Development of coupled IMPGYRO-SOLPS codes for analyzing tokamak plasmas with tungsten impurities

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Tungsten has been used as a wall material for some tokamaks. Tungsten is also one of the wall material candidates proposed in future devices. The IMPGYRO code has been developed with the aim to analyze plasma including tungsten impurities on such devices with tungsten walls [1]. The IMPGYRO code follows trajectories of tungsten impurity particles. Their equations of motion are directly solved without using the guiding center approximation. Therefore, the incident angle of the impurity particle impinging onto each wall component can be obtained, and the effect of the finite Larmor radius is naturally taken into account. Coulomb collisions and ionization / recombination are simulated using the Monte-Carlo method. The EDDY (Erosion and Deposition based on a DYnamic model) code [2] has been coupled with the IMPGYRO code to simulate self-sputtering and reflection from each wall.

The IMPGYRO code uses background plasmas which are calculated by the SOLPS codes [3]. The IMPGYRO and SOLPS codes have been coupled to simulate tungsten impurity and background plasmas self-consistently [4]. The IMPGYRO code obtains and transfers the following source / sink terms: 1) electron particle source / sink due to tungsten ionization / recombination, 2) electron heat sink by tungsten radiation cooling, 3) background plasma ion momentum source / sink due to Coulomb collisions with tungsten ions, and 4) background plasma ion heat source / sink due to Coulomb collisions with tungsten ions. Then the updated plasma parameters, such as electron / background ion density, momentum, and temperature, are returned from the SOLPS code. The plasma parameters and source / sink terms are not only transferred at the beginning of the calculation, but also every certain number of time steps.

Test calculations of the coupled codes have been done for the ASDEX Upgrade tokamak geometry. Tungsten impurity transports and its effects on the background plasmas are compared between with and without coupling. Recent progress of the coupling and test calculations, e.g., the local transport near the target plate (e.g. the effect of the prompt re-deposition) as well as the global transport in the SOL will be discussed with gyro and kinetic effects of high-Z impurity by the coupled IMPGYRO-SOLPS code. Not only the physics aspects, but also numerical aspects (synchronizing and data transfer scheme using MPI, and iteration algorithm between SOLPS and IMPGYRO to obtain the steady state solution) will be discussed in the presentation.

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