§18. DKES Results of Plasma Viscosity in Finite Aspect Ratio Tokamaks

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One of the approaches to improve the economy of a tokamak fusion reactor is to increase the plasma β, the ratio of the plasma pressure to the magnetic field pressure. One way to increase the first stability limit of β determined by the ballooning mode is to design a low aspect ratio tokamak. It is an interesting question whether the neoclassical transport is also favorable in the low aspect ratio tokamak or not. To this end, analytic expressions of neoclassical fluxes valid for arbitrary aspect ratio and collisionality are useful. It has been shown that neoclassical fluxes can be expressed in terms of viscosity and friction coefficients. Because the friction coefficient are valid for all collisionality and independent of aspect ratio, we only need an approximate analytic expression for plasma viscosity under the standard assumptions for the neoclassical theory. It is noted that the expression shown in Ref.1) may produce all the asymptotic limits. Here the accuracy of this expression is compared with numerical calculations with the DKES code$^{2)}$.

Figure 1 shows the normalized viscosity coefficient μ_n versus CMUL, which is a parameter proportional to collision frequency in the DKES, with the analytic expression. The results of DKES calculated for the same set of parameters are shown in Fig.2. The agreement in the banana and Pfirsch-Schlüter regimes is very good. When the inverse aspect ratio ϵ increases, the magnitude of the viscosity coefficient also increases for a finite q (safety factor) value in all collisionality regimes, as shown in Fig.1 and Fig.2. Because of this property, the bootstrap current is expected substantial in the Pfirsch-Schlüter regime. In the extreme case of $\epsilon \to 1$, the viscosity coefficient approaches infinity. Thus the bootstrap current, ion thermal conductivity and plasma electrical conductivity may have no collisionality dependence.

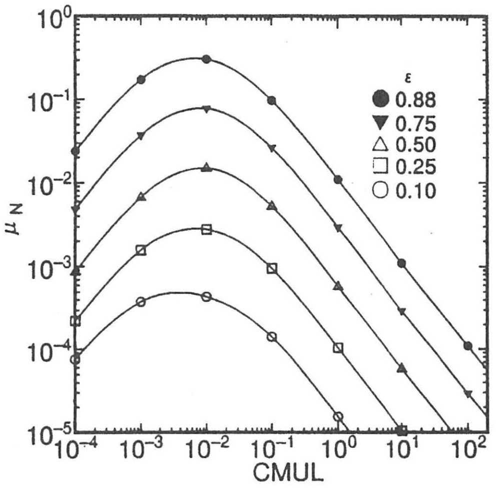

Fig.1. Normalized viscosity coefficients μ_n versus CMUL for various values of ϵ with the analytic expression.

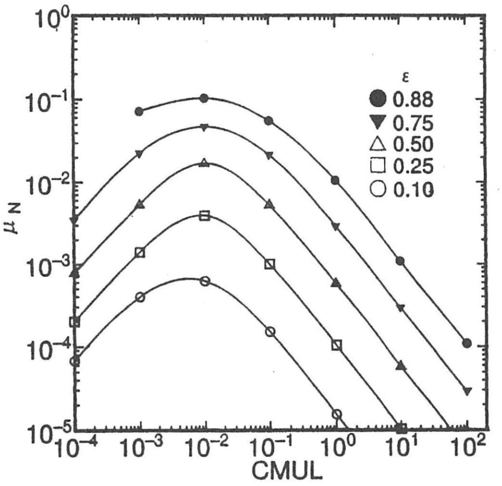

Fig.2. Normalized viscosity coefficients μ_n versus CMUL for various values of ϵ with the DKES code.

References

1) Shaing, K. C., Yokoyama, M., Wakatani, M., and Hsu, C. T., Phys. Plasmas 3 (1996) 965.

2) Van Rij, W. I., Hirshman, S. P., Phys. Fluids B1 (1989) 563.