Gyrokinetic analyses of roles of toroidal rotation in core heat transport in JT-60U

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There are several types of improved confinement plasmas in JT-60U. Some types of them have an internal transport barrier (ITB). The 'parabolic type' ITB, which is one kind of ITBs, can be observed not only in reversed shear plasmas but also in normal shear plasmas. [1] The plasmas with this ITB have steeper pressure gradient in the core region than that in the peripheral region. In JT-60U, roles of toroidal rotation in these plasmas have been studied using neutral beam injector (NBI) units, and it was found that rotation in the co direction with respect to the plasma current provides the better electron temperature T_e-ITB. [2] On the other hand, the ion temperature gradient in core region is not influenced by the direction of toroidal rotation. These plasmas have the normal magnetic shear, and the radial electric field shear in the core region is weak. In addition, the similar power deposition profile is kept when rotation is varied. In this study, core heat transport in co- and counter(ctr)- toroidal rotating plasmas with parabolic type ITB is analyzed with the gyrokinetic code GS2. [3,4] The linear calculations are performed including collisions and electromagnetic effects. MHD equilibrium is taken from JT-60U database. The linear calculations in the low wave number region ($0 < k_\theta \rho_\mathrm{i} < 1$) show that the linear growth rates are similar for co and ctr cases, and the both plasmas have ion temperature gradient (ITG)-trapped electron mode(TEM) hybrid modes, but there is the difference in the real frequencies: the ctr-rotating plasma has more TEM-like frequency. The discrepancy in the real frequency may relate to the difference in the heat flux ratio of electron heat flux to ion 's $Q_\mathrm{e}/Q_\mathrm{i}$. The ratio is estimated with a quasi linear model [5] using the results of GS2 linear calculations. As a consequence, $Q_\mathrm{e}/Q_\mathrm{i}$ is higher for the ctr case than that for co case. This result does not change even if the gradients of electron and ion temperatures and the density vary $\pm 20\%$. Because of the higher $Q_\mathrm{e}/Q_\mathrm{i}$ for ctr case and similar deposition power profiles for two cases in the experiments, electron heat transport may be enhanced in ctr case. Therefore, the difference in the real frequencies may be linked to the electron temperature T_e-ITB.
The influence of the shear in toroidal rotation on the linear growth rates is also investigated. Recently, toroidal flow shear has been implemented in gyrokinetic codes, and is studied. (e.g. [6]) In GS2, $E \times B$ shear, which suppresses turbulent transport, and parallel velocity gradient, which drives instability are included as sheared toroidal flow. A comparison of the reductions in the linear growth rates for co- and ctr- rotating cases will be reported in the paper.

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