Non-linear gyro-kinetic modeling of the I-mode pedestal on DIII-D*

A. Marinoni[1], J.C. Rost[1], M. Porkolab[1], E.M. Davis[1], A.E. Hubbard[1], A.E. White[1], D.G. Whyte[1], K.H. Burrell[2], T.H. Osborne[2] and the DIII-D Team

[1]Massachusetts Institute of Technology, Cambridge, MA, USA
[2]General Atomics, PO Box 85608, San Diego, CA, USA

The I-mode regime is a relatively new scenario, observed on the Alcator C-Mod, DIII-D and Asdex-U tokamaks, where thermal and particle transport at the edge are decoupled [1]. Because it is characterized by an edge energy transport barrier without an accompanying particle barrier, and thus does not produce large ELMs that can damage plasma facing components, it is currently being considered for operations in a burning reactor.

The present work shows modeling of the I-mode phase on DIII-D, where the edge electron temperature slowly evolves towards an H-mode-like profile over several energy confinement times while maintaining a typical L-mode edge density profile, and the radial electric field at the edge gradually reaches values typically observed in H-mode. The intensity of fluctuations in this phase is observed to progressively decrease as measured by the Phase Contrast Imaging diagnostic [2].

Previous linear gyro-kinetic modeling was performed with the GS2 code and its recently upgraded model collision operator that conserves particles, energy and momentum. It was shown that, in the pedestal region, the eigenfunction of the dominant instability features multiple peaks located away from the outboard mid-plane, differing from the typical ballooned structure computed at inner radii. Furthermore, during the I-mode phase, the steady increase in the bootstrap current and flow shear generated by the evolving temperature pedestal were shown to weaken growth rates, thus possibly generating a positive feedback mechanism that progressively stabilizes turbulent fluctuations and improves the energy confinement [3].

Non-linear modeling presented in this study expands the linear work above by quantitatively estimating the impact of the two afore-mentioned stabilizing effects, as well as by further characterizing the linear modes. Threshold conditions for the decoupling of heat and particle transport are also investigated in an effort to identify key differences in the basic mechanisms that govern the I- and the H-mode transitions.

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