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Anomalous and Neoclassical Transport of Hydrogen Isotope and Impurity Ions in LHD Plasmas

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Gyrokinetic and drift kinetic simulations are carried out to investigate anomalous and neoclassical transport of hydrogen isotope and impurity ions in Large Helical Device (LHD) plasmas.
Turbulent transport in high electron temperature regime, where the trapped electron mode (TEM) is dominant, is a critical issue for future burning plasmas. To clarify an impact of hydrogen isotope species on the turbulent transport in LHD system, TEM turbulence simulations in hydrogen and deuterium LHD plasmas with real-mass kinetic electrons have been carried out for the first time by gyrokinetic simulations with multi-species collision operator. The strong isotope dependence on the growth rate of collisionless TEM branch appears through the stabilization effect due to a mass dependence in the normalized electron-ion collision frequencies. Nonlinear simulations clarify the significant dependence of the isotope species in the reduction of the electron and ion energy fluxes in deuterium plasma. Here, stronger TEM stabilization in the deuterium plasma leads to the enhancement in the ratio of ZF energy to total energy.
Transport in high ion temperature (Ti) plasmas with extremely hollow impurity density profiles (impurity hole) is also a critical issue hole phenomena is also a critical issue for high-performance. In high-Ti LHD plasma, the simulation indicates the neoclassical particle fluxes of electron and bulk ion species are outward directed, although the flux of the impurity carbon is extremely small and its value and direction are sensitive to the radial electric field. On the other hand, the microinstability analyses by gyrokinetic simulations show that the anomalous contributions of quasi-linear particle fluxes of all species are inward-directed which is consistent with the fact that the positive neoclassical particle fluxes and the negative turbulent fluxes should be balanced in a steady state. The ratio of each particle flux is almost consistent with the neoclassical contributions.

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Primary author: Dr NUNAMI, Masanori (National Institute for Fusion Science)

Co-authors: Prof. SUGAMA, Hideo (National Institute for Fusion Science); Dr VELASCO, José Luis (CIEMAT); Prof. YOKOYAMA, MASAYUKI (National Institute for Fusion Science); Dr SATO, Masahiko (National Institute for Fusion Science); Dr NAKATA, Motoki (National Institute for Fusion Science); Dr SATAKE, Shinsuke (National Institute for Fusion Science, Japan)

Presenter: Dr NUNAMI, Masanori (National Institute for Fusion Science)

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