§18. Electron Temperature Gradient Instability in Toroidal Plasmas

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Recent experiments indicate that the electron thermal diffusivity is often still anomalous even in discharges with an ITB. The observations on DIII-D tokamaks have shown that, within ITBs, electron thermal transport hardly changes while ion thermal diffusivity was reduced to the neoclassical level. As a result, electron temperature gradient (ETG) instability and anomalous electron thermal transport become a hot topic. The correlation of the ETG turbulence and the electron thermal transport was first studied with quasilinear theory in sheared slab geometry. The formula for electron conductivity in these discussions successfully explained the so-called electron temperature profile consistency (stiffness as called recently) observed in experiments. Recently, the correlation of the ETG turbulence and the electron thermal transport was studied with gyrokinetic nonlinear simulation. In addition, the critical temperature gradients for the ETG instability and in electron transport were studied experimentally and theoretically. It seems apparent that critical gradient is the few physics quantities for which results from the linear theory may be compared quantitatively with the experimental observations.

The integral eigenvalue equation for the study of ITG modes is upgraded and employed for toroidal ETG mode study in the present work. New numerical scheme is adopted. This allows not only the growing modes but also damping modes to be investigated. Therefore, the critical gradients are accurately calculated. The basic characteristics of the modes are investigated and described in detail. The threshold with respect to toroidicity and to the ratio of electron temperature over ion temperature is given. In Fig.1a, the mode growth rate as functions of $\varepsilon_n = L_n/R$, where L_n, R are density scale length and major radius, respectively, are given for $k_\vartheta = 0.3$(Squares), 0.6(open circles) and 0.7(closed circles), respectively.

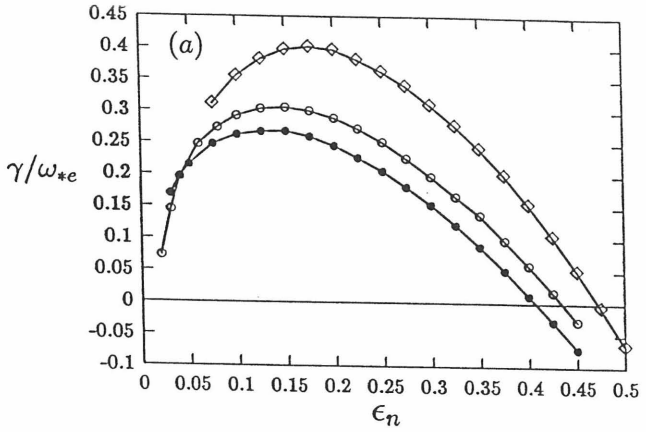

Fig.1a Mode growth rate versus ε_n for several values of k_ϑ.

The experiments on ASDEX-Upgrade clearly show that there is a threshold of electron temperature gradient above which the transport increases strongly to keep the profiles to close to $(\nabla T_e/T_e)^c$. The present theoretical results seem to support these experimental observations although more parameter scan and systematic analysis are needed.