Sawtooth control using beam ions accelerated by fast waves in the DIII-D tokamak

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Abstract. The accuracy of the Porcelli sawtooth model is evaluated using realistic numerical calculations for a DIII-D [J. L. Luxon, Nuclear Fusion 42 614 (2002)] experiment with neutral beam injection and fast wave heating. Simulation results confirm that beam ions accelerated by the fast waves play a crucial role in delaying the normal sawtooth crash and inducing giant sawteeth with large amplitude and long period. A single giant sawtooth period was analyzed in detail in an effort to evaluate the efficacy of the Porcelli model in quantitatively predicting a particular sawtooth crash by evaluating the model through the sawtooth period using equilibria reconstructed from the discharge data. The kinetic stabilizing contribution of fast trapped ions is found to depend strongly on both the experimentally reconstructed magnetic shear at the $q=1$ surface (s_1) and the calculated poloidal beta of trapped beam ions inside the $q=1$ surface. To within estimates of the error from the equilibrium reconstructions and the simulation fast ion particle statistics, the results are consistent with the observed sawtooth crash. The calculations indicate that the sawtooth crash is ultimately triggered by the resistive kink in the ion kinetic regime after the stabilizing contribution from the fast ions is reduced due to an increase in s_1 as the discharge evolves.

Keywords: Energetic ions, Fast wave heating, Sawtooth stabilization

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