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Analytic characterisation of ideal infernal type instabilities in tokamaks with large edge pressure gradients

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The quiescent high confinement mode (QH-mode) tokamak regimes share with the H-mode a large edge pressure gradient and a high energy confinement time. Experimental observations in QH-mode conditions showed the appearance of low-n magnetohydrodynamic oscillations which replace the ELM activity (ELMs have n >> 1). The associated energy loads on the plasma facing components are much lower compared to regimes where ELMs are present. The appearance of these benign low-n oscillations has been linked with kink/peeling modes.

The steep edge pressure gradient in the low collisionality regime is associated with a significant bootstrap current contribution which reduces locally the magnetic shear. When the magnetic shear is allowed to become small, infernal modes can be driven unstable by an increase of the pressure gradient. These instabilities are characterised by toroidicity induced coupling between a main Fourier mode and its neighbouring sidebands. Numerical studies of low-n MHD instabilities in the QH-mode regime with a plateau in the safety factor near the edge found infernal-like features.

We focus our attention on the analytic description of low-n edge localised infernal-type instabilities with the inclusion of the equilibrium toroidal rotation and a vacuum region that separates plasma and the metallic wall (ideal or resistive).