Session 4aUW

Underwater Acoustics: Rough Surface Scattering, Bubbles and Noise

Darrell R. Jackson, Chair
Applied Physics Laboratory, University of Washington, Seattle, Washington 98105, USA

Contributed Papers

9:20

4aUW1. A new, semiempirical model for predicting bistatic surface backscattering strengths. Roger Gauss (Naval Res. Lab., Washington, DC 20375-5350, roger.gauss@nrl.navy.mil) and Joseph Fialkowski (Planning Systems, Inc., McLean, VA 22102-3304)

A Lloyd-mirror model of bubble-cloud scattering, along with perturbation theory for the rough air–sea interface, have been used as a basis for generating a new algorithm for predicting the strength of acoustic backscatter from the ocean surface. Multiparameter curve fits of the model to acoustic data from the Critical Sea Test program (1988–1996) and other at-sea experiments have been used to derive a new, semiempirical description of the dependence of surface backscattering strength on the incident and scattered grazing angles, the acoustic frequency, and environmental descriptors. The model represents an advance on previous algorithms (Chapman–Harris, Ogden–Nicholas–Erskine) in several ways: (1) a much improved, physics-based description of the grazing-angle dependence, applicable to arbitrarily low grazing angles; (2) a much improved description of low-to-moderate sea-state bubble scattering; (3) can handle vertically bistatic geometries; and (4) is applicable to a broader range of frequencies (50 to 5000 Hz). [Work supported by ONR.]

9:40

4aUW2. Time-dependent scattering from bubble clouds: Implications for the use of acoustic pulses. James W. Clarke, Tim G. Leighton (Inst. of Sound and Vib. Res., Univ. of Southampton, Highfield, Southampton SO17 1BJ, UK, jwlc@isvr.soton.ac.uk), Gary J. Heald, and Hugh A. Dumbrell (Defence Evaluation Res. Agency, Weymouth, Dorset DT4 8UR, UK)

A theoretical model has been developed to investigate the ring-up times, or time taken to reach steady-state oscillation, of gas bubbles in fresh water. The model utilizes numerical solutions of the Herring–Keller bubble model and damping values after Prosperetti's 1977 analysis to calculate the extinction cross-sectional area of a bubble as a function of time in response to a continuous harmonic sound field. The model has also been extended to determine the extinction cross-section area of multiple bubbles of varying population distributions assuming no bubble–bubble interactions. The results have shown that the ring-up time of a bubble is dependent on its closeness to resonance and the driving pressure amplitude. Investigation of various bubble populations has shown that the ring-up time of the resonant bubbles may be masked by the presence of large off-resonant bubbles and that high-amplitude sound fields enhance this effect. The implications of these findings for the use of acoustic pulses are explored. [Work supported by DERA.]

10:00

4aUW3. A time-domain path integral method for analyzing reflections from a rough sea surface. S. E. Forsythe, Jean C. Piquette (Naval Undersea Warfare Ctr., 1176 Howell Rd., Newport, RI 02841, forsythese@code20nl.npt.nuwc.navy.mil), Mohsen Badiey (Univ. of Delaware, Newark, DE 19716), and J. Simmen (Office of Naval Res., Arlington, VA 22217)

Recently, experimental data were gathered for broadband (500 Hz–20 kHz) sound transmissions in shallow water over a period of seven days. The processed data form a good approximation to the impulse response of the environment, including direct signal paths, surface interactions, and bottom interactions, from a source to both local and remote receivers. Since the signals resulting from a single interaction with the ocean surface can be cleanly separated from other arrivals, these signals become a rich source of information about surface wave motion and thus about the state of the sea. To analyze the effects of surface waves (surface wave height, period, wave number, wave direction) on the received signal, including frequency dependence, a tool for efficiently calculating broadband response of a rough sea is needed. Instead of solving for the wave field at many frequencies and synthesizing the result into a broadband response using Fourier techniques, a direct computation of the response uses raylike techniques to sum over all significant paths in the time domain. For some problems, this technique is much more efficient than frequency-domain approaches such as PE or wave number integration, while providing the low-frequency accuracy that is only approximated by ray theory approaches. [Work supported by ONR.]

10:20–10:40 Break

10:40

4aUW4. Surf zone breaking wave air entrainment and noise generation. Ming-Yang Su (Naval Res. Lab., Code 7332, Stennis Space Center, MS 39529) and Joel C. Wesson (Neptune Sci., Inc., Slidell, LA 70458)

During two field experiments conducted at CERC (Coastal Engineering Research Center) at Duck, NC in 1997 and 1998, NRL made simultaneous measurements of air void fraction and sound intensity due to wave breaking across the surf zone under various weather conditions with or without wind forcing. The void fraction sensors, wave pressure gauges, and hydrophones were deployed by two distinctly different methods. The first method used a new and unique swinging-bar which has the top end attached to a surface float, with its bottom end attached to a universal joint anchored in the sandy bottom. The second method used the CERC Sensor Insertion System (SIS), to place the instruments in the water at various points and depths along the 600-m-long pier at the facility. This paper presents the characteristics and statistics of the spatial and temporal variations of these void fraction measurements associated with surface wave profiles, and power spectra and time-frequency spectra of sound intensity under wave breaking. The corresponding relationship between the void fraction variation and sound intensity shall also be presented.

11:00

4aUW5. Acoustic measurements of air entrainment by a plunging free water jet. Thomas R. Hahn, Thomas K. Berger, and Michael J. Buckingham (Marine Physical Lab., Scripps Inst. of Oceanogr., Univ. of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0238, thahn@ucsd.edu)

Low-frequency acoustic emissions of a free plunging water jet were studied to determine the volumetric rate of gas transfer across the pool surface. At the studied jet velocities, up to 10 m/s, air bubbles are entrained at the interface and form well-defined bubble clouds penetrating up to 20 cm into the pool. The resulting biphasic region of the submerged jet was found to be an efficient acoustic resonator. The radiated sound field was recorded with hydrophones close to the region of the submerged jet