Experimental detection of three dimensional plasma edge structures due to application of resonant magnetic perturbations at TEXTOR and DIII-D

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Application of resonant magnetic perturbations (RMP) is a promising candidate for control of large type-I edge localized modes (ELMs). At TEXTOR the dynamic ergodic divertor (DED) was mounted as a flexible tool to investigate many aspects of the response of tokamak plasmas to externally applied RMPs. In this contribution we will concentrate on the experimental detection of 3D plasma edge structures in comparison to results of modeling of the perturbed magnetic field structure in the vacuum approach. Here the perturbation field of the RMP is superimposed linearly onto the axissymetric plasma equilibrium without any plasma feedback. Results of vacuum magnetic field modeling are used in many 1-,2-, and 3-D transport models of edge transport under influence of RMP. Therefore it is crucial to resolve the range of applicability of this approach and suggest improvements based on the experimental results.

For TEXTOR limiter L-mode plasmas, in general a good agreement between the vacuum magnetic topology and plasma edge structures on the wall elements as well as in the radial/poloidal plane was found unless tearing modes were driven. One direct measure of the perturbation level is the detection of the imprint of the tangles of the invariant manifolds of resonant magnetic island chains in heat and particle flux pattern on the DED target. The basics of this technique will be described and examples will highlight cases with both, good agreement and starting deviation in dependence on different toroidal rotation levels. These magnetic structures span a complex 3-D magnetic boundary consisting of laminar flux tubes, i.e. bundles of short connection length field lines embedded into a domain of stochastic field lines with enhanced radial particle and heat transport. However, the actual markedness of this topology in the experimentally measured poloidal (ϑ) and radial (r) electron density $n_e(\vartheta, r)$ and temperature $T_e(\vartheta, r)$ fields depends on the toroidal rotation as the particle and heat flux target pattern do.

For DIII-D poloidally diverted RMP H-mode plasmas, the existence of a new 3-D plasma boundary was demonstrated by observation of the perturbed separatrix manifolds in divertor heat and particle flux pattern. Due to RMP application, the ideal, axissymetric separatrix is replaced by lobes of the invariant manifolds of the perturbed separatrix. This leads to a pronounced striation of the divertor target particle fluxes as a clear imprint of this new 3-D boundary. However, the target heat flux follows this boundary only for high pedestal electron collisionality $\nu_e^* \sim 2.5$ while marginal heat flux into the outer lobes is visible at low $\nu_e^* \sim 0.1$. Possible candidates for explanation of this counter intuitive experimental observation are the different location of particle and heat sources feeding the stochastic edge region consisting of open, perturbed field lines or different penetration characteristics of the RMP field in dependence on ν_e^*.