DPP06-2006-000814

Abstract for an Invited Paper
for the DPP06 Meeting of
the American Physical Society

Sawtooth Behavior in Bean and Oval Shapes[1]

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Experiments and modeling of sawtoothing plasmas on DIII-D show that plasma shape has a severe effect on core transport, leading to significant differences in sawtooth behavior. We compare discharges with different cross-sectional shapes: an indented bean shape and a low-triangularity oval. Results in the two shapes are quite different. The oval has a small electron but a large ion sawtooth with very small changes in safety factor at the crash. The bean has a large electron and somewhat smaller ion sawtooth with a large change in safety factor at the crash. In both cases, the axial safety factor is found to be near unity following the crash. The two shapes are designed so that the Mercier instability threshold is reached when the axial safety factor is below unity for the bean and above unity for the oval cross-sections. This allows the role of interchange modes to be differentiated from that of the kink-tearing mode. A feature of the experiment is that the two shapes can be alternated in successive plasmas, minimizing the effect of systematic errors. T_e, T_i, and B_θ profiles are resolved to 5, 160, and 500 μs respectively. The differences in the nature of the sawtooth oscillations in the bean and oval discharges are determined primarily by extreme differences in the electron heat transport during the reheat. Although the electron transport rate is effectively infinite in the oval, the ion confinement is excellent, near neoclassical. By contrast, in the bean the electron transport rate is low. Modeling the sawtooth evolution with TRANSP, the current evolution during the ramp is found to be neoclassical; the very different results arise from the very different T_e profiles through the plasma resistivity. The bean and oval collapses are internal kink and quasi-interchange respectively.

[1]Supported by US DOE under DE-FC02-04ER54698 and DE-AC05-00OR22725.