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Short Mean Free Path Transport for a Drift Ordering

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Abstract

The short mean free path description of magnetized plasma as originally formulated by Braginskii [1] assumes an ordering in which the ion mean flow is on the order of the ion thermal speed. Mikhailovskii and co-workers [2] realized that this ordering is not the one of most interest in many practical situations in which the flow is weaker and on the order of the ion heat flux divided by the pressure. In their ordering the ion flow velocity is allowed to be on the order of the diamagnetic drift velocity - the case of interest for most fusion devices in general, and the edge of many tokamaks in particular. Indeed, most short mean free path treatments of turbulence in magnetized plasmas must use some version of the Mikhailovskii results to properly treat the temperature gradient terms in the gyro-viscosity. However, the orderings employed by Mikhailovskii et al. are somewhat restrictive since they assume comparable parallel and perpendicular scale lengths as well as the collision frequency small compared to the cyclotron frequency. In many magnetized devices, including tokamaks, the perpendicular scale lengths can be much shorter than the parallel ones so that the ion gyro-radius over the perpendicular scale length can be comparable to the mean free path over the parallel scale length. In this case additional effects quadratic in the heat flux arise that can alter turbulent transport in tokamaks and allow stronger poloidal density and temperature variation than the normal Pfirsch-Schlüter ordering. In addition, the truncated polynomial expansion technique of Mikhailovskii gives only an approximate solution to the gyrophase dependent portion of the ion distribution function and is unable to completely and properly evaluate some of the terms in the perpendicular collisional viscosity.

[1] S. I. Braginskii, Soviet Phys. JETP **6**, 358 (1958) and in Reviews of Plasma Physics, edited by M. A. Leontovich (Consultants Bureau, NY 1965) Vol. 1, p. 205.
[2] A. B. Mikhailovskii and V. S. Tsypin, Beitr. Plasmaphys. **24**, 335 (1984) and references therein.

This work funded by the US Department of Energy.