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Island Rotation with Island-Induced Viscosity in Tokamaks

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Abstract

Island rotation is an important part of the island dynamics in tokamaks. In an island rotation theory, momentum equation is used to determine the current density perpendicular to the magnetic surface. The Braginskii viscosity is employed in the momentum equation for such a purpose in most of the recent theories. The radial electric field profile is also determined using Braginskii viscosity. Here, we develop a theory for the island rotation using island-induced viscosity. In the vicinity of a magnetic island in tokamaks, the toroidal symmetry is broken due to the variation of the toroidal magnetic field strength over the distorted island magnetic surface. This symmetry breaking effect leads to a non-vanishing toroidal component of the viscosity. The radial electric field profile function can be determined from the island magnetic surface averaged toroidal component of the momentum equation. The time dependent terms in this equation describe the rate of change of the plasma momentum and the electromagnetic field momentum of the rotating island. At the steady state, it describes the ambipolarity across the island magnetic surface. Once the electric field profile function is determined, the perpendicular current density is calculated from the un-averaged version of the toroidal momentum equation. Island rotation frequency is then calculated from the *sine* component of the Ampere's law. To complete the description of the island dynamics with island-induced viscosity, we also calculate island width from the *cosine* component of the Ampere's law.

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