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P4.227 Development and Application of Neutronics Design Software SuperMC for Fusion

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Super Multi-functional Calculation Program for Nuclear Design and Safety Evaluation, SuperMC, developed by FDS Team in China, is a large-scale integrated software system. Taking neutron transport calculation as the core, SuperMC supports the whole process neutronics calculation containing depletion, radiation source term/dose/biohazard, material activation and transmutation. Besides, SuperMC has three main advanced capabilities including CAD/image-based accurate modeling, intelligent data analysis based on multi-D/multi-style visualization and network collaborative nuclear analysis on cloud computing platform.

The whole process of fusion neutronics design, i.e. radiation transport, depletion, activation, and dose calculations are inner-coupled in SuperMC. Advanced radiation transport methods, such as Global weight window generator (GWWG), leads to the calculation efficiency for ITER analysis speed up by 637 times. For activation calculation, the exponential transformation Chebyshev rational approximation method (CRAM) was adopted, in which long time step is divided into several short time steps to avoid inaccurate results caused by long time step problem. Shutdown dose rate (SDR) calculation based on both rigorous two step (R2S) and direct one step (D1S) methods were developed, in which CAD-based accuracy homogenization method was employed for multi-material activation mesh, and the flexible sector cylinder activation mesh division method was implemented to support direction angle sampling.

Complex irregular geometry can be accurately described by hybrid CSG and facet geometry representation, which enables direct use of complicate CAD models including spline surfaces without pre-processing. Meanwhile physical modeling including materials, sources, tallies, etc. has been developed, by which the complex fusion plasma sources could be modeling by one-click, greatly simplified the fusion radiation safety simulation.

SuperMC has been verified and validated by more than 2000 benchmark models and experiments, including SINBAD, fusion reactors (ITER benchmark, ITER C-lite, FDS-II) and ITER SDR benchmark. It has been applied in over 30 major nuclear engineering projects, such as ITER, Europe DEMO, etc.

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