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Investigation of MHD Instabilities and Active Mode Control Supporting Disruption Avoidance on KSTAR

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H-mode plasma operation in KSTAR has surpassed the n = 1 ideal MHD no-wall beta limit, $\beta_N^{\text{no-wall}}$, computed to occur at normalized beta, β_N = 2.5 when the plasma internal inductance, l_i = 0.7 [1]. Figure 1 shows the achieved β_N and l_i values in the recent device operations. High β_N operation was extended to longer pulse resulting in β_N of 3.3 sustained for 3 s, limited by resistive tearing mode instabilities rather than global kink/ballooning or resistive wall modes (RWMs) [2]. High fidelity kinetic equilibrium reconstructions have been developed to support steady-state, high confinement operation in KSTAR. The present kinetic equilibrium reconstructions include Thomson scattering and charge exchange spectroscopy data, and allowance for fast particle pressure

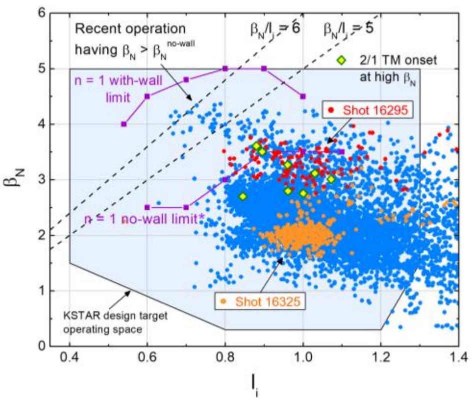

Figure 1. The KSTAR equilibrium operating space and ideal stability limits in (l_i, β_N) space.

following an approach used successfully in NSTX [3]. In addition, up to 25 channels of motional Stark effect data are used to produce reliable evaluation of the safety factor, q, profile. The reconstructed high performance equilibria can exhibit significant variation of the reconstructed q-profile dependent upon the broadness of the bootstrap current profile as computed by TRANSP analysis. Figure 2(a) shows the non-inductive current density profiles in the high $\beta_N > 3$ plasma that has a broad bootstrap current profile with a total non-inductive current fraction of 67%.

The ideal and resistive stability of these plasmas is examined by using different physics models. The stability of the observed m/n = 2/1 tearing mode that limited the high β_N operation is computed by using the resistive DCON code [4] and by the M3D-C[1] code with the kinetic EFIT reconstructions as input. For equilibria at high $\beta_N >$ 3, the tearing stability index, Δ', at the q = 2 surface is more unstable compared to that of equilibria at reduced β_N (FIG. 2(b)), indicating that stabilizing neoclassical

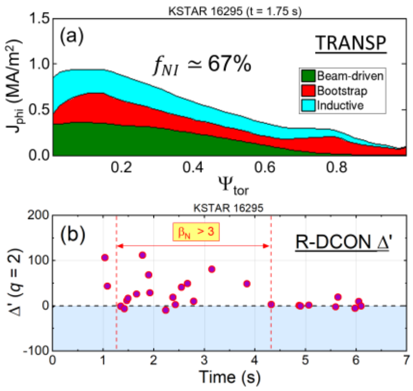

Figure 2. For high β_N plasma, (a) non-inductive current profiles from TRANSP and (b) resistive DCON computed Δ'.

components of tearing stability may need to be invoked to produce consistency with experiment. MISK code [5] analysis which examines global MHD stability modified by kinetic effects shows significant passive kinetic stabilization of the RWM.

In preparation for plasma operation at higher beta utilizing the second NBI system now being installed, three sets of magnetic field sensors will be used for RWM active feedback control. To accurately determine the dominant n-component produced by unstable RWMs, an algorithm has been developed that includes magnetic sensor compensation of the prompt applied field and the field from the induced current on the passive conductors. This real-time compensation of the RWM sensors is being implemented in the KSTAR plasma control system. Developed mode identification using the compensated magnetic measurements well measures the toroidal phase of a slowing rotating n = 1 MHD mode. This analysis on stability, transport, and control provides the required foundation for disruption prediction and avoidance research on KSTAR.

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