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Stability, Transport, and Active MHD Mode Control Analysis of KSTAR High Performance Plasmas Supporting Disruption Avoidance

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H-mode plasma operation in KSTAR has surpassed the n = 1 ideal MHD no-wall beta limit computed to occur at beta_N = 2.5 with l_i = 0.7. High beta_N operation produced beta_N of 3.3 sustained for 3 s, limited by tearing instabilities rather than resistive wall modes (RWMs). High fidelity kinetic equilibrium reconstructions have been developed to include Thomson scattering and charge exchange spectroscopy data, and allowance for fast particle pressure following an approach used in NSTX. In addition, motional Stark effect data are used to produce reliable evaluation of the safety factor, q, profile. The reconstructed equilibria can exhibit significant variation of the q-profile dependent upon the broadness of the bootstrap current profile as computed by TRANSP analysis. Correlations of these differences with observed MHD instabilities are examined to determine favored scenarios for instability avoidance. TRANSP analysis indicates that the non-inductive current fraction has exceeded 50%, and can reach up to 75% while its profile can vary significantly. The stability of the m/n = 2/1 tearing mode that limited the high beta_N operation is computed by using the resistive DCON code and by the M3D-C1 code with the kinetic EFIT as input. For equilibria at high beta_N > 3, the tearing stability index, Delta′, is more unstable compared to that of equilibria at reduced beta_N, indicating that the neoclassical components of tearing stability need to be invoked to produce consistency with experiment. MISK code 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 new second NBI system, three sets of magnetic field sensors will be used for RWM feedback control. To accurately determine the dominant n-component produced by 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. Developed mode identification using the compensated magnetic signals well measures the toroidal phase of a slowly rotating n = 1 MHD mode. This analysis on stability, transport, and control provides the required foundation for disruption prediction and avoidance research on KSTAR. *Supported by US DOE Grant DE-FG02-99ER54524 and DE-SC0016614

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