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#05-203 Characterization of high harmonics frequencies in reactor noise experiments within the CORTEX project

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The Laboratory for Reactor Physics and Systems Behavior (LRS) of the école Polytechnique Fédérale de Lausanne (EPFL) has in recent years been involved with the European CORTEX project, which aims to characterize reactor perturbations such as local bubbling, mechanical vibrations, etc. by neutron flux measurements. The goal of the LRS is the preparation and execution of experiments and experimental data analysis, to provide quantities of interest for newly developed neutron transport code validation. In this paper, we present a method of discriminating the origins of spectral power peaks at different harmonic frequencies: either due to higher modes of the reactor perturbation inducing device or due to effects of different harmonics.

The European CORTEX project aims to develop an instrumentation system framework with the capability of localization and identification of different reactor neutron noise sources, leading to improved reactor diagnostics and ultimately safety. The project involves development stages from ground up: from experiment design, execution and analysis for code development and validation to instrumentation development supported by machine learning.

As part of the experimental data analysis is to provide the data for code validation. Initial developments enabled simulations of frequency effects of the same order, which changed during the CORTEX project. In terms of the actuall experiments, a more rigorous approach was employed by including the position signal of the induced perturbation device in the form of oscillating absorber or fuel. This enabled for an estimate of two different contributions: due to higher harmonics of the oscillator itself, or higher order harmonics of lower order oscillations, which have different origins.

An estimate on the two contributions can be made by comparison of spectral power peaks of the detector signals and the oscillator position signal. This can help distinguish between the two effects and provide higher quality data for code validation.

This is possible by utilizing a high frequency resolution analysis technique based on bootstrapping with replacement. The oscillation and the detector data are synchronized in time. The data is then sectioned by well defined oscillator position data features (e.g. crossing neutral position), and used for spectral density calculations using Fourier transform and the bootstrapping re-sampling process. The developed analysis scripts also use modern graphics processors (GPU's) to speed up the re-sampling process by a factor of ~10.

The methodology has already been applied to the data from the 1st experimental campaign of the CROCUS reactor, yielding higher harmonics up to the 14th order. The data is already being utilized for the code validation and further developments.

The improved capabilities of reactor noise propagation codes identified the need for higher harmonics experimental oscillator and detector data. The newly developed analysis techniques enable the distinction between higher order effect of the oscillator movement itself and higher order effects due to lower harmonics oscillations. The analyzed experimental data is available to the CORTEX consortium members for code validation and comparison.

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