

4.5.26. SYMMETRY ANALYSIS SIGNAL PROCESSING FOR LOCAL NONLINEAR SCATTERERS SIGNATURE OF COMPLEX MATERIALS STRUCTURAL INTEGRITY

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Over the last few decades, increasing interest has been bestowed on employing nonlinear wave propagation effects, which possess the intrinsic property of enlarging bandwidth frequency of analysis, to detect, at a sub-wavelength scale (below the ultrasonic wavelength), the early damage in the degradation process leading to mechanical fracture. Higher frequencies are used for resolution improvement and lower frequencies for aging monitoring. The NDT community today refers to methods based on analysis of nonlinear effects as Nonlinear Elastic Wave Spectroscopy (NEWS). Recent years have seen considerable development (both in numerical- and experimental aspects) of TR-based NEWS methods using TR invariance and reciprocity. The defined TR-NEWS methods were integrated into applications for improving identification of nonlinear scatterers, such as bubbles, landmines, cracks in complex aeronautic materials and these techniques are now widely recognized as extremely reliable [1].

The complexity of the experimental set-up has been studied using a recent nonlinear signal processing and analysis methodology: Symmetry Analysis combined with localization methods using the Decomposition of the Time Reversal Operator (DORT) were used to detect and localize spatially the nonlinear scatterers responsible of the damaged properties of complex material [2]. Several experimental configurations will be presented in the paper: cracked aluminum samples, damaged composites and heated layered materials from aeronautic industry, epoxy adhesive joints from the maritime systems, and bio-materials from the bio-medical characterization. The specimens under test are analyzed using ultrasonic transducers (10 MHz) amplified using 150 W power amplifier. Arbitrary waveform generators and portable acquisitions devices (Artann Laboratories, USA) were connected to the high precision Polytec vibrometer measurement device, which insures the calibration of the metrology necessary for nonlinear measurements.

References:

1. **Ostrovsky L.A., Rudenko O.V.** What problems of Nonlinear Acoustics Seem to be Important and Interesting Today? in proc. of the 18th International Symposium on Nonlinear Acoustics ISNA (Stockholm, Sweden), ISBN 978-0-7354-0544-8, American Institute of Physics, 2008, p. 9 – 16.
2. **Serge Dos Santos, Sarka Vejvodova, and Zdenek Prevorovsky.** Local Nonlinear Scatterers Signature using Symbiosis of the Time-Reversal Operator and Symmetry Analysis Signal Processing, J. Acoust. Soc. Am. (2009) in press.