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Investigation of MHD Stability in KSTAR High Normalized Beta Plasmas

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H-mode plasma operation in KSTAR reached high normalized beta, beta_N, up to 4.3 with reduced plasma internal inductance, l_i, to near 0.7. This significantly surpassed the computed n = 1 ideal no-wall beta_N limit by a factor of 1.6. The high beta_N above 4 has been achieved in discharges having lowered B_T in the range 0.9-1.3 T with plasma current of 0.35-0.43 MA. The l_i was maintained at low values which resulted in high ratios of beta_N/l_i up to 6.3. Pulse lengths at maximum beta_N were initially limited by a loss of equilibrium radial control but were extended to longer pulses in 2015 by new, more rapid control resulting in beta_N greater than 3 sustained for ~1 s. A significant conclusion of the analysis of these plasmas having beta_N > beta_N^no-wall is that low-n global kink/ballooning or RWMs were not detected, and therefore were not that cause of the plasma termination. Kinetic modification of the ideal MHD n = 1 stability criterion, computed by the MISK code, has been used to analyze kinetic RWM stability in the achieved high beta_N equilibria with measured density, temperature and rotation profiles. This first examination of kinetic RWM stability for experimental KSTAR equilibria shows the kinetic RWM to be stable, which is consistent with the observation. The analysis is under active development and will soon examine reconstructed equilibria that include internal profile measurements. A m/n = 2/1 tearing mode onsets at the achieved high beta_N > 3 and experimentally reduces beta_N by more than 30%. The stability of the observed 2/1 tearing mode at high beta_N is examined by using the M3D-C^1 code solving the linearized single fluid, resistive MHD equations coupled with the EFIT reconstruction. The linear stability calculation shows a stable 2/1 mode while the equilibrium is experimentally unstable to the 2/1 mode. The mode eigenfunction shows a clear tearing parity at q = 2 but the mode growth rates are negative. The negative linear growth rate implies that the mode is classically stable, and the pressure driven neoclassical terms dominate over the current gradient term in the target equilibrium expected to have a non-negligible bootstrap current. Further calculations including the pressure driven terms and toroidal rotation effect are presently underway to better understand tearing stability with near steady-state plasma profiles.

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