§7. Magnetohydrodynamic Relaxation in Multi-pinch

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The multipinch device constructed by General Atomics Technologies Inc. is a toroidal axi-symmetric pinch configuration with an hour-glass shaped cross-section, and has an internal figure-eight separatrix and a magnetic well near the plasma edge [1]. It was expected that the magnetic well would improve the stability and transport properties over those of a pinch without a well. When magnetic helicity was increased higher than the field-reversal point, however, the up-down symmetric configuration relaxed into an asymmetric one without a magnetic well. The transition from the symmetric to the asymmetric configuration is explicable by the Taylor's relaxation theory [1,2].

We have performed 3-D MHD simulations on the multipinch relaxation. Fig.1 shows a trajectory of the multipinch simulation in a magnetic helicity-energy diagram. As a result of the initial kink instability and the coalescence of magnetic islands in turbulent field, two columnar magnetic fluxes are largely deformed. When the magnetic energy becomes lower than that of the symmetric configuration, the two fluxes start to merge through magnetic reconnection. As merging advances further, the magnetic field configuration relaxes towards the asymmetric one.

In order to obtain an up-down symmetric configuration with the reversed field, we have considered a twisted-multipinch configuration where the multipinch is twisted in such a way that the top half connects to the bottom half after once around the torus. The twisted configuration can eliminate the asymmetric state with $n = 0$, hence, the lowest eigenmode of the Taylor state becomes periodic ($n \neq 0$). In Table 1, we have summarized some properties of the lowest eigenmode for untwisted- and twisted-multipinches, where a twisting effect is introduced by a boundary condition that is rotated by 180 degree after a period. System length is $2\pi a$ where a is a typical scale length in the poloidal plane. Here, W, K, and F denote the magnetic energy, the magnetic helicity, and the field-reversal ratio ($\equiv B_{\phi,shellwall}/ < B_\phi >$) which are calculated at the bifurcation point of the coupled and mixed solutions. The negative F-value in the twisted configuration is 7.5 times larger than that in the untwisted case, although the energy and the helicity are increased only 9%. The F-value in the twisted case becomes larger, as the "waist" in the cross section is made narrower. The above result shows that the reversed toroidal field can be sustained in the twisted-multipinch, while the reversal ratio is quite small.

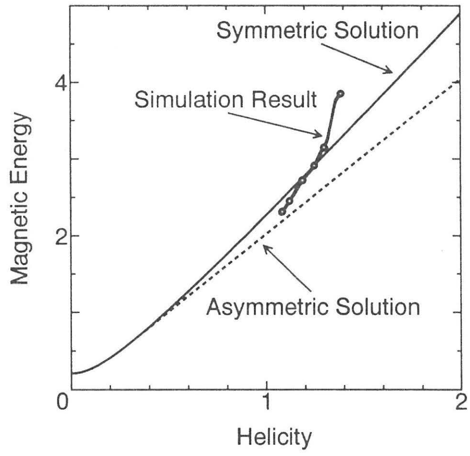

Figure 1: Trajectory of multipinch simulation.

Table 1

	Untwisted Multipinch	Twisted Multipinch
Eigenmode	$n = 0$	$n \neq 0$
Eigenvalue	4.15	4.26
W	0.648	0.707
K	0.314	0.342
F	−0.0125	−0.0941

References

[1] LaHaye, R.J., T.H.Jensen, P.S.C.Lee, R.W.Moore, and T.Ohkawa, Nucl.Fusion, **26**, 255 (1986).

[2] Gimblett, C.G., P.J.Hall, J.B.Taylor, and M.F.Turner, Phys.Fluids, **30**, 3186 (1987).