Projection of Transport Barrier Physics to ITER

G.T. Hoang

Association Euratom-CEA
CEA/DSM/DRFC, Cadarache, France
tuong.hoang@cea.fr

Next step magnetic fusion devices must demonstrate the feasibility of commercial reactors. The construction of ITER aims at demonstrating controlled thermonuclear fusion in conditions suitable for power production. ITER is designed to produce a significant fusion gain in long pulse ($Q \geq 10$ lasting typically 400s) and to achieve in a later stage burning plasmas in steady-state ($Q \sim 5$). New challenges for magnetic fusion research will emerge on both physics and technology fronts, integrating numerous physics aspects and technological concepts collected from the existing devices. High β plasmas have to be realized in ITER.

The H-mode, governed essentially by edge physics and wall conditioning, is presently considered to be the standard operation in ITER. High plasma current is used to maximize the energy confinement, but this strategy limits the duration of the pulses because of the limited capability of the primary transformer driving the resistive current. Alternative Hybrid mode (large volume of zero or weak magnetic shear) is envisaged to extend the duration of the H plasmas, operating at a lower current value. Advanced tokamak (AT) scenario is a favorable candidate to achieve high β plasmas in continuous reactor conditions.

AT operating mode requires an Internal Transport Barrier (ITB) which allows achieving a high core pressure gradient to generate a large bootstrap fraction, thus reduces the external current drive requirement. ITB physics has been widely reviewed in previous papers [e.g., Wolf (03), Connor (04), Litaudon (06)...], figuring out significant progress in the present specific conditions. It should be stressed that ITER physics parameters will differ from the existing experiments (ρ^*, ν^*, β_N, M_ϕ, T_i/T_e...). Physics of fusion born alpha particles will appear, including associated MHD. Also, ITER specifications are much more demanding in terms of ITB active control. Operating and controlling AT mode in ITER conditions will be therefore the challenge to meet.

It is the purpose of this review to collect the constraints on major physical and technological (H/CD systems) aspects of ITER and discuss how they can be incorporated in the new design basis.