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ELMs onset triggered by mode coupling near rational surfaces in the pedestal

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Investigations of pedestal evolution between edge-localized-modes (ELMs) in DIII-D provide strong evidence that coupling of modes located near rational surfaces close to the separatrix leads to the onset of an ELM. While the peeling ballooning model is the leading candidate for the ELM phenomenology, the triggering mechanism is not yet understood and remains one of the most outstanding challenges of both theoretical and experimental fusion science. In this work, the physical mechanism of the triggering of ELMs is studied on the DIII-D tokamak. We extract the dynamics of the most dominant modes localized in the pedestal during multiple inter-ELM periods. We observe a transition from a regime dominated at the beginning of the inter-ELM period by a single mode located near q=5 towards a more balanced organization between this mode and two secondary modes located near the q=6 surface just before the ELM onset. This redistribution suggests a transfer of energy which provides strong evidence that these secondary modes are triggering the ELM onset, because they are strongly coupled to the region extending to the separatrix. The radial expansion to the separatrix provides a channel for the expulsion of energy and particle, which is the ELM. The locality of these modes is determined through the spatial coupling between j_(||) and δn_e. While pedestal width growth has long been the leading explanation of the ELM onset, the results presented describe a different mechanism for ELM onset. In our explanation, the pedestal temperature and density gradients are clamped over multiple transport time scales and it is posited that the inter ELM fluctuations play a key role in the ELM onset. As shown above, the onset results from modes coupling between the q=5 & q=6 rational surfaces during the ELM cycle. We propose that such coupling opens up a channel from the pedestal top to the separatrix through which the energy to trigger the ELM is released. This work was performed under US DoE contract DE-AC02-09CH11466, DE-FC02-04ER5469, DE-FG02-08ER54984 and DE-FC02-04ER54698.

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