Contribution ID: **491** Type: **Poster**

TH/P3-26: Numerical Modeling of Formation of Helical Structures in Reversed-Field-Pinch Plasma

Wednesday, 10 October 2012 08:30 (4 hours)

A unique control method which makes use of the self-concentrating nature of the plasma perturbations into a small number of modes has been proposed both experimentally and theoretically in the reversed-field-pinch(RFP) to avoid the degradation of confinement due to the chaotizing of the field lines in the core region. Several types of such states termed QSH or SHAx have been observed. In this study nonlinear 3D MHD simulations have been executed for the low-aspect-ratio RFP plasma to reveal the physical mechanism of the formation processes of such helical structures. Time development of the MHD plasma is solved explicitly in a cylindrical full-toroidal geometry with finite difference grids by using the MIPS code. The initial conditions are the reconstructed equilibria obtained by the RELAXFit code which roughly follow the experimental data of the RELAX machine. Two cases, where the q=1/4 rational surface does(Case 1) and does not(Case 2) exist, are examined. Under the condition of finite resistivity, the n=4 component dominates the growth compared to the other modes for both cases. For the Case 2, the system undergoes relaxations twice before reaching to the dissipative phase. At the relaxed state, a helically twisted structure with a dominant n=4 component is formed clearly. It should be noted that such an n=4 structure is also formed for the Case 1. The poloidal pressure profile gradually deforms into a highly hollow bean-shaped structure for both of the cases. The formation mechanism of the hollow structure is different between the two cases. For Case 1, the resonant m/n=1/4 mode grows with a large single magnetic island, showing a typical behavior of the tearing modes. The original magnetic axis shrinks gradually, whereas the created O-point of the island forms a new magnetic axis. Such a mechanism has been conventionally proposed for the model of the QSH or SHAx states. On the other hand, for Case 2, the original nested surfaces are directly deformed into a helical one by the non-resonant mode. Then, for both of the cases, the core pressure flows out along the deformed magnetic field lines, probably through a magnetic reconnection between the core and the bean-shaped surface region. Such a transient concentration to the n=4 mode is comparable to the experiment.

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Session Classification: Poster: P3

Track Classification: THS - Magnetic Confinement Theory and Modelling: Stability