Wigner Distribution of Ultrasonic Transducers Applied to Scattering in Polycrystalline Media

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The scattering of elastic waves in polycrystalline materials is relevant for ultrasonic materials characterization and nondestructive evaluation (NDE). Diffuse ultrasonic backscatter measurements have been especially useful for extracting microstructural information such as grain size and for detecting flaws in materials. Accurate interpretation of experimental data requires robust scattering models. Quantitative ultrasonic scattering models include components of both transducer beams as well as microstructural scattering information. Here, the Wigner distribution is used in conjunction with a radiative transfer equation (RTE) to model this scattering problem. The Wigner distribution represents a distribution in space and time of spectral energy density as a function of wave vector and frequency. In the first part of the presentation, the Wigner distributions of various transducer beams of common interest are derived and discussed. Then, an RTE is derived within the context of the Wigner distribution such that the source and receiver distributions are included in the analysis in a rigorous fashion. The resulting RTE is then simplified in the single-scattering limit typical of many diffuse backscatter experiments. Such experiments, usually done using a modified pulse-echo technique, utilize the variance of the signals in space as the primary measure of microstructure. The resulting backscatter model derived here is compared with previous derivations. In addition, experimental backscatter results are compared with the model for materials of common interest under assumptions of statistical isotropy. These results are anticipated to impact ultrasonic nondestructive evaluation of polycrystalline media. [Work supported by US DOE]

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