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Impact of edge turbulence spreading on broadening the heat flux width in plasma approaching the density limit

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High density plasma is important to achieve high triple product and fusion power in fusion devices. The heat load in the divertor targets with high density scenario should be investigated for future devices. This paper focuses on the significant role of edge turbulence spreading on broadening the heat flux width when plasma approaches the density limit.

In the experiments, the heat flux widths on J-TEXT Ohmic plasma are 10 times larger than the predicted values from GHD model. With increasing plasma density, fluctuation levels and turbulent particle flux increase while $\mathbf{E}\times\mathbf{B}$ shearing rate decreases; the electron adiabaticity decreases to be smaller than 1; the heat flux width increases dramatically.

Based on the SOL turbulence production theory [1], turbulence energy branching ratio R_a, which characterize the competition between the turbulence spreading into the SOL and the local SOL turbulence production is investigated. Measurements show that R_a increases with the heat flux width as well as density, as shown in figure 1. Moreover, R_a is much larger than 1, indicating the significant increased edge turbulence spreading with increasing density. Figure 2 shows the impact of $\mathbf{E}\times\mathbf{B}$ shearing rate on the edge turbulence spreading and SOL local production. Edge turbulence spreading decreases with density, while local production seems to be affected by $\mathbf{E}\times\mathbf{B}$ shearing rate in the LCFS. This result suggests that, it is the edge turbulence spreading across the LCFS, rather than the local production on the SOL, plays the major role in the SOL turbulent transport and hence broadening of the heat flux width.

Furthermore, the roles of blob transport in turbulence energy production ratio and heat flux width are examined in figure 3. Both parameters are increasing with higher ratios of blob turbulent particle to the total turbulent flux. This also suggests that the intermittency - i.e. the blob - is the major contributor to the turbulence spreading phenomenon when plasma approaches its density limit.

The above results indicate that the dominant contribution to the SOL turbulence is the spreading from the plasma edge, and that edge turbulence spreading can significantly broaden the SOL width when plasma approaching density limit.

Keyword: turbulence spreading, heat flux width, density limit

Reference:

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[3] Chu X. et al. 2022 Nucl. Fusion **62** 066021

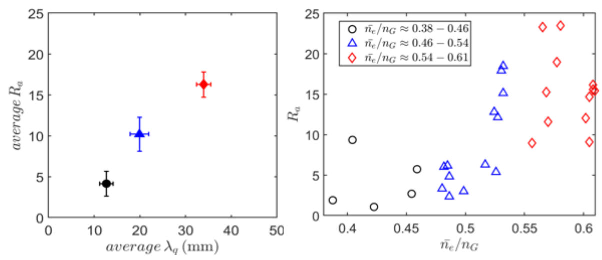

Figure 1 (Left) The average heat flux width vs and average energy branch ratio with different density, and (right) the ratio of line average density to the Greenwald density limit vs the energy branch ratio.

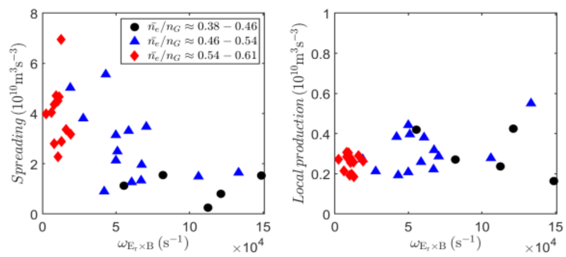

Figure 2 The EXB shearing rate vs the (left) edge spreading and (right) SOL local production term.

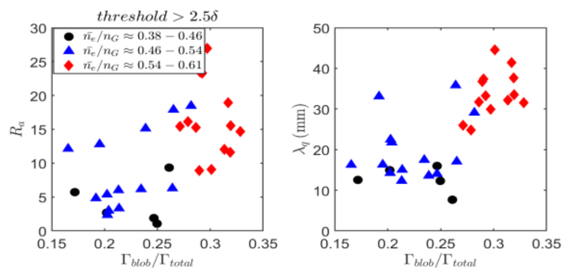

Figure 3 The blob transport vs the turbulence energy product ratio and hear flux width.