§9. A Convergence Study for the Laguerre Expansion in the Neoclassical Transport

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The dependence of neoclassical parallel flow calculations on the maximum order of Laguerre polynomial expansions is investigated [1] in a magnetic configuration of the Large Helical Device [2] using the mono-energetic coefficient database obtained by an international collaboration [3]. On the basis of a previous generalization (the so-called Sugama-Nishimura method [4]) to an arbitrary order of the expansion, the 13M, 21M, and 29M approximations are compared. In a previous comparison, only the ion distribution function in the banana collisionality regime of single-ion-species plasmas in tokamak configurations was investigated. In this study, the dependence of the problems including electrons and impurities in the general collisionality regime in an actual nonsymmetric toroidal configuration is reported. In particular, qualities of approximations for the electron distribution function are investigated in detail.

With a recent extension of the moment equation solver allowing arbitrary Laguerre orders and arbitrary number of particle species [1], the dependence of the obtained flow moments on the expansion method for the Legendre order l=1 of the distribution (the 13M, 21M, and 29M approximations corresponding to the truncation at the orders $j_{\max}$=1, 2, and 3) is investigated. Figure 1 shows an example of this dependence of the flux-surface-averaged flow moments $\langle Bu_{\|ak}\rangle$ in a e^-+H^++Ne^{10+} plasma (T_e=2.0keV, T_i=1.0keV, $Z_{\rm eff}$=5.74, n_e=1×10^{18}m^{-3}, $\partial\langle p_e\rangle/\partial r/\langle n_e\rangle$ = $\partial\langle p_i\rangle/\partial r/\langle n_i\rangle$ = $\partial\langle T_e\rangle/\partial r$ = $\partial\langle T_i\rangle/\partial r$ = −3.0keV/m) as functions of the radial electric field strength E_r in a LHD configuration ($R_{\rm ax}$=3.6m, B=2.45T, r/a=0.5) [2]. Here, the mono-energetic DKES coefficients [3] in the LHD configuration are used for obtaining the required viscosity coefficients $M^a_{j+1,k+1}$, $N^a_{j+1,k}$, which are defined in Ref.[4].

This result indicates that although light particle species sometimes requires the three terms expansion ($j_{\max}$=2) for $\langle Bf_{a1}^{(l=1)}\rangle$, that of heavy particle species can be well approximated by the two terms expansion ($j_{\max}$=1). In most of cases with our practical interest, 29M approximation ($j_{\max}$=3) is not required. Since all of non-diagonal coupling effects between arbitrary species are included in this present calculation, the result will be useful for future studies on the bootstrap current, helium ash control, impurity transport, and so on.

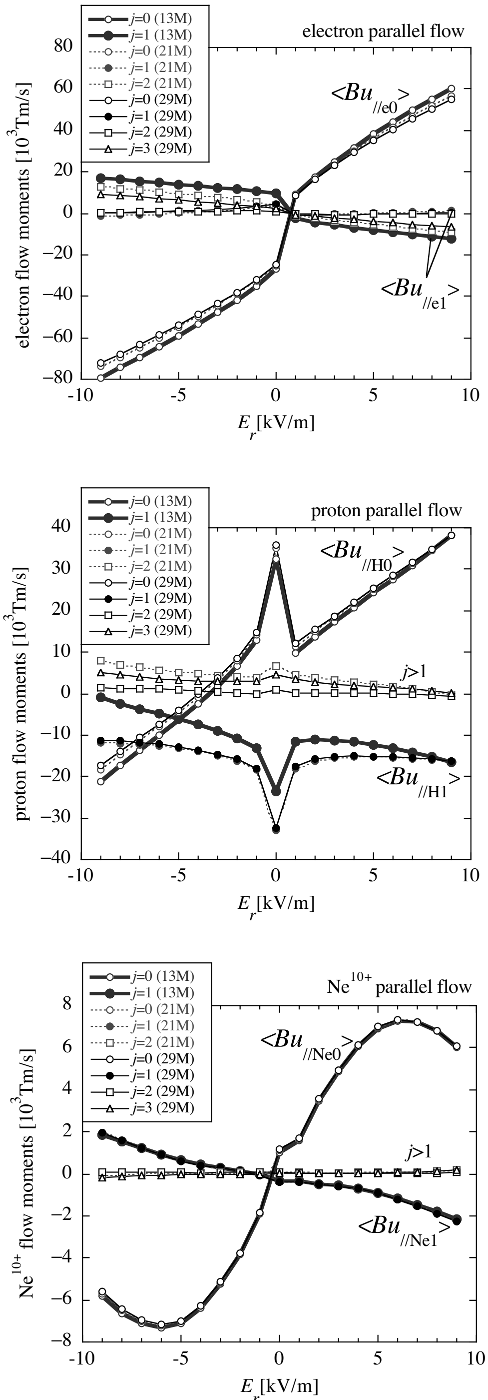

Fig.1 The 0≤j≤3 Laguerre moments of the flux-surface-averaged parallel flow given by the 13M, 21M, and 29M approximations for a e^-+H^++Ne^{10+} plasma in a LHD configuration with $R_{\rm ax}$=3.6m, B=2.45T (at r/a=0.5).

1) S.Nishimura, et al., in 17th ISHW and ICST (Princeton, 12-20 Oct. 2009) P02-16, in this report, to be published in Phys.Plasmas
2) S. Murakami, et al., Nucl. Fusion **42**, L19 (2002)
3) C.D. Beidler, et al., in 22nd IAEA FEC (Geneva, 13-18 Oct. 2008) TH/P8-10
4) H.Sugama and S.Nishimura, Phys. Plasmas 15, 042502 (2008)