Semi-analytical study of the tokamak pedestal density profile in a single-null diverted plasma with puffing–recycling gas sources

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Abstract

The tokamak pedestal density structure is generally studied using a diffusion-dominant model. Recent investigations (Stacey and Groebner 2009 Phys. Plasmas 16 102504) from first principle based physics have shown a plausible existence of large inward convection in the pedestal region. The diffusion–convection equation with rapidly varying convection and diffusion coefficients in the near edge region and model puffing–recycling neutral particles is studied in this paper. A peculiar property of its solution for the existence of the large convection case is that the pedestal width of the density profile, qualitatively different from the diffusion-dominant case, depends mainly on the width of the inward convection and only weakly on the neutral penetration length and its injection position.

(Some figures in this article are in colour only in the electronic version)

1. Introduction

The structures of the density and temperature profiles in the tokamak edge region have long been attracting interest since they are closely related to the physics of confinement mode transition (from low (L) to high (H) mode and vice versa) (e.g., [1–3]). The pedestal density is also related to the density limit problem (e.g., [4–6]). The related physics, though, is very complex and rather involved, the transport processes of particle and heat are always important, and many studies are devoted to this aspect (e.g., [6–9]).

According to a recent analysis by Stacey and Groebner [10] of the DIII-D edge pedestal experiments, it seems that the particle pinch is important for explaining the pedestal density structure. A common trend to represent the tokamak radial particle flux is to use a diffusive-convection model, such as $\Gamma_r = -D \nabla n + n V_{\text{pinch}}$, while the mechanisms for producing the