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Theoretical research on the interplay between impurity and drift wave-zonal flow system in the D-T plasma

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The interplay between impurities and drift wave-zonal flow system [1] is systematically studied in the deuterium (D)-tritium (T) plasmas. **First, the effects of various impurities on the arbitrary radial wavelength residual ZF is systematically investigated based on the bounce kinetic theory [2].** Impurities with gyroradius larger (smaller) than that of main ions can increase (decrease) the level of intermediate wavelength residual ZF; the level of short wavelength residual ZF is increased (decreased) by impurity which increases (decreases) the total polarization shielding. Even for the high ionized trace W impurity with concentration being 10^{-4}, it can still significantly impact the level of residual ZF. The effects of helium ash from the D-T reaction on residual ZF depend on the temperature ratio between electron and impurity.

Then, the impact of impurities on the generation of ZF driven by collisonless trapped electron mode (CTEM) turbulence is also investigated via the wave kinetics approach [3]. Impurity effects on both polarization shielding and CTEM instability are comprehensively considered. It is shown that the normalized ZF growth rate can be enhanced by fully ionized non-trace light impurities with relatively steep density profile. In DIII-D, the flow shearing rate is found to be increased due to the injection of neon and confinement improvement is also observed [4]. Our findings shown here are qualitatively consistent with this experimental result and could provide a possible theoretical explanation for it. In particular, we also found that high temperature helium from D-T reaction on ZF can enhance the normalized ZF growth rate, thus is possible to improve the confinement of future burning plasmas.

Furthermore, isotopic effects are long-standing puzzlement for magnetic fusion plasmas. Thus, we studied the **isotopic effects on residual zonal in plasma with impurity [2],** and it is found that the trend of stronger intermediate wavelength residual ZF in D-T plasmas with heavier effective isotope mass is weakened by non-trace light impurities, but is not influenced by trace W. We also found that the **increase of hydrogenic ion mass is favorable for transporting light impurity and W impurity driven by ion temperature gradient (ITG) turbulence [5],** and the isotopic effects on impurity transport get stronger with stronger magnetic shear.

References

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