SM20S_12364

XXI International Congress of Theoretical and Applied Mechanics
Warsaw, Poland, August 15–21, 2004

On the Use of Second-Order Topological Information for Subsurface Imaging by Elastic Waves

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This paper summarizes the generalization and application of topological derivative, rooted in structural shape optimization, to 3D inverse scattering involving elastic-wave identification of subsurface obstacles. Recently, elastodynamic expressions for topological sensitivity have been proposed for the imaging of both semi-infinite and finite solid bodies. Despite their utility, however, these developments are limited in the sense that they are restricted to the identification of subsurface cavities and do not provide an explicit link between the nucleated (infinitesimal) cavity and finite void(s) being sought. To deal with these impediments, the proposed generalization is two-fold and involves i) development of a formula for the nucleation of a solid inclusion, and ii) rigorous analysis of the second-order topological information that permits direct estimation of the obstacle size through the solution of a canonic least-squares problem established on the basis of (first-order) topological sensitivity. Numerical examples are included to illustrate the proposed developments.

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