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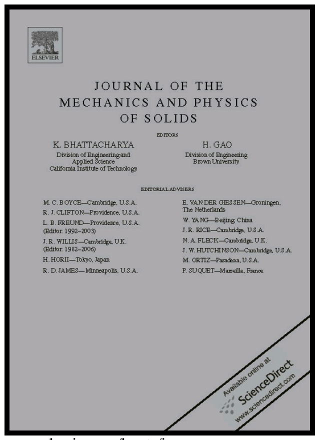

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PII: S0022-5096(15)30323-9
DOI: http://dx.doi.org/10.1016/j.jmps.2016.07.006
Reference: MPS2946

To appear in: *Journal of the Mechanics and Physics of Solids*

Received date: 11 December 2015
Revised date: 15 June 2016
Accepted date: 5 July 2016

Cite this article as: Cédric Bellis, Converting strain maps into elasticity maps fo materials with small contrast, *Journal of the Mechanics and Physics of Solids* http://dx.doi.org/10.1016/j.jmps.2016.07.006

Converting strain maps into elasticity maps for materials with small contrast

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Abstract

This study addresses the question of the quantitative reconstruction of heterogeneous distributions of isotropic elastic moduli from full strain field data. This parameter identification problem exposes the need for a local reconstruction procedure that is investigated here in the case of materials with small contrast. To begin with the integral formulation framework for the periodic linear elasticity problem, first- and second-order asymptotics are retained for the strain field solution and the effective elasticity tensor. Properties of the featured Green's tensor are investigated to characterize its decomposition into an isotropic term and an orthogonal part. The former is then shown to define a local contribution to the volume integral equations considered. Based on this property, then the combination of multiple strain field solutions corresponding to well-chosen applied macroscopic strains is shown to lead to a set of local and uncoupled identities relating, respectively, the bulk and shear moduli to the spherical and deviatoric components of the strain fields. Valid at the first-order in the weak contrast limit, such relations permit point-wise conversions of strain maps into elasticity maps. Furthermore, it is also shown that for macroscopically isotropic material configurations a single strain field solution is actually sufficient to reconstruct either the bulk or the shear modulus distribution. Those results are then revisited in the case of bounded media. Finally, some sets of analytical and numerical examples are provided for comparison and to illustrate the relevance of the obtained strain-modulus local equations for a parameter identification method based on full-field data.

1 Introduction

1.1 Context

Imaging the mechanical properties of a solid body is a problem with applications to material characterization, non-destructive testing or medical diagnosis. In this context, displacement or strain field measurements are generally assumed to be available within the domain or at its boundary and the reconstruction of distributions of elastic moduli from such data constitutes an ill-posed inverse problem. Over the last few decades a variety of identification methods have been developed for a number of constitutive models associated with a range of measurement modalities, see [9].

The specific focus of the present study is the quantitative reconstruction of the elasticity maps that characterize a heterogeneous and linear isotropic elastic medium, from full strain field maps associated with a set of static mechanical excitations applied to the investigated body. This problem is motivated by the flourishing development of kinematic full-field measurement techniques, see