Microturbulence simulations in optimised stellarators

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Control of plasma transport is a necessity in the design of a fusion power plant. In neoclassically optimised stellarators such as Wendelstein 7-X (W7-X), the turbulent transport may also need to be reduced. The large configuration space of stellarators could provide ample possibility to find configurations with reduced transport in both the neoclassical and turbulent channels. While the suppression of neoclassical transport is well established, that of the turbulence is less well developed. Very recently, a reduction of ion temperature gradient turbulence by magnetic-field optimisation was achieved in a W7-X-like stellarator [1]. However, trapped-electron modes (TEM) can also be expected to produce significant transport. Recent analytical findings [2] suggest TEMs are stable in large parts of parameter space when all trapped particles experience bounce averaged “good curvature”. This is true for perfectly quasi-isodynamic stellarators, but it has been shown numerically [3] that even configurations like W7-X, where a small fraction of the trapped orbits experience bad average curvature, benefit from enhanced TEM stability. We present first-of-a-kind TEM turbulence simulations demonstrating that this enhanced stability leads to much reduced transport. Using this knowledge, a “proxy” function was designed to estimate the TEM growth rate, allowing optimal configurations for TEM stability to be determined with the STELLOPT code [4] without extensive turbulence simulations. A first optimised equilibrium of the TEM-dominated stellarator experiment HSX is presented. A reduction of the linear growth rates is achieved over a broad range of wave numbers and density gradients. In future investigations we will study the turbulence level in optimised configurations, as well as create optimised equilibria for devices such as W7-X that are accessible by adjusting the magnetic-field coil currents.

References