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Hysteresis effects in nonlinear acoustic landmine detection

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In nonlinear acoustic landmine detection the vibration interaction of the top-plate of the buried plastic landmine with the adjacent soil is a subject of interest due to the strong nonlinear coupling. Using airborne sound excitation (in buried plastic anti-tank inert VS 1.6 and VS 2.2 landmine experiments) tuning curve behavior and generation of combination frequencies from two-tone tests were similar to the mesoscopic/nanoscale nonlinear elastic behavior observed in geomaterials like sandstone [J. Acoust. Soc. Am. **116**, 3354-3369 (2004)]. Tuning curve measurements near resonance for increased acoustic amplitude (exhibiting softening) can be explained if hysteresis effects (characteristic of mesoscopic nonlinearity) are considered. The backbone curve (peak amplitude vs. corresponding resonant frequency from a family of tuning curves) exhibits mostly linear behavior for "off target" soil surface vibration measurements of a soil layer resonating over a rigid boundary. Backbone curves for "on target" measurements exhibit significantly more bending and curvature when a soil layer resonates over the compliant top-plate of the landmine. An oscillator with hysteresis modeled by a distribution of parallel spring elements each with a different threshold slip condition seems to describe the "off target" behavior, while a single bilinear hysteresis element describes the "on target" results. [Support by USNA.]