§5. Spheromak Injection into Magnetized Plasmas

Suzuki, Y., Watanabe, T-H.,
Kageyama, A., Sato, T., and Hayashi, T.

The spheromak injection is one of the most promising schemes for deep fueling of a fusion device. Our main objective is to investigate the dynamics of the injected spheromak as well as the possibility of deep fueling. To achieve this, we study three-dimensional dynamics of a spheromak which is accelerated by a spheromak gun and is injected into a magnetized target plasma which corresponds to a device region by using magnetohydrodynamic (MHD) numerical simulations. We carry out four simulation runs as shown in Table 1.

Simulation results of the case 1 are shown in figure 1. From this figure, we can see that the spheromak field which confines the high density plasma penetrates into the device region. ($t = 0, 20\tau_A$). In this process the magnetic reconnection between the spheromak field and the device field takes place in front of the spheromak. Thus, the magnetic configuration of the spheromak is almost disrupted and the high density plasma confined in the spheromak field diffuses in the device region ($t = 40, 60\tau_A$). The magnetic reconnection plays a role to supply the high density plasma into the device region.

Figure 2 shows the time evolution of the penetration depth of the spheromak high density plasma (L_p). In the case 1, the spheromak high density plasma enters the device region at $t = 12\tau_A$ and penetrates with time. However, after about $t = 30\tau_A$, the penetration depth becomes shorter than that in the case 2, where the device field B_{dev} is assumed to be null. As shown in figure 1, the reconnection process successively proceeds around $t = 20\tau_A$. It means that the magnetic reconnection suppresses the penetrating motion of the spheromak high density plasma.

In this figure, results of the case 3 and the case 4 are also shown. These results clearly indicate that the density and the pressure of the device plasma are important in determining the transfer rate of the kinetic energy of the spheromak. For the lower device density and the lower pressure, the penetration depth is longer. In order to study in detail, the dependence on the strength of the device field as well as the injection velocity should be considered.

	spheromak			device		common
case	B_{sph}	ρ_{sph}	V_{sph}	B_{dev}	ρ_{dev}	P_{com}
1	1	10	0.3	0.1	1	0.4
2	1	10	0.3	0	1	0.4
3	1	10	0.3	0	0.1	0.4
4	1	10	0.3	0	0.1	0.1

Tab. 1: Several parameters in four different simulation runs.

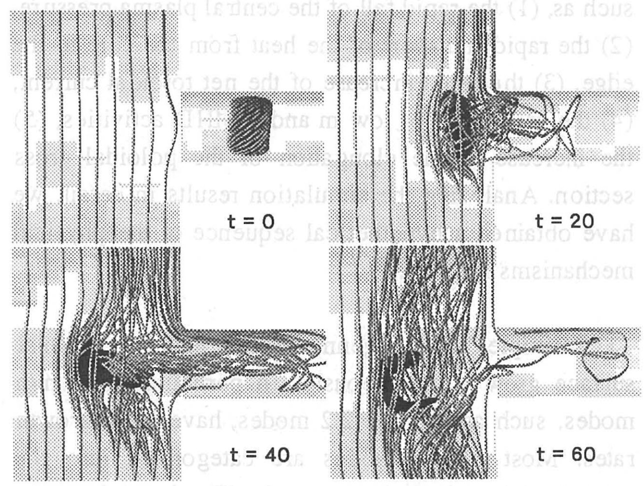

Fig. 1: The spatial structure of the magnetic field lines and the high density plasma (black region).

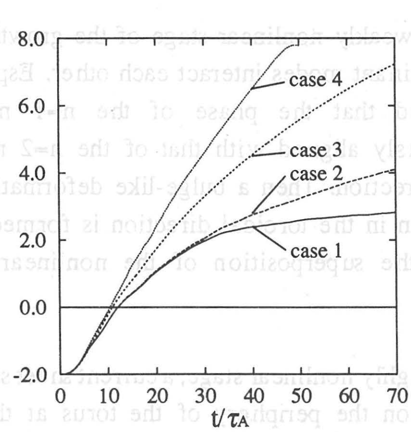

Fig. 2: Time evolution of the penetration depth of the high density plasma. (The region $0 \leq L_p \leq 8$ corresponds to the device region.)