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#4-158 Predicting neutron noise detector responses for zero-power Molten Salt Reactor experiments

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We use Monte Carlo simulations to predict the experimental conditions for neutron noise experiments in Molten Salt Reactors (MSRs). Several MSR designs are in the process of obtaining construction and operation licenses around the world. For example, the Danish company Copenhagen Atomics recently announced a cooperation with the Swiss Paul Scherrer Institute (PSI) to deploy their 100 MW 'onion core'MSR at PSI by 2026. As for conventional reactors, the initial testing of a newly constructed reactor often comprises zero-power tests and criticality experiments. In zero-power environments, neutron noise experiments can be part of the experimental portfolio to provide experimental data on integral kinetic parameters such as the prompt neutron decay constant α, reactivity ρ or the effective delayed neutron fraction β_{eff}. Neutron noise experiments exploit the statistical correlations in neutron detector signals via noise analysis methods, such as the Rossi-α method. By auto-correlating a detector signal in time, one can observe the exponential decay associated with the prompt chain decay, thereby enabling the determination of α via curve fitting. The results are then used for code validation, nuclear data feedback or safety monitoring purposes. For MSRs, the flowing fuel –and the therefore flowing precursors –leads to a unique dynamic behaviour that could be experimentally studied with neutron noise techniques. For example, β_{eff} depends on the fluid velocity: For higher velocities the precursors are swept out of the core and therefore might not contribute to the reactivity, and in many MSR designs β_{eff} therefore goes down with higher flow rate. The validation of this sort of behaviour has yet to be accomplished in experiments, and the prediction of what neutron noise experiments would measure in a zero-power testing environment has hitherto not been performed. In this work, we present simulations using several MSR models (the Molten Salt Reactor Experiment and a Molten Salt Fast Reactor) in OpenMC and Serpent 2 to predict the Rossi-α curves for different operational scenarios. We investigate the effect of flow rate, primary circuit length, and possible detector locations to achieve the desired measurement results with sufficient statistical certainty. Our approach is novel in its use of explicit Monte Carlo modelling for noise experiments in MSRs, as well as in providing early feedback on experimental design and instrumentation needs. Our results indicate that noise experiments in zero-power MSRs are feasible and that noise responses could reveal fuel velocity, recirculation time, and kinetic parameters. We discuss potential challenges in the experimental implementation and required measurement times.

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