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RELAXにおける低アスペクト比RFPの緩和現象

MHD relaxation phenomena in low-aspect-ratio RFP in RELAX

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The reversed field pinch (RFP) is one of the toroidal magnetic confinement systems for high-beta plasmas. Recent RFP research has developed the single helical (SH) RFP scenario which allows only a single dominant mode to grow to recover nested flux surfaces. In this paper we will discuss the SH RFP states in RELAX with relaxation model predictions.

The Taylor's relaxation model predicts that when the pinch parameter Θ exceeds a critical value, the minimum energy state transit from axisymmetric to a mixture of axisymmetric and m=1 helical states, where Θ ($=B_{pa}/\langle B_t \rangle$) is the ratio of the edge poloidal field to the average toroidal field. However, the predicted state has the opposite helicity (sign of the toroidal mode number) to experimental observations. In order to resolve this difficulty, the two-region (TR) relaxation model [1] has been proposed, and it is shown that when the TR model is combined with the Single Helical (SH) relaxation model by Bhattacharjee et al. [2], some of the characteristics of SH RFP states in (Θ, F) space can be reproduced, where the reversal parameter F ($=B_{ta}/\langle B_t \rangle$) is the ratio of edge to average toroidal field.

Results of somewhat statistical analysis are summarized in Fig.1. In shallow reversal region the dominant mode is n=4, while in deep reversal regime n=5 or n=6 can become dominant. The SH RFP states in RELAX are relatively short-lived, probably due to the low values of the Lundquist number S of ~10^4, which is lower than those in MST or RFX-mod by a factor 10^3 - 10^4. The dominant higher modes decreases as the persistence threshold is increased, indicating that the most robust mode is n=4.

Figure 2 shows the comparison of the model prediction and experimental data of SH RFP states in (Θ, F) space. We will discuss the model and its predictive capabilities in detail.

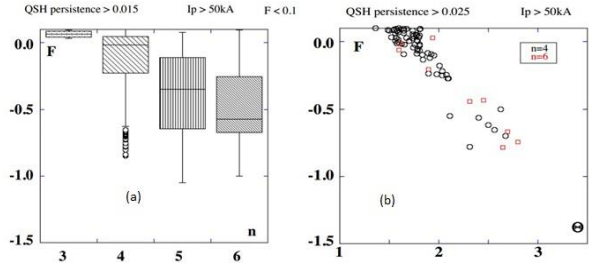

Fig.1. Statistical characteristics of SH RFP states in RELAX. Dominant toroidal mode number n at different F values. Each box encloses 50% of the data with the median value (line).

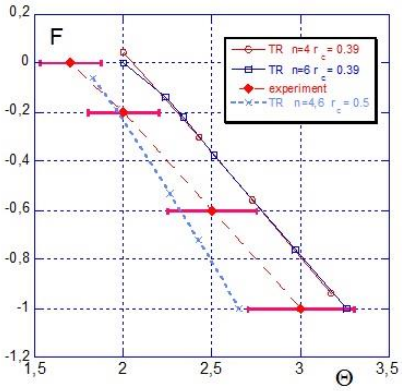

Fig.2. Comparison of the model prediction and experimental data in (Θ, F) space. Experimental fit with error bars (red long dashed), TR model with r_c=0.4 (circles and squares), TR model with r_c=0.5 (light blue short dashed).

References

[1] R. Paccagnella, S. Masamune, A. Sanpei, Phys. Plasmas 25, 072507 (2018) and references therein.
[2] A. Bhattacharjee, et al., Phys. Rev. Lett. 45, 347 (1980).