Enhancement of the divertor-leg instability by tilting of the divertor plate

D.D. Ryutov, R.H. Cohen

Lawrence Livermore National Laboratory
Livermore, CA, 94551

A very fast instability driven by sheath boundary conditions exists on the open field lines of fusion devices [1]. Its presence is generally not related to the sign of the field-line curvature, although it becomes somewhat faster in the case of unfavorable curvature. In the presence of the X point, potential perturbations cannot penetrate beyond the X point, because of the very strong shear present in this area [2]. A semi-quantitative way of describing this effect in terms of the effective surface resistivity attributed to a "control plane" just below the X point has recently been suggested and a fast instability driven by the sheath boundary conditions and limited to the divertor leg was predicted [3]. The importance of this instability is that it could increase cross-field transport in the divertor leg (and thereby reduce the heat load on the divertor plate) while, at the same time, have a minimum effect on the transport above the X point (and, accordingly, not lead to deterioration of core plasma confinement). We extend the analysis of Ref. 3 to include effects of finite beta and to find conditions for the strongest enhancement of the instability by radial tilting of the divertor plate [3,4]. We provide a list of experimental signatures of the instability: i) phase velocity and wave-numbers of the most unstable modes; ii) correlations between fluctuations of various parameters, including signals from the flush-mounted probes and iii) the differences between fluctuations in the common and private flux regions. This work was performed under the auspices of the U.S. Department of Energy by University of California Lawrence Livermore National Laboratory under contract # W-7405-Eng-48.

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