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How Accurate is Analytic Theory of Neoclassical Ion Transport?[1]

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The idea underlying analytic theory of neoclassical transport is pervasive in plasma physics. The pioneering work of Rosenbluth [1] employs a variational principle to justify the dominance of pitch angle scattering in the limit of small inverse aspect ratio δ and $\nu_* \ll 1$. We derive [2] the same result using the method of matched asymptotic expansions. Because of the complexity of the Fokker-Planck operator, the accuracy of the analytic approach is not easily ascertained. We have written a code to solve the linearized drift kinetic equation with the exact Fokker-Planck operator, using expansion of the distribution function in Legendre/Laguerre polynomials in velocity space and Fourier decomposition in poloidal angle. Using the code, we find that while the analytic method is justified, its numerical accuracy requires extreme values of the parameters δ and ν_*. A rather large number of terms in the expansion are also found necessary in these parameter ranges.

[1] M. Rosenbluth, et al., Phys. Fluids **15**, 116 (1972).
[2] S.K. Wong & V.S. Chan, Phys. Rev. E **67**, 066406 (2003).

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