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High density and high neutral particle pressure in the divertor for steady state operation in LHD

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This study shows the experimental results on the density limit and ultra-high neutral pressure in the sub-divertor volume at LHD for high density steady state operation, and good particle exhaust.

A new density scaling for tokamaks was reported in [1] based on edge turbulent transport. It shows a strong dependence on heating power and is similar to the Sudo density limit in the helical device, LHD [2]. In LHD, it is possible to observe a large number of density collapse events with the measurement of microscopic turbulence such as phase contrast imaging (PCI) and Doppler back-scattering (DBS). Preliminary results show that the density fluctuation level increases at the density collapse, and this study focuses on the relation between the density limit and edge turbulence.

Ultra-high neutral pressures were recently observed in the helical divertor in LHD [3]. The record value was 1.4 Pa, which is in the order of magnitude of the values known from poloidal divertors of tokamaks (e.g. 5 Pa in ASDEX Upgrade or 20 Pa in ITER). This result has been observed only at a specific magnetic field configuration of Rax = 3.55 m with an inward directed magnetic axis position. The high divertor pressure is probably caused by volume recombination. In general, volume recombination can be easily achieved in tokamak divertors, but this has not been the case for stellarator/heliotron divertors. Therefore, these results have not been seen in previous stellarator/heliotron divertors, and the process will be discussed in this study.

[1] M. Giacomin et al., Phys. Rev. Lett. 128 (2022) 185003.
[2] S. Sudo et al., Nucl. Fusion 30 (1990) 11.
[3] U. Wenzel et al., Nucl. Fusion 64 (2024) 034002.

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