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Physics of thermal transport and increased electron temperature turbulence in the edge pedestal of ELM-free, H-mode regimes on DIII-D[1]

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It has been observed, for the first time, that suppression of Edge Localized Modes (ELMs) in tokamak plasmas is accompanied by an increase in electron temperature turbulence. A correlation electron cyclotron emission technique has been utilized to quantify the observed increase: 40% increase in Quiescent H-mode (QH-mode) and 70% increase in 3D field ELM suppressed H-mode. Since reliable ELM-free H-mode operation is essential for future burning plasma experiments, it is crucial to develop a validated predictive capability for these plasmas. Linear stability analysis using TGLF has provided an explanation for the observations and has indicated that the underlying physical mechanisms are different in the two regimes. In QH-mode, profile gradients and the associated linear growth rate are decreased compared to ELMing H-mode. However, the ExB shearing rate is reduced by an even greater factor such that turbulent transport is no longer suppressed by flow shear. In contrast, during 3D field ELM suppressed H-mode, gradients are increased and TGLF predicts that a large increase in linear growth rate is primarily responsible for the increased turbulence. Power balance analysis using ONETWO is also consistent with the changes in electron thermal transport being due to the increased turbulence. These new findings are significant since they i) provide a physics explanation of these changes via TGLF analysis and enable validation of the model in the key pedestal region, and ii) support the hypothesis that turbulent transport partially replaces ELM-dominated transport during ELM-free operation. These results form a basis to develop a predictive understanding of pedestal regulation in ELM suppressed regimes.

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