Impact of plasma density/collisionality on divertor heat flux width

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The latest studies of the divertor heat flux width $\lambda q$ show that $\lambda q$ is inversely proportional to the poloidal magnetic field $B_p$ which is only for the low-gas-puff H-mode conditions \cite{1, 2}. BOUT++ simulations of the divertor heat flux width for the attached divertor conditions of H-mode discharges show a good agreement with this scaling \cite{3, 4}. However, ASDEX-Upgrade (AUG) data showed that the scrape-off width broadens as the density/collisionality increases which is outside the scaling law for the detached divertor conditions of H-mode discharges \cite{5}. Two possible physics mechanisms cause the width broadened. As the SOL density increases, the SOL residence time is likely increased \cite{6} and the SOL transport is likely enhanced \cite{7}. In order to investigate the scaling characteristics of the divertor heat flux width vs density/collisionality, a series of BOUT++ transport and turbulence simulations are conducted to capture the physics via a plasma density scan with fixed pressure profiles. BOUT++ transport simulations show that with the density increasing, the residence time of energy in the scrape-off-layer (SOL) increases from the low collisionality to high collisionality due to the classical electron parallel thermal conductivity, leading to the heat flux width $\lambda q$ broadening. The heat flux width is proportional to the square root of mass for low collisionality while it has a weakly dependence on mass for high collisionality. BOUT++ turbulence simulations show that as the density/collisionality increases, the turbulence transport enhances which lead to the increasing of divertor heat flux.

\cite{1} T. Eich et al., Nucl. Fusion 53 (2013) 093031.
\cite{2} R.J. Goldston, Nucl. Fusion 52 (2012) 013009.
\cite{3} B. Chen et al., Nucl. Fusion 57 (2017) 116025.
\cite{4} X.Q. Xu et al. Nucl. Fusion 59(2019) 126039.
\cite{6} R.J. Goldston, EPS 2019, APS 2019.
\cite{7} T. Eich et al., EPS 2019