Poloidally asymmetric distribution of light and heavy impurities in KSTAR plasmas with high rotation speed

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Under fast toroidal plasma rotation, heavy impurities inside the tokamak plasmas are known to experience strong centrifugal force that drives dramatic increase of the neoclassical transport and inward convection of the impurities. Here, we provide experimental observations of poloidally asymmetric density distribution of not only heavy W impurity but also light species caused by rapid toroidal rotation in KSTAR plasmas. The analysis was performed by using the KAIST Impurity Modelling (KIM) code with our recently-developed tomographic reconstruction method for a space-resolved EUV spectrometer with a limited field of view [1]. The results show that the effective Mach number of impurity species in KSTAR exceeds the unity when the toroidal rotation speed is larger than 50 km/s (W), 100 km/s (Kr), 300 km/s (O), and 320 km/s (C), resulting in exhibiting poloidally asymmetric emission profiles. In KSTAR shot #16611, C VI (3.37 nm), C V (4.03 nm), and O VIII (second, 3.80 nm) line transitions measured by the EUV spectrometer CAES [2] show significant asymmetry of the emission lines from low field side to high field side. In the case of heavier impurity such as tungsten or krypton, the synthetic diagnostics calculated by KIM code showed good agreement with the experimental observations (Kr 28+ and W 28+ lines) in KSTAR when the strongly peaked inward convection is assumed.

[1] I. Song et al., Nucl. Fusion 60 (2020) 036013

[2] I. Song et al., Rev. Sci. Instrum. 88 (2017) 093509

[3] K. Kim et al., Nucl. Fusion 57 (2017) 126035