Finite amplitude method for the determination of the acoustic nonlinearity parameter *B/A*

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WEDNESDAY MORNING, 10 NOVEMBER 1982

DADE AND FLORIDA KEYS ROOMS, 8:45 TO 10:50 A.M.

Session V. Physical Acoustics IV: Nonlinear Acoustics

Mark B. Moffett, Chairman

Naval Underwater Systems Center, New London, Connecticut 06320

Chairman's Introduction—8:45

Contributed Papers

8:50

V1. Finite amplitude method for the determination of the acoustic nonlinearity parameter *B/A*. Wesley N. Cobb (Applied Mechanics, Yale University, New Haven, CT 06520)

The acoustic nonlinearity parameter B/A is determined using a method based on the finite amplitude distortion of a sine wave emitted by a piston. We measure the growth of the second harmonic component of this wave using a piston receiver, which is coaxial with and the same size as the source. In order to determine B/A, the experimental measurements are compared to a theory which incorporates the nonlinearity parameter. The theory developed for this study accounts for the influence of both diffraction and attenuation on the experimental measurements. For this reason, the method is more accurate than previous techniques that employ plane wave theory for a lossless medium. To test the measurement method, we compare the experimental results for B/A in distilled water, ethylene glycol and glycerol to established values. The agreement between these values suggests that the measurement accuracy is plus or minus 4% for common liquids. [Work supported by ONR.]

9:05

V2. Effective acoustic nonlinear parameter (*B/A*) of a mixture. Robert E. Apfel and Wesley N. Cobb (Applied Mechanics, Yale University, New Haven, CT 06520)

We derive an expression for the effective nonlinearity parameter, B/A, of a mixture for which the density, compressibility, B/A, and mass (volume) fraction of each component is known. We then compare the predictions with experimental results reported in the literature and with our own experimental results for compositions ranging from solutions to tissues. Finally, we attempt to rationalize differences between predictions and experimental results, where they exist. [Work supported by U.S. Office of Naval Research.]

9:20

V3. Rapid cavitation in water induced by the reflection of shock waves. Bruce T. Unger and Philip L. Marston (Department of Physics, Washington State University, Pullman, WA 99164)

Negative pressures were produced in distilled water by reflecting shock pulses of 11 MPa off a quasifree water–Mylar–air interface. The incident pulses, created by conventional impact techniques, were typically 1.7 μs in duration. An interferometer measured the displacement of the interface from which the velocity history of the Mylar could be extracted. Tension is created in the water when rarefaction waves collide. The tension results in cavitation which is evidenced by a rapid rebound of the Mylar's velocity. Difficulties experienced in previous experiments [P. L. Marston and G. L. Pullen, in *Shock Waves in Condensed Matter, 1981*, edited by W. J. Nellis *et al.* (AIP, New York, 1982), pp. 515–519] have been overcome by reducing the thickness of the Mylar which initially constrains the water. Velocity histories give a clear indication of cavitation in the sample; the abrupt tension being relieved by bubble formation within 1 μs. Also evident is reverberation within the spalled layer of the pressure wave radiated by the bubbles. The results suggest an apparent dynamic tensile strength >5 MPa for moderately clean water. [Work supported by ONR and the American Chemical Society Petroleum Research Fund. Marston is an Alfred P. Sloan Research Fellow.]

9:35

V4. Finite-amplitude waveforms produced by a circular piston projector. Mark B. Moffett (Naval Underwater Systems Center, New London, CT 06320) and Jerry H. Ginsberg (Georgia Institute of Technology, Atlanta, GA 30332)

Measurements were made of the waveforms produced at six different locations on the axis of a 0.51-m-diam projector driven at 60 kHz in the NUSC/Newport large acoustic tank facility. The locations were at the last three pressure maxima in the nearfield, a quasifarfield point at 5 m, and two farfield positions at 10 m and 15 m. The projector was driven at several levels, and yielded waveforms ranging from sinusoidal at the lowest levels and shortest ranges to shock formation at the highest levels and longer ranges. Two different hydrophones were used, but neither had a flat enough response to avoid ringing when shocks were present. The waveforms exhibit the asymmetry (sharp pressure peaks and rounded pressure troughs) previously observed by Browning and Mellen [J. Acoust. Soc. **44**, 644–646 (1968)] and predicted by recent work of Ginsberg which accounts for diffraction as well as nonlinear propagation effects. [Work supported by ONR Code 425 UA.]

9:50

V5. Pulsed parametric array revisited. D. H. Trivett (Naval Research Laboratory, Washington, DC 20375) and Peter H. Rogers (Office of Naval Research, Arlington, VA 22217)

In a previous paper [J. Acoust. Soc. Am. Suppl. 1 **71**, S30 (A)] we presented the results of an investigation of the pulsed parametric array. We found that while the primary pulse exited the transducer a sum and difference frequency signal was scattered. However, once the interaction region was freely propagating (i.e., both boundaries moving at the sound speed) no further scattered signal was generated. This results in the observed scattered signal having a pulse length equal to the primary pulse length and the appearance of direct radiation from the face of the transducer. We also concluded that the directivity pattern, identical to the cw parametric array, was not due to a volume distribution of virtual sources. On re-examination this conclusion has been found to be incorrect. In this paper we demonstrate that the observed signal at a given farfield point is generated by a volume distribution of virtual sources, as long as contributions to the field at that point are still being received from the stationary boundary. Once signals from the stationary boundary cease there is no further scattering to that point. The extent of the scattering region is dependent upon the primary pulse length and the observation angle and is given by $L_{\text{eff}} = L/(1 - \cos\phi)$, where L is the primary pulse length and ϕ is the observation angle. This result may have some practical applications.