Non-linear interplay between edge localized infernal mode and plasma flow

G. Q. Dong,[1] Y. Q. Liu,[2,1] Y. Liu,[1] S. Wang,[1] N. Zhang,[1] G. Z. Hao,[1] and G. L. Xia[1]

[1]*Southwestern Institute of Physics, Chengdu, People's Republic of China*

[2]*General Atomics, PO Box 85608, San Diego, California 92186-5608, USA*

Quiescent H-mode (QH-mode) was first discovered in DIII-D as an ELM-free H-mode regime, which is usually achieved at relatively low plasma density and found to be accompanied by the presence of edge harmonic oscillations (EHOs). EHOs are believed to provide necessary transport to eliminate ELMs by dynamics of the plasma itself. The saturated kink-peeling mode has been suggested as a possible candidate for EHO. In this work, we consider another instability – the edge localized infernal mode (ELIM) – as a possible candidate, for plasmas where the large edge bootstrap current causes local flattening of the plasma edge safety factor, or even the magnetic shear reversal in the pedestal region. An ELIM is a low-n (n is the toroidal mode number) instability similar to the conventional infernal mode, but being localized at the plasma edge where safety factor is locally flattened. Finite plasma pressure in the pedestal region drives this mode. A saturated ELIM, due to non-linear interaction with toroidal plasma edge flow, can be responsible for EHO. A systematic numerical investigation, utilizing the free boundary MARS-F/K codes, shows that both plasma resistivity and toroidal flow shear destabilize the ELIM. The drift kinetic effects, due to mode resonance with precessional and bounce motions of trapped thermal particles, are found to be stabilizing for the mode, albeit not dramatic. We also find that the low-n ELIM instability is strongly affected by a close-fitting resistive wall. The presence of a resistive wall can fully stabilize an otherwise flow-shear destabilized ELIM. The ELIM instability, like other MHD instabilities, generates toroidal torques which in turn can affect the plasma flow. The non-linear interplay between the ELIM and the plasma flow, by running initial value simulations with the quasi-linear code MARS-Q, is investigated. We start simulations at a prescribed rotation speed. Compared to the linear runs, the quasi-linear run shows partial saturation of the mode. Meanwhile, the toroidal rotation profile especially that near the plasma edge where the mode is located, is significantly reduced, together with the local flow shear near the q=4 surface. It is this reduction of the local flow shear that leads to the eventual mode saturation in this simulation.