The effective Larmor radius: a parameter of order defining the H-mode rotation layer

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The stationary states of a plasma in poloidal rotation (a layer at the edge of the tokamak in the H-mode regime) are characterized by suppression of high poloidal k modes and reduction in amplitude of all but low-frequency drift waves in that region. This can be associated with the fact that the non-adiabatic electron response has a singularity associated with a resonance where the rotation speed becomes closer, still being higher, to the diamagnetic speed. This resonance defines a space of variables and parameters \((\omega, \omega_{se}, k_\perp, u, k_\parallel)\) where \(u\) is the poloidal plasma velocity. In this space there is a region where the conditions of resonance take a particular form, \(\omega \to 0, u - \omega_{se}/k_\perp \to 0\), which practically means that slowly oscillating perturbations, carried by the poloidal flow, propagate poloidally at about the same speed as the electron diamagnetic drift. In this regime, the usual treatment fails and a singular perturbation approach is necessary. This is required since the problem is structurally unstable, i.e. \((1 - v_{se}/u) \to 0\) removes the linear term (i.e. proportional with \(\phi\)) in the potential of the Schrodinger-type equation. The solution of the mode equation is expressed in terms of elliptic functions. The possible local absence of radial variation of \(\omega_{se}\) renders the system even closer to a radially long-range, quasi-harmonic, structure. We discuss the propagation in the radial direction of perturbations along the radially elongated structures. The quantity \(\rho_{eff} = (1 - v_{se}/u)^{-1/2} \rho_s\) (which we call effective Larmor radius) and the effective sound speed \(c_{s eff} = \rho_{eff} \Omega_i\) are the parameters which characterize this regime, \(\rho_{eff} \to \infty, c_{s eff} \to \infty\). The same parameters govern the existence of vortical structures. Emission of drift waves (Cherenkov-type radiation) when \(u\) approaches from above \(v_{se}\) makes that the regime identified is privileged and is an attractor for the system ([1]). We will show that using a realistic value of \(\rho_{s eff}\) in an equation derived from the extremum of an action functional leads to profiles of vorticity in tokamak that are close to the observed ones.
References