ABSTRACT

Studies of edge and scrape-off layer (SOL) turbulence of tokamak plasmas are important as the turbulence plays a major role for determining overall particle and energy confinement time. Turbulence in these regions mainly consists of stable and unstable drift type of low-frequency modes; among them interchange and ballooning types of modes are most virulent.

In the first part of this thesis, two-dimensional (2D) SOL turbulence based on interchange instability has been studied using three different SOL models analytically as well as numerically. The models have the following distinguishing features. In the two-field (2F) model, coupled density and potential equations are investigated with the assumption of uniform electron temperature and zero ion temperature. In order to study the effect of electron temperature gradients, a three-field (3F) model that includes dynamics of electron temperature with the coupled equations for density and potential fields is used. Dynamics of coherent structure in the presence of electron temperature has been studied and compared with experiment for the first time anywhere in the world. Four-field (4F) model, in which ion temperature dynamics is included, has also been investigated in this thesis. Ion temperature modifies the SOL turbulence by decreasing radial electric field and SOL thickness as compared to the 3F model. Particle and energy fluxes, and decay of plasma 'blobs' obtained from these 2F, 3F and 4F models have been compared.

In the next part of the thesis we have studied edge and SOL turbulence jointly using a unified model. The unified model has demonstrated (numerically) a significant influence of edge turbulence on the SOL. Radial electric field and Reynolds stress in
the edge-to-SOL transition region are also measured. Mechanism of density blob formation has been investigated for the first time, by this model. These blobs form in the edge-to-SOL transition region where shear of radial electric field is maximum. It is found that these blobs contribute almost 60% total transport. In the above studies, the role of molecular beam injection (MBI) and gas puff (GP) has also been investigated.

Finally, for relevance to edge plasmas under fusion reactor conditions, tokamak plasma instability in the edge region in collisionless and conditions, has been investigated in the presence of magnetically trapped particles, using simple drift types of modes. Electron inertia mainly drives instability in the presence of electrostatic and electromagnetic perturbations. Trapped particles are found to destabilize the modes.