§4. Spheromak Injection into Magnetized Plasmas

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For steady state operation of a fusion reactor, the feasibility of the central fueling by spheromak injection has been suggested in several theoretical models [1] and experiments [2]. To control the fueling by this scheme, it is important to understand the interaction between the injected spheromak and device magnetic fields, which might prevent deep penetration. Our main objective is to investigate this interaction and reveal the possibility of the central fueling. To achieve this, the dynamic process where the spheromak is injected into magnetized plasmas, is considered by using a three-dimensional magnetohydrodynamic (MHD) numerical simulation.

In this study, we use Cylindrical coordinates (r, θ, z). The simulation region is given by two cylinders which connect with each other (Fig. 1). One with a small radius (R) corresponds a plasma gun and the other with a large radius ($4R$) is a fusion device. All boundaries are assumed as a perfectly conducting wall. The governing equations are given by MHD equations. The explicit finite difference method scheme and Runge-Kutta-Gill method are used to solve basic equations numerically. Initially a spheromak is located in the gun region and it is injected into the device region with the velocity V_{z0}.

Simulation results show that the injected spheromak penetrates into device region (Fig. 2). Through this process, the spheromak suffers from a tilting instability and magnetic reconnection successively takes place. As a result, the spheromak is disrupted. Also, we carried out three runs where the initial velocity of the spheromak is different with each other and we found that the penetration length until disruption increases with its initial velocity. These results suggests that if the injected velocity is sufficiently fast, the central fueling by this scheme is promising.

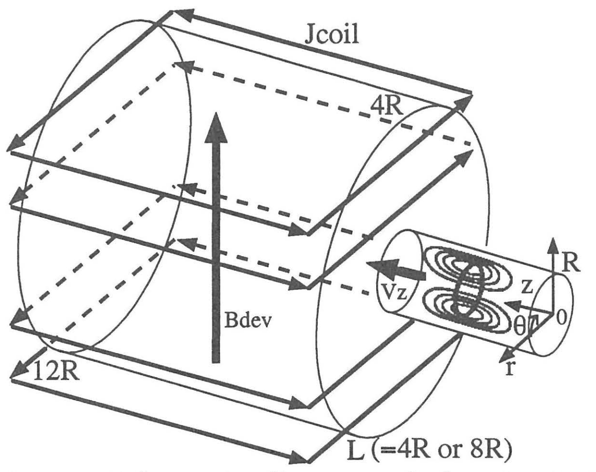

Fig. 1: Schematic diagram of the simulation region

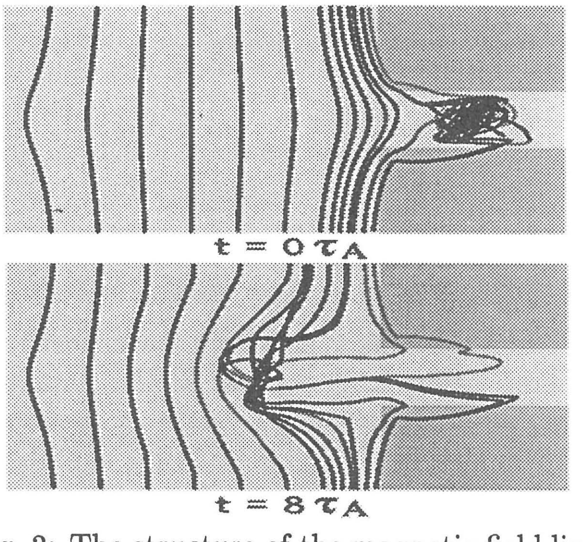

Fig. 2: The structure of the magnetic field lines viewed from $\theta = 0$ at $t = 0\tau_A$ and $8\tau_A$.

In the simulations, however, we neglect the effects of the pressure gradient force and the density gradient for simplicity. For more detail analysis, these effects will be considered in our future work.

References

1) Parkins,L.I., Ho,S.K., and Hammer,J.H., Nuclear Fusion 28, (1988) 1365.

2) Brown,M.R., and Bellan,P.M., Physical Review Letters 64, (1990) 2144.