Flux driven two-dimensional fluid turbulence simulation in the edge and scrape-off layer tokamak plasma

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Abstract

A novel two-dimensional (2D) fluid model is proposed for investigating flux driven plasma turbulence in the tokamak edge and scrape-off layer (SOL). Unlike most previous turbulence simulations of this region, our model treats the two regions in a consolidated manner with a smooth transition region in between. Our unified 2D model is simpler and less computer intensive than three-dimensional (3D) models, but captures most features of 3D edge and 2D SOL turbulence. It also illustrates the influence of tokamak edge turbulence on the SOL transport, something not captured by the earlier 2D SOL simulations. Existence of an equilibrium radial electric field in the edge and SOL regions is confirmed, this electric field is found to change sign in the edge-to-SOL transition region. Turbulence in the edge is characterized by radially elongated streamers and zonal flows. The streamer structures occasionally break to form blobs. We obtain a phenomenological condition for the breaking of streamers. Formations of density blob and its dynamics in the edge and SOL regions have been studied. It is found that blobs are created in the edge region where the radial electric field changes sign. All the blobs, which form in this region are not ejected deep into the SOL. Only few of them are ejected. The ejection condition has been discussed. In the SOL region, the effective diffusion co-efficient has been calculated from the simulation results and is found to be consistent with most tokamak experimental values. Statistical properties of the particle transport obtained from this simulation are compared with the earlier flux driven 2D SOL turbulence simulation results and also with Aditya tokamak results.