# § 29. Neoclassical Transport Coefficients in the 2b32 Configuration of CHS-qa

Nishimura, S., Sugama, H., Okamura, S., Isobe, M., Suzuki, C., Shimizu, A., Matsuoka, K.

The qualities of the quasi-axisymmetry of the designed CHS-qa configurations[1] are being examined from the viewpoint of the neoclassical radial and parallel transports based on a recently developed calculation method[2]. In this method, 3 kinds of numerically obtained mono-energetic transport coefficients ($M(K)$, $N(K)$, and $L(K)$ defined in Ref.[2]) are used to express the parallel viscosities and radial diffusion fluxes in terms of the radial gradient forces and the parallel flows. By combining this expression with the well-known parallel momentum balance equation, in which the collisional momentum conservation is already taken into account, the full neoclassical transport matrix can be obtained in general toroidal configurations. Figure 1(a) shows the normalized mono-energetic transport coefficients $L^* \equiv L(K)/[(1/2)(v_{th}/T)(Bv_{th}/\Omega)^2 K^{3/2}]$ and $M^* \equiv M(K)/[m v_{th} K^{3/2}]$ at the minor radial position of $r/a$=0.5 of 2b32 configuration as the functions of $\nu/v$ and $E_r/v$ where $\nu(v)$, $v$, and $E_r$ are the pitch-angle-scattering collision frequency and the velocity of the test particle, and the radial electric field strength, respectively. Figure 1(b) shows the geometric factor for the bootstrap current $G^{(BS)} = e\langle B^2\rangle N(K)/M(K)$. For the comparison, the results in the imaginary axisymmetric limit (pure QA model), in which the non-axisymmetric components $B_{mn}(n \neq 0)$ of the Fourier expanded magnetic field strength are artificially set to be zero while the other quantities are unchanged, are also shown. Instead of the well-known $1/\nu$ dependence of the radial diffusion $L^*$ in the low collision frequency regime of conventional helical configurations, the $\nu^{-1/2}$ dependence appears for the wide range of the collision frequency. It suggests that the contribution of the ripple-trapped/untrapped boundary layer in the velocity space, which was formerly studied in rippled tokamaks[3], becomes relatively important compared with the contribution of the ripple-trapped part of the distribution. The parallel viscosity coefficient $M^*$ in 2b32 deviates from that in the axisymmetric limit largely in the Pfirsch-Schlueter collisionality regime while the deviation is small in the banana regime since this coefficient in the banana regime is determined only by the fraction of banana-trapped and untrapped particles. The geometric factor does not show the polarity reversal depending on the collisionality, which often appears in conventional helical configurations[4], and has the polarity to make the bootstrap current in co-direction in all collisionality regimes. In contrast to the axisymmetric limit in which the $G^{(BS)}$ is independent of the collisionality, however, the $G^{(BS)}$ in actual quasi-axisymmetric configuration 2b32 depends on the collisionality and the radial electric field and thus the bootstrap current in this configuration depends on the radial electric field[5]. It will be important future theme to include the effect of the radial electric field in the precise study of MHD equilibrium and stability.

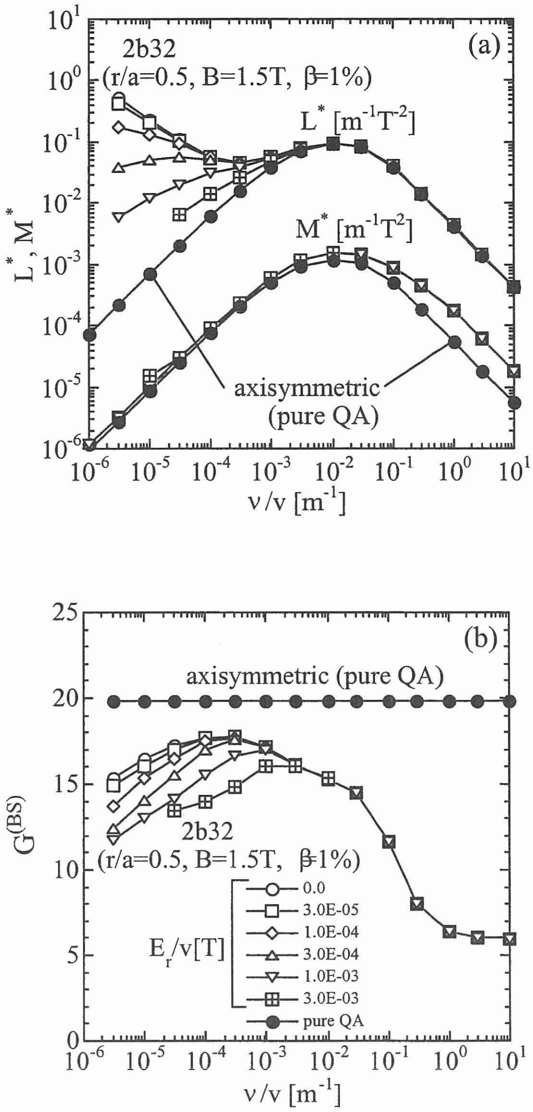


Fig.1 The normalized mono-energetic transport coefficients, $L^*$(radial diffusion), $M^*$(parallel viscosity) and $G^{(BS)}$ (geometric factor for the bootstrap current) in 2b32 ($r/a$=0.5) as the functions of the colisionality ($\nu/v$) and the radial electric field ($E_r/v$).

References

[1] Okamura,S., Matsuoka,K., Nishimura,S., et al., IAEA-CN-94/IC/P-07 (Lyon, 14-19,Oct. 2002)
[2] Sugama,H. and Nishimura,S., Phys.Plasmas 9, 4637(2002)
[3] Hinton,F.L. and Rosenbluth,M.N., Phys.Fluids 15,2211(1972) Shaing,K.C. and Callen,J.D., Phys.Fluids 25, 1012 (1982)
[4] Shaing,K.C., Hirshman,S.P., and Callen,J.D., Phys.Fluids 29, 521 (1986)
[5] Nakajima,N., Okamoto,M., and Fujiwara,M., J.Plasma Fusion Res. 68, 503 (1992)