Exploration of RMP ELM control on ITER similar shape (ISS) in KSTAR

Sang-hee Hahn¹, Y. In², N.W. Eidietis³, J.W. Juhn¹, J. Kang¹, M. Kim¹, W.H. Ko¹, J. K. Lee⁴, M.W. Lee¹, Y. H. Lee¹, G.W. Shin¹, J. Barr³, M.L. Walker³, D.A. Humphreys³

¹Korea Institute of Fusion Energy (KFE), Daejeon, Korea | ²UNIST, Korea | ³General Atomics, USA | ⁴UST, Korea

hahn76@kfe.re.kr

ABSTRACT

• Recent control advances at KSTAR enabled us to not only sustain the ITER-similar shape (ISS) in a stationary manner but also experimentally demonstrate the ISS-compatible RMP-ELM control in KSTAR for the first time, using the n=2, +90 deg phasing RMP.

BACKGROUND

• the estimated heatload by a single edge localized mode (ELM) burst may endanger machine safety of ITER: The RMP-ELM control, introduced first in [1], is anticipated to resolve the issue.
• RMP-ELM control has strong shape dependence; KSTAR has developed various method for this topic [2-4], but all for “standard” shape (high-$\delta$=0.6-0.8) - requires a dedicated test of RMP-ELM control to the ITER reference geometry, which has been challenging for KSTAR.

CHALLENGES / METHODS / IMPLEMENTATION

Challenge for achieving ITER relevant parameters in KSTAR
- low q95=3.1-3.4 requirement is prone to face n=1 mode-locking
- the independent control of up/down asymmetric triangularities with constraints by a large portion of up/down symmetric central solenoid (CS)

Access to ISS
Advanced magnetic controllers are integrated for the goal, including
- enhanced vertical stabilization [5] decoupled from shape control
- a MIMO X-point controller for X-point position, more suitable to KSTAR
- real-time feedforward algorithm [6] for minimizing integral gain errors
- in-vessel radial coils (IRC) to compensate radial movements by huge ELM bursts

OUTCOME: RMP-ELM suppression in ISS

n=2, +90deg phasing RMP used for avoiding low-q95 mode-locking.

Investigate

• density: suppression at mid-range $n_e=5\times10^{19}$ m$^{-3}$, strong mitigation at high density $n_e=7\times10^{19}$ m$^{-3}$
• Strength of RMP current: suppression observed at 2.5~2.9 kA/turn

• other remarks:
  - n=1 RMP application led to immediate disruptions
  - locking threshold (3.1-3.3 kA/t) is very close to the effective range
  - Accompanied by global density pumpout & Ip drop, similar as the “standard” n=2 RMP experiment with $q_{95}=3.3-3.6$

CONCLUSION

• A special plasma target reflecting ITER shape, for exploration of RMP-ELM control, is developed in KSTAR at experimentally accessible range
• The observed ELM responses at the ISS by n=2 RMP shows similar characteristics of the typical RMP-ELM suppression found at KSTAR using the KSTAR standard shape
• The RMP-ELM control has strong dependency on the plasma density

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Part of the data analysis was performed using the OMFIT integrated modeling framework [7]

References