Integral Elasticity for Nonlocal Nanorods

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Abstract

One-dimensional structural components - such as thick nanorods - play a crucial role in modern nanotechnology, particularly in the development of advanced nano-electromechanical systems. Their mechanical behavior and design requirements can be effectively investigated using nonlocal continuum mechanics, which provides substantial computational benefits over fully atomistic simulations while still capturing size-dependent effects.

This work aims to refine the theoretical modeling of small-scale thick rods for nano-technological applications by employing a nonlocal continuum framework. In particular, it introduces a stress-driven nonlocal integral formulation that overcomes the well-known inconsistencies and paradoxes that arise when using Eringen's classical differential nonlocal theory. The primary contribution of the study is the integration of a stress-driven nonlocal elasticity model into Bishop's rod theory, resulting in a formulation specifically designed for finite, bounded structural domains. This feature makes the model more naturally compatible with the types of boundary conditions typically encountered in nanoscale structures, improving its physical relevance.

Remarkably, the proposed approach guarantees a well-posed mechanical boundary-value problem for thick rods, enabling closed-form analytical solutions, something that is often difficult to achieve in traditional nonlocal elasticity formulations. With this foundation, a comprehensive parametric analysis can be carried out to investigate how nonlocal interactions influence the rod's response. The study also examines the role of different boundary constraints, providing valuable insights into the realistic mechanical behavior of nanoscale rods.