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Observation of Multiple Helicity Mode-Resonant Locking Leading to a Disruption on DIII-D

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Experimental evidence of the formation of multiple helicity island chains during the mode locking phase preceding plasma disruption is providing a clear picture for the understanding of locked-mode triggered disruptions. This emerging picture uses measurements from a new dual soft x-ray (SXR) tangential imaging system that measures localized internal perturbations in combination with local temperature profile flattening. In mode locking experiments with low-beta (β_N~0.5), inner-wall limited L-mode discharges, a low-order rational surface (2/1) locks and reduces the plasma rotation across the edge region allowing higher order island chains (3/1, 4/1) to form. These signatures are measured by SXR imaging that show the presence of resonant perturbations that have been reproduced consistently with synthetic modeling and local temperature flattening measured by Thomson scattering. The edge 4/1 island cools rapidly by extending into the boundary region. On a slower time scale over 300ms, both the 2/1 and 3/1 islands widen. This growth leads to eventual island overlap and enhanced stochastic transport that allows a cold boundary region or cold pulse to penetrate into the core resulting in a rapid loss in thermal energy and plasma collapse. The observed growth of multiple island chains and evolution of edge cooling are successfully reproduced by a non-linear simulation (TM1 code) using a single fluid model without radiation effects. In this picture, the formation and slow widening of multiple helicity island chains leads to a locked mode disruption.

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