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新古典輸送、平行方向フロー計算における外部運動量入力の適用
An inclusion of external momentum input into the calculation of neoclassical transport and parallel flows

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NBI system is one of the most common systems for the heating and current drive at magnetic confinement fusion devices. This system is very useful, but external parallel momentum is also added and this results the change of parallel momentum balance. This change requires the redefinition of neoclassical transport relation, which is based on the balance equation. Therefore, when we analyze neoclassical transport of plasma with NBI, we have to consider the external source term to the momentum balance equation.

The corrected parallel momentum balance is as follow:

$$\nabla p_a + \nabla \cdot \boldsymbol{\pi}_a - e_a n_a \boldsymbol{E} = \boldsymbol{F}_a + m_a \int v_{\parallel} S_a(\boldsymbol{x}, \boldsymbol{v}) \mathrm{d}\mathbf{v}, \quad (1)$$

and the last term of right hand is the additional term of this research, and this (1) results $\sum_a \langle \boldsymbol{B} \cdot \nabla \cdot \boldsymbol{\pi}_a \rangle \neq 0$. When we consider fast ion effect, we should note that collision between fast ion and thermal ion shows quite different from between thermal particles, and have to treat with a unique process [1]. From this corrected balance, we analyzed neoclassical transport with moment method, and resulting moment equation, which is more complicated form and doesn't satisfy self-consistent property, is as follow [2, 3]:

$$[-\mathbf{M} + \boldsymbol{\Lambda}] \cdot [\mathbf{U}] = [\mathbf{N}][\mathbf{X}] - [\mathbf{Z}]\langle BE_{\parallel} \rangle - [\mathbf{C}]\langle BF_{\parallel f1} \rangle. \quad (2)$$

There are new requirements for calculation on parallel friction force term of fast ion and collision term. At this research, we adopted the Gaffey's function [4] as a velocity distribution function of fast ion, which is independent of magnetic field structure and we obtained parallel friction force of fast ion from FIT code [5]. From these calculations, we aim to estimate the effect of NBI to neoclassical transport and parallel particle flow with moment method and compare with the measured one in the experiment.

At this works, we targeted the plasma at Heliotron J equilibrium field and NBI of this device (28keV, parallel injection) at this research. Figure 1 shows the radial dependence of parallel particle flow with no NBI. This result indicates lower particle flow speed at plasma inboard than outboard because this calculation reflects only the smallness of thermodynamic forces. We will discuss about the influence of additional momentum source to neoclassical transport and flow speed, and in addition, the comparison with the ion flow speed from CXRS measurement.

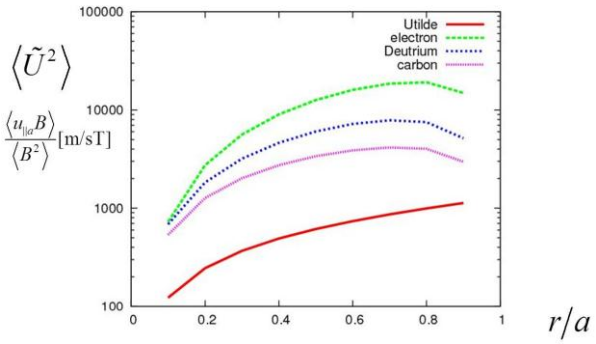

Fig.1 particle flow speed and PS flow

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