Emulation Based Calibration for Parameters in Parameterized Phonon Spectrum of ZrH_x in TRIGA Reactor Simulations

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Abstract

We investigate the calibration of the uncertainties of thermal scattering of ZrH_x in the fuel material in TRIGA reactor simulations. Thermal scattering cross sections of ZrH_x are heavily affected by the solid-state frequency distributions, also called "phonon spectra". In previous work, we have proposed parameterized phonon spectrum models and explored the effects on quantities of interest (QoIs) of changing spectra with such models by varying the parameters. In this work we establish a more general calibration framework for the phonon spectrum of ZrH_x. To accomplish this calibration we introduce two emulators: Gaussian process regression and Bayesian multivariate adaptive regression splines, to create a map from the input parameters to the QoIs into the calibration framework. Using these emulators we perform calibrations using the emulation results with the same QoIs. Test simulations using data generated with calibrated parameters show that uncertainties of the QoIs shrink over 50%. Moreover, we extend the test to the reactivity at at a different temperature, 293.6 K, and obtained close results to the surrogate experiment. The efficacy and efficiency of implementing emulators in the calibration framework are demonstrated.

Keywords: Phonon spectrum, Thermal neutron scattering, Uncertainty quantification, Calibration, BMARS, GPR, TRIGA reactors

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