

Non-Newtonian Viscosity in Magnetized Plasma

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Abstract

The particle and momentum balance equations can be solved on concentric circular flux surfaces to determine the effective viscous drag present in a magnetized tokamak plasma in the low aspect ratio limit. An analysis is developed utilizing the low-order Fourier expansion of the poloidal variation of quantities on the flux surface akin to that by Stacey and Sigmar [Phys. Fluids, 28, 9 (1985)]. Expressions to determine the poloidal variations of density, poloidal velocity, toroidal velocity, radial electric field poloidal electric field and other radial profiles are presented in a multi-species setting. Using as input experimental data for the flux surface averaged profiles of density, temperature, toroidal current, toroidal momentum injection, and the poloidal and toroidal rotations of at least one species of ion, one may solve the equations numerically for the remaining profiles. The resultant effective viscosities are compared to those predicted by Stacey and Sigmar and Shaing, et al., [Nuclear Fusion, 25, 4 (1985)]. A velocity dependence of the effective viscosity is observed, indicating the presence of non-Newtonian fluid behavior in magnetized plasma.

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