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非対称トーラスにおける新古典的不純物輸送
Neoclassical transport of impurities in non-symmetric toroidal plasmas

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Though many extensions and applications of the moment equation method for neoclassical transport in non-symmetric toroidal plasmas had been conducted [1-3], handling methods of the multi-ion-species plasmas with finite ambipolar radial electric field had not yet been completed. In fact, an extension to cases with multiple ion species [1], an inclusion of external momentum input due the tangentially injected neutral beams [2-3], and comparisons of calculated impurity flows with measured ones in experiments [3] were reported. The non-diagonal term connecting the particle species in the transport matrix given by these theories is expected to be an important key to understand the recent impurity transport problem in helical devices [4]. However, these previous studies are discussions only on the surface-averaged component of the parallel flows $\left\langle Bf_{a1}^{(l=1)} \right\rangle$ and parallel force balances including the surface-averaged friction moments $\left\langle BF_{\|aj} \right\rangle$, and thus resulting transport matrix excludes the Pfirsch-Schlüter diffusion, which gives an important non-diagonal coupling between the ion species in finite Z_{eff} operations. In multi-ion-species plasmas in non-symmetric toroidal configurations especially those with finite ambipolar radial electric fields, the poloidal and toroidal variation of parallel flow is not so simple because of an orbit squeezing effect. Additional viscosity effects also should be evaluated when this drift effect is included. In this study, we extend the transport matrix for the impurity transport study by including these effects, which are peculiar to non-symmetric toroidal configurations. This understanding on the spatial structure of particle and heat flows will be useful also for recent impurity velocity distribution measurements with excellent spatial resolutions.

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[3] K.Nishioka, H.Y.Lee, et al, in 22nd International Toki Conference, 2012
[4] T.Ido, A.Shimizu, et al., Plasma Phys. Control. Fusion **52** (2010) 124025