Rotational shielding of resonant magnetic perturbations from an H-mode pedestal*,
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Schneider, MPI-Greifswald – The application of resonant magnetic perturbations (RMPs)
to an H-mode plasma can suppress edge localized modes by reducing the edge pressure
gradient below the Type-I peeling-ballooning MHD stability threshold. An important
paradox in the description of this process is that the RMPs produce large particle
transport, but little thermal transport. Although the applied fields produce a stochastic
band of overlapping islands in the infinitely resistive vacuum limit, the perturbations are
predicted to be strongly modified by the near-ideal response of a collisionless plasma.
Unless the perturbation induces large enough Lorentz braking forces at the resonant
surfaces to overcome the force of viscous friction in the bulk plasma, a thin boundary layer
of current will flow near the rational surface that will act to screen out the applied field.
In single fluid theory, the plasma core, where the resistivity is small and large ExB
rotation predominates, is predicted to lie in the inertial limit where no actual reconnection
can take place. Calculations using the NIMROD code show qualitative agreement with
core screening, but the dimensionless parameters of the simulation lie in the visco-
resistive limit and allow some amount of reconnection. Order unity resonant field
amplification was observed in the simulation, demonstrating that such estimates can only
be correct to order of magnitude. In theory, electron diamagnetic rotation is large enough
to flow counter to the ions near the plasma edge in the standard DIII-D ELM suppression
scenario, and this requires a two-fluid description of the plasma response. In fact, the
width of the resonant current channel is predicted to become smaller than an ion
gyroradius, requiring kinetic analysis. While two-fluid theory would predict a large
torque on the ions, a kinetic model in a cylindrical plasma demonstrates that the electrons
experience most of the torque. As the Lorentz force acts to brake the electron flow, the
electrons accelerate the ions through the electric field. In fact, Carbon-VI impurity ions
are observed to spin up during RMP application in a narrow region near the plasma edge.
A phenomenological model of the magnetic plasma response has been developed by
discarding the poorly known details of the non-ideal physics involved in the reconnection
process. The Ideal Perturbed Equilibrium Code (IPEC) is used to describe the ideal MHD
plasma interior and the VACUUM code is used to describe the resistive stochastic
exterior. This two state model allows the boundary between the ideal and stochastic
regions to be placed at an arbitrary point within the separatrix and can accurately account
for resonant field amplification.

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