Equivalent Fundamental-Mode Source Simulations for Spherical Uranium and Plutonium Systems

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The equivalent fundamental-mode source refers to a "source" which is identically distributed in space, energy, and angle as that of a fundamental-mode fission source distribution. It has previously been shown that the system fixed source multiplication (M_{fs}) relates to the effective multiplication factor (k_{eff}) as $M_{fs} = \frac{g^*}{1-k_{eff}}$. The term g^* therefore relates the system source distribution to the system equivalent fundamental-mode source. As previously shown, the g^* term is approximately 1 for deeply subcritical systems and then diverges as the system multiplication increases. For a system with a point source located in the center of an assembly (such a sphere), g^* will be greater than 1; this happens because there is a higher probability of induced fission when all of the starter neutrons originate from the center of the sphere. For a uniform source, g^* is less than 1, but does not diverge from 1 as dramatically as seen by a point source. One reason that g^* is an important parameter is that it is used in measurement methods to infer reactor kinetics parameters (β_{eff} being one example).

This work will discuss multiple ways to simulate g^* using MCNP®6.2, which include use of traditional methods versus a single input file method that was recently published. A discussion related to methods to simulate M_{fs} will be presented. Spherical systems of Highly Enriched Uranium (HEU) will be compared with previous works. In addition, results of plutonium including multiple reflector materials will be investigated. Simulated systems will include both parametric studies as well as configurations used in recent experiments performed at the National Criticality Experiments Research Center (NCERC). These studies will include subtleties associated with system geometry that have not been previously shown. Last, this work will investigate the relationship between g^* and reactor kinetics parameters (such as β_{eff}).