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Transient Underwater Bubble Sound

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ABSTRACT

Gas bubbles in the sea may act as separate sound sources and thus contribute to the overall ambient noise level. Some examples of natural gas bubble generation in the sea are wind induced breaking waves, capillary-gravity waves and rain drops falling on the surface. Due to these processes, gas bubbles can be brought into or generated in the sea surface layer and then set into transient motion. The resulting scattered sound pulses and in particular the induced acoustic power have been of major concern in a number of recent investigations. From the vast amount of experimental data it is found that to a first approximation, the gas bubbles act as linear spherical sound sources oscillating at the fundamental mode. Due to the interaction with the sea surface, the overall acoustic field has the character of a transient dipole. By modelling a gas bubble as a linear oscillator, one can extract information from experimentally obtained pulses. Typical examples are the equilibrium radius, transient frequency, damping constant, source strength and power spectrum. In these investigations, free linear oscillations are assumed which is relevant in looking for the parameters mentioned.

In this work, however, we consider driven oscillations and thus consider the full transient problem also including the finite time of excitation. As a result, we also model the wave front of the scattered pulses including information about the excitation. This means that a time-scale related to the excitation enters into our analysis. By means of this model we are able to simulate scattered pulses which to a great extent agree with experimentally obtained data. Although the model presented is here used in order to simulate sound from wind, capillary- gravity and rain drop induced bubbles it can also be used in studying wave propagation in bubbly fluids in general. It is finally suggested that the time-scale of duration of the excitation that enters into our analysis can be used in a further understanding of gas bubble generation and excitation in the sea.