Contribution ID: **383** Type: **Poster**

Measuring and extending vertical stabilization controllability of KSTAR

Wednesday 19 October 2016 14:00 (4h 45m)

The paper summarizes a series of multi-year experimental activities done under the ITPA MHD stability TG from year 2012 to year 2015. The relevant activity, MDC-18, addresses many axisymmetric control issues needing resolution for ITER, which include 1) fundamental controllability of axisymmetric equilibria and relevant metrics, 2) effect of noise in the principal diagnostics and 3) evaluate candidates of control algorithms/approach in operating devices. As the first step, a series of dedicated "release-and-catch"experiments are performed at KSTAR to measure the principal metrics for vertical stability –the stability margin and the maximum controllable vertical displacement ΔZMAX. The dynamics of the vertical movement is measured and analyzed by magnetic reconstructions, validations against the non-magnetic diagnostics, and an axisymmetric plasma response model which can simulate the experimental results in the appropriate time resolution. Through the year-by-year experiments, the effect of the outboard passive stabilizer structure changes on the VS characteristics has been quantitatively recorded.
Based on the plasma response model obtained in the experiment, relevant experimental approaches are described for extending controllability of the vertical stability feedback controls. The present scheme is briefly described and analyzed first. Effects of new diagnostics design are also analyzed, with real experimental demonstration. Finally, results of a new control approach using decoupling in the frequency domain are introduced, in order to reduce competition between the "fast"feedback for vertical displacement of the plasma center and the "slow"feedback for the boundary control. The decoupling method has been demonstrated in a full shape as a prerequisite for the ITER similar shape (ISS) development research.

Paper Number

EX/P4-12

Country or International Organization

Republic of Korea

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Session Classification: Poster 4

Track Classification: EXW - Magnetic Confinement Experiments: Wave–plasma interactions; current drive; heating; energetic particles