Development and Experimental Validation of Super Monte Carlo Simulation Program for Fusion Applications

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The complexity of fusion reactors brings great challenges for Monte Carlo (MC) codes on geometry description, deep penetration, extensive calculation time for convergence, validation adaptability and correctness for fusion application, etc. SuperMC is a CAD-based MC program for integrated simulation of nuclear system by making use of hybrid MC-deterministic method and advanced computer technologies. SuperMC 2.2, the latest version, can perform neutron, photon and coupled neutron and photon transport calculation and integrates intelligent functions of modeling and visualization. It greatly reduces the human effort and has the capability to deal with the complex fusion models. Series of acceleration methods such as adaptive variance reduction techniques using SN for pre-calculation and coupled MC-SN modeling and transport method based on domain splitting have been developed and incorporated.

SuperMC2.2 has been validated by series of international benchmarks. With the ITER benchmark model, SuperMC2.2 can perform transport calculation directly using CAD model and the calculation efficiency is higher than MCNP. Besides, international integral leakage rate experiments, fusion neutron source FNG and etc. were used for validation to demonstrate the correctness and capability of SuperMC for fusion applications. To remedy the present defects of MC methods for fusion application, following types of experiments are specially planned using High Intensity D-T Fusion Neutron Generator (HINEG) and other equipments: cross section measurement of key nuclides such as Pb, deep penetration problem of shielding, tritium breeding, material activation and etc.

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