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Development and application of advanced nuclear software SuperMC for fusion

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SuperMC, developed by FDS Team in China, is a general, intelligent, accurate and precise program for the nuclear design and safety analysis. The latest version supports n , γ transport calculation, depletion calculation, activation calculation and shutdown dose rate (SDR) calculation, with the advanced features of automatic modeling, visualization and cloud computing.

Built-in activation calculation was newly developed based on a new matrix exponential method-Chebyshev rational approximation method (CRAM) method. Depth first searching based dynamic construction of activation chain was developed to avoid redundant nuclides. Adaptive reduction of massive matrix order was developed to accelerate coefficient matrix solving. The SDR calculation was developed based on both rigorous two step (R2S) method and direct one step (D1S) method.

To improve performance of transport calculation, several novel methods were developed. Global Weight Window Generator (GWWG) was proposed, in which the expected contribution to a uniform particle distribution was considered, and an automatic iteration scheme was implemented to speed up the weight window generation.

Hybrid geometry representation and modeling methods was implemented in SuperMC. Hybrid facet and constructive geometry modeling method has been implemented, which enables SuperMC directly using complicated CAD models including spline surfaces without pre-processing. Besides, unstructured mesh was newly applied in SuperMC to enhance the description capability of arbitrary shape and process the multi-physics coupling analysis. A new speedup method called feature size tree was presented to accelerate the unstructured mesh geometry processing and further reduce the memory consumption.

SuperMC has been verified and validated by more than 2000 benchmark models and experiments, such as SINBAD, ITER C-lite. Meanwhile, series of SDR benchmark tests were used to verify the activation and SDR calculation, such as the ITER shutdown dose rate benchmark and ITER-T426 shutdown dose rate experiment. The results of SuperMC agree well with other codes and experiment results. In addition, with the new developed acceleration methods, calculation speed of SuperMC was greatly increased by about 200 times for ITER Alite model.

Eligible for student paper award?

No

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