substrate. The presentation will demonstrate initial evidence of using silent sound and clean water-controlled acoustic microcavitation for removing xerographic ink from paper, and paint layers from metal surfaces without damaging the underlying substrates, paper and metal, respectively. More significantly such microcavitation-assisted surface erosion permits an easy method for determining the bonding strength between the thin film and its substrate. [Work supported by Navy and NSF.]

## *Contributed Papers*

**10:20**

**2aBB7. Surf-zone bubble detection using multiple techniques: The Worbarrow Bay experiment.** Timothy G. Leighton, Matthew D. Simpson, Steve D. Meers, Paul R. White (Inst. of Sound and Vib. Res., Univ. of Southampton, Highfield, Southampton SO17 1BJ, UK), Gary J. Heald, Hugh A. Dumbrell, James W. Clarke (DERA Bincleaves, Weymouth, Dorset, UK), Peter R. Birkin, and Yvonne Watson (Univ. of Southampton, Highfield, Southampton SO17 1BJ, UK)

This paper describes a multisensor experiment to characterize the bubble population and its effects in the surf zone. Active bubble detectors (combination-frequency sensors, and the inversion of sound speed and attenuation) provided estimations of the bubble-size distribution, and allowed better interpretation of more novel sensors. These include acousto-electrochemical sensors, and estimations of the bubble population from the ring-up time associated with the insonification of the population, and from the ambient noise (attention being paid to how the ringing population so determined differs from the full population measured by active techniques). [Work supported by the U.K. Defence Evaluation Research Agency and the EPSRC.]

**10:35**

**2aBB8. The effects of oceanic surfactants on acoustic propagation in bubbly liquids.** Joseph C. Jankovsky and Ronald A. Roy (Dept. of Aerosp. and Mech. Eng., Boston Univ., 110 Cummington St., Boston, MA 02215, jankov@bu.edu)

The chemical composition of the top layer of the ocean is known to contain surface-active substances that are readily adsorbed to an air-water interface. The presence of surfactants in a liquid induces a viscoelastic stress along a two-dimensional interface. These surfactants can coat bubbles that alter their individual dynamics. A model is presented that incorporates the effects of surface viscoelasticity for acoustic propagation in bubbly fluids. The effects of both surface dilatational viscosity and surface elasticity on the phase speed and attenuation are considered. Surface viscosity is found to decrease the attenuation near bubble resonance frequencies, yet increase damping below resonance. Surface viscosity also diminishes the resonant effects for the phase speed in bubbly fluids. Both effects become significant for bubble sizes below 100 microns. The addition of surface elasticity is found to decrease the mean oscillation bubble radius, and thus shift bubble resonance to a higher frequency. The effects of the model on *in situ* acoustic bubble sizing methods will also be discussed. [Work supported by ONR.]

**10:50**

**2aBB9. Acoustic scattering from an elastic tube filled with bubbly fluid.** Preston S. Wilson, Ronald A. Roy, and William M. Carey (Dept. of Aerosp. and Mech. Eng., Boston Univ., Boston, MA 02215)

A complete model describing broadband sea surface scattering at high wind speeds has not been developed. One difficulty is accounting for scattering from near-surface bubble clouds. This problem has been addressed in the literature for low frequencies. To first order, an acoustically compact bubble cloud can be modeled as a compressible sphere, where the scattering strength depends only on spherical cloud volume and mean void fraction, not the bubble size distribution or cloud shape. This hypothesis has been experimentally tested using freely rising artificial bubble clouds [J. Acoust. Soc. Am. **92**, 2993–2996 (1992)]. The measured low-frequency monopole target strength of the cloud agreed with theory but higher-frequency results did not. To further understand scattering from these objects, laboratory scattering experiments are underway using geometrically well-characterized bubbly fluid targets. Initial measurements of scattering from a bubbly fluid-filled latex tube are presented and compared to an effective medium theory. These initial results lack independent void fraction determination but good qualitative agreement is found, even above the monopole resonance frequency. A new method used in these experiments to generate large volumes of nearly monodisperse bubbly fluid samples will also be described. [Work supported by ONR.]

**11:05**

**2aBB10. Acoustic scattering from partially voided compliant and fluid spheres.** Joseph C. Jankovsky, Ryan D. McCormick, Ronald A. Roy, and William M. Carey (Dept. of Aerosp. and Mech. Eng., Boston Univ., 110 Cummington St., Boston, MA 02215, jankov@bu.edu)

The presence of bubbles has been shown to change the compressibility and complex sound speed in a liquid. In the ocean, acoustically compact bubbly mixtures manifest themselves as highly compressible regions that effectively scatter low-frequency sound. To study low-frequency sound scattering, multifrequency backscattering experiments have been performed in a tank using partially voided three-quarter-inch diameter polyurethane spheres as targets. Target strengths (2-20 kHz) were measured for four spheres with void fractions of 0%, 3.4%, 4.2%, and 6%. Measured target strengths for the voided spheres were on the order of $-40$ to $-60$ dB ($re$ 1 m). The frequency response exhibited modal structure, with peaks shifting to lower frequencies for higher void fractions. No backscatter signal was detected for the solid polyurethane sphere. Target strength was also measured for a hollow polyurethane sphere containing a suspension of bubbles in polymer gel. The void fraction was determined by fitting the scattering theory and low-frequency bubbly fluid compressibility model to the measured data. [Work supported by ONR.]

**11:20**

**2aBB11. Comparing the predictions of a numerical model of SBSL in a variable acceleration environment to experiment.** Charles Thomas, Sean Wyatt,[a] Ronald Roy, and R. Glynn Holt (Dept. of Aerosp. and Mech. Eng., Boston Univ., 110 Cummington St., Boston, MA 02215)

The results of an August 1999 KC-135 SL experiment will be discussed and compared to a numerical model [Wyatt *et al.*, J. Acoust. Soc. Am. **106**, No. 4, Pt. 2, 2290 (1999)] for SL in a cubic acoustic resonator in a varying acceleration environment. The model takes into account gravitational effects and varying ambient pressure effects, and predicts the maximum bubble size, light intensity, and levitation position of the bubble. A review of and comparison to other investigators experimental results will be included. [Work supported by NASA.] [a] Currently at Ford Motor Company, Detroit, MI.

**11:35**

**2aBB12. Sonoluminescence at the nanoscale.** Carlos G. Camara, Keith R. Weninger, and Seth J. Putterman (Phys. Dept., Univ. of California, Los Angeles, Los Angeles, CA 90095)

Sonoluminescence (SL) has been observed to be robust over a wide parameter space ranging from 8 kHz to 11 MHz. Although some lines can be discerned in the spectra of some cavitation clouds, they sit on top of a broadband ultraviolet continuum that spans to at least 6 eV. Experiments and theory indicate that the light-emitting region can reach tenths of nanometers. Although the SL mechanism and its huge parameter space remain a mystery, it has already been put to use as a surgical device. At 30 kHz it is used for internal lipectomy and at 1 MHz it is used for externally assisted lipectomy. At 11 MHz a dense cloud of light-emitting bubbles is observed in the far field of the transducer. These observations could be exploited for future uses of nonintrusive ultrasound surgery.