Exploring the Regime of Validity of Global Gyrokinetic Simulation with Spherical Tokamak Plasmas

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Plasma turbulence is considered one of the main mechanisms for driving anomalous thermal transport in magnetic confinement fusion devices. Based on first-principle model, gradient-driven gyrokinetic simulations have often been used to explain turbulence-driven transport in present fusion devices, and in fact, many present predictive codes are based on the assumption that turbulence is gradient-driven. However, using the electrostatic global particle-in-cell Gyrokinetic Tokamak Simulation (GTS) code \cite{1}, we will show that while global gradient-driven gyrokinetic simulations provide decent agreement in ion thermal transport with a set of NBI-heated NSTX H-mode plasmas (see Fig. 1), they are not able to explain observed electron thermal transport variation in a set of RF-heated L-mode plasmas, where a factor of 2 decrease in electron heat flux is observed after the cessation of RF heating \cite{2}. Thus, identifying the regime of validity of the gradient-driven assumption is essential for first-principle gyrokinetic simulation. This understanding will help us more confidently predict the confinement performance of ITER and future magnetic confinement devices.

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\textbf{References}


\begin{figure}[h]
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\includegraphics[width=\textwidth]{Figure1.png}
\caption{Red circles: ion energy flux, $Q_{\text{GTS}}$, at $t=332$ ms as a function of major radius from a nonlinear GTS simulation of an NSTX H-mode plasma, shot 141767; magenta band: radial profile of experimental ion heat flux, $Q_{\text{exp}}$, at $t=332$ ms from power balance analysis; black band: radial profile of neoclassical ion heat flux, $Q_{\text{nc}}$. Note that the vertical widths of the magenta and black bands denote the experimental uncertainties. $Q_{\text{GTS}}$ is averaged over a quasi-steady saturation period, and the errorbars of $Q_{\text{GTS}}$ are the standard deviation of $Q_{\text{GTS}}$ in the averaging time period. Also note that, at larger radius, i.e. $R \geq 136$ cm, taken into account of uncertainties in each term, $Q_{\text{GTS}}+Q_{\text{nc}}$ is approximately equal to $Q_{\text{exp}}$, indicating that the ion-scale turbulence is responsible for observed anomalous ion thermal transport.}
\end{figure}