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Development of test-carbon-ion transport simulation code with atomic and collision process in HL-2M tokamak

W. J. Chen[1], **D. L. Yu**[1], **L. W. Yan**[1], **G. Z. Hao**[1], **L. Liu**[1], **C. F. Dong**[1], **X. F. He**[1], **X. X. He**[1], **Y. L. Wei**[1], **N. Zhang**[1], **Y. P. Zhang**[1], **L. Nie**[1], **Z. B. Shi**[1], **Y. Liu**[1], **Q. W. Yang**[1]

[1]*Southwestern Institute of Physics, Chengdu, China*

The HL-2M tokamak (Huan Liu Qi-2 Modification) is a new tokamak with an advanced divertor configuration. At the first stage, the carbon material will be applied to the first wall and divertor. Therefore, study of carbon impurity behavior in HL-2M is extremely important for realizing steady-state operation. In general, impurity ions give rise to degradation of the plasma performance through fuel dilution and radiation loss. Now, a space-resolved extreme ultraviolet (EUV) spectrometer system has been developed in the HL-2A/2M tokamak for impurity monitoring and transport studies [1]. And a tri-band high spectral resolution spectrometer is developed to measure the plasma parameters such as ion temperatures, rotation velocities as well as ion density profiles of He, C and D simultaneously [2]. These measurements can provide rich data for impurity transport research.

There have been developed two types of impurity transport models, one is a fluid model, such as EMC3-ERINCE [3] and SOLIP-ITER [4], and the other is a test particle model [5]. Although the test particle model takes longer computational time, it has several advantages compared with the fluid model: (1) the model directly follows the charged particle trajectories, and therefore, it can simulate the advanced divertor configuration for HL-2M, (2) various atomic and collisional effects on impurities (ionization, recombination, charge exchange and Coulomb collision with background particles) and (3) the interaction with wall materials can be simulated more directly.

Our initial goal is to develop a test-ion particle code to simulate the spatial distribution of carbon impurity in HL-2M configuration. The motion of charged particles are in the guiding-center phase space [6]. The neoclassical transport is caused primarily by the varying depth of particle trapping in the magnetic well along the magnetic field with collision. The Monte Carlo pitch angle scattering model of the Lorentz collision operator is implemented to update the particle pitch angle [7]. A new random velocity sampling is adopted, which plays a key role in plasma heating, instead of conserving total momentum and energy. In order to make the charge of carbon ions evolve self-consistently, some atomic processes are considered, including ionization, charge exchange and recombination [8].

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Presenting Author Email Address: *chenwj@swip.ac.cn*