Kinetic theory of the non-diffusive convective flows, generated in the tokamak edge plasma by the parametric inhomogeneous ion cyclotron turbulence in the fast wave heating regime

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It was found in essentially all fast wave (FW) heating experiments in tokamaks, that a significant fraction of the FW power does not appear in the plasma core and is lost presumably in the cold low density scrape-off layer (SOL) plasma adjacent to the FW antenna. It was observed [1] in the FW heating experiments in NSTX tokamak that a significant part of the edge FW power loss occurs due to the formation of large heat flux, which flows through the SOL to the divertor.

In this report, we present new two-scale approach [2-4] to the theory of the mesoscale convective flows generated by the radially inhomogeneous ion cyclotron (IC) parametric microturbulence in the pedestal plasma with a sheared poloidal flow. This theory involves the theory of the microscale IC parametric instabilities of the inhomogeneous plasma, driven by the inhomogeneous FW, and the theory of the mesoscale evolution of the plasma caused by the mesoscale inhomogeneity of the IC microturbulence. It was derived in [2, 3] that the spatial inhomogeneity of the parametric IC turbulence and of the drift turbulence is at the origin of the sheared poloidal and of the radial compressed non-diffusive convective flows with radial gradients of the flows velocities. The velocity of the radial compressed convective flow is in the direction opposite to the gradient of the spectral intensity of the microscale turbulence. In the pedestal plasma, this convective flow moves outward of pedestal to SOL region. This theory gives the possible explanation of the underlying mechanism of the convective flow formation in the FW heating experiment on NSTX [1]. We found that this flow is responsible for a significant part of the FW power loss due to the anomalous non-diffusive transport of the collisionless dense hot plasma from the edge to the cold low density scrape-off layer (SOL) plasma, which is delivered eventually to the divertor.

It was found, that the dynamical processes in the pedestal and near SOL are heavily determined by the sheared-compressed convective flows formed in this region by the inhomogeneous microturbulence and by interplay of these convective flows with the sheared poloidal edge flow of a tokamak plasma. The developed hydrodynamic mesoscale theory [3] reveals the radial convective flow as the dominant factor in the formation of the steep pedestal density profile with plasma density gradient exponentially growing with time.

Because of the presence of such flows in the edge of the tokamak plasma, the conventional modal theory of plasma stability is not valid for the dynamical edge, where any perturbation in the compressed-sheared flows experiences the persistent growing with time spatial distortion. The new nonmodal theory of the stability of the sheared-compressed flows, which accounts for the effects of the distortions of the perturbations in edge flows is developed[4].

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