A FREQUENCY-DOMAIN REACTOR NEUTRON NOISE SIMULATOR BASED ON A DISCRETE ORDINATES METHOD

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CORTEX Core monitoring techniques and experimental validation and demonstration

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1. Background

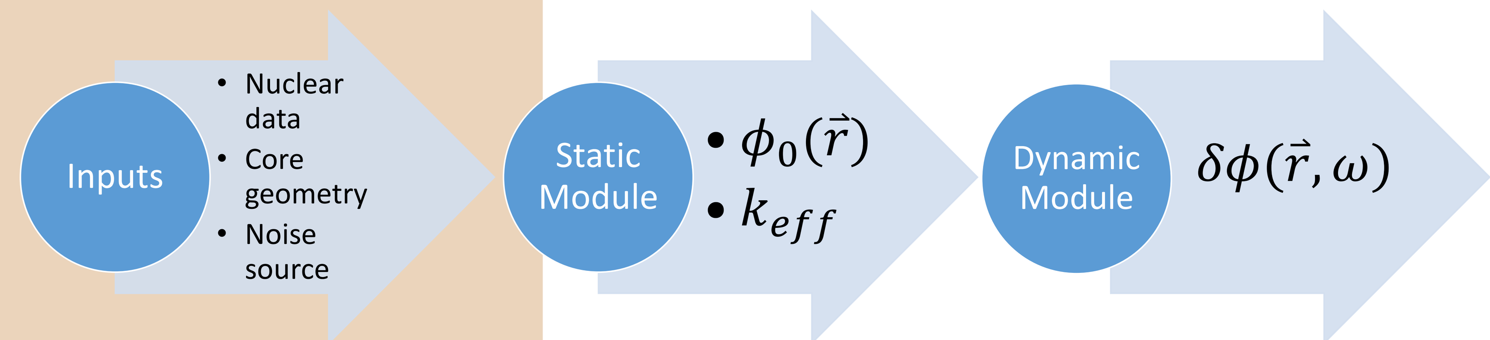
- Neutron noise are referred to as the fluctuations of neutron flux measurements around an expected mean value because of variations of nuclear reactor properties
- The analysis of neutron noise is helpful to core monitoring and diagnostics
- Modelling of the reactor transfer function is needed for the analysis
- Most of the past modeling work is based on a low order approximation of the neutron transport equation (e.g. diffusion theory)

2. Aim of the project

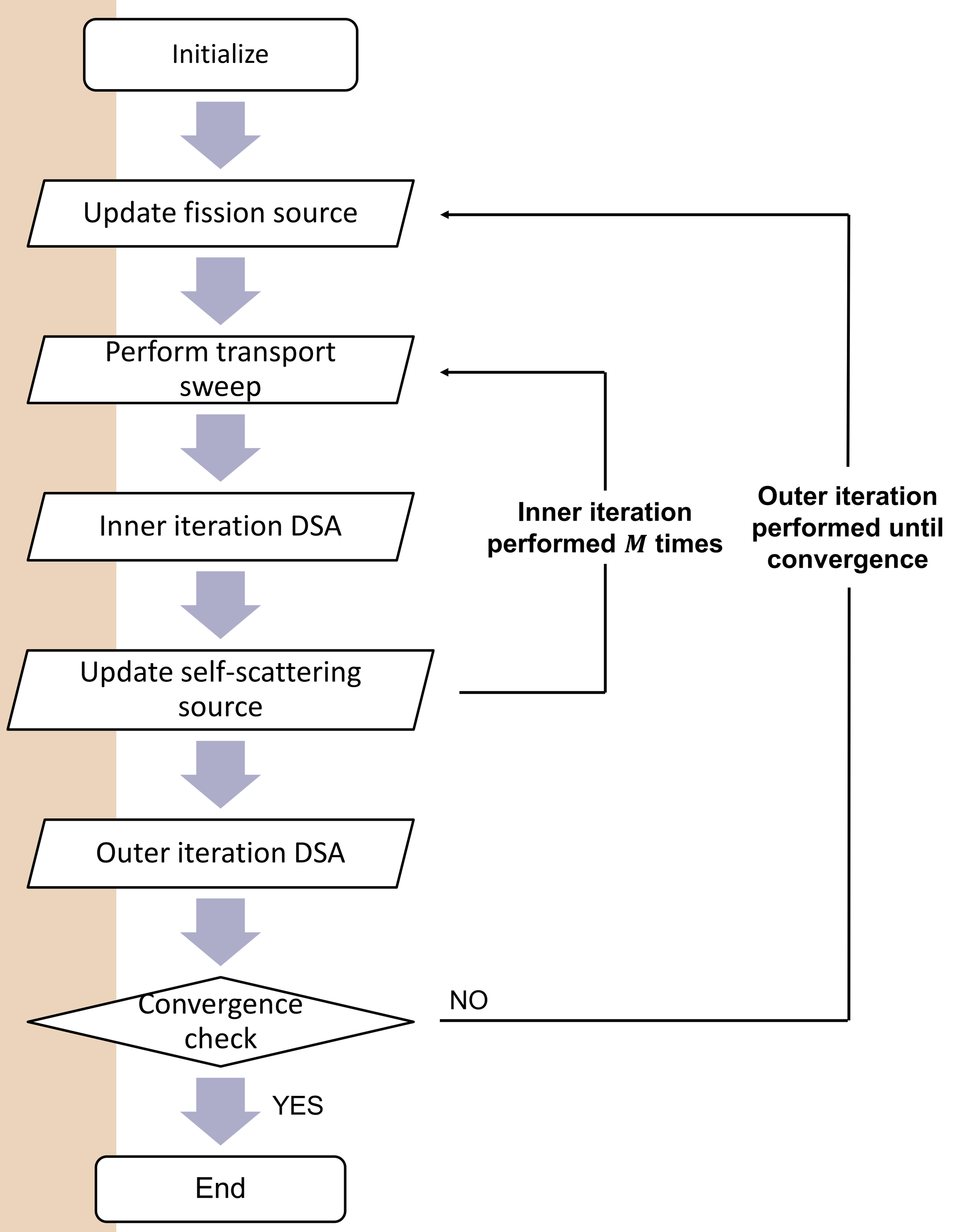
- Development of a solver for more accurate neutron noise calculations, based on a higher-order transport method

3. The Simulator

- Calculation scheme based on a two-step procedure



- Dynamic simulation in the frequency domain
- Spatial discretization based on a diamond finite difference scheme
- Discrete ordinates method is used for the treatment of the angular dependence of the neutron fluxes
- Two-energy-group formulation
- Acceleration of the convergence rate for both modules using the diffusion synthetic acceleration (DSA) technique



3. Convergence analysis

- The convergence rate is studied via a theoretical Fourier analysis and compared with numerical results
- DSA leads to smaller spectral radius and consequently faster convergence

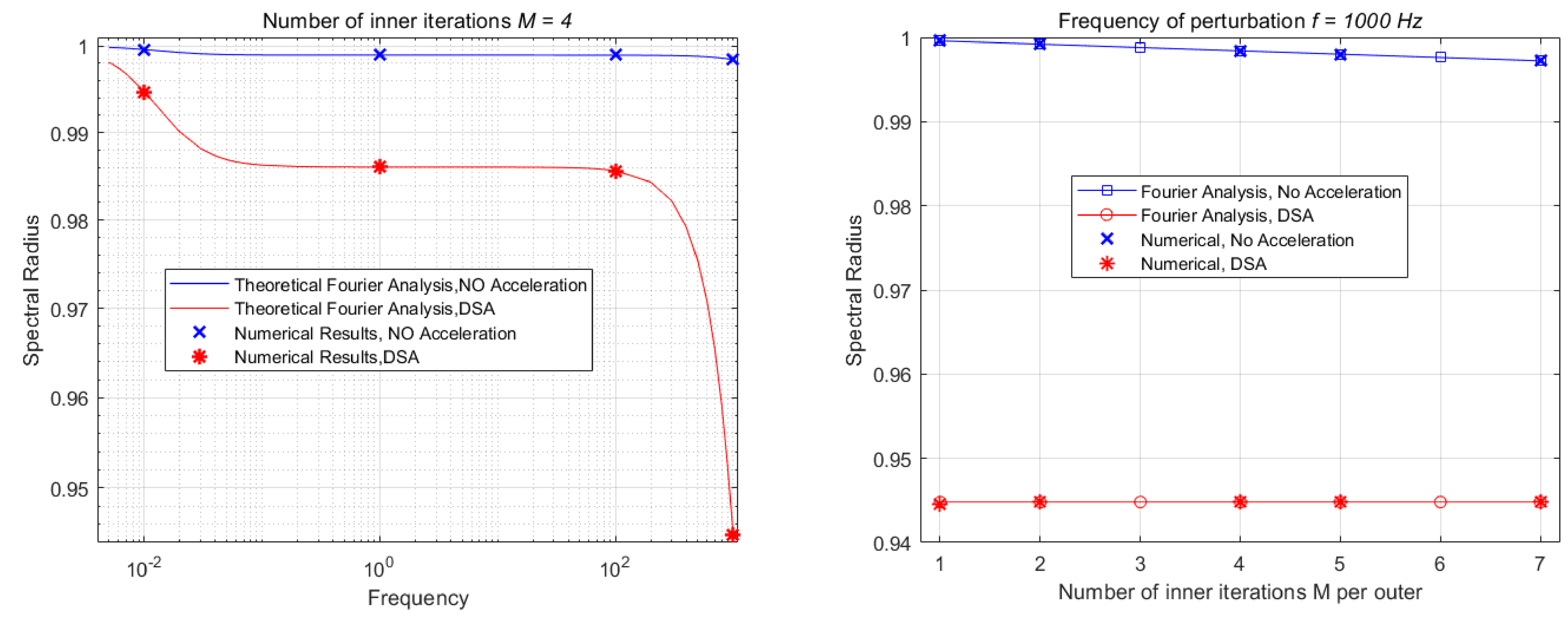


Figure 1: Spectral radius as a function of frequency (left) and number of inner iterations (right).

4. Simulation of a localized neutron noise source

- 2-D heterogeneous configuration
- Perturbation of the capture cross section in one point of the system

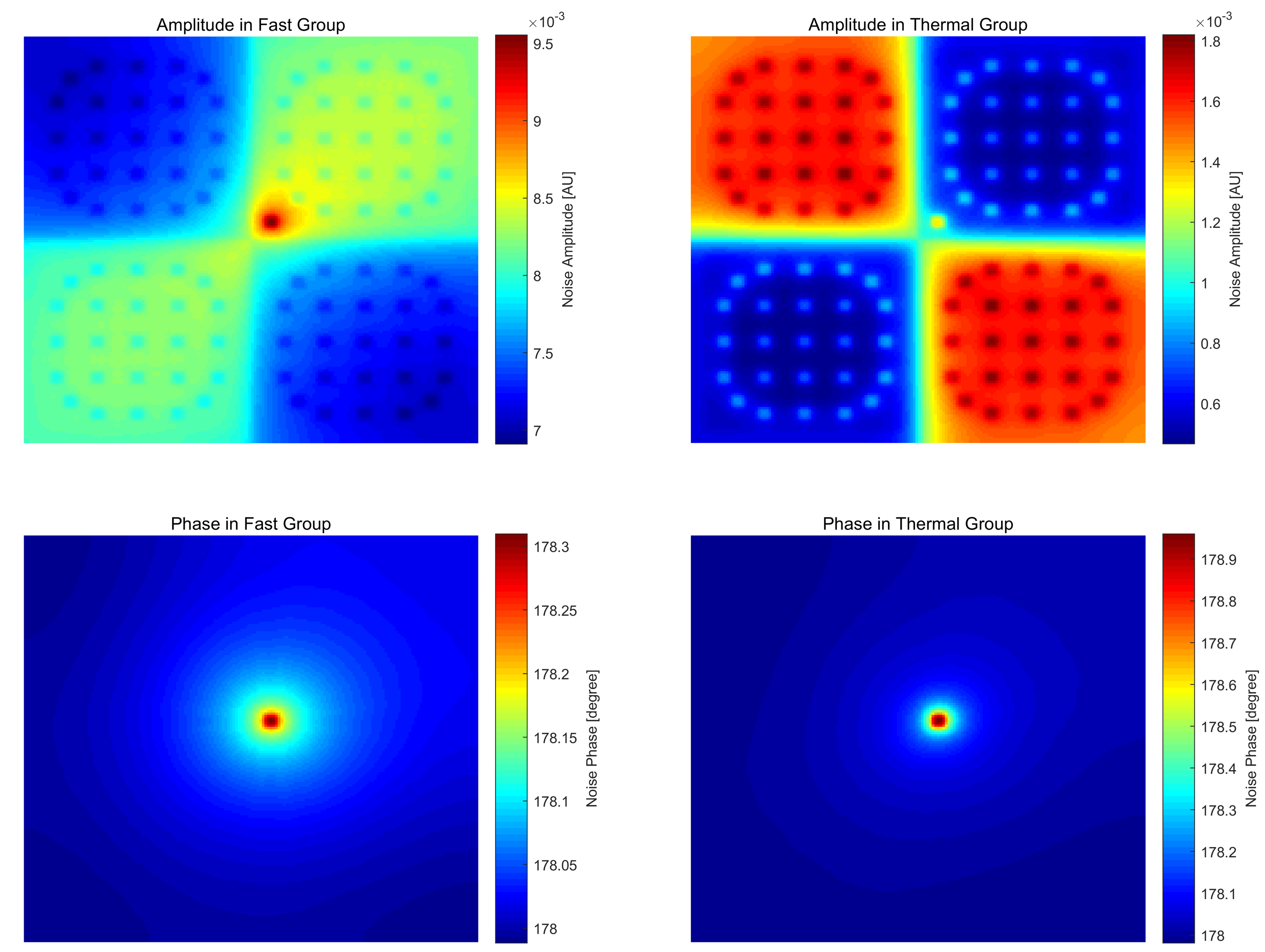


Figure 2: Amplitude and phase of the fast (left) and thermal (right) neutron noise at frequency of 1 Hz

- Simulated neutron noise with respect to frequency is consistent with the theoretical zero-power reactor transfer function

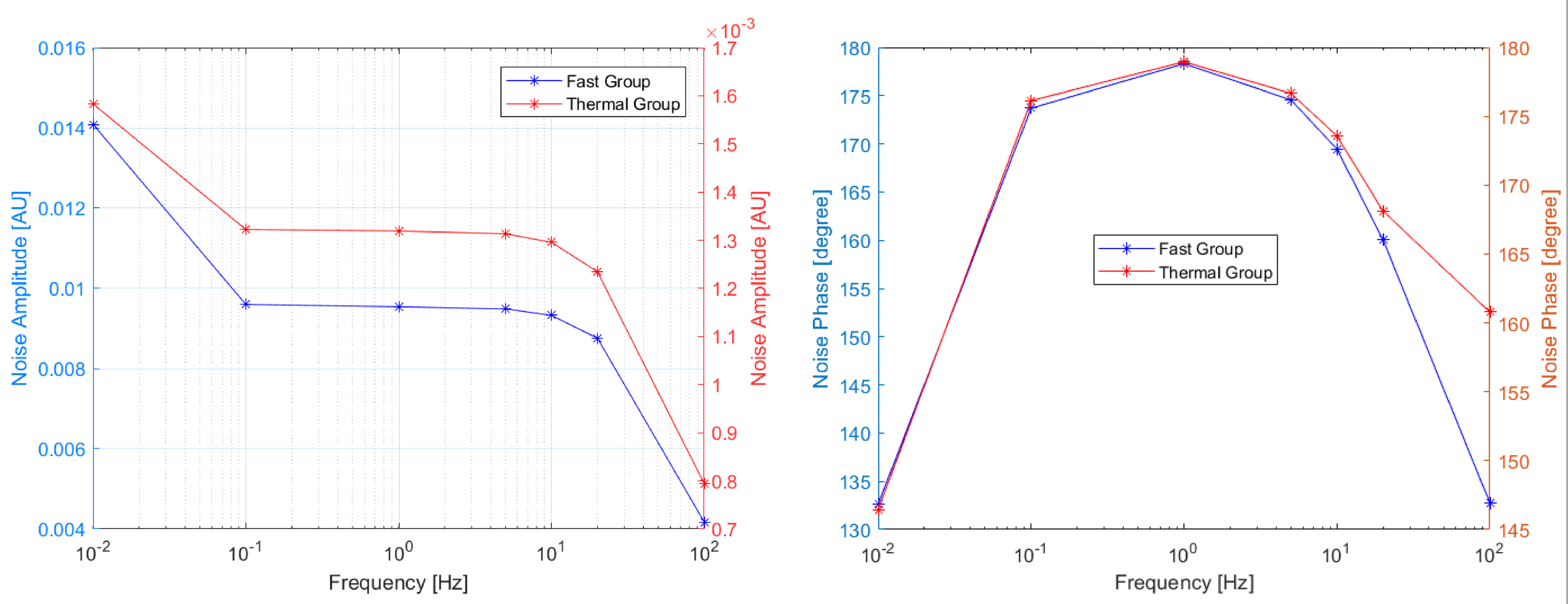


Figure 3: Neutron noise amplitude (left) and phase (right) as a function of perturbation frequency, taken at the position of the noise source.