Electromagnetic effects on zonal mode generation and turbulent transport in tokamak plasmas

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Drift wave turbulence and zonal flows generated from it have been extensively studied, since they may play an important role in anomalous transport and formation of transport barriers in fusion plasmas. We have investigated zonal flow behaviour driven from ion temperature gradient (ITG) turbulence and its effect on turbulent transport in tokamak plasmas at very low beta or in the electrostatic limit in recent years. In this paper electromagnetic or finite beta effects on generation of zonal modes, which include zonal magnetic fields as well as the zonal flows, and turbulent transport are investigated by global fluid simulations of electromagnetic ITG turbulence.

Three drives for the zonal flows, Reynolds stress, Maxwell stress and geodesic transfer, are analysed for various beta values from low value where the ITG mode is dominant to high value where kinetic ballooning mode (KBM) is dominant. The Reynolds stress contribution balances with the geodesic transfer in the ITG dominant regime and drives the zonal flows in almost whole region. It is found that the Reynolds stress and the geodesic transfer contributions change sign at low order rational surfaces. This is not observed in the electrostatic case. When the safety factor profile used is $q = 1.05+2(r/a)^2$, the principal low order rational surfaces are 1.5 and 2. If only even toroidal mode numbers like $n = 2, 4, \cdots$ are included, the lowest order rational surface is $q = 3/2 = 1.5$. In this case the reversal of the Reynolds stress and the geodesic transfer contributions is the most significant at $q = 1.5$ surface. On the other hand, the reversal of them is the most significant at $q = 2$ in the case where all toroidal mode numbers are included in the simulation. The generation of the zonal magnetic fields is similar to the above. More detail analysis about energy flows between the turbulence and the zonal modes will be presented in the meeting.