Effect of shaping on turbulent transport in JT-60SA

O. Beeke\textsuperscript{1}, M. Barnes\textsuperscript{1,2}, M. Romanelli\textsuperscript{2}, M. Nakata\textsuperscript{3}, M. Yoshida\textsuperscript{4}

\textsuperscript{1} Rudolf Peierls Centre for Theoretical Physics, University of Oxford, UK
\textsuperscript{2} EURATOM/CCFE Fusion Association, Culham Science Centre, UK
\textsuperscript{3} National Institute for Fusion Science, Toki 509-5292, Japan
\textsuperscript{4} National Institute for Quantum and Radiological Science and Technology, Naka, Japan

Plasma shaping is known to affect the properties of micro instabilities that cause outwards radial transport of heat and particles in tokamaks. In particular, the elongation $\kappa$ has been observed to have a stabilizing effect on the ion-temperature-gradient (ITG) instability in low-$\beta$ plasmas, whilst increased triangularity can have varied effects on confinement [1–3]. The effect of shaping in high-$\beta$, high-$\beta'$ plasmas such as those expected in JT-60SA advanced scenarios is less documented and is the focus of this work.

Here we use the local $\delta f$-gyrokinetic code GS2 [4] to extend an earlier modelling study [5] of the tokamak JT-60SA and investigate the ideal plasma shaping parameters for the machine in two different scenarios - one low (1.4\%) $\beta$ and one high (3.7\%) $\beta$ plasma equilibrium. We confirm, using electrostatic simulations with both kinetic ions and electrons, that the low-$\beta$ plasma exhibits monotonic stabilization with increasing elongation, whilst the effect of triangularity varies with $\kappa$ (destabilizing and stabilizing at low and high $\kappa$, respectively). However, the analysis of the high-$\beta$ plasma shows that moderate increases in elongation (up to $\kappa \sim 1.4$) have a destabilizing effect; beyond this elongation is again stabilizing.

To explain this observation, we use a simplified Miller parametrization for the poloidal cross section to determine how an interaction between $\beta'$ and $\kappa$ is responsible for this behaviour. In particular, increasing $\kappa$ at large $\beta'$ increases the local magnetic shear (destabilizing) but also the perpendicular wavenumber (stabilizing). The competition between these two effects leads to the observed peak in maximum growth rates as a function of $\kappa$. We also present results from electromagnetic simulations for the high-$\beta$ equilibrium.

References