ACOUSTICS2008/3377
The Parametric Array in Berea Sandstone, Revisted

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Previous measurements of the characteristics of the parametric array in sandstone by Johnson and Shankland [J. Geophys. Res., 94, 17729-17734 (1989)] were difficult to perform and, given the apparatus of the day, only qualitative. Since then, memory effects have been found to play a strong role in the dynamic behavior of rocks. This experimental study was performed to find out how well the "classical" theory of nonlinear acoustics, i.e., all compressional waves with no memory effects, works at describing the parameteric array in a granular solid. An array of PZT disk transducers (every other one broadcasting one of two frequencies) was epoxied to a large block of Berea sandstone (1.2x0.4x0.4 m). The two primary frequencies were near 100kHz and chosen to produce a difference frequency around 15kHz. Using a scanning laser vibrometer (Polytec), several scans of the beampatterns were made at the opposite end of the rock and the results compared with calculations based on those commonly used for parametric arrays in water. A narrow beam generated from the two primaries was measured and the beampattern compared with those of the primaries. The agreement is surprisingly good using a beta of around 200 and a Q of about 50.