

Preface

We first became interested in the interaction between mechanical deformation and magnetic or electric fields just over 10 years ago. This interest was in part motivated by the development of elastomeric materials capable of large deformations that can be generated by the application of an electric or magnetic field. These were beginning to be used in various devices, ranging from activators and sensors to vibration and damping controls. Modelling of the behaviour of such materials requires an adequate theory of nonlinear deformations that can also accommodate electric or magnetic fields in the constitutive description. Although there were nonlinear theories in the literature based on continuum mechanics, we didn't find that they lent themselves easily to applications, in particular to the formulation of boundary-value problems. We therefore decided to seek an approach that could simplify the structure of the constitutive equations and, as a result, the governing equations of equilibrium and motion. We feel that this aim has been achieved in the last few years, and the subject is now at a point where it would be useful to write a connected account of this recent work, and this monograph is the result.

After an introductory chapter, we begin with a chapter (Chap. 2) that summarizes the necessary background from electrostatics, magnetostatics and electrodynamics, aimed primarily at those who have not previously been exposed to much of this theory. This is followed by Chap. 3, which summarizes the essential ingredients of continuum mechanics and nonlinear elasticity theory, partly for the benefit of those who have not attended a course of continuum mechanics. For those with relevant backgrounds the material in these first two chapters will be familiar, but they provide the basic theory and notations that are required in order to merge these distinct subject areas and to derive a coupled nonlinear theory of electroelastic interactions and, separately, of magnetoelastic interactions. In each case the theory is applied to simple representative problems to illustrate the influences of the electric and magnetic fields on the elastic behaviour of materials in the finite deformation regime. We also include a chapter on variational approaches to both electroelasticity and magnetoelasticity. We then provide a discussion of the (linearized) incremental equations superimposed on an underlying configuration consisting of a finite deformation in the presence of either an electric field or a magnetic field. This is

used, first in the electroelastic case, to evaluate the stability of the underlying configuration for some simple body geometries, and, for magnetoelastic materials, the magnetoacoustic approximation is adopted in order to study the propagation of magnetoelastic homogeneous plane waves and surface waves.

In the course of writing we have obtained a significant number of new results, which are included here but otherwise unpublished. We have also tried to unify the notation, and therefore much of the notation in the later chapters differs from that in our various papers.

We have been very much helped by the encouragement of colleagues and friends who have been very positive about this project and by those researchers who have taken on board our approach and developed it in different directions.

This monograph is aimed at researchers and graduate students whose interests are at the interface of electromagnetism and continuum mechanics, whether they are mathematicians, engineers or physicists. It requires some familiarity with vector and tensor calculus and some basic knowledge of electromagnetic theory and continuum mechanics.

Medford, MA, USA
Glasgow, UK

Luis Dorfmann
Ray W. Ogden

Nonlinear Theory of Electroelastic and Magnetoelastic
Interactions

Dorfmann, L.; Ogden, R.W.

2014, XI, 313 p. 19 illus., Hardcover

ISBN: 978-1-4614-9595-6