Modeling of sawtooth-induced fast particle redistribution in NSTX-U

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The effects of sawtooth on fast ion transport have been studied in L-mode sawtoothing discharges during the 2016 experimental campaign on National Spherical Torus Experiment Upgrade (NSTX-U) [1]. Experimental observations show that passing particles are strongly redistributed from the plasma core to the edge, while trapped particles are weakly affected by sawteeth [2]. TRANSP [3] simulations using the implemented standard sawtooth models can reproduce the experimental neutron rate drops with a proper parameter set. However, since the different effect of sawtooth crash on fast ions with different orbit type and energy is not taken into account in the sawtooth model, detailed simulation results do not agree with the experimental measurement. Therefore a more comprehensive and improved model for quantitative simulations needs to be developed including the characteristics of fast ion so that more reliable interpretation of sawtoothing discharges can be possible. As a first step of the development of the improved sawtooth model, simulations using the ORBIT code [4] have been carried out [5]. The simulation results confirm the experimental observation that fast ions are redistributed by sawtooth crash based on their orbit type and energy. In real space, due to a sawtooth crash passing particles in the core region are expelled and move outside the q=1 surface while a sawtooth crash does not have significant effects on trapped particles. The initial TRANSP simulation using the kick model [6] based on the ORBIT modeling result shows improvement of fast ion redistribution before and after a sawtooth crash but more simulations are required as the neutron rate still has discrepancy compared to the experimental measurement.

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