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Drift kinetic formulation of alpha particle transport by tokamak MHD perturbations[1]

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A series of DT experiments, including the JET DT campaign, SPARC, and ITER, are expected to have large alpha particle populations. In some cases these populations dominate plasma heating and control tokamak behavior. Such experiments motivate new attention to the theory and modelling of alpha particle confinement and transport. A key topic is the interaction of alpha particles with perturbations to the tokamak fields, including those from magnetohydrodynamic modes like Alfvén eigenmodes and neoclassical tearing modes. These perturbations can transport alphas, leading to changed localization of alpha heating, loss of alpha power, or damage to device walls. Alpha interaction with these perturbations is often studied with single particle theory. In contrast, we derive a drift kinetic formulation capable of calculating the alpha heat flux resulting from arbitrary perturbation frequency and periodicity (provided the frequency and periodicity can be studied drift kinetically). Novel features of this technique include the retention of a large effective collision frequency resulting from the resonant alpha collisional boundary layer, correlated interactions over many poloidal transits, and finite orbit effects. The calculated heat flux scales with the square of the perturbation amplitude and increases with toroidal mode number. The heat flux expression can be used to derive a constraint on mode amplitude for avoidance of significant alpha depletion. The talk concludes by discussing the implications of the work for future DT experiments. For example, a simple saturation condition suggests that toroidal Alfvén eigenmodes in SPARC will not lead to significant alpha transport via the mechanisms in this theory. However, saturation above the level suggested by the simple condition, but within numerical and experimental experience, could cause significant transport.

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