§6. Plasma Turbulence near the Plasma Edge

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The plasma blobs that have recently been observed in tokamak experiments are considered to be a possible cause of the anomalous transport in the Scrape Off Layer (SOL). This might explain formation of the 2nd SOL by convective transport. Research of the 2nd SOL is important since it affects the recycling rate and impurity concentration near the first wall[1]. Many research studies on the mechanism of radial propagation and stability of the blobs have been performed so far. However, self-consistent blob generation by SOL turbulence and multi-scale interaction between blob and turbulence have not been considered yet. In this research, multi-scale interaction between plasma blob and SOL turbulence is investigated using 2 dimensional Hasegawa-Wakatani equations with a density source term[2]. Intermittent convective transport is generated by the plasma blob and formation of the 2nd SOL, whose thickness depends on the intensity of turbulence, is observed.

The following model is introduced to investigate plasma blob transport:

$$\frac{\partial}{\partial t}\nabla_\perp^2\phi + [\phi, \nabla_\perp^2\phi] = \alpha\phi - \beta\frac{1}{n}\frac{\partial n}{\partial y} + \mu\nabla_\perp^4\phi \tag{1}$$

$$\frac{\partial}{\partial t}n + [\phi, n] = -\alpha n + \beta n\frac{\partial\phi}{\partial y} - \beta\frac{\partial n}{\partial y} + D\nabla_\perp^4 n \tag{2}$$

where α implies the intensity of plasma current into the divertor plate and β, the intensity of grad-B and curvature drift. If the terms are proportional to β in Eq.(2), then the model is reduced to that given in Ref. 3). Our model has an advantage because it conserves the total energy in the limit that $\alpha, \mu, D \to 0$.

Firstly, we have benchmarked the spectral code and pseudo-spectral code in the limit that $\beta\frac{1}{n}\frac{\partial n}{\partial y} \to \beta\frac{\partial n}{\partial y}$ in Eq.(1) and $\beta n\frac{\partial\phi}{\partial y} \to \beta\frac{\partial\phi}{\partial y}$ in Eq.(2) to confirm the numerical accuracy of the pseudo-spectral code. Then, using the pseudo-spectral code, the simulation of the SOL interchange turbulence is investigated. It is found that the 2nd SOL is formed by the convective transport of plasma blobs. However, its thickness depends on the intensity of SOL interchange turbulence. When parameters α, μ, and D become large, the linear growth rate of SOL interchange decreases and as the result, formation of the 2nd SOL is suppressed. The results show that dissipation and the sheath boundary condition at the divertor plate play an important role in SOL transport.

The following items are left for future works: (1) quantitative estimation of convective transport in SOL, (2) sensitivity check of boundary conditions. The latter is because blobs are reflected at the first wall, which might affect transport in the 2nd SOL. Regarding the boundary conditions, an extension to 3D and comparison with 2D results should be performed. At the next step, we will introduce an intermittent source term to simulate the Edge Localized Mode (ELM). Finally, this code will be connected with the SONIC code, which is used to predict profiles in the SOL region[4]. Once the SONIC code is connected with the core transport code TASK, self-consistent coupling between the core and edge is possible.

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