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Enhanced understanding of the MHD dynamics and ELM control experiments in KSTAR

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In KSTAR, H-mode discharges have been achieved reliably at toroidal fields from 1.4 to 3.5 T with a heating power of $\sim$ 5 MW. Using real-time plasma shape control [1] the flattop time in H-mode has been extended to over $\sim$ 16 s at 600 kA in the 2012 campaign and the extended plasma operation boundary has surpassed the $n = 1$ no-wall limit with β_N/l_i up to 4.1. In order to achieve a high beta steady state operation in KSTAR, establishment of predictive MHD simulation and first-principle-based control of the harmful MHD are the first steps. Visualization of MHD dynamics via a 2-D Electron Cyclotron Emission Imaging (ECEI) [2] has significantly enhanced the level of understanding of the MHD dynamics. Following the first 2-D ELM measurements in H-mode plasmas [3] in KSTAR the measured 2-D ELM images were compared with synthetic images [4] from the BOUT++ code. The physics of ELMs is characterized based on a wide range of measured mode numbers (n, m) local magnetic shear and pressure gradients. The observed ELM dynamics during control experiments have been enlightening and consistent with the stability models. Near the $q \sim 2$ surface, the island width and Δ' of the $m = 2$ tearing mode have been verified through the modified Rutherford model based on the 2-D images. With the aid of a second (toroidally separated) ECEI system installed in the 2012 KSTAR campaign, a 3-D reconstruction of the MHD instabilities has allowed further validation of the computed magnetic field pitch angles, rotation speeds, and toroidal asymmetries of the MHDs Work supported by NRF of Korea under contract No. 20120005920 and the U.S. DoE under contract No. DE-FG-02-99ER54531

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