Numerical investigations of transition to high confinement plasmas

A.H. Nielsen[1], G.S. Xu[2], J. Madsen[1], V. Naulin[1], J. Juul Rasmussen[1], B.N. Wan[2]

[1] *Association EURATOM – DTU, Dept. of Physics,*

Technical University of Denmark, Kgs. Lyngby, Denmark

[2] *Institute of Plasma Physics, Chinese Academy of Sciences*

Hefei 230031, People's Republic of China

One of the most outstanding issues in magnetic fusion research is the understanding of the transition from the Low (L-mode) to the High (H-mode) confinement regime, which ITER will rely on to achieve the goal of ignition. Although the H-mode is routinely achieved in a multitude of magnetic confinement devices since the first observation more than 30 years ago the transition still lacks full theoretical explanation and predictive modelling.

We present a numerical modelling of the L-H transition based on the first-principle fluid model HESEL (Hot Edge-Sol-Electrostatic). The model - an extension of the ESEL model - is a four-field drift-fluid model using the Braginskii closure for collisions and including generalized vorticity, density, electron and ion pressure equations. The model is solved on a 2D domain at the out-board mid-plane of a Tokamak including both open and closed field lines. The parallel dynamics is parameterized in each region accounting consistently for the parallel losses in the open field line region – the scrape of layer.

The results reveal different types of L-H-like transitions in response to ramping up the input power. For a fast rising input power we obtain a fast abrupt transition, and for a slow rising power we obtain the slow L-I-H transition, involving a so-called dithering I-mode appearing between the L- and H-mode. The L-I-H transition has been observed in several devices and investigated in great detail by applying advanced imaging systems. We have furthermore obtained a density scaling of the threshold power for the transitions.

Here we particularly focus on the L-I-H transition, where our results essentially reproduce recent experimental findings in the Experimental Advanced Superconducting Tokamak – EAST [1]. This includes the dynamics of the oscillatory I-mode, and the phase relations of the triggering events in response to the ramp up of the input power.

These results hold promises for developing a full predictive modelling of the L-H transition, which is an essential step in understanding and optimizing future fusion devices and a future fusion power reactor.

[1] G.S. Xu et al, Nuclear Fusion **54** (2014) 013007.