Karlsruher Institut für Technologie

Institut für Technische Mechanik
- Dynamik und Mechatronik -

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Master thesis

Model Reduction of Strongly Coupled Chains with Periodic Structure

Background

Model reduction is a crucial technique in engineering and applied sciences, aimed at simplifying complex systems without losing key characteristics. It involves distilling a system with many degrees of freedom into a more manageable form, retaining essential dynamics while easing analysis and computation. This method is advantageous across various scales, from simplifying large-scale structural analyses to streamlining intricate electronic circuits. Effective model reduction facilitates faster simulations, enhances understanding of system behavior, and can significantly reduce costs in both research and industry. It is pivotal for optimizing designs in automotive engineering, improving control systems in aerospace, and advancing the development of medical devices, among other applications.

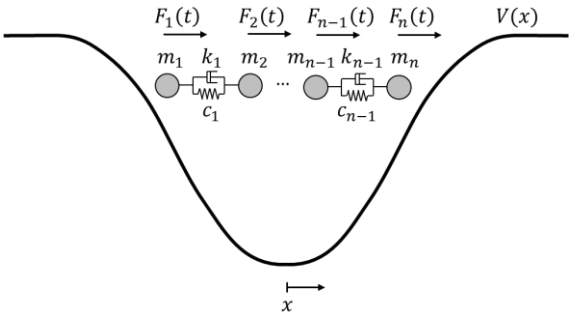

Figure 1 - Excited chain of particles in a potential well

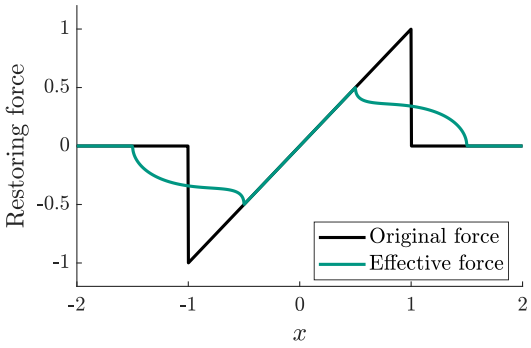

Figure 2 – Original and effective restoring force caused by two rapidly oscillating particles

At the Institute of Engineering Mechanics (ITM), we primarily investigate the reduction of slow-fast mechanical systems by calculating the net effect of fast oscillations on the slow dynamics of the system.

For a strongly coupled n-particle chain (see Fig. 1), calculating the internal vibration modes and resonant frequencies is analytically not feasible, considering arbitrary particle mass, damping, and stiffness values. However, if these values are evenly distributed, the analytic calculation of the chain's vibration modes and resonant frequencies is viable. It turns out that relative vibrations have a smoothing effect on the effective potential that underlies the motion of the center of mass of the chain (see Fig. 2).

Topic

The main scope of this thesis is to investigate the effect of a periodic chain structure on the motion of the chain's center of mass. Such periodic structures with high-frequency vibrations often emerge in mechanical engineering on shafts with blades or disks; or in material science as phonon vibrations where the rotation of the shaft in an external force field or the propagation of waves and deformations in the solid represents the slow processes.

Requirements

- Strong mathematical background
- Programming skills in MATLAB or in a similar programming language

Start: immediately

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