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Theory of the generation of non-axisymmetric scrape-off-layer perturbations for controlling tokamak edge plasma profiles and stability[1]

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The ability to control both steady-state and transient divertor heat loads is a critical requirement for successful tokamak fusion reactors. We propose driving toroidally-asymmetric perturbations through the scrape-off layer (SOL) plasma both to control the edge pedestal pressure gradient by generating currents that drive resonant magnetic perturbations (RMPs) [1] and to broaden the SOL by generating potentials that drive radial convection [2]. Both types of perturbations can be superposed in the same divertor, but lower mode numbers are favored for generating strong RMPs, while higher mode numbers are favored for generating strong convective transport. Calculations show that choosing the appropriate width and phasing of the biasing region at the target plate can amplify the RMP generated by the SOL current. Steady-state cross-field transport on open field lines can be enhanced if the convection frequency exceeds the rate of parallel transport. Analytic estimates and calculations will be made for the MAST and NSTX tokamaks, which have already produced relevant experimental information. Generation of the necessary currents by electric biasing of mutually-insulated divertor segments is the most straightforward technique, but requires the use of in-vessel insulators that are poorly suited to the fusion reactor neutron environment. Therefore, passive current-drive mechanisms that rely on puffing and pumping of neutral gas and/or impurities in a toroidally asymmetric fashion are analyzed using reduced 1d and 2d numerical models.

[1] I. Joseph, R. H. Cohen and D. D. Ryutov, Phys. Plasmas **16**, 052510 (2009).
[2] R. H. Cohen and D. D. Ryutov. Nucl. Fusion **37**, 621 (1997).

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