Tungsten impurity effects on the coupling of TEM and ITG mode in tokamak plasmas

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The turbulence processes that govern anomalous transport in tokamak plasmas occur on multiple temporal and spatial scales. At the scale of ion gyro-radius, the trapped electron mode (TEM) and ion temperature gradient (ITG) mode are two of the most plausible contributors to turbulent transport, which may couple into one hybrid mode or coexist simultaneously in certain parameter regimes [1, 2].

A gyrokinetic integral eigenvalue equation is applied to investigate mode coupling and particle transport in tokamak plasmas with light impurities [3, 4]. Systematic analysis of tungsten impurity effects on mode characteristics and induced quasi-linear particle flux is performed and results are compared for positive and reversed magnetic shears in a wide regime of plasma parameters such as density gradient $L_{ez} = L_{ne}/L_{nz}$, charge concentration f_z, and charge number Z of impurity ions, and poloidal wave number $k_\theta \rho_s$ spectrum [5]. It is found in this work that the impurity ions with inwardly peaked density profile have strong stabilizing effects on modes and can suppress outward transport of background particles. As shown in Figure 1, the TEM and ITG mode are strongly coupled for both reversed and positive magnetic shears with $Z = 2, 4,$ and 6, while the two instabilities dominate in low and high η_i regimes for reversed magnetic shear, respectively, and coexist for positive magnetic shear with $Z = 8, 10$. This means that the increasing Z tends to decouple the hybrid mode into coexisting modes or dominating TEM/ITG mode in different parameter regions. Besides, the increasing Z can weaken outward transport of main ions.

This work is supported by National Natural Science Foundation of China (Grant Nos. 11925501, 11875099, 12075077).

References

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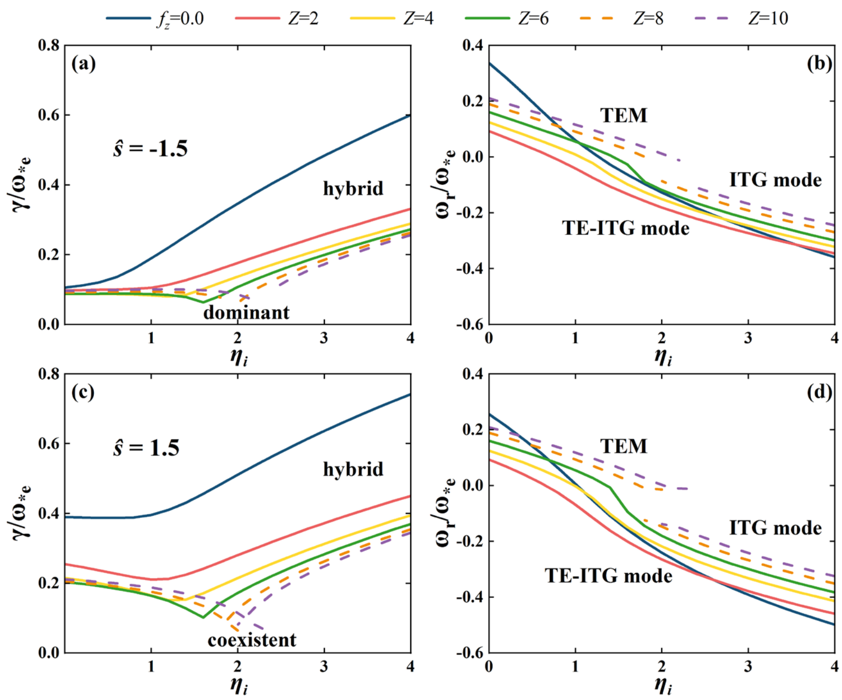

Figure 1. The normalized growth rate γ/ω_{*e} and real frequency ω_r/ω_{*e} of the coupling modes versus η_i for $Z = 2, 4, 6, 8,$ and 10. The solid lines represent the hybrid mode, while the dashed ones represent the coexistent mode or dominant TEM and ITG mode.