On novel explicit expressions of Green's function and its derivatives for magnetoelectroelastic materials

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Abstract

It is well known that the Green's function for anisotropic magnetoelectroelastic materials can be written as a line integral by solving the governing equations and thereafter explicit expressions can be obtained by applying the Cauchy residue calculus to the line integral. Alternatively, the Green's function can be evaluated explicitly by constructing the integral in terms of the solutions of a standard eigen-system known as the Stroh eigen-relation. In this paper, explicit expressions of the Green's function for the magnetoelectroelastic materials are successfully constructed by the solutions of the Stroh eigen-relation associated with the oblique plane perpendicular to the position vector \( x \). With the distinctness assumption on the eigenvalues, the first and second derivatives of the Green's function are expressed as linear combinations of the eigenvectors, where the corresponding coefficients are determined explicitly. As a special case, the numerical results of these explicit expressions are validated by analytical results for the transversely isotropic magnetoelectroelastic materials. Furthermore, the present explicit expressions of the Green's function and its derivatives are applied to calculate the generalized displacement and stress fields due to a buried quantum dot in an infinite magnetoelectroelastic solid.

1. Introduction

Magnetoelectroelastic solids and/or multiferroic materials have magneto-electro-mechanical energy conversion capacities. Due to the potential applications in the technologies of smart and adaptive materials and structures such as magnetic/electric transducers, actuators and sensors, the magnetoelectroelastic solids have drawn increasing interest of the scientists and engineers. The natural single-phase multiferroic materials have very weak magnetoelectric coupling at room temperature, while the magnetoelectric composites constituting of piezoelectric and piezomagnetic material phases, reported for example by van Suchtelen (1972) may have a strong magnetoelectric coupling even at room temperature (Eerenstein et al., 2006; Srinivasan, 2010).

Although there is no magnetoelectric coupling in either piezoelectric materials or piezomagnetic materials, the magnetoelectric composites have a magnetoelectric coupling due to the interaction between the electromechanical and magnetomechanical behaviors of the constituent materials. Many investigations can be found in literature on the theoretical modeling of magnetoelectric composites. Alshits et al. (1992) investigated the existence of the surface wave in semi-infinite anisotropic magnetoelectroelastic solids, Benveniste (1995), Huang and Kuo (1997) and Li and Dunn (1998) analyzed the inclusion and inhomogeneity problems of the magnetoelectric composites by treating both the piezoelectric and the piezomagnetic materials as single-phase magnetoelectroelastic materials. These previous works may be considered as some of the pioneer works on the magnetoelectroelastic materials after which numerous theoretical models have been proposed.

It is well known that the Green's function plays an important role in the solution of many boundary value problems. It can be used to solve inhomogeneity, contact and fracture problems. Particularly, the Green’s function as well as its derivatives are basic stones of boundary integral equation method (BIEM) or the boundary element method (BEM) which is very popular in the engineering analysis. For the transversely isotropic magnetoelectroelastic materials, the Green's function could be obtained

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