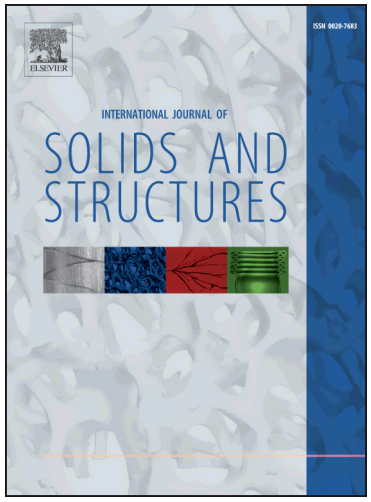

Manipulation of the propagation of out-of-plane shear waves

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Manipulation of the propagation of out-of-plane shear waves

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Abstract: For a given elastic medium, there is a one-to-one correspondence relation between material properties (elastic moduli and density) and the propagation path of elastic waves. Based on this idea, we propose a new method for designing a cylindrical cloak invisible to out-of-plane shear waves. We begin by writing the Hamiltonian governing the path trajectory of out-of-plane shear waves in an inhomogeneous orthotropic medium. Based on Hamilton's equations of motion, we derive the ray equation for out-of-plane shear waves and the differential equation that describes the optimal spatial distribution of material properties in the cylindrical cloak. To solve these two differential equations, two boundary conditions are imposed in terms of the continuity conditions of displacement and traction on the outer boundary of the cylindrical cloak. The two differential equations and two boundary conditions constitute a solvable system from which various cloak profiles can be designed. The proposed approach, which differs from the transformation optics approach, provides an intuitive and flexible design platform and allows considerable freedom to construct invisibility cloaks with a specific spatial distribution of material properties. The effects of the material properties and boundary conditions on cloak invisibility are analyzed in detail. Numerical simulations show that optimized cylindrical cloaks with finite material properties can be easily constructed.

Keywords: Cylindrical cloak; ray trajectory; out-of-plane shear wave; Hamiltonian

1. Introduction

Pendry et al. (2006) and Leonhardt (2006) independently showed that it is