Characterization of Isotope Effect on Confinement of NBI-Heated Plasmas on LHD

H. Yamada[1,2], K.Tanaka[1,3], T.Tokuzawa[1], R.Seki[1,4], C.Suzuki[1], M.Yokoyama[1,4], K.Ida[1,4], M.Yoshinuma[1], K.Fujii[5], S.Murakami[5] and LHD Experiment Group

[1] *National Institute for Fusion Science/NINS, Toki, Japan*

[2] *The Univ. Tokyo, Kashiwa, Japan,* [3] *Kyushu Univ., Kasuga, Japan,*

[4]*SOKENDAI, Toki, Japan,* [5]*Kyoto Univ., Kyoto, Japan*

Energy confinement and thermal transport has been widely regarded as gyro-Bohm in tokamak as well as stellarator-heliotron for a single kind of ion. However, this gyro-Bohm model predicts confinement degradation in deuterium (D) plasmas because of larger normalized gyro radius ρ* than in hydrogen (H) plasmas, which conflicts with major experimental observations. This study aims to quantify a peculiarity in dependence on ρ* in H and D plasmas in order to address this unresolved issue. The first deuterium plasma campaign in LHD reveals characteristics of isotope effect from elaborated experiments on NBI-heated plasmas. Thermal energy confinement time gives the regression expression scaling with the isotope mass (A) as $A^{0.15}$, which shows moderate improvement in D plasmas. This positive isotope dependence contradicts with gyro-Bohm and is similar to the recent result from L-mode plasmas in JET-ILW. Operational flexibility of magnetic field, density, and heating power enables adjustment of three major non-dimensional parameters, those being ρ*, collisionality ν* and β , and dimensionally similar plasmas of H and D in all these three parameters can be obtained. Then TASK3D-a / FIT3D is used for analysis of heating power deposition, power balance and local thermal transport. If gyro-Bohm nature predominates in these plasmas, thermal diffusivity normalized by Bohm diffusion should be the same in a pair of dimensionally similar plasmas of H and D. Different characteristics from this conjecture have been found in electron and ion loss channels. Electron heat diffusivity normalized by Bohm diffusion in H is lower than that in D and even lower by more than a factor of 1/√2 which means net improvement. This trend is robust and insensitive to parameters such as ρ*, ν*, β and L_n. In contrast, ion thermal diffusivity shows same characteristics in low collsionality regime while that in D compared with the case with H degrades with the increase of collsionality. These results have shown definitively that the gyro-Bohm nature is violated in the comparison of H and D plasmas in LHD.