A New View of Internal Kink Modes and Their Relation to the Sawtooth Instability*

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Understanding the physics of sawteeth is crucial for avoiding large sawtooth crashes in tokamaks. Analyses of equilibria reconstructed through consecutive cycles of the ramp and crash phases of DIII-D sawtooth experiments have shed new light on the interplay of the underlying ideal MHD instabilities, the cross section, and the profiles, and a consistent picture is emerging. The discharges comprised two low beta oval and bean shaped discharges and a single null ICRF heated discharge, chosen since they have very different sawtooth characteristics. The crash in the bean is fast and violent but the oval is slow with negligible energy loss. The ICRF discharge exhibited giant sawteeth. The aim is to understand the different characteristics through analysis of both the crash and ramp phases since they are inextricably linked through the triggering mode - the onset from the linear threshold and the crash by the nonlinear consequences. The results are surprising in view of the conventional sawtooth picture. The underlying ideal mode can have characteristics more like the quasi-interchange mode and this leads to the qualitatively different crash features observed experimentally. Also, the ideal stability does not necessarily degrade during the ramp as q0 decreases; the sawtooth is generally triggered by weakening of the kinetic stabilization. MHD relaxation events observed during the ramp are found to be associated with a nonmonotonic q profile near unity and an underlying quasi-interchange mode, with apparent reconnection at the inner q=1 surface. The crash onset itself is described qualitatively by a Porcelli-like model and the return to q~1 by full reconnection. However, if the model is to be a quantitative predictor of the crash onset, it will require plausible but specific adjustments to some key terms and coefficients.

*Supported by US DOE under DE-FG03-95ER54309.