A quasi-linear model of edge plasma transport from magnetic perturbations+

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Plasma transport in magnetized toroidal devices is very sensitive to the structure of the magnetic field, especially whether or not the field lines lie on nested magnetic flux surfaces. Non-axisymmetric magnetic perturbations have been applied to tokamaks by external coils in an effort to suppress large MHD-like edge localized modes (ELMs) that can cause damaging expulsion of plasma onto open magnetic field lines that intersect material surfaces [1]. The application of the magnetic perturbations is often observed to substantially modify the edge plasma profiles of density and temperature, which are known to impact ELM stability. A model of edge plasma transport is presented based on the weakly stochastic magnetic field lines arising from the applied magnetic perturbation. The parallel drift-kinetic equation is expanded in powers of the weak perturbation to obtain a quasi-linear transport matrix yielding the gradient-driven fluxes of density, momentum, and energy across the unperturbed flux surfaces [2] in terms of the field-line diffusion coefficient [3,4]. This model is implemented in the 2D UEDGE edge transport code and is applied to experimental conditions where magnetic perturbations are observed to modify plasma profiles [1]. The radial profile of underlying magnetic field-line diffusivity can then be treated as an unknown that is deduced by requiring the computed profiles to agree with the experimental profiles, thereby obtaining information on the local magnetic perturbations as a function of minor radius. The neutral-gas recycling component is included in the transport simulations in order to obtain the effect of self-consistent plasma sources. The ability of the stochastic transport hypothesis to accurately represent the experimental data is compared to other transport hypotheses, such as a diagonal transport matrix model that allows for an arbitrary ratio of particle diffusivity to thermal diffusivity.

+Work performed for U.S. DoE by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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