Calculation of the Thermal Footprint of Resonant Magnetic Perturbations in Poloidally-Diverted Tokamaks*

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The effect of resonant magnetic perturbations (RMPs) on heat transport in DIII-D H-mode plasmas has been calculated by combining the TRIP3D field-line tracing code with the E3D two-fluid transport code. RMPs have been shown to suppress and eliminate ELMs in high-performance discharges at ITER-similar collisionalities and shapes by decreasing the pressure gradient in the pedestal region. TRIP3D superimposes a detailed model of the external vacuum fields upon an axisymmetric EFIT equilibrium. E3D uses Monte Carlo integration of the fluid advection-diffusion equations to accurately compute the stochastically enhanced heat transport caused by the RMP-induced 3D geometry. Simulations show that the effective area of thermal wetting can be increased in proportion to RMP amplitude because heat flux is efficiently guided to the divertor along the invariant manifolds of the magnetic field. Observations by infrared and filtered tangential X-point cameras as well as high resolution Langmuir probe array strike point sweeps have verified non-axisymmetric strike-point structure and confirm a reduction of heat flux to the divertor target. On the other hand, the predicted magnitude of stochastic heat transport is too large to match the pedestal plasma profiles measured by Thomson scattering and charge exchange recombination spectroscopy. The Braginskii thermal conductivity may overestimate the expected heat transport in the pedestal because the mean free path is longer than the natural length scale for thermal variations — the Kolmogorov length — and heat flux-limited kinetic transport may be required for accurate description. An alternative explanation may be that rotational shielding allows a number of good KAM surfaces to remain intact near the region of steep gradients.

*Supported by the US Department of Energy under DE-FG02-05ER54809, DE-FG02-04ER54758, DE-FC02-04ER54698, W-7405-ENG-48, and DE-AC04-94AL85000.