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Spatial behavior in the electromagnetic theory of microstretch elasticity

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ABSTRACT

This paper is concerned with the electromagnetic theory of microstretch elasticity. First, the initial boundary value problem is formulated in the framework of the linear dynamic theory of microstretch magnetoelectroelastic solids. Then, the spatial behavior of solutions is studied in both bounded and unbounded regions. The obtained result gives an exact idea of the domain of influence, in the sense that for each fixed time in a given interval, the entire activity vanishes at distanced from the support of the given data greater than a time-dependent threshold value. The study of spatial behavior is completed by an exponential decay estimate inside the domain of influence. As a by product a uniqueness result holding for both bounded and unbounded bodies is derived. Finally, the effect of a concentrated microstretch body force is studied.

1. Introduction

The interaction of electromagnetic fields with deformable bodies has been the subject of many theoretical investigations in continuum mechanics (see for example the books of Tiersten, 1969; Eringen and Maugin, 1990; Zhou, 1999; Yang, 2005).

Several recent works (Eringen, 1999, 2003, 2004; Lee et al., 2004) are dedicated to formulate electromagnetic theories for elastic bodies with inner structure. Thus, in the papers by Eringen (2003) and Lee et al. (2004) it was introduced a continuum theory of micromorphic electromagnetic thermoelastic solids, while Eringen (2004) derived the electromagnetic theory of microstretch elasticity. The intended applications of these theories are to porous elastic bodies such as bones and ceramics, synthetic materials containing microscopic components (e.g., nanocomposites), solids with microcracks, etc. (see Eringen, 1999).

Special cases of the field equations are the theory of piezoelectricity and the theory of magnetoelasticity. These theories consider only static or quasi-static electromagnetic fields. Thus, the mechanical equations are dynamic while the electromagnetic equations are static and the electric field and the magnetic field are not dynamically coupled. We recall that the linear theory of microstretch piezoelectricity was studied by Ieşan (2006) and Quintanilla (2008), while in the paper by Ieşan and Quintanilla (2007) some important theorems have been proven for microstretch thermopiezoelectricity. Moreover, the basic equations governing the bending of microstretch piezoelectric plates have been treated by Ieşan (2008a), and a linear theory of microstretch thermopiezoelectricity without energy dissipation has been presented by Ieşan (2008b).

Here we consider the full electromagnetic theory of microstretch elasticity (Eringen, 2004). Our goal is to investigate the spatial behavior of solutions to the magnetoelectroelastic initial boundary value problem. It is worth to note that in the framework of microstretch piezoelectricity, the problem of spatial behavior of solutions has been tackled by Quintanilla (2008). He derived a spatial decay estimate for the solution to the problem of a homogeneous and isotropic semi-infinite cylinder in motion, subject to homogeneous initial and boundary data except for that prescribed on the base. Quintanilla (2008) utilized a measure of solution which leads to a polynomial decay estimate in terms of the distance from the loaded end of the cylinder. The reason for which the result is not of exponential type is due to the quasi-static feature of the considered problem. In piezoelectricity the electric fields are considered quasi-static, although the mechanical equations are dynamic. Or in mathematical terms, the theory of piezoelectricity combines hyperbolic with elliptic equations.

The purpose of this paper is to show that if the full electromagnetic theory of microstretch elasticity is considered then a stronger result can be obtained, in contrast with the special case of quasi-static piezoelectricity. Thus, introducing an adequate measure of solutions and utilizing its properties we get both a domain of influence and an exponential decay estimate inside the domain of influence (see Chiriţă and Ciarletta, 1999 for corresponding results in elasticity and viscoelasticity). The result is proved in the general context of anisotropic and inhomogeneous magnetoelectroelastic microstretch bodies. And clearly, the result holds for dynamic piezoelectricity (or dynamic magnetoelasticity).

Such studies are motivated by the rapid development of smart structures technology and the current models introduced to

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