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外部トロイダル磁場を変化させた合体球状トーラスプラズマの生成と緩和に関する実験的研究

Experimental Studies of Formation and Relaxation of Merging Spherical Torus Plasma with Varied External Toroidal Magnetic Field

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Introduction

Past research in TS-3 showed that ST plasma became stabilized when Itfc is increased from zero to the high-q regime[1]. Results from HIST also confirmed this[2]. However, TS-4 experiments showed that plasma became violently unstable at Itfc in the low-q regime[3]. The phenomenon in TS-4 was attributed to q=1 instability, while the stabilization in TS-3 and HIST was attributed to n=1 mode suppression, so the truth is not clear. In this research, we re-investigatie plasma equilibrium and stability by scanning Itfc on the new TS-6 device. The detailed goals of this research are:

A) Modify TS-6 device to enable experiment at low-q.

B) Build a new magnetic probe array system that measures Bz and Bt components in the 2d r-z plane.

C) Conduct Itfc scan experiment using the TS-6 device and clarify its effect on plasma stability.

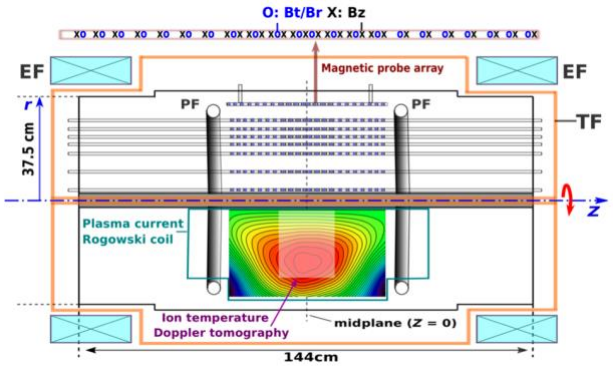

Fig. 1: The TS-6 device and the 2d magnetic probe array.

Experimental Setup

TS-6 is a ST/CT device with aspect ratio ~1.5, capable of formation and merging of two torus plasma. Low-q discharge is enabled by inserting 4 pairs of electrodes sandwiching PF coils on both sides. The electrodes provide toroidal flux injection independent of external toroidal field. The main diagnostic is the 2d pickup coil array. The array for Bz measurement consists of 8x29=232 channels. The array for Bt measurement consists 8x22=176 channels. The coils are 5mm in size, and their spacing ~10mm, which is comparable to ion larmour radius (H), and smaller than ion skin depth (20-50mm) and ion mean free path (10-30 mm). L/R ~5us for Bz and ~2us for Bt coils. The coils are mounted on a 3d printed probe holder for better spatial precision. The TS-6 device and the probe array are shown in Fig. 1.

Results and Discussion

Fig. 2 shows the 2d poloidal flux contour and Bt colormap before and after merging of low-q STs, which indicates successful formation of low-q ST.

The left of Fig. 3 shows that the plasma decay time increases slowly with Itfc, which agrees with the results of TS-3 and HIST. As shown in the right of Fig. 2, q at magnetic axis q0 is < 1 for the low-q case at peak current, but the growth rate of low-n mode might be too slow to be significant. Toroidal mode measurement is necessary to fully interpreting the result. The abnormal results of TS-4 may be due to flux-core plasma formation, and it needs to be tested in the future.

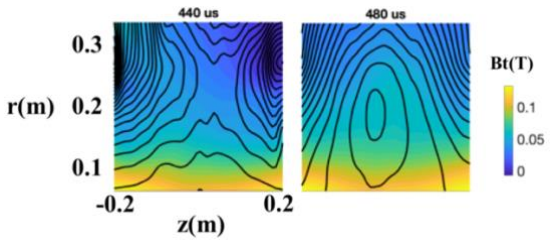

Fig. 2: 2d profile of Psi and Bt. Contour spacing is 0.5mWb.

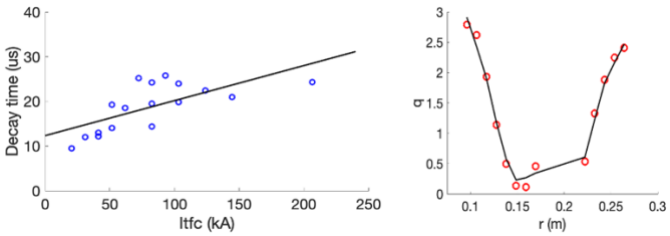

Fig. 3: Left: Itfc scan of decay time. Right: q profile of low-q ST at peak current (Itfc=40kA, Ip=50kA).

Reference

[1] A. Morita, *et al.*, Phys. Plasma 4, 315 (1997)
[2] M. Nagata, *et al.*, Phys. Plasma 10, 2932 (2003)
[3] M. Tsuruda, *et al.*, IEEJ TFM 124(2) 209-216(2004)