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Study on the coherent structure of drift wave turbulence by eigenmode method

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The feeding and ash discharge process is one of the key scientific problem in steady-state operation in fusion reactors. The existing injection technology and transport provided by random turbulence can not satisfy the requirement of explosive fusion reactions. Coherent structures have large spatial scale and long time scale and the movement of particles tends to be a certain trace instead of random walk process. This can generate effectively particle transport along radial directions, which can provide an new path way to solve the feeding and ash discharge problem. Another advantage of the coherent mode is that the strong coherence between physical variables, so the transport amplitude and directions can be decided and control by several external physical parameters. The establishment of the eigenmode structure of drift wave turbulence is the basis for the study of new transport modes.

This work observed and researched the coherent structures in drift wave turbulence. Based on the data of probe and camera, the frequency spectrum characteristics of particle density and floating potential are diagnosed experimentally. The perturbation of the density and floating potential in drift wave frequency is shown to have specific and separate frequency spectrum with continuous wave vector distribution, opposite to the traditional theory where the special distribution is assumed to be discrete due to periodic boundary with continuous temporal spectrum. This spatially continuous and discrete time characteristic indicates that the coherent structure is time eigenmode. A theoretical model is proposed by study the time eigenvalue of a Schrödinger-like equation derived from the two-fluid equation. In cylindrical coordinate system, two quantum numbers m and n is given according to the periodicity in the polar direction and the symmetry in the axical direction. Suth the Schrodinger equation gives a series of eigen vectors of the $\partial/\partial\theta$ and $\partial/\partial z$. the dispersion relation function $D(r,\omega)$ related to the equilibrium profiles provide a non-homogenous terms in the equation make the eigen vectors collapse into time eigen vectors. The theoretical and experimental results is compared, the time eigenvalue and coherent structure are given. This work will provides theoretical support for the study of the mechanism of coherent turbulence and patterns.

Figure 1