Neutral recirculation, the key control parameter for divertor operation

A.S. Kukushkin\textsuperscript{1,2}, H.D. Pacher\textsuperscript{3}

\textsuperscript{1}National Research Centre "Kurchatov institute", Moscow, Russia
\textsuperscript{2}National Research Nuclear University "MEPhI", Moscow, Russia
\textsuperscript{3}INRS-EMT, Varennes, Québec, Canada

e-mail address: ank755@gmail.com

Interaction of the plasma with neutral gas in the divertor is a most important mechanism opening the way to control of the operational regime of a tokamak reactor. It affects virtually all aspects of the divertor functionality (power loading of the targets, pumping and fuelling, sustaining the operational conditions of the core plasma). In the course of the ITER design development, this interaction has been the subject of intense modelling analysis, supported by experiments on various tokamaks. Neutral gas puffing is found to be the most effective means of divertor control. The results of those studies are summarized and assessed in the paper. The role of the “dome” in the divertor operation, the effect of gas leakage through the targets and other divertor structures, the importance of the neutral particle exchange between the inner and outer divertors and the role of neutrals in the discharge collapse in the case of over-fuelling are discussed. In particular, the massive influx of neutrals into the divertor plasma from the private flux region causes a progressive relaxation of the power flux from the x-point toward the target in such a way that the relative reduction of the power flux density is stronger where the flux is higher. This results in further widening of the power deposition profile and renders the peak power loading of the targets acceptable even for the narrow power SOL upstream ($\lambda_q \sim 1$ mm in ITER) projected by extrapolation of the data from present experiments.