Study of tearing modes using real time control of ECRH/ECCD on TCV

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Neoclassical Tearing Modes (NTMs) are expected to significantly degrade energy confinement, and therefore fusion efficiency, of next-step Tokamak devices such as ITER. The study of the creation and suppression mechanisms for these modes is therefore essential. Tearing Modes and their Neoclassical variants are generally described in terms of the so-called Modified Rutherford Equation, which contains stabilizing and destabilizing terms due to several effects in the plasma. These terms depend on diverse plasma features such as the local safety factor (q) profile and its derivatives, local current drive, bootstrap current effects, resistive wall effects and others. The systematic study of these effects and their relative importance requires flexibility in exploring the relevant parameter space. Tokamak à Configuration Variable (TCV), with its ability to apply Electron Cyclotron Resonance Heating (ECRH) and Current Drive (ECCD) locally at different locations in the plasma, offers the opportunity to study the dependence of tearing mode stability on the local current density profiles. Cylindrical tokamak calculations show that ECCD power can have a stabilizing or destabilizing effect depending on the direction of the driven current and the deposition location with respect to the rational flux surface. Experiments are planned to investigate these effects.
In parallel, a real-time control system is under development to allow control of temperature, current and/or pressure profiles using ECRH/ECCD. Since direct measurements of the profiles are not readily available on TCV, real-time estimates of these profiles have to be obtained in an indirect way. As a first step, the X-ray emission profile, which is roughly proportional to n^2TZ_{eff}, will be controlled. In later stages, the X-ray emission profile will be combined with other measurements of density and/or temperature to obtain estimates of other profiles. Preliminary experiments have demonstrated the ability to control the peak of line-integrated X-ray emissions in feedback. This is done via digital processing of a multichannel X-ray camera connected to TCV's flexible ECH system featuring six independently steerable launchers. Profile control will aid in many aspects the TCV physics programme, such as real-time control of electron internal transport barriers (with significant bootstrap current fraction) and of the sawtooth period. Finally, as NTMs are driven by the bootstrap current profile and are often triggered by long period sawteeth, profile control will be a valuable tool in NTM studies.