato, H.J.Gardner and J.D.Meiss, Phys. Plasmas **2** (1995) 752.
[12] A.Bhattacharjee, T.Hayashi et al, Phys. Plasmas **2**, 883 (1995).
[13] T.Hayashi et al, *Plasma Phys. Controlled Fusion Res.* (IAEA,1996), Vol.3, p.309.
[14] J.Nührenberg et al, Fusion Tech. Trans. **27**, 71 (1995).
[15] T.Hayashi and N.Nakajima, J. Plasma and Fusion Research **71**, 501 (1995).
[16] R.Kanno et al, J. Plasma Fusion Res. (1998) in press.
[17] S.S.Lloyd et al, J. Plasma Fusion Res. (1998) in press.
[18] T.Hayashi, N.Nakajima and T.Sato, Fusion. Tech. Trans. **27**, 182 (1995).