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Finite Ion Orbit Effects on Magnetic Islands in Toroidal Plasmas

XINZHENG LIU, CHRIS HEGNA, UW-Madison — A kinetic theory for the interaction of an ion population with an isolated magnetic island in a high aspect ratio tokamak plasma is presented. We examine islands whose characteristic widths are larger than the ion gyro radius but comparable to the ion banana width. In this regime, the ion response to the island has a non-local feature due to the banana drifts. When solving the drift kinetic equation for ions, a change in coordinates is used to account for this behavior. A bounce averaging procedure is developed to separate out and solve the lower order distribution function. For small islands relative to banana width, the trapped ions do not respond to the island electrostatic potential and helical magnetic geometry. A two-fluid model is adopted to determine the density of electrons. Quasineutrality leads to a self-consistent calculation for the electrostatic potential. An iteration procedure is introduced to calculate the potential, which is shown to be a combination of functions of the helical flux surfaces and the topologically toroidal flux surfaces. The contribution to the perturbed current is composed of bootstrap current and the perpendicular ion polarization current. The closure parallel current ($J_{//}$) is calculated and compared with some recent numerical results. Using this current in the Rutherford equation, the island width evolution equation is determined and compared with calculations for large island width.

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