Modeling of Impurity Transport in Edge Plasmas and Tritium Codeposition on Plasma Facing Walls in ITER

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Long-distance transport of carbon and hydrocarbons in edge plasmas causes a formation of tritium-rich C layer on plasma facing components (PFC). It drastically changes tritium inventory over the entire machine. Modeling of the tritium codeposition requires self-consistent calculation of (1) impurity release from the PFC, (2) impurity transport in the edge plasmas, and (3) impurity reflection and deposition on the PFC and others. In order to simulate the codeposition on the ITER PFCs, a plasma surface interaction code, EDDY [1], is coupled to an ITER edge plasma calculated using a plasma code, SOLPS.

The PFCs are bombarded by fuel tritium and impurity ions of various species and charge states. EDDY calculates physical sputtering yield and species, energy and angle of sputtered atoms, whereas chemical sputtering yield depending on the surface temperature, ion flux and energy is taken from Roth formula where a CH_4 molecule is sputtered. Ionizations and dissociations of the sputtered particles in edge plasmas are calculated using rate coefficients according to existing empirical formulae. The local plasma parameters are taken from the SOLPS. The interaction of ionized particles with the plasma is caused by friction and thermal forces parallel to the local magnetic field lines and cross-field diffusion perpendicular to it, in addition to the gyromotion. Each particle has a probability to return to the surface and to stick on it after transport through the plasma. The probability is calculated for atoms by the EDDY, whereas for molecules the distribution of reflected (not stuck) species is taken from molecular dynamic calculations [2].

Our calculation results reproduce dominant tritium codeposition on an inner divertor target as predicted by other modeling for the present designed ITER. It estimates extremely large tritium retention rate of the order of 10 mg T/s, which limits to be less than 100 discharges in a ITER standard operation. The results also show that the heating of the target up to a temperature of ~500 ^{o}C reduces the retention rate by a factor of 10 or more.

[1] K. Ohya, Physica Scripta T124 (2006) 70.
[2] K. Ohya et al., 22nd Proc. IAEA FEC, TH/P4-8 (2008).