The Large Aspect Ratio Limit of Neoclassical Transport Theory

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Abstract. This article presents a comprehensive description of neoclassical transport theory in the banana regime for large aspect ratio flux surfaces of arbitrary shapes. The method of matched asymptotic expansions is used to obtain analytical solutions for plasma distribution functions and to compute transport coefficients. The method provides justification for retaining only the part of the Fokker-Planck operator that involves the second derivative with respect to the cosine of the pitch angle for the trapped and barely circulating particles. It leads to a simple equation for the freely circulating particles with boundary conditions that embody a discontinuity separating particles moving in opposite directions. Corrections to the transport coefficients are obtained by generalizing an existing boundary layer analysis. The system of moment and field equations is consistently taken in the cylinder limit, which facilitates discussion of the treatment of dynamical constraints. It is shown that the nonlocal nature of Ohm's law in neoclassical theory renders the mathematical problem of plasma transport with changing flux surfaces nonstandard.