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改善電子エネルギー閉じ込めに対する電流分布効果に関する H モードデータベース解析と乱流輸送解析

H-mode Database and Turbulence Analyses of the Current Profile Effect on Improved Electron Energy Confinement

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The confinement degradation of H-mode plasmas has been generally observed when the electron temperature T_e exceeds the ion temperature T_i [1]. The International Global H-mode Confinement Database [1,2] has been surveyed with an emphasis on the dependence of the H_H factor ($H_H \equiv \tau_{th}/\tau_{th,IPB98(y,2)}$) on the temperature ratio at the magnetic axis T_{e0}/T_{i0}. As a consequence, the degradation of H_H factor with an increase in T_{e0}/T_{i0} has been found. The transport simulations showed that the confinement degradation can be attributed to enhanced transport by ITG/TEM turbulence [3]. However, as depicted in figure 1, however, there are data that have the H_H factor exceeding unity in $T_{e0}/T_{i0} > 1$ region (open circles). In these data, the electron thermal energy is nearly twice larger than ion one, and the internal inductance l_i is lower than that of the other data in $T_{e0}/T_{i0} > 1$ region (open and closed circles in figure 2). The dataset of these high energy confinement discharges, which were heated by NBI, includes the data with $P_e/P_i < 1$, where P_e and P_i denote NBI power absorbed by the electrons and the ions, respectively. It is suggested that the current profile affects the electron heat transport.

In order to study a role of the current profile in turbulent transport, the gyrokinetic linear stability calculations have been performed by the GS2 code [5], paying attention to the magnetic shear s that has a close affinity with the current profile. Figure 3 shows the calculation results, where the input parameters are $\rho = 0.5$, $T_{e0}/T_{i0} = 1.2$, normalized electron and ion temperature gradients $R/L_{Te} = 6$ and $R/L_{Ti} = 7.5$, normalized density gradient $R/L_n = 2$ and the safety factor $q = 1.5$, which are consistent with the values from the database, and the wave number $k_\theta \rho_i$ is 0.3, around which ITG/TE mode has the maximum growth rate. The increase in s significantly reduces the electron heat flux compared to the ion one. The analyses infer the relationship between the increase in s in the core region and the decrease in l_i. Based on quasilinear theory and a modified mixing length estimate [6], the electron and ion thermal diffusivities are estimated, which we will present in the paper.

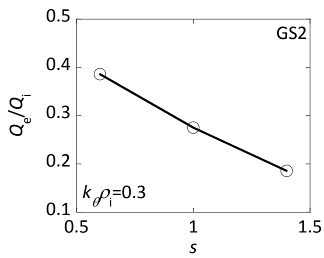

Figure 3 The dependence of heat flux ratio on magnetic shear from GS2.

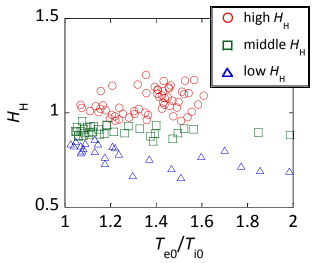

Figure 1 The plot of H_H factor as a function of temperature ratio at the magnetic axis.

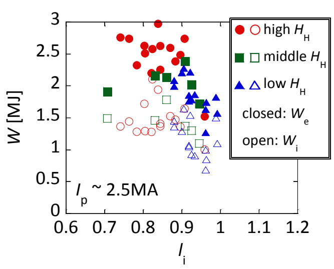

Figure 2 The dependence of thermal energy on internal inductance.

References

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