Advanced Capabilities of Monte Carlo Program SuperMC for Fusion Applications

Jing Song, Liqin Hu, Pengcheng Long, Lijuan Hao, Mengyun Cheng, Huaqing Zheng, Shengpeng Yu, Guangyao Sun, Qi Yang, Bin Wu, Chaobin Chen, Peng He, Yican Wu, FDS Team

Key Laboratory of Neutronics and Radiation Safety, Institute of Nuclear Energy Safety Technology, Chinese Academy of Sciences, Hefei, Anhui, 230031, China

Lead-author e-mail: jing.song@fds.org.cn

Great challenges exist in fusion application for the current Monte Carlo (MC) methods including the modeling of complex geometries, deep penetration problem simulationetc. Super Monte Carlo Simulation Program for Nuclear and Radiation Process (SuperMC), a general purpose, intelligent and multi-functional program for the design and safety evaluation of nuclear systems, is evolving to perform the comprehensive fusion neutronics calculation.

The latest version can accomplish the transport calculation of n, γ, and the activation calculation. It is integrated with the functions of automatic modeling, visualization and cloud computing. SuperMC has powerful automatic and accurate modeling of complex-configuration geometry and physics, and series of novel algorithms for accelerating transport calculation. To meet the requirements of simulation of deep penetration problem in radiation shielding, a new global variance reduction method, named Global Weight Window Generator was proposed and developed, which is computationally efficient and requires little user interference. It speeds up the global flux calculation 249 times for the ITER Alite model.

SuperMC has been verified and validated by more than 2000 benchmark models and experiments such as Shielding Integral Benchmark Archive Database (SINBAD). For validating the comprehensive capability for fusion applications, series of fusion reactors were employed, such as ITER Alite, Clite, FDS-II, etc. Furthermore, SuperMC was applied in the shielding analysis of ITER bio-shield plug to evaluate the shielding performance and surrounded dose distribution of bio-shield plug.