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Purohit, Prashant K. (2001-11-08) Dynamics of phase transitions in strings, beams and atomic chains. <http://resolver.caltech.edu/CaltechETD:etd-11072006-100058>

Type of Document	Dissertation														
Author	Purohit, Prashant K.														
URN	etd-11072006-100058														
Persistent URL	http://resolver.caltech.edu/CaltechETD:etd-11072006-100058														
Title	Dynamics of phase transitions in strings, beams and atomic chains														
Degree	PhD														
Option	Applied Mechanics														
Advisory Committee	<table border="0"> <thead> <tr> <th>Advisor Name</th> <th>Title</th> </tr> </thead> <tbody> <tr> <td>Kaushik Bhattacharya</td> <td>Committee Chair</td> </tr> <tr> <td>Ares J. Rosakis</td> <td>Committee Member</td> </tr> <tr> <td>James K. Knowles</td> <td>Committee Member</td> </tr> <tr> <td>Michael Ortiz</td> <td>Committee Member</td> </tr> <tr> <td>Rob Phillips</td> <td>Committee Member</td> </tr> <tr> <td>Thomas Y. Hou</td> <td>Committee Member</td> </tr> </tbody> </table>	Advisor Name	Title	Kaushik Bhattacharya	Committee Chair	Ares J. Rosakis	Committee Member	James K. Knowles	Committee Member	Michael Ortiz	Committee Member	Rob Phillips	Committee Member	Thomas Y. Hou	Committee Member
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Keywords	<ul style="list-style-type: none"> • kinetic relations • dynamics of strings • Godunov methods • Martensitic phase transitions 														
Date of Defense	2001-11-08														
Availability	unrestricted														

Abstract

This thesis presents a theory for dynamical martensitic phase transitions in strings and beam Shape memory alloys that rely on such phase transitions for their unique properties are often used in slender configurations like beams and rods. Yet most studies of phase transformation are in one dimension and consider only extension. The theory presented in this thesis to model these slender structures is based on the general continuum mechanical framework of thermoelasticity with a non-convex Helmholtz free energy. This non-convexity allows for the simultaneous existence of several metastable phases in a material; in particular, it leads to the formation of phase boundaries. The study of the laws governing the propagation of phase boundaries is the object of this thesis.

Phase boundaries in strings are studied first. It is demonstrated that the motion of phase boundaries is not fully described by the usual balance laws of mass, momentum and energy. Additional constitutive information must be furnished from outside, and this additional information is referred to as the kinetic relation. While this notion is well-accepted in continuum theory, there is no definitive experiment or theoretical framework to determine the kinetic relation. This study of strings proposes a simple experiment to determine the kinetic relation. It also proposes a numerical method that accurately describes the complex behavior of strings with phase boundaries.

The kinetic relation can also be viewed from the atomic scale. Phase transformations involve a complex rearrangement of the atoms the explicit details of which are averaged in a continuum theory. The kinetic relation may be viewed as an aggregate of those aspects of the atomistic rearrangement that have a bearing on macroscopic phenomena. This view is explored using a simple one dimensional model of an atomic chain with non-convex interaction potentials. A kinetic relation is obtained from dynamic simulations of impact experiments on the chain.

The latter part of this thesis studies beams made of materials capable of phase transitions. It develops a conceptual framework that accounts for extension, shear and flexure in such beams using a non-convex stored energy function. Specific constitutive assumptions that relate to the underlying crystallography are developed. The theory is applied to design a simple experiment on single crystals of martensitic materials with the objective of measuring the kinetic relation.

Finally, propulsion at small scales is discussed as an application of beams made of phase transforming material. The goal is to mimic the flagellum of a micro-organism by propagating phase boundaries through a shearable rod.

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