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ROLE OF MAGNETIC SHEAR ON THE CORE MHD INSTABILITIES (1/1 KINK AND HIGH ORDER TEARING MODES) IN THE TOKAMAK PLASMAS

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The long-standing problem of the central safety factor (q_0) and its shear during sawtooth oscillation [1] has been revisited in KSTAR with the recent progress of the advanced diagnostics systems. The magneto-hydro-dynamic (MHD) condition of the current driven 1/1 kink instability could be universal in tokamaks as well as the current carrying flux ropes in solar flare [2]. In tokamak plasmas, the originally proposed "full reconnection model" [3], in which the q_0 has to be below ~1.0 before the sawtooth crash and above ~1.0 after the crash, was abandoned as the experimental measurement of q_0 was never above ~1.0 [4,5]. Then new Motional Stark Effect (MSE) measurements [6, 7] merged that the full reconnection model may be correct with the value close to ~1.0 with a similar small relative variation but uncertainty of the measurement discarded these measurements for a long time. The MSE system with a great accuracy on KSTAR measured q_0 value revisited this measurement and the value was ~1.0±0.03. Indeed the improved measurement confirmed that the previous MSE measurements were correct. (i.e, the measured q_0 is close to ~1.0 not ~0.08. Since the measured median

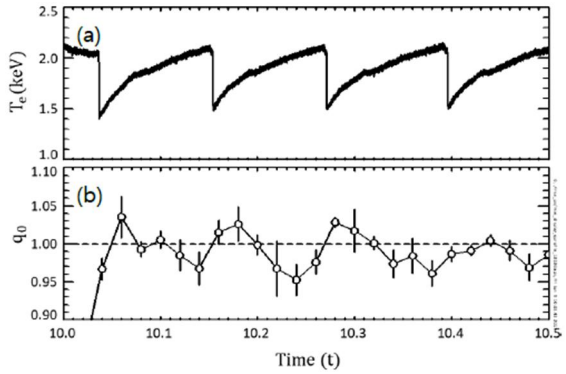

Figure 1. An example of the time evolution of (a) the central electron temperature and (b) q_0 in a sawtoothing discharge [shot #18186].

value is close to ~1.0 with the system error of ~0.05 and the relative variation of the central q_0 is small (0.05 peak to peak during the oscillation), it is not possible to validate the model without a supplementary experiment that is sensitive to the central q_0 and its magnetic shear. There are a couple of instabilities that are known to be sensitive to the magnetic shear and they are high order tearing modes [8] and Alfven waves [9] in the core of the plasmas. In this experiment, a high order tearing modes were excited using a current blip by ECH/ECCD system on KSTAR. In parallel with the experiment, the reduced resistive MHD code, M3DC1 [10] was used to validate the measured 2-D images of excited modes by ECEI system in the MHD quiescent time right after the crash of the sawtooth. The agreement between the predicted model and measured high order modes were excellent and the results are recently published in Reference [11]. The static and temporal behaviors of the excited m=2, m=3 modes that are extremely sensitive to the background q_0 and core magnetic shear definitively validated the "full reconnection model". The radial position of the excited modes right after the crash and time evolution into the 1/1 kink mode before the crash in a sawtoothing plasma suggests that $q0 \geq 1.0$ in the MHD quiescent period after the crash and $q0 < 1.0$ before the crash. Additional measurement of the long lived m=3, m=5 modes in a non-sawtoothing discharge (presumably $q0 \geq 1.0$) further validates the "full reconnection model."

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