Plasma Instability Issues for ITER and their Possible Impact on Plasma Performance

W.A. Houlberg, D. Campbell
ITER Organization, CS 90 046, 13067 St. Paul-lez-Durance Cedex, France
E-mail contact of main author: Wayne.Houlberg@iter.org

There are many types of plasma instabilities that may affect ITER performance. Prediction of their impact, however, is complicated by scaling relative to present plasmas. Here we summarize some of the potential impacts of a variety of instabilites on ITER performance and the uncertainties in evaluating those impacts.

ELMs are one of the most significant issues because of the high localized heat loads on the plasma facing components walls caused by the filamentary structures. ITER presently plans to employ two methods to attempt to amelioriate the localized damage from large ELMS: resonant magnetic perturbations and pellet pacing. In either case, the net effect on confinement must be minimized relative to the expected confinement under natural ELMy conditions. Pacing ELMs with high frequency pellet injection raises at least two fundamental physics questions: i) how effective are very localized perturbations from the pellet cloud at triggering ELMs?, and ii) can we assure that the local perturbation does not lock the ELMs into a pattern of localized deposition? It is expected that answering these questions would require 3-D models, while present models are based on peeling-ballooning stability with 1-D models for plasma profiles.

A similar set of complicating factors can be identified for other instabilities. Alfvén eigenmodes in ITER are expected to be driven primarily by the energetic alphas, but MeV neutral beam injection of up to 33 MW raises the issue of synergistic effects (e.g., loss of NB fast ions from AEs driven by fast alphas), and non-linear interaction among a ‘sea’ of many high-n potentially unstable modes expected from ITER’s large size. Instabilities that are weakened by the strong toroidal rotation (e.g. turbulence or resistive wall modes) in present NB-heated machines may be more robust under the much weaker external torque provided by ITER’s high energy beams. A better understanding of extrinsic rotation driven largely by conditions at the plasma edge and propagated by turbulent transport processes is then critical. There are also issues of burn stability (profile dynamics) governed by internal bootstrap current and fusion heating, sawtooth stabilization by energetic particles and sawtooth triggering of NTMs through seed island generation, and avalanche generation of runaway electrons during disruptions that provide significant challenges to the theoretical understanding of instabilities and their projection to ITER conditions.