Experimental studies of H-mode divertor detachment with deuterium gas injection in KSTAR plasmas

J. H. Hwang\textsuperscript{a}, J.-S. Park\textsuperscript{b}, R. A. Pitts\textsuperscript{b}, H. H. Lee\textsuperscript{c}, J.-W. Juhn\textsuperscript{c}, J. Jang\textsuperscript{c}, J. G. Bak\textsuperscript{c}, S. Wiesen\textsuperscript{d}, M. Bernert\textsuperscript{e}, S.-H. Hong\textsuperscript{c}, and W. Choe\textsuperscript{a}

\textsuperscript{a} KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Korea
\textsuperscript{b} ITER Organization, Route de Vinon-sur-Verdon, CS 90 046, 13067 St. Paul Lez Durance Cedex, France
\textsuperscript{c} National Fusion Research Institute, 169-148 Gwahak-ro, Yuseong-gu, Daejeon 34133, Korea
\textsuperscript{d} Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, D-52425 Jülich, Germany
\textsuperscript{e} Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany

junghoo.hwang@kaist.ac.kr; wchoe@kaist.ac.kr

Detached divertor operation under high performance (H-mode) conditions is the baseline ITER scenario for the achievement of Q = 10 plasmas [1]. Although the basic ingredients of divertor detachment are well recognized, there remain gaps in our ability to reproduce experimental observations with the plasma boundary modelling tools which have been deployed to assess ITER divertor performance. It is thus important to continue code-experiment validation attempts at every possible opportunity, to build confidence in, and continue to refine the models. On KSTAR, L-mode detachment has been successfully simulated with the SOLPS-ITER code [2], showing how the clear experimental observation of an inverted in-out divertor target detachment asymmetry in comparison with most other devices could be explained by geometrical effects.

These studies are now being extended to the more complex arena of H-mode detachment, beginning with the simplest possible situation of pure deuterium fuelled discharges, several of which have been executed in a recent dedicated experiment on KSTAR. This paper reports on these experimental results and on the efforts to reproduce them with SOLPS-ITER. The baseline target plasma in the study is a single null lower, Type I \(\rightarrow\) III ELMing density ramp discharge with the BxVB drift directed towards the active X-point. These plasmas have a \(\sim 8\) s flattop with \(I_p = 0.7\) MA, \(B_T = 1.8\) T, \(\sim 3\) MW of neutral beam injection heating and with an ELM frequency varying from \(\sim 30\) Hz (Type I) to the 1-2 kHz (Type III) range across the density ramp. Using arrays of tile embedded Langmuir probes to measure target ion fluxes, broadly similar behaviour to L-mode is found: detachment occurs earlier at the outer target, with the inter-ELM strike point particle flux reduced by a factor 3. At the inner target, although particle flux roll-over occurred, there was no significant reduction of the inter-ELM peak particle flux right up to the maximum achieved line averaged density of \(\sim 6 \times 10^{19} \text{ m}^{-3}\) (\(f_{GW} \approx 0.7\)). Pronounced detachment was not achieved, with further attempts to increase the density resulting in an H-mode density limit, similar to the findings on AUG [3]. Modelling of this discharge with SOLPS-ITER has started and the first findings will be reported at the conference.