Neoclassical Transport Theory For Orbits With Finite Width In Tokamaks

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Standard neoclassical theory in tokamaks is formulated for bananas with zero width [1,2]. However, the physics of finite orbit width is often important in some applications. For example, the effects of orbit squeezing [3] and the resonance between parallel particle speed $v_{\parallel}$ and $U_{p,m}$ [4] become important in the pedestal region of H-mode plasmas. Here, $U_{p,m}$ is a combination of the poloidal components of the parallel mass flow speed $V_{\parallel}$ and the $\boldsymbol{E}\times\boldsymbol{B}$ drift, $\boldsymbol{E}$ is the electric field, and $\boldsymbol{B}$ is the magnetic field. Bananas with zero width are not squeezed under the influence of the steep radial electric field profile because they experience constant radial electric field along their trajectories. Only bananas with finite width suffer orbit squeezing as they drift to a different magnetic surface and experience a different value of the radial electric field. Thus, to understand transport processes in the pedestal region, neoclassical theory must be formulated for bananas with finite width. The formulation of such a theory is illustrated using squeezed bananas together with the resonance between $v_{\parallel}$ and $U_{p,m}$ as an example. The results for poloidal flow, reduced ion heat conductivity and bootstrap current that are relevant to H-mode plasmas are summarized for both moderate and strong squeezing cases. The importance of including the parallel flow in the theory will also be discussed.

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[1] F. L. Hinton, and R. D. Hazeltine, *Rev. Mod. Phys*. **48**, 239 (1976).
[2] S. P. Hirshman, and D. J. Sigmar, *Nucl. Fusion* **21**, 1079 (1981).
[3] H. L. Berk, and A. A. Galeev, *Phys. Flu*ids **10**, 441 (1967).
[4] K. C. Shaing, and E. C. Crume, Jr., *Phys. Rev. Lett*. **63**, 2369 (1989).