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Dynamo magnetic fluctuation driven by CHI and its influence on HIST equilibrium configurations

CHIダイナモ駆動磁場揺動とHIST平衡配位への影響

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We have observed magnetic field flucutations during the amplification and sustainment of the spherical torus (ST) plasmas in the HIST device. To identify the detail mechanisms regarding a helicity transport, we have investigated the characteristics of the observed magnetic fluctuations in double pulsing CHI experiments. Fluctuation has been found to propagate from the open flux column region toward the core region.

1. Introduction

Flux amplification and current drive by dynamo effect is one of the most interesting physical phenomena in astrophysical and laboratory plasmas. The coaxial helicity injection (CHI) pulse produces effectively fluctuating flows and magnetic fields which are considered to play a role in the dynamo activity needed for driving a current in the closed flux regions. We have identified propagation characteristics of the magnetic flucutations during the driven and decaying process in the double pulsing operations on HIST.

2. Experimental setup

The HIST device is a low aspect ratio torus with major radius R = 0.30 m, minor radius a = 0.24 m, and aspect ratio A=1.25. The capacitor banks (V_{max}=10 kV, C=0.6-2.6 mF) are used for ST formation. The two sustainment banks (V_{max}=900 V, C=195 mF and 335 mF) have been prepared for the double gun pulsing experiment.

Figure 1 shows the main elements of the HIST device, indicating the flux conserver (FC), magnetized coaxial plasma gun (MCPG), the toroidal field (TF) coil, and diagnostics. The HIST device's diagnostics are 16-channel surface poloidal pick-up coil, a current density probe, internal magnetic probing arrays, Ion Doppler Spectrometer (IDS), a three-axis MHD dynamo probe (Mach probe with magnetic pick-up coils), a three-axis Hall dynamo probe and a CO_2 laser interferometer. We have used a 6-channel probe incorporating both small size Rogowski loops and flux loops with a rectangular cross section (2.4×10^{-3} m^2) to measure the toroidal current density profile and the force-free parameter $\lambda \equiv \mu_0 j_t / B_t$ on the FC midplane. We have measured ion saturation current from a double probe of the Mach probe.

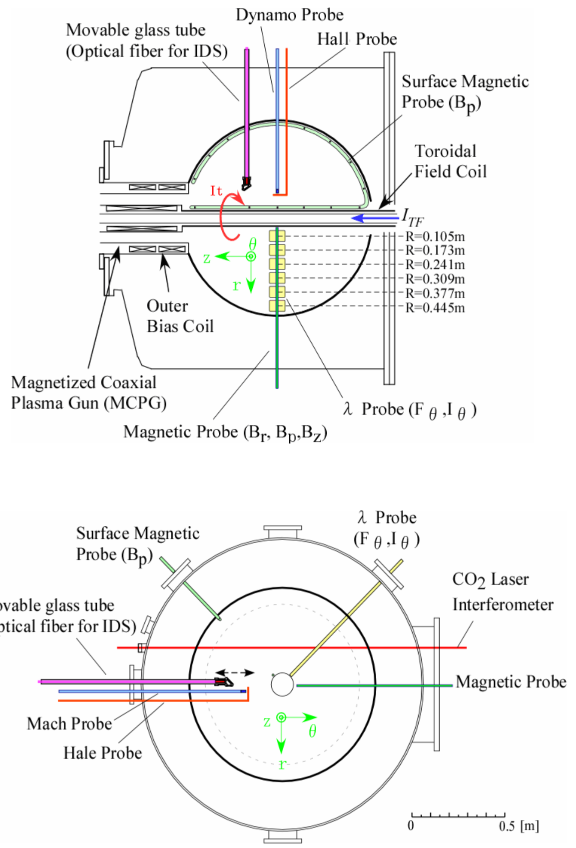
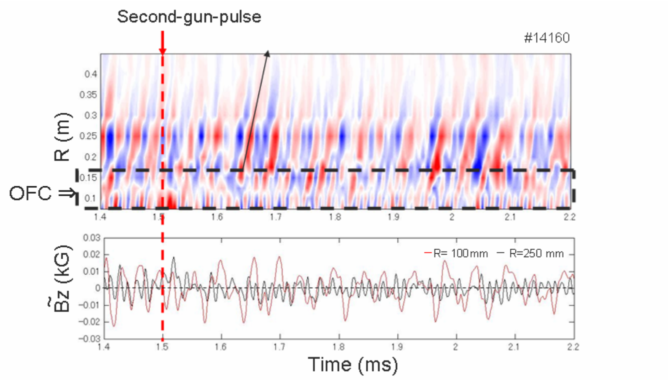


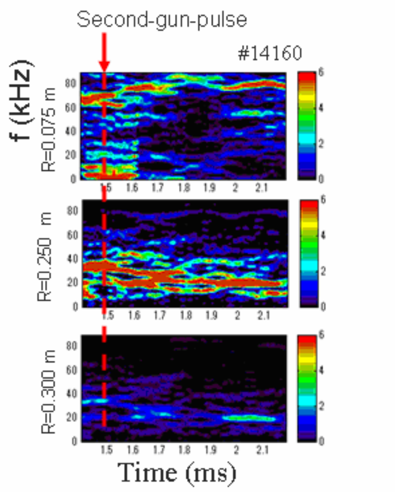
Fig.1. Schematic diagram of the HIST device and diagnostics.

3. Experimental Results

Figure 2 displays (a) temporal behavior of contour plots of the radial profile of the magnetic fluctuation, (b) short-time Fourier transforms spectra at *R*=0.075 m, *R*=0.25 m and *R*=0.3 m on the midplane. We have found that the magnetic fluctuation propagates from the open flux column (OFC) region toward to the core region. Here, the separatrix locates in *R*~0.15 m. Fluctuation frequency of 80 kHz can be seen in the both regions. In the core region only, however, the fluctuations with 20-40 kHz become dominant. There is a good correlation between the magnetic field and the flow velocity fluctuation at 80 kHz. Therefore, this may suggest that the magnetic fields fluctuation with 80 kHz contributes to generate the dynamo electric field.



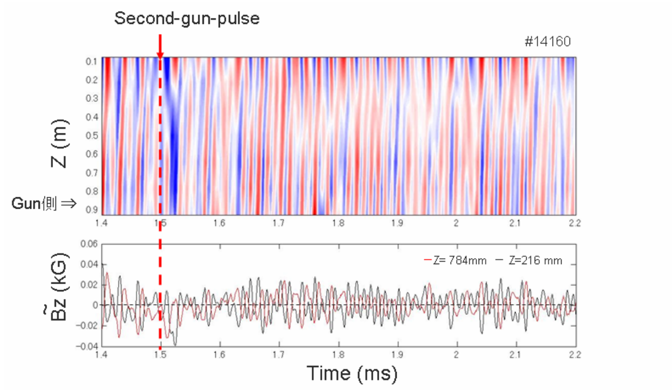
(a)



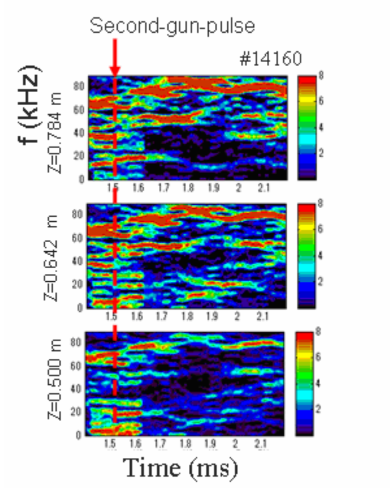
(b)

Fig.2. (a) Time evolution of radial profile of the magnetic fluctuation amplitude observed on the midplane, (b) FFT analysis at each radial position.

Figure 3 shows (a) temporal behavior of the magnetic fluctuation in the axial direction, (b) FFT spectra at *z*=0.5 m, *z*=0.642 m and *z*=0.784 m. The fluctuation with 80 kHz is clearly excited by the second CHI pulse all over three axial locations. Magnetic fluctuation propagates from the gun to FC. Fluctuation velocity is identified to be Alfven velocity as shown by Fig. 4.



(a)



(b)

Fig.3. (a) Time evolution of axial profile of the magnetic fluctuation amplitude observed at the inboard, (b) FFT analysis at each axial position.

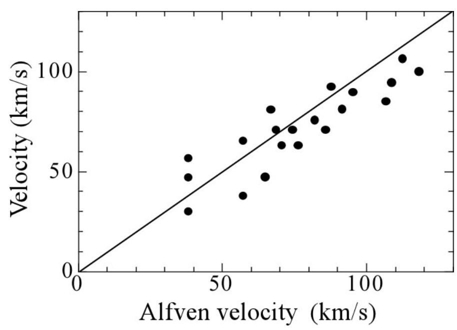


Fig.4. Propagation velocity versus Alfven velocity

3. Summary

The propagation of magnetic fluctuations with 80 kHz suggests that helicity may be transported from the plasma gun source to the closed flux surfaces through the OFC.