ME Seminar

Nonlinear ultrasonic/acoustic characterization of disparate solid media across length scales

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ABSTRACT

Nonlinear ultrasonic/acoustic testing relies on the principles of elastic wave propagation. When a finite amplitude wave interacts with a medium containing micro-scale defects and discontinuities such as grain boundaries, dislocations, and relatively closed cracks, it introduces subtle but measurable distortion in the traveling wave response. Measuring such changes (known as nonlinear ultrasonic/acoustic parameters) makes the basis for nonlinear ultrasonic/acoustic testing methods. The measured nonlinear ultrasonic parameters are directly related to the higher-order elastic constants of the medium. Such nonlinear acoustic parameters are sensitive to micro-scale incipient damage that may go undetected by conventional (linear) testing and have shown great potential in characterizing a wide range of materials across the length scales. Further, nonlinear acoustic techniques can be exploited to understand microstructure, contact properties, and frictional constitutive behaviors. In this seminar, I will describe three nonlinear ultrasonic/acoustic testing methods: dynamic acousto-elastic testing (DAET), nonlinear resonant ultrasound spectroscopy (NRUS) and second harmonic generation (SHG) and present some of the applications of these techniques to characterize disparate solid media. In the first part of this seminar, I will present DAET laboratory quake experiments to understand the nonlinear elastodynamic response of fractured rock under in-situ stress and saturation conditions. The nonlinear elastic response of fractured rocks has important implications in understanding the triggering of earthquakes and remote prediction of rock poromechanical properties from their seismic signatures. Secondly, I will present engineering applications of nonlinear acoustic testing that include: (1) DAET for detection of closed fatigue cracks in aluminum, which go undetected by traditional linear ultrasonic testing, NRUS and SHG for characterization of (2) additively manufactured samples, (3) cranial suture a form of joints that connect two adjacent bone regions in the skull, and (4) thermally sprayed coatings. Finally, I will briefly describe some of my recent work on bio-inspired phononic crystal and piezoelectric metamaterials for wave manipulation and vibration control and high intensity focused ultrasound for high strain rate testing of materials.

ABOUT THE SPEAKER

Dr. Prabhakaran Manogharan is a noise and vibration engineer at the acoustic organization of Apple. Prior to this he was a Postdoctoral fellow at the mechanical engineering department of Georgia Institute of Technology. His research focused on diverse areas of acoustics/ultrasonics and vibration that include power ultrasonics, phononic crystals and piezoelectric metamaterials, High intensity focused ultrasound and nonlinear acoustics. He received his Ph.D in Engineering Science and Mechanics with a minor in Acoustics from Pennsylvania State University. Prior to his Ph.D at Penn State, he worked as an Edison Engineer at the General Electric, Aerospace division Bangalore for three years. He received his master's degree in mechanical engineering from the Indian Institute of Technology Madras and bachelor's degree in mechanical engineering from Pondicherry Engineering College with a gold medal.

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