# A Reduced Order Model for the Fast Predictions of Reactivity and Neutron Distributions within Reactor Cores

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**Abstract:** A new Reduced Order Model (ROM) is developed for solving the neutron eigenvalue problem for the fast and accurate prediction and simulation of the neutron flux within light water reactor cores. The method of Proper Orthogonal Decomposition is employed to form the ROM which uses snapshots obtained from a full order model based on the finite element discretisation of the spatial dependence of the multi-group neutron diffusion equation. We detail how the temperature variation and control rod adjustments can be efficiently integrated into the model and their influence then accurately predicted within the model's solution. This is particularly important as the former poses the non-linearities that form within the neutron transport equations, whilst the later can easily form challenging fluxes for the ROM to resolve.

The ROM is used to predict eigenvalues for studying the reactivity of a PWR assembly under varying operating conditions, with varying temperatures, control rod settings and fuel compositions. It is able to accurately resolve reactivity under these different scenarios and provide detailed solutions of the energy dependent neutron scalar flux distributions. Importantly the run times to produce these solutions are drastically reduced, amounting to several orders of magnitude in comparison to a full order model using methods such as the finite element method. Thus it allows extremely fast solutions to a large array of calculations that may be required in scoping calculations, uncertainty quantification, and time dependent reactor transient analysis.