The Fourth Heart Centre European Symposium on Ultrasound Contrast Imaging
21-22 January 1999, Rotterdam, The Netherlands

ACOUSTIC CROSS-SECTIONS: IMPLICATIONS OF STEADY-STATE AND TRANSIENT MODELS FOR EXPERIMENTS WITH CONTINUOUS-WAVE AND PULSED ULTRASOUND

T. G. Leighton

Institute of Sound and Vibration Research, University of Southampton, Highfield, Southampton SO17 1BJ, UK

There are two common ways of defining acoustic cross-sections with respect to bubble-based ultrasonic contrast agents. The first is empirical, and simply normalises the scattered intensity invested in the n^{th} harmonic to that scattered at the fundamental frequency. As such, this allows a description of certain nonlinear characteristics of the bubble, such as the generation of harmonics; and it can readily be calculated from measurements. However it contains no information about the fundamental properties of the agent, and cannot be interpreted in terms of the underlying bubble dynamics. The dimensions of area are introduced by the somewhat artificial multiplication of the intensity ratio by the geometrical cross-sectional area, which has very little acoustical significance when the conditions are near resonance.

None of these limitations are true of the second method of defining the acoustic scattering cross-section, which is from the ratio of the power scattered spherically by the bubble to the intensity of a plane wave incident upon it. An equivalent acoustic extinction cross-section can similar be defined using the total power loss from the beam. This loss results from all the scatter and absorption which the target causes. Scatter and extinction cross-sections are extremely useful, since they can be interpreted in terms of the effective 'target area' which a gas body presents to an ultrasonic beam. However to date the only expressions for these cross-sections have been analytical solutions based on linear, steady-state bubble pulsations. As such they are applicable in the main to the response of gas bodies when subjected to continuous-wave fields of low amplitude. Bubble-based contrast agents are, however, usually subjected to high amplitude, pulsed fields. This paper describes a scheme for calculating the extinction and scattering cross-sections of gas bodies using a nonlinear model of their pulsations, and demonstrates how the 'efficiency' of the scatter (i.e. the backscattered proportion of the energy contained within the incident pulse) can be enhanced by modifying the pulse length, frequency, and amplitude.