Scaling of Divertor Heat Flux Profile Widths in DIII-D


Background

The width of the divertor heat flux profile, $q_{B5}$, is of great interest in future high beta tokamaks. Experimental values of $q_{B5}$ have been recently shown to correlate with plasma edge $\beta_p$ (1-4). Previous DIII-D divertor scaling studies (5) have reported a linear dependence on $\beta_p$ while, on other machines, the divertor heat flux profile in ITER (6) and the JET divertor (7) have been found to scale linearly with $\beta_p$. This presents a unique opportunity to examine the impact of $\beta_p$ on the divertor heat flux profile, with the expected variation of divertor edge and separatrix layer thermal transport properties (8).

Experimental procedure

We performed experiments in DIII-D with low and high $\beta_p$ values (1-4). Measurements were made using a bolometric array located at the divertor strike point. For each discharge, a series of poloidal profiles were measured by a linear array of bolometers separated by $\approx 1^\circ$. In these measurements, the divertor plate was kept at a constant temperature of $500 \pm 25$ K with an error of $\pm 200$ K.

IR camera and heat flux analysis

The IR camera located under the divertor plasma target plane on the divertor legs provides time resolved measurements of the heat flux profile. A line of sight from the camera to a divertor target surface is depicted in Fig. 2. Each line of sight has a FOV of $1^\circ$ and a resolution of $0.5^\circ$. The camera provides a spatial resolution of $\approx 5$ mm.

Comparison with previous results

For such experiments, a high spatial resolution of $\approx 5$ mm was achieved using an infrared camera. The average of each poloidal profile was used to calculate the $\lambda_B$ value for each $\beta_p$, and a linear relationship between $\lambda_B$ and $\beta_p$ was found. Previous DIII-D studies have reported a linear relationship between $\lambda_B$ and $\beta_p$, while in experiments on JT-60U and ASDEX Upgrade, the $\lambda_B$ value was found to be independent of $\beta_p$.

Acknowledgments

This work was supported by the U.S. Department of Energy under DE-AC02-09CH11466. This paper was written with funding from the U.S. Department of Energy under DE-AC02-09CH11466.

References


Author contributions

All authors contributed to the concept and methodology of this work, and all authors contributed to the writing of this paper.

Funding

This work was supported by the U.S. Department of Energy under DE-AC02-09CH11466. This paper was written with funding from the U.S. Department of Energy under DE-AC02-09CH11466.

Presented at EPS 2020 Fall, Atlanta.