Contribution ID: **1299** Type: **Regular Poster**

Experiment and modelling of divertor detachment with deuterium injection in KSTAR H-mode plasmas

Tuesday, May 11, 2021 2:20 PM (20 minutes)

For future fusion devices including ITER and DEMO, it is crucial to handle the power flux to the divertor targets in order not to exceed the steady-state material limit, $q_{t,} \leq 10$ Wm^{-2} [Ref. 1]. One of the viable effective methods to achieve it under development is divertor detachment via impurity gas seeding or deuterium injection in the divertor region in order to dissipate the excessive power flux. In KSTAR, L-mode detachment studies have been performed extensively, and the in/out divertor asymmetry was found where the detachment occurred at a lower upstream electron density at the outer target than at the inner target [Ref. 2], as opposed to the observations in other tokamaks. In a recent dedicated experiment, the first step toward divertor detachment in H-mode was successfully done by pure deuterium fueling and the study on the asymmetric characteristics of detachment has been extended to more complicated H-mode plasmas. This paper reports on the results of the experiment and numerical modelling using the SOLPS-ITER code to get better understanding of physical processes behind divertor detachment.
The discharges in the H-mode detachment study had a plasma current of I_p = 0.7 MA and a forward toroidal magnetic field of B_T = 2.0 T with 8 s flattop (1.5 s –9.5 s). Shot traces of plasma parameters for the experiment (#22849) are shown in figure 1. The total heating power was about 3 MW by neutral beam injection. The outer strike point was swept for 2 –4 cm during the current flattop phase in order to obtain target ion saturation current (j_{sat}) profiles by the tile-embedded Langmuir probe array. D_α line emissivity near the outer target (Fig. 1(e)) gradually increased with some periodic fluctuations which are due to the strike point sweeping. The deuterium fueling rate was linearly increased, such that the line averaged density $\bar{n}_e$ kept increasing up to 6x10^{19} m^{-3} ($f_{GW} \approx 0.7$) during the discharge before the H-L back transition. Consequently, the divertor regime was changed from low recycling to high recycling and then detached states. A partial detachment was achieved on both inner and outer divertor targets during the inter-ELM phase and the similar behavior to L-mode was found in terms of the in/out divertor asymmetry. The peak particle flux at the outer target reduced by a factor of 4 compared to the maximum value shown in the attached divertor regime, although there was no significant reduction at the inner target as illustrated in figure 2. This asymmetry that was generally found in the detachment experiment in KSTAR was explained by the neutral particle dynamics and geometrical effect through the SOLPS-ITER modelling without particle drifts [Ref. 2].
Meanwhile, drifts are considered as one of the driving factors of the asymmetry along with the geometry. Thus, we have performed the SOLPS simulations of L-mode plasmas including drifts to check how the drifts influence the asymmetry. The modeling setup is basically same as in [Ref. 2] but with diamagnetic drift and ExB drift turned on. The multiplying factor to the drift terms was scanned in parallel to the separatrix density scan. According to the preliminary result, the drifts modify the target profiles including particle flux density, electron density and temperature, and their effects are larger at the inner target than at the outer target.
Simulations using the SOLPS-ITER code have been performed for the H-mode discharges with pure deuterium injection. The input power into the simulation domain was 2.4 MW by taking into account that 20% of the heating power is radiated inside the core plasma. The fueling rate was scanned from 2.5x10^{21} s^{-1} to 1.0x10^{22} s^{-1} to mimic the density ramp experiment. Figure 3 presents the parallel particle flux density onto the targets obtained from the modelling, and it indicates that the modelling successfully reproduces the anomalous asymmetry as observed in the experiment. Larger reduction of the particle flux is shown at the outer target than at the inner target. However, contrary to the experiment, the attached heat flux to the outer target well exceeds 1 MWm^{-2} which is rarely seen from the divertor infrared television (IRTV) system in KSTAR. The analysis on the total radiation profiles in the divertor region was also demonstrated. As the separatrix density increased, the maximum radiation front moved upstream from the targets to the X-point and the radiation finally became concentrated at the X-point in the detached state. Refinement of the radial profiles of the perpendicular transport coefficients is underway which will give better quantitative agreement between the simulation results and the experimental data.

Indico rendering error

```
Could not include image: [404] Error fetching image
```

Indico rendering error

```
Could not include image: [404] Error fetching image
```

Acknowledgements
This work was supported by the National R&D Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (NRF-2019M1A7A1A03087560).

References:
(1) A. Loarte $_{\alpha}$, Nucl. Fusion **47**, S203-63 (2007).
(2) J.-S. Park $_{sat}$, Nucl. Fusion **58**, 126033 (2018).

Affiliation

Korea Advanced Institute of Science and Technology (KAIST)

Country or International Organization

Korea, Republic of

Primary author: HWANG, Junghoo (Korea Advanced Institute of Science and Technology)

Co-authors: PARK, Jae-Sun (ITER Organization); PITTS, Richard (ITER Organization); LEE, Hyungho (National Fusion Research Institute); BAK, Jun Gyo (National Fusion Research Institute); JUHN, June-Woo (Seoul National University); Dr JANG, Juhyeok (National Fusion Research Institute); HAN, Yoon Seong (Korea Advanced Institute of Science and Technology); HONG, Suk-Ho (National Fusion Research Institute); CHOE, Wonho (Korea Advanced Institute of Science and Technology)

Presenter: HWANG, Junghoo (Korea Advanced Institute of Science and Technology)

Session Classification: P2 Posters 2

Track Classification: Magnetic Fusion Experiments